

TRANSMISSION OF ENVIRONMENTAL KNOWLEDGE AND LAND SKILLS IN
ADAPTATION TO CLIMATE CHANGE IN THE ARCTIC

A Thesis
Presented to
The Faculty of Graduate Studies
of
The University of Guelph

by
TRISTAN DAVID PEARCE

In partial fulfillment of requirements
for the degree of
Doctor of Philosophy

September, 2011

© Tristan David Pearce, 2011

ABSTRACT

TRANSMISSION OF ENVIRONMENTAL KNOWLEDGE AND LAND SKILLS IN ADAPTATION TO CLIMATE CHANGE IN THE ARCTIC

Tristan David Pearce
University of Guelph, 2011

Advisor:
Professor Barry Smit

This thesis investigates the relationships between skills transmission and human adaptation to climate change. Elements of the relationships are empirically examined in an arctic community to document how environmental knowledge and land skills (referred to hereafter together as ‘land skills’) are transmitted among Inuit men and what role, if any, skills transmission plays in adaptation to climate change with respect to subsistence harvesting.

It is well documented that climate change is already being experienced in the Arctic with implications for Inuit subsistence harvesting. The ability of Inuit to adapt to changing environmental conditions in the past has been associated with a profound knowledge of the Arctic ecosphere and land skills, which were transmitted from the older generations to the younger through hands-on training in the environment.

Based on a review of vulnerability and skills transmission scholarship, a conceptual model for interpreting the relationships between skills transmission and adaptive capacity is developed. The model conceptualizes land skills as a key determinant of Inuit adaptive capacity to deal with climatic changes that affect subsistence. The ability of a hunter to draw on land skills to adapt to changing conditions also depends on whether or not a given skill has been transmitted, and transmission success depends on the level of skill mastery.

The transmission of land skills was studied among Inuit men in Ulukhaktok, Northwest Territories, Canada. The research found that there is a difference in the rate of land skills transmission among generations, with average transmission rates lowest among younger respondents. Several skills had not been transmitted, or were transmitted incompletely among younger respondents. Whereas these same skills had been transmitted by that age among older Inuit. Changes in skills transmission are attributable to changes in the educational environment, loss of native language, absence of skills teachers, and declining levels of involvement in some subsistence activities. These factors appeared to impair the traditional mode of skills transmission and hands-on learning in the environment, resulting in several skills not being transmitted to younger respondents. Incomplete skills transmission has already reduced some individuals' involvement in subsistence, and has increased the sensitivity of others to changing climatic conditions.

ACKNOWLEDGEMENTS

I dedicate this Ph.D. to my dad, Philip Richard Pearce.

Thank you to the people of Ulukhaktok for welcoming me into your community and lives. Jimmy Kudlak, Jimmy Memorana, Nora Memorana, Mel Pretty, Harry and Margaret Egotak, George Okheena, and Wilma Memogana you are remembered and missed. I acknowledge the intellectual contributions, logistical support, and friendships of all those who contributed to this research including, Harold Wright, Adam Kudlak, Roland Notaina, Mel Pretty, Winnie Akhiatak, Robert and Agnes Kuptana, Albert Elias, Jerry Sr. Akoaksion, Annie Goose, Fred Kataoyak and everyone who participated in the research. This research would not have been possible without your help. Thank you to the members of my committee, Dr. Barry Smit, Dr. Ben Bradshaw and Dr. Chris Furgal for their support and advice. Thank you also to the members of my examining committee, Dr. Gary Kofinas (external examiner), Dr. Wayne Caldwell (internal examiner), and Ze'ev Getalof (chairperson). A gracious thank you to my advisor Dr. Barry Smit who has provided me with intellectual guidance, support, friendship and encouragement throughout my M.A. and Ph.D. Thank you also to Dr. James Ford, Frank Duerden, Dr. Peter Collings, Mark Andrachuk and Laura Flemming for intellectual contributions and continued friendships. The support and friendships among faculty, staff and students at the University of Guelph, in the Geography Department and the Global Environmental Change Group, in the Inuvialuit Settlement Region (ISR), and elsewhere in the Arctic are strongly acknowledged.

This research benefited from financial support from ArcticNet; International Polar Year (IPY) Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) Project; Social Science and Humanities Research Council (SSHRC) Vanier Doctoral Scholarship; Association of Canadian Universities for Northern Studies (ACUNS) Canadian Polar Commission Scholarship;

Indian and Northern Affairs Canada (INAC) Climate Change Impacts and Adaptation Program; Aurora Research Institute (ARI) Fellowships and Research Assistantships; University of Guelph: Deans Graduation Scholarship, Board of Graduate Studies Research Scholarship, and Global Environmental Change Group (GECG); Ontario Graduate Scholarship (OGS); and the Northern Studies Training Program (NSTP).

Thank you to Trevor, Marie, Alexandra and Julia Elmslie, and Bill, Susan, Robin and Max Moffat for being my Guelph family, Dave DeBurger for continued friendship, and Kelsey Rideout who stood with me through exams and field seasons. Mom and Dad, Graham, Vicki (Lili) and Zephyr, Daniel and Katherine, Auntie, Ivy, Lily, Tova and Aria, you are everything to me and I share this achievement with you.

The research was undertaken as part of the Global Environmental Change Group at the University of Guelph, and was conducted under Aurora Research Institute scientific research license No. 14440.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	i
TABLE OF CONTENTS	iii
LIST OF TABLES	v
LIST OF FIGURES	vi
CHAPTER 1: INTRODUCTION.....	1
1.1 Research Context	1
1.2 Research Aim and Objectives	8
1.3 Thesis Structure and Contributions.....	10
CHAPTER 2: THEORY AND CONCEPTS OF VULNERABILITY, ADAPTIVE CAPACITY, AND SKILLS TRANSMISSION	15
2.1 The Concept and Application of ‘Vulnerability’ in Environmental Change Research	15
2.2. Skills Transmission and Human Adaptation to Climate Change.....	21
2.3 Defining Inuit Environmental Knowledge.....	26
CHAPTER 3: REVIEW AND CRITIQUE OF CLIMATE CHANGE VULNERABILITY AND ADAPTATION RESEARCH IN THE INUVIALUIT SETTLEMENT REGION (ISR)	30
3.1 Introduction to Manuscript	30
3.2 Manuscript	31
CHAPTER 4: COMMUNITY-RESEARCHER COLLABORATION	61
4.1 Introduction to Manuscript	61
4.2 Manuscript	62
CHAPTER 5: TRANSMISSION OF ENVIRONMENTAL KNOWLEDGE AND LAND SKILLS	95
5.1 Introduction to Manuscript	95
5.2 Manuscript	96

CHAPTER 6: CONCLUSIONS	142
BIBLIOGRAPHY	150
APPENDIX 1: TRANSMISSION OF ENVIRONMENTAL KNOWLEDGE AND LAND SKILLS IN ADAPTATION PLANNING FOR CLIMATE CHANGE	176
APPENDIX 2A: CONSENT FORM	190
APPENDIX 2B: INTERVIEW GUIDE	191
APPENDIX 3: PUBLISHERS PERMISSION TO REPRODUCE MANUSCRIPTS	199
APPENDIX 4: CO-AUTHORS' STATEMENT	202
APPENDIX 5: SCIENTIFIC RESEARCH LICENSE.....	213

LIST OF TABLES

Table 1.1 Thesis chapters and their respective contributions	11
Table 3.1 Search terms identified through an iterative process and used to locate relevant literature	40
Table 3.2 Criteria used in the systematic literature review to exclude literature from the study.....	46
Table 3.3 References specifically addressing climate change impacts and adaptation in the ISR	49
Table 3.4 References by sector and sub-sector.....	50
Table 3.5 Geographic focus of literature.....	51
Table 3.6 Types of literature reviewed.....	51
Table 3.7 Examples of current adaptive strategies and adaptation constraints to climate change in the ISR.....	62
Table 5.1 Transmission of land skills, mean scores by groups of skills, by percentage.....	120
Table 5.2 Depth of knowledge about selected hunting activities, by percentage.....	123
Table 5.3 Transmission of navigation, way-finding, sea ice travel and weather forecasting skills, by percentage.....	126
Table 5.4 Age of skill acquisition, transmission of selected land skills (hands-on learning) and level achieved on the learning sequence (Fig. 4.2).....	129
Table 5.5 Primary and secondary teachers in the transmission of land skills, by number of respondents and by percentage.....	131
Table 5.6 Transmission success (hands-on learning): Adopted by grandfather as active teacher (GF) vs. father as active teacher (F) vs. no father/grandfather as active teacher (No F/GF).....	132
Table 5.7 Skills training and land camps offered in Ulukhaktok.....	141

LIST OF FIGURES

Figure 2.1 Determinants of adaptive capacity to climatic exposure-sensitivities related to subsistence harvesting in Ulukhaktok and other communities in the Canadian Arctic.....	31
Figure 2.2 The relationships among adaptive capacity, environmental knowledge and adaptations to some climate driven exposure-sensitivities in the Arctic.....	32
Figure 3.1 Map of ISR and the Inuvialuit communities	37
Figure 3.2 Distribution of literature according to the date it was made available	46
Figure 4.1 Location of case study communities: Ulukhaktok, Arctic Bay, Igloodik, Cape Dorset and Pangnirtung	65
Figure 4.2 Key considerations for engaging Arctic communities in collaborative research.....	82
Figure 5.1 The location of Ulukhaktok in the Inuvialuit Settlement Region (ISR), Northwest Territories in relation to the Western and Central Canadian Arctic	107
Figure 5.2 8-stage learning complex for environmental knowledge and land skills. After Ruddle and Chesterfield (1977) and Ohmagari and Berkes (1997).....	118
Figure 5.3 Hunting, fishing and trapping involvement for the period February 2009-February 2010 by percentage based on respondent interviews, Ulukhaktok, NWT.....	121

Chapter 1: Introduction

1.1 Research Context

Climate change is already being experienced in the Arctic with implications for ecosystems and the human communities that depend on them (ACIA 2005; Hinzman et al. 2005; IPCC 2007a; Furgal and Prowse 2008; Huntington et al. 2009; Laidler et al. 2009). Temperatures are increasing at twice the global average, recent years have witnessed an unprecedented reduction in summer sea-ice cover, permafrost is melting, and extreme weather conditions have been described as being more unpredictable and frequent (McCabe et al. 2001; Macdonald et al. 2005; IPCC 2007b; Barber et al. 2008; Comiso et al. 2008; Graversen et al. 2008; Moline et al. 2008; Perovich et al. 2008; Stroeve 2008; Prowse et al. 2009; Serreze 2010). These, and other socio-economic, political, and cultural changes are having implications for Canada's Inuit population, the majority of who live in small, remote, coastal communities, and continue to depend on the harvesting of fish and wildlife for food security, income, and cultural well-being (AHDR 2004; Nuttall et al. 2005; ITK 2008). Climate models indicate continued and accelerated climate change into the foreseeable future, with further affects on Inuit livelihoods (Anisimov et al. 2007; Furgal and Prowse 2008; Holland et al. 2010).

The main response of governments to concerns over climate change has been to seek reductions in greenhouse gas emissions to mitigate changes to the climate system. However, it is recognized that even with the most aggressive control measures, current greenhouse gas emissions commit the Earth to some degree of climate change requiring nations, regions, communities and individuals to undergo some level of adaptation (Klein et al. 2005; Hare and Meinshausen 2006; Rogelj et al. 2010). *Adaptation* in the context of human dimensions of climate change refers to an adjustment in human systems in response to actual or expected climatic stimuli or their effects,

which moderates harm or exploits beneficial opportunities (IPCC, 2007a). Adaptation to climate change is recognized as an important policy issue by international institutions, including the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 1992) (see Article 4.1b and 4.1e), the scientific community (Huntington et al. 2007; Dowlatabadi et al. 2009; Ford et al. 2010a), Inuit Organizations (Nickels et al. 2006), and governments (Furgal and Prowse 2008; GNWT 2008a).

Past research on climate change impacts and adaptations has often focused on modeling hypothetical adaptations in response to specific future climate change scenarios (e.g. IPCC 2001). Referred to as the ‘impact-based approach,’ these studies have been conducted at large scales, and focused on long-term changes in average climate conditions (variables most readily available from climate models) for the purpose of quantifying the net impact of climate change (Brooks 2003). Adaptation, if addressed at all, focused on implementing hypothetical technical measures (e.g. Klein et al. 1999). The impact-based approach has improved our understanding of the potential severity of future climate change impacts, but has not explicitly addressed adaptation processes (Jones 2001). Recognizing this deficiency in knowledge and understanding of adaptation, recent adaptation research has drawn on theory from social vulnerability (e.g. Sen 1981; Bohle 1994; Adger 2003) and work in human ecology of natural hazards and risk management (e.g. Blaikie and Brookfield 1987; Blaikie et al. 1994; Cutter 1996) to develop an integrated understanding of vulnerability.

To initiate adaptation, decision makers need to know the nature of vulnerability, in terms of who and what (e.g. economy, food security, infrastructure, etc.) are vulnerable, to what stresses, and in what way, and also what is the capacity of the system to adapt to changing conditions (Smit et al. 2000; Turner et al. 2003; Schroter et al. 2005). In the climate change field, the term *vulnerability* refers to the susceptibility of a system (community) to harm relative to a climate stimulus or

stimuli, and relates to the exposure-sensitivity of the community to a climate stimulus and the capacity to adapt (Adger 2006; McLeman and Smit 2006; Smit and Wandel 2006). Beyond the climate change impact research, studies have built on the natural hazards field to focus on the social dimensions of human sensitivity and adaptability, and have considered vulnerability to climate change in the context of the other economic, social, cultural and environmental forces that affect communities (Adger et al. 2001; Kasperson and Kasperson 2001; Cutter et al. 2003; Turner et al. 2003). Some vulnerability studies have aimed to calculate comparative rankings or indices (e.g. Downing and Patwardhan 2003; O'Brien et al. 2004), others have sought to identify and describe the nature of vulnerability, its underlying forces and its dynamics (e.g. Adger and Kelly 1999; Parkins and MacKendrick 2007; Tschakert 2007; Tyler et al. 2007). Furthermore, it is now widely accepted that adaptation initiatives are most effective when they are integrated, or mainstreamed, into other resource management, disaster preparedness, and/or community planning programs and institutions (Burton et al. 2002; Huq et al. 2003; Ford et al. 2007; Klein et al. 2007). It is argued that this integration requires active involvement and collaboration with community members, and knowledge of local institutions and policies and the forces that influence vulnerability.

In this conceptualization of vulnerability, adaptive capacity and adaptation are closely related. *Adaptive capacity* refers to the potential of a community to adapt to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2007a). In the case of communities, adaptive capacity is often conceptualized as a function of key attributes or features of a human system that influence the propensity or ability to adapt, known as the determinants of adaptive capacity (Smit and Pilifosova 2001; Adger 2006; Smit and Wandel 2006). These determinants may include the range of available technological options for adaptation, availability of resources and their distribution across the population, structure of critical institutions and decision-making,

human capital including education, knowledge and personal security, social capital including property rights, the system's access to risk-spreading processes, ability of decision-makers to manage information, and the public's perceived attribution of the source of stress (Yohe and Tol, 2002). These and other attributes will differ among regions, communities, and individuals and will vary over time, translating into different capacities to adapt (Cutter 1996; Adger and Kelly 1999; Duerden 2004; Smit and Wandel 2006). Adaptations are the manifestation or the realisation of adaptive capacity (Smit et al. 2000; Brooks 2003; Smit and Wandel 2006). The question is whether or not adaptive capacity will be drawn upon to bring about adaptation, something that depends on a range of uncertain variables (Vincent 2007).

A number of studies conducted in the Canadian Arctic and elsewhere in the Circumpolar North have documented human exposure-sensitivities to climate change risks and how people are already having to adapt (e.g. Berkes and Jolly 2002; Ford et al. 2006a; Ford et al. 2006b; Furgal and Seguin 2006; Gearheard et al. 2006; Nickels et al. 2006; Wesche and Armitage 2006; Krupnik and Ray 2007; Lynch and Brunner 2007; White et al. 2007; Andrachuk 2008; Furgal and Prowse 2008; Ford 2009a; Sakakibara 2008; Kofinas et al. 2010; Pearce et al. 2010a; Pearce et al. 2010e). In the context of Inuit subsistence hunting, climatic changes have exacerbated hazards associated with hunting and travel on the land and ice, and have affected the health and availability of some species of wildlife important for subsistence. These changes, together with social, economic and political changes already affecting Inuit, have implications for food security and health status, travel safety and harvest success, and the ability of Inuit to practice cultural activities. In many cases, climatic and non-climatic factors have acted synergistically to affect individuals and communities, and studies of vulnerability are increasingly considering the multiple variables that drive sensitivity to climate exposures and adaptations (e.g. Ford et al. 2006a; Ford et al. 2006b; Tschakert 2007; Pearce et al. 2010e; Prno et al. in press).

Key determinants of adaptation and associated policy initiatives to help realize adaptive capacity and overcome adaptation barriers have also been identified (Ford et al. 2007; Dowlatabadi et al. 2009; Ford et al. 2010a; Pearce et al. 2010a). In the context of adaptation among Inuit hunters, the ability to adapt is often associated with a profound knowledge of the arctic ecosphere and land skills, which affords Inuit dynamic and flexible use of the environment and its resources. Hunters manage the risks of hunting by knowing what equipment to take along and what preparations to make and being sensitive to critical signs in the environment and knowing how to respond. Inuit are astute observers of the sea ice and their knowledge and understanding of ice, sea, and weather conditions, assures safe travel and successful hunting (Nelson, 1969; Wenzel, 1991; Krupnik, 2002; Laidler, 2006; Laidler and Elee, 2008). Knowledge of animal behavior enables hunters to adapt to changing animal numbers and location, while knowledge of the land underpins the ability to do this (e.g. Collings 1997; Berkes and Jolly 2002; Ford et al. 2006a; Peloquin and Berkes 2009).

Traditionally, land skills were developed and transmitted from the older generations to the younger through on-the-land education or hands-on, practical engagement with the environment (Wenzel 1987; Condon 1996; Takano 2004). The rate of social, economic, and political change in the Canadian Arctic, however, has had a profound effect upon younger generation Inuit, most of whom have been exclusively raised in the context of fixed settlements and Eurocentric education (since the 1940s). Unlike their parents and/or grandparents, younger generation Inuit are generally spending less time involved in subsistence activities beyond organized land-camps and occasional hunting trips but comparatively more time engaged in formal education, wage employment, and community socialization (e.g. sports, Internet, television). As a result, many younger and inexperienced hunters are not as well equipped to cope with the risks of hunting (MacDonald 1998; Aporta and Higgs 2005; Ford et al. 2007; Pearce et al. 2010c; Prno et al. in press). There have been several cases of young Inuit encountering dangers on the land, and

changing climatic conditions are making it even more hazardous for them (Aporta and Higgs 2005; Ford et al. 2006a). The rate of climate change coupled with the dramatic social changes already proceeding in arctic communities, raises questions about the capacity of younger generation Inuit to adapt to future climate change risks. To plan for adaptation decision makers need to know what skills are important for safe and successful hunting under changing conditions, to what degree they are being transmitted and how, and what factors facilitate or impede transmission. Few, if any, studies have empirically investigated the transmission of land skills among Inuit and broad understanding of the relationships between skills transmission and Inuit adaptability is limited.

This research builds upon a large body of scholarship on the transmission of cultural items in human populations. These studies have most often focused on the transmission of values, personality traits, and attitudes among cultural groups (Hewlett and Cavalli-Sforza 1986). Other studies have focused on the detailed transmission of particular knowledge/skill items among populations in a variety of geographic regions and research contexts. These studies include, for example: the transmission of traditional food procurement techniques in the Orinoca Delta in Venezuela (Ruddle and Chesterfield 1977); the transmission of bush skills and cultural knowledge among Aka Pygmies of the tropical forest region of Central Africa (Hewlett and Cavalli-Sforza 1986); the transmission of indigenous knowledge and bush skills among the Western James Bay Cree women of Subarctic Canada (Ohmagari and Berkes 1997); the documentation of patterns of use and knowledge of wild edible plants in a Mapuche community from northwestern Patagonia (Ladio and Lozada 2003); and the transmission of ethnobotanical knowledge in a rural community of northwestern Patagonia (Lozada et al. 2006). The transmission of knowledge and skills, however, remains a neglected field generally (Ruddle 1993) and in the Arctic specifically (with the exception of Ohmagari and Berkes 1997); more significantly, skills transmission has yet to be studied in the context of human adaptation to

climate change. The thesis responds to these knowledge gaps and investigates the relationships between skills transmission and human adaptation to climate change in an arctic setting. The research seeks to understand how environmental knowledge and land skills are transmitted among Inuit under changing environmental conditions using the case study of Ulukhaktok located in the Inuvialuit Settlement Region (ISR)¹, Northwest Territories (NWT), Canada.

The community of Ulukhaktok is an ideal location to conduct the research. The lead researcher (Pearce) has a positive track record of conducting climate change research with the community and has built strong collaborative research relationships with community members since 2004 (see Pearce et al. 2009). There is also a legacy of research conducted in the community upon which this research project builds upon. Previous research in Ulukhaktok has focused principally on the effects of culture change and modernization on Inuit psychology. Various projects have studied changes among youth and adolescence resulting from permanent settlement in the community (Condon 1987; Condon 1995; Collings and Condon, 1996), the affects of acculturation on community social structure (Condon 1990), factors influencing participation in subsistence hunting (Condon et al. 1995), an examination of food sharing networks in the community (Collings et al. 1998), aging and life course (Collings 2000), housing (Collings 2005), subsistence hunting and wildlife management (Collings 1997), and Inuinnaqtun place names for geographic locations (Collignon 2006). In recent years, research on climate change impacts, vulnerability and adaptation has been conducted in the community. Research has recorded elders' observations of changing climatic conditions (Joss and Inuktalik 2000), and beginning in 2004, Pearce worked with local research partners to examine the vulnerabilities of people and their livelihoods to climate change. Pearce et al. (2010e) documented how changes in seasonal

¹ The ISR was created in 1984 with the signing of the Inuvialuit Final Agreement (IFA), a land settlement agreement between six Inuit communities and the Canadian Government.

patterns, precipitation, sea ice dynamics, and weather variability have affected the health and availability of some species of wildlife important for subsistence and have exacerbated risks associated with hunting and travel. Factors which influence the adaptive capacity of community members to respond to these changes include, access to economic resources, the strength of sharing networks (e.g. food sharing), the health and availability of wildlife, and environmental knowledge and land skills (Pearce et al. 2010e).

The thesis was conducted over four years and builds on an additional two years of previous research conducted with the community of Ulukhaktok. The thesis research involved four community visits, totaling six months. Understanding sensitivity to environmental change and skills transmission requires active involvement and collaboration with community members. Arctic communities are already experiencing and adapting to environmental and socio-cultural changes, and researchers have a practical and ethical responsibility to engage communities who are the focus of the research. Key considerations for effectively engaging arctic peoples in community-environment research were developed and employed (Pearce et al. 2009). Community members were involved as interviewees, research partners, interpreters, cultural guides, and co-authors and each played an integral role in the success of the research. Community and academic feedback was integrated into the thesis throughout the research process.

1.2 Research Aim and Objectives

The aim of the research is to investigate the relationships between skills transmission and human adaptation to climate change. Elements of these relationships are empirically examined in Ulukhaktok to document how environmental knowledge and land skills are transmitted among Inuit men and what role, if any, land skills transmission plays in adaptation to climate change with respect to subsistence harvesting.

The term 'land skills' is used hereafter to refer to both environmental knowledge and land skills together. For example, 'how to set fish nets under the ice in the fall' represents one item in this research and includes both the practical knowledge of where to set the nets and why, and the hands-on skills necessary to set the fish nets underneath the ice. *Transmission* refers to the process of transferring cultural items, such as a skill, among individuals through participation and experience in an environment and where transmission success depends on the level of mastery of a particular item (Ohmagari and Berkes, 1997; Ingold, 2000).

Consistent with the broad aim of the research, five objectives have been developed:

1. review relevant literature addressing climate change vulnerability and adaptation in the Inuvialuit Settlement Region (ISR), identify knowledge gaps, and document priorities for future adaptation research and planning;
2. develop a theoretical understanding of the relationships between skills transmission and adaptive capacity to climate change;
3. contribute to an established approach to vulnerability analysis by identifying key considerations for effectively engaging arctic communities in collaborative research;
4. document and explain how land skills are being transmitted among Inuit men in Ulukhaktok;
and
5. draw key lessons and implications from the research findings for climate change adaptation planning in Ulukhaktok specifically, and arctic communities generally.

1.3 Thesis Structure and Contributions

Structure

This thesis is based upon self-standing manuscripts. Three manuscripts published or in review for publication in peer-reviewed journals are included (chapters 3, 4 and 5). An additional published manuscript is included in Appendix 1 to complement the material included in the chapters. Table 1.1 outlines how the published and submitted manuscript and other chapters relate to each other to form the thesis and lists their respective contributions.

A key feature of this work is the multiple authors who contributed to each manuscript. Please refer to the written statement (Appendix 6) that outlines the nature of each author's role and contribution. Research that engages communities and seeks to integrate information from multiple research disciplines, and from both western scientific knowledge and traditional knowledge necessarily entails working with several authors. The value of co-authorship is highlighted by the detail and accuracy of the information documented and the continued positive researcher-community relationships. Collaborations with researchers working on similar issues elsewhere in the Arctic generated important insights for developing the community engagement component of the analytical approach to vulnerability analysis.

Table 1.1 Thesis chapters and their respective contributions

Chapter	Publication Status	Contribution
CH 1. Introduction	n/a	<ul style="list-style-type: none"> • Research context; research aim and objectives; and thesis structure and contributions
CH 2. Theory and Concepts of Vulnerability, Adaptive Capacity and Skills Transmission	n/a	<ul style="list-style-type: none"> • Reviews main theoretical perspectives on vulnerability • Outlines how vulnerability has been operationalized in climate change research • Develops a conceptual model for understanding the relationships between skills transmission and human adaptation to climate change • Reviews terms used to describe traditional knowledge
CH 3. Review and Critique of Climate Change Vulnerability and Adaptation Research in the Inuvialuit Settlement Region (ISR)	Pearce T et al. (2010a) Advancing adaptation planning for climate change in the Inuvialuit Settlement Region (ISR): A review and critique. <i>Regional Environmental Change</i> . doi: 10.1007/s10113-010-0126-4	<ul style="list-style-type: none"> • Review and critique of existing research on climate change vulnerability and adaptation in the ISR • Makes recommendations for advancing adaptation planning in the ISR • Identifies the importance of thesis research
CH 4. Community-Researcher Collaboration	Pearce T et al. (2009) Community research collaboration in the Canadian Arctic. <i>Polar Research</i> , 28: 10-27.	<ul style="list-style-type: none"> • Identifies key considerations for effectively engaging arctic communities in community-environment research
CH 5. Transmission of Environmental Knowledge and Land Skills among Inuit Men in Ulukhaktok	Pearce T et al. (In Review) Transmission of environmental knowledge and land skills among Inuit men in Ulukhaktok, Northwest Territories and adaptation to climate change. <i>Human Ecology</i>	<ul style="list-style-type: none"> • Conceptualizes the relationships among skills transmission, adaptive capacity and adaptation to climate change. • Empirical application of considerations for engaging communities in research • Documents the transmission of environmental knowledge and land skills among Inuit men in Ulukhaktok, discusses the changes in the nature of the transmission process, identifies factors that affect or impede transmission, and discusses some policy measures to support skills transmission

CH 6. Conclusions	n/a	<ul style="list-style-type: none"> Highlights the theoretical, empirical, and practical contributions of the research and gives the conclusions and final remarks
Appendix 1. Transmission of Environmental Knowledge and Land Skills in Adaptation Planning for Climate Change in the Arctic	Pearce T et al. (2010c) Transmission of Environmental Knowledge and Land Skills in Adaptation Planning for Climate Change in the Arctic. <i>Meridian</i> : 6-11.	<ul style="list-style-type: none"> Overview of results from land skills transmission research conducted in Ulukhaktok (Chapter 5) and directed at policy-makers
Appendix 2a. Consent Form	n/a	<ul style="list-style-type: none"> Consent form used with interview participants
Appendix 2b. Interview Guide	n/a	<ul style="list-style-type: none"> Interview guide for semi-structured interviews

Contributions of Chapters

Chapter 2: This chapter provides the theoretical and conceptual context for the research, by: (a) reviewing the main theoretical perspectives on vulnerability and how vulnerability has been operationalized in climate change research; (b) developing a conceptual model for understanding the relationships between skills transmission and human adaptation to climate change; and (c) reviewing terms that have been used to describe traditional knowledge.

Chapter 3: The first manuscript, “Advancing Adaptation Planning for Climate Change in the Inuvialuit Settlement Region (ISR): A Review and Critique” is published in the journal *Regional Environmental Change* (Pearce et al. 2010a). The article provides the general context for this research project by reviewing what we know and do not know about the implications of climate change for human communities in the ISR. The chapter outlines priorities for future adaptation research and planning including the need for research on the determinants of adaptation (e.g. transmission of land skills).

Chapter 4: The second manuscript, “Community Collaboration and Climate Change Research in the Canadian Arctic” is published in the journal *Polar Research* (Pearce et al. 2009). The article contributes to the approach to vulnerability analysis described by Ford and Smit (2004), Turner (2003), Smit and Wandel (2006) and others by developing key considerations for effectively engaging arctic communities in community-environment research. Examples of each consideration are drawn from environmental change research conducted with communities in the Canadian Arctic including the Ulukhaktok case study (Pearce et al. 2010e). These considerations have since been applied by Pearce et al. (2010c) and in Chapter 5 to study the transmission of land skills in Ulukhaktok.

Chapter 5: The third manuscript, ‘Transmission of Environmental Knowledge and Land Skills among Inuit Men in Ulukhaktok, Northwest Territories and Adaptation to Climate Change’, is under review by the journal *Human Ecology*. The article first conceptualizes the relationships between skills transmission and human adaptation to climate change. The considerations for effectively engaging arctic communities in community-environment research outlined in Chapter 4 are then applied in an empirical case study to document the transmission of land skills among Inuit men in Ulukhaktok. Transmission rates, learning age and teachers, skill competency, changes in the present system of transmission, and factors that affect or impede transmission are identified and discussed.

Chapter 6: ‘Conclusions’ summarizes the thesis and highlights the theoretical, empirical, methodological, and practical contributions of the research.

Appendix 1: The manuscript ‘Transmission of Environmental Knowledge and Land Skills in Adaptation Planning for Climate Change in the Arctic’ is published in the journal *Meridian*

(Pearce et al. 2010c). The manuscript complements Chapter 5 and provides a summary of research findings, which is directed at northern policy makers and practitioners.

Chapter 2: Theory and Concepts of Vulnerability, Adaptive Capacity, and Skills Transmission

The central concepts employed in the research include vulnerability and its components exposure-sensitivity and adaptive capacity, and skills transmission. This chapter first describes the concept of vulnerability, the relationships among its components and their application in environmental change research. Next the relationships between skills transmission and Inuit adaptive capacity are described, and a theoretical model for understanding these relationships is developed. Finally, terms used to describe environmental knowledge are reviewed and environmental knowledge, as used in this research, is defined.

2.1 The Concept and Application of ‘Vulnerability’ in Environmental Change Research

The term ‘vulnerability’ has been used in many different ways by a number of research disciplines. The lack of a consistent definition of vulnerability has been a frequent cause for misunderstanding in interdisciplinary research on adaptation to climate change and a challenge for developing formal models of vulnerability. Several conceptual frameworks for assessing human vulnerability to climate change exist. Some focus exclusively on the impact of a hazard event, and others consider social, economic and political factors in mediating vulnerability and shaping adaptation. This section describes, with reference to their theoretical origins, the key conceptual frameworks for assessing human vulnerability to climate change and highlights the conceptualization of vulnerability used in the thesis research.

Vulnerability has numerous definitions in a variety of research disciplines, but there is broad consensus that *vulnerability* refers to the susceptibility of a system (community) to harm relative

to a climate stimulus or stimuli, and relates both to sensitivity to climate exposures and capacity to adapt (Adger 2006; McLeman and Smit 2006; Smit and Wandel 2006). The concept of vulnerability, as related to environmental change, has been developed in geography and research on risks and natural hazards (Hewitt and Burton, 1971; Timmerman, 1981; Hewitt, 1983; Whilhite and Easterling, 1987; Mitchell et al., 1989; Blaikie et al., 1994). Vulnerability has also been conceptualized in several different ways by various research communities, such as those concerned with food security (Dreze and Sen, 1990; Watts and Bohle, 1993; Dilley and Boudreau, 2001), poverty alleviation (Prowse, 2003), national security (Homer-Dixon and Blitt, 1998), environmental change (Liverman, 1990; Kasperson et al., 1995), and climate change (Adger and Kelly, 1999; Smit and Pilifosova, 2001; Adger 2006). While the concept of vulnerability has sometimes been applied to ecosystems (e.g. Lassiter et al., 2000; Metzger et al., 2006), the focus here is on its application to human systems, as in communities, societies, and economies at various scales. Among the many theories of vulnerability, this section focuses on some of the common ones, labeled here as **biophysical** vulnerability, **social** vulnerability, and **integrated** vulnerability. These categorizations are not exhaustive, but they help to broadly identify the theoretical origins and key conceptual frameworks for assessing human vulnerability to climate change.

Consistent with a **biophysical** theory of vulnerability, the vulnerability of the system is considered to be determined primarily by the nature of the physical hazard(s) to which it is exposed, the likelihood or frequency of occurrence of the hazard(s), the extent of human exposure to the hazard, and the system's sensitivity to the effects of the hazard(s) (Blaikie et al., 1994; IPCC, 2001). The physical component of biophysical vulnerability is concerned mainly with the nature of the hazard and its physical impacts, and the biological or social component relates to the properties of the affected system that act to amplify or reduce exposure and sensitivity to these physical impacts (Susman et al., 1984; Whilhite and Easterling, 1987).

Biophysical vulnerability has been empirically applied in climate change research using a ‘scenario-based framework’ or ‘impact-based approach.’ This assessment of vulnerability begins with projections of future emissions trends, moving onto the development of climate scenarios, then to biophysical impact studies, and the identification of possible vulnerabilities and hypothetical adaptive options at the end of the assessment (Carter et al., 1994; Gornitz et al., 1994; Klein et al., 1999; IPCC, 2001). Impact-based assessments are often conducted at broad scales, and focus on long-term changes in average climate conditions (e.g. annual mean temperature, precipitation, and sea-level rise – variables most readily available from climate models) for the purpose of quantifying the net impact of climate change (Carter et al., 1994). The role of the human system in influencing vulnerability is downplayed with vulnerability being viewed in terms of the magnitude of damage experienced by a system, as a result of the impact from a hazard (e.g. degree of loss (life and property), production costs, and ecosystem damage (Hewitt and Burton, 1971; Brooks, 2003; Jones and Boer, 2003). Studies that have applied the impact-based approach have improved our understanding of the potential severity of the broad affects of climate change on ecosystems (e.g. ACIA, 2005; IPCC, 2007a) but they have contributed less to understanding the nature of human vulnerability and adaptation processes (Smit and Wandel, 2006). As a result, alternative approaches for assessing human adaptation to climate change have emerged that explicitly consider the role of the human system in influencing sensitivity to hazard exposures and adaptive capacities.

The **social** theory of vulnerability focuses on people, in terms of who are vulnerable, how and why. Vulnerability is considered at the starting point of an assessment, as an inherent property of a human system arising from its internal characteristics (Adger and Kelly, 1999; Allen, 2003). Social vulnerability theory postulates that societies are differentially vulnerable because of factors including: access to entitlements (Adger and Kelly, 1999); economic conditions (Leichenko and O'Brien, 2002); food insecurity (Sen, 1981; Watts and Bohle, 1993; Bohle et al., 1994);

institutions (Handmer et al., 1999; Adger, 2000); poverty (Tschakert, 2007); and the presence and strength of social networks and social capital (Adger, 2003).

Conceptual frameworks for assessing social vulnerability include ‘entitlement frameworks’ and ‘political economy frameworks,’ and have been developed to explain food insecurity, civil strife, poverty, and social upheaval. In these conceptual frameworks, vulnerability refers exclusively to people, and is based on an explanatory model of socioeconomic vulnerability to multiple stresses (Fussler, 2007). In the poverty, development and food security literature, vulnerability is determined by the availability of resources and the entitlement of individuals and groups to call on these resources (Sen, 1981). Vulnerability is explained as a set of linked economic and institutional factors (Bohle et al., 1994). While entitlement frameworks highlight social differentiation in cause and outcome of vulnerability, they tend to underplay the role of ecological or physical risks which may influence vulnerability (Adger, 2006).

A third theory of vulnerability, **integrated vulnerability**, has attempted to integrate elements from biophysical and social theory to assess human vulnerability to climate change (Kasperson and Kasperson, 2001; Cutter et al., 2003; Turner et al., 2003; Ford and Smit, 2004). In Cutter’s (1996) ‘hazards of place model,’ vulnerability is conceived as both a physical risk as well as a social response within a specified area or geographic domain. Vulnerability is determined by the outcome of a hazard event, and also by the individual/societal ability to respond (Blaikie and Brookfield, 1987; Cutter, 1996). The recognition of a system’s ability or capacity to adapt to a hazard in influencing vulnerability is explicitly recognized in the climate change vulnerability scholarship (Kelly and Adger, 2000; Smit and Pilifosova, 2001), concepts of coupled human-environment systems (Turner et al., 2003), and in the reflexive dependency approach (Fraser et al., 2003).

Conceptual frameworks for assessing integrated vulnerability have been applied at various scales - countries (O'Brien et al., 2004; Brooks et al., 2005), regions (Leichenko and O'Brien, 2002), and communities (Wall and Marzall, 2006) - and to address different research and policy questions. Some assessments seek to map vulnerability, which involves identifying the most vulnerable members of society (Cannon et al., 2003; Downing and Patwardhan, 2003; O'Brien et al., 2004). The exposures and sensitivities of the human system of interest are often assumed to be known, and populations are given an aggregate, numerical score of vulnerability (Watts and Bohle, 1993; Moss et al., 2001; Cannon et al., 2003; Cutter et al., 2003). However, several authors have argued that vulnerability is a relative measure, rather than something that can be expressed in absolute terms (Downing et al., 2001). Other conceptual frameworks for assessing integrated vulnerability characterize the vulnerability of a certain community, sector, or region to climate change (Adger, 1999; Berkes and Jolly, 2002; Turner et al., 2003; Ford and Smit, 2004; Belliveau et al., 2006; Ford et al., 2006a; Ford et al., 2006b; Tyler et al., 2007). Climate conditions, exposures, sensitivities and adaptations are not pre-determined by researchers; rather, it is the individuals in the human system of interest that identify what conditions are relevant and what adaptations are realistic. These assessments seek to describe the processes and forces that influence and structure vulnerabilities in particular places; this is done not to rank vulnerability, but to help identify why vulnerability exists, in a way that identifies clear opportunities for facilitating adaptation to reduce vulnerability. A research approach that addresses these needs, and has been recognized by the ACIA (2005), IPCC (2007a) and Canada's national assessment on climate change report (Lemmen et al. 2008) is the 'vulnerability approach' (Ford and Smit 2004).

The vulnerability approach includes **two stages of assessment**. The first stage assesses current vulnerability by documenting how people are exposed and sensitive to climatic variables, and the adaptive strategies employed to deal with these conditions. The second stage assesses future vulnerability by incorporating future climate change probabilities and future social probabilities

to estimate directional changes in exposure-sensitivities and associated adaptive capacities (Ford and Smit 2004). *Exposure-sensitivity* refers to the susceptibility of people and communities to variable conditions. It is a joint property of the community characteristics (location, livelihoods, economy, infrastructure, etc.) and the characteristics of climate related stimuli (magnitude, frequency, spatial dispersion, duration, speed of onset, etc.) (Cutter 1996; Adger, 2006; Smit and Wandel 2006). *Adaptive capacity* refers the potential of a community to adapt to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2007a).

Case studies provide an effective means of identifying local effects of climate change and adaptation processes (Jones 2001; Ford et al. 2010b). Variations of the vulnerability approach have been applied in several geographic regions and contexts (e.g. Adger 1999; Eriksen et al. 2005; Sutherland et al. 2005; Belliveau et al. 2006; McLeman and Smit 2006; Pouliotte et al. 2006; Wall and Marzall 2006; Pearce et al. 2010b), and in the Arctic (e.g. Pratley 2005; Duerden and Beasley 2006; Furgal and Seguin 2006; Ford et al. 2006a; Ford et al. 2006b; Huntington et al. 2007; Tyler et al. 2007; Wolfe et al. 2007; Keskitalo 2008a; Keskitalo 2008b; Ford 2009a; Pearce et al. 2010e).

A key distinction between the described approaches for assessing human vulnerability to climate change is the role that the human system plays in the conceptualization of vulnerability. The impact-based approach focuses on physical exposure to a hazard event, whereas entitlement and political economy approaches focus on societal factors and the properties of the human system that influence vulnerability. Both of these perspectives have contributed to an understanding of human vulnerability to climate change; however, it is increasingly recognized that assessing human vulnerability to climate change requires an integrated understanding of both the physical

hazard and the characteristics of the community that influence how people are sensitive and exposed to climate variables and the adaptive capacity to deal with these conditions.

The next section focuses on the concept of adaptive capacity and its determinants. It theorizes that land skills which are transmitted through hands-on practice and experience in an environment, are a key source of human adaptive capacity to deal with climatic changes.

2.2. Skills Transmission and Human Adaptation to Climate Change

As described in Chapter 1, the term *transmission* refers to the process of transferring cultural items, such as a skill, among individuals through participation and experience in an environment and where transmission success depends on the level of mastery of a particular skill (Ohmagari and Berkes, 2001; Ingold, 2000). The idea that skills transmission and human adaptation to climate change are related is not new. Researchers including Krupnik (1993), Freeman (1996), Berkes and Jolly (2002), Ford et al. (2006a), Ford et al. (2006b), Peloquin and Berkes (2009) and Pearce et al. (2010e) have suggested that ecological understandings of Indigenous (including Inuit) hunters and land skills allow them to account for and deal with a large number of variations in the arctic ecosystem. These claims have been made on the basis that Indigenous hunters have a long history of coping with and adapting to environmental changes. Knowledge of the Arctic environment and related land skills were continually tested and revised with new experiences and were transmitted to younger generations through hands-on experience and observation. Hunters also relied on oral traditions and group memory of past experiences to respond to fluctuations in the physical environment and extreme events (Minc 1986). The literature, however, suggests that there has been an erosion of environmental knowledge and land skills among younger generations and hence there is a concern about the adaptive capacity of young Inuit to deal with impending

climatic changes. Relationships between skills transmission and human adaptation to climate change have been suggested but have yet to be conceptualized or empirically examined in the literature. This section provides a theoretically grounded explanation of the relationship between skills transmission and human adaptation to climate change with reference to Inuit in the Arctic.

In a climate change context, adaptive capacity is often conceptualized as a function of certain characteristics of human systems that influence the propensity or ability to adapt, known as the determinants of adaptive capacity (Smit and Pilifosova, 2001; Adger, 2006; Smit and Wandel, 2006). These determinants may include: the range of available technological options for adaptation, availability of financial resources and their distribution across the population, structure of critical institutions and decision-making, human capital including education and personal security, social capital including property rights, the system's access to risk-spreading processes, ability of decision-makers to manage information, and the public's perceived attribution of the source of stress (Yohe and Tol, 2002). These and other attributes will differ among regions, communities and individuals, and will vary over time, translating into different capacities to adapt (Cutter, 1996; Adger and Kelly, 1999; Duerden, 2004; Smit and Wandel, 2006).

A common perspective on the relationship among adaptive capacity, its determinants, and the process of adaptation itself focuses on 'the realization of adaptive capacity' (Brooks, 2003) or 'manifestation of adaptive capacity' as adaptation (Smit and Wandel, 2006). Adaptive capacity is described as a set of resources that represent an asset base from which adaptations can be made (Smit et al., 2000; Brooks, 2003; Vincent, 2007). The question is whether or not adaptive capacity will be drawn upon to bring about adaptation, which is something that depends on a range of uncertain variables (Vincent, 2007). Before traveling on the sea ice, experienced hunters closely observe the weather, clouds and wind, and look for subtle warning signs that are precursors to

hazardous conditions. Drawing on past knowledge, lessons and experiences traveling on the ice, hunters determine when and where it is safe to travel (Aporta, 2002; Laidler and Ikummaq, 2008; Laidler et al., 2009). To assess adaptive capacity we must understand the adaptation process – how adaptive capacity is constituted and how it is translated into adaptation (Smit et al., 2000).

The Arctic is a highly variable environment and Inuit have long known about and coped with this variability. Anthropologists and other social scientists have identified several groups of cultural practices that are considered to be adaptive responses to the changing arctic environment, including mobility and flexibility in terms of group size, flexibility with regard to seasonal cycles of harvest and resource-use supported by oral traditions to provide social memory, detailed local environmental knowledge and land skills, sharing networks to provide mutual support and minimize risk, and intercommunity trading (Berkes and Jolly, 2002; Balikci, 1968; Krupnik, 1993; Freeman, 1996; Ford et al., 2006a). However, the changes in the Arctic associated with climate change are recent, and how Inuit have responded up to now may not be a reliable indicator of their ability to adapt in the future (Berkes and Jolly, 2002; Wenzel, 2009). Inuit adaptive capacity to changing environmental conditions will likely depend in part on their ability to learn and reorganize and in part on culturally available options (Berkes and Jolly, 2002). Some traditional adaptive strategies are clearly less feasible, namely mobility and flexibility in terms of group size since Inuit across the Canadian Arctic now live in fixed settlements. Other traditional adaptive strategies such as ‘flexibility’ in terms of harvesting techniques, locations, timings and species sought continue to be an important source of adaptive capacity in Inuit society (Wenzel, 1995; Damas, 2002).

Flexibility and skills of improvisation and adaptability are associated with Inuit knowledge of the local environment and land skills. Developed, applied, and tested through personal interaction with the environment and from knowledge and skills handed down through generations by

cultural transmission, this collective, dynamic, and cumulative social memory represents both competence on the land and in skills and technology necessary for safe and successful hunting. Land skills also represent an asset base from which adaptation actions can be made to deal with both routine and novel events. Rather than trying to predict or plan for the future, Inuit deal with the present and respond to each situation as, and when it presents itself (Bates, 2007). Having adequate knowledge of the present is more important than predicting what might happen next as adaptability is a process of continual learning and readjustments. Innovation and improvisation skills are gained through personal experience in the environment, and are transmitted among generations to generate a wealth of flexibly utilized opportunities at any given point in time. Inuit knowledge is dynamic, continually evolving and being updated and revised in light of observations, new experiences, and the incorporation of non-traditional knowledge alongside traditional knowledge (Stevenson, 1996; Berkes, 1999; Usher, 2000; Takano, 2004; Bravo, 2009). Ford et al. (2006a), working with hunters in the community Igloodik, Nunavut, documented how Inuit knowledge is evolving with changing climate conditions through social learning, thereby moderating the risks of a changing environment. As a reservoir of accumulated knowledge of changing conditions and experiences of adaptation, environmental knowledge and land skills allow ‘response with experience’ to climatic risks (Ford et al., 2006b); this increases adaptive capacity (Gunderson and Holling, 2002; Berkes et al., 2003).

It is theorized that environmental knowledge and land skills are a source of human adaptive capacity to deal with climatic changes. This relationship is illustrated using two figures.

Figure 2.1 shows the relationship between adaptive capacity and some documented determinants. The figure illustrates how adaptive capacity is influenced by many, often related, determinants, operating at different scales. For example ‘health and well-being’ contributes to individual or household capacity whereas ‘flexibility of resource management regimes’ enhances the capacity

of several stakeholders in a community. Together, this suite of determinants, expressed synergistically, represents an asset base from which adaptations can be made.

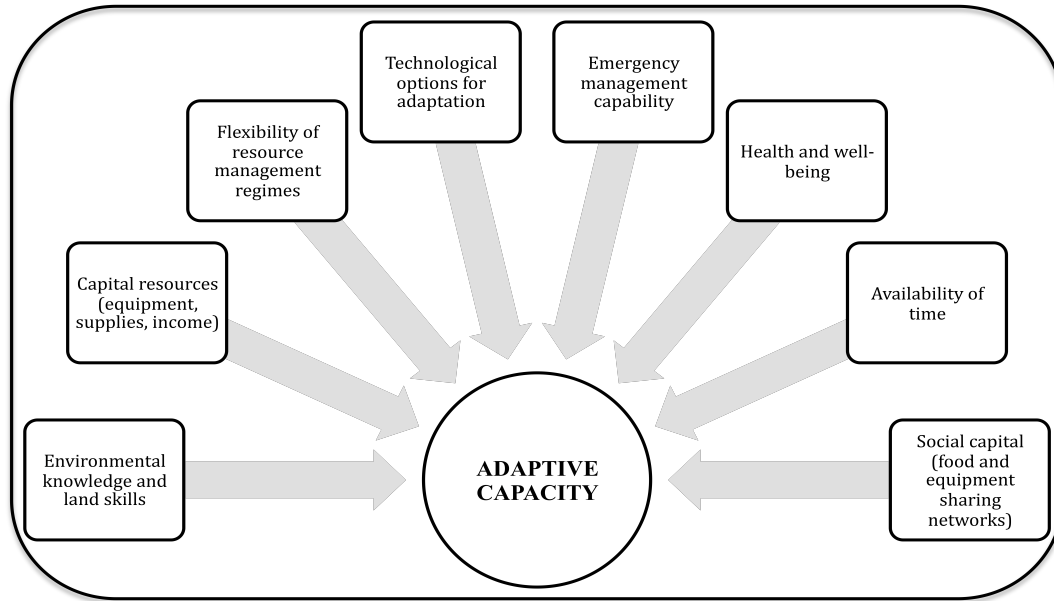


Figure 2.1 Some determinants of adaptive capacity to climatic exposure-sensitivities related to subsistence harvesting in Ulukhaktok and other arctic communities.

Figure 2.2 shows how adaptive capacity can be translated into adaptations to respond to climate-driven exposure-sensitivities. The figure highlights a key determinant of adaptive capacity, environmental knowledge and land skills. The figure simplifies the adaptation process by highlighting one determinant; however, multiple determinants of adaptive capacity will work together to bring about adaptation. For example, the ability to adapt to changing travel routes can require traveling via alternative modes of transportation (e.g. a boat instead of a snow machine) and in unfamiliar locations. In this instance, adaptation hinges on the capital resources held by the individual and/or social capital (e.g. equipment sharing) together with the skills necessary to travel and harvest in unfamiliar locations, and the availability of time to participate in the harvest.

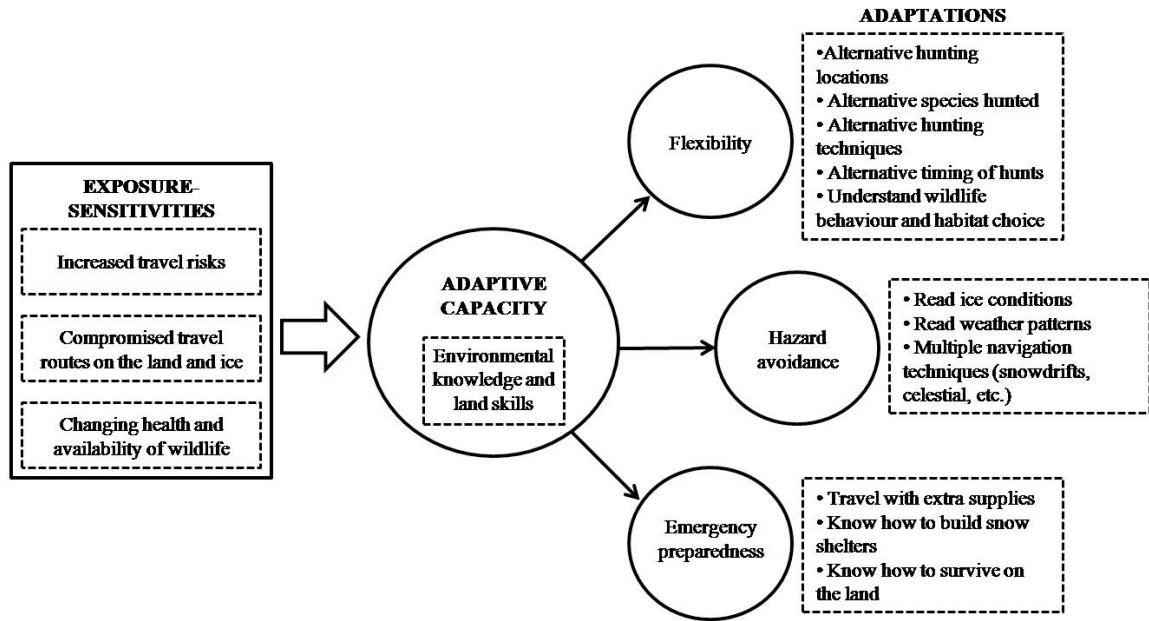


Figure 2.2 The relationships among adaptive capacity, environmental knowledge and land skills, and adaptations to some climate driven exposure-sensitivities in the Arctic.

2.3 Defining Inuit Environmental Knowledge

A central concept used in this research is environmental knowledge, specifically Inuit environmental knowledge. Scholars have used a variety of terms to describe components of Inuit environmental knowledge, most which are closely related. This section clarifies the distinctions among these terms and explains the use of environmental knowledge in this research.

The seamless and holistic nature of Inuit knowledge, as understood by Inuit, has been well documented (Barnhardt and Kawagley, 2005). Inuit do not separate the spiritual, physical and socio-psychological relationships; ecological and community health become one and the same. Hence, it is somewhat ironic that in defining Inuit knowledge, scientists have categorized the content in a manner consistent with reductionist scientific workings. Some of the terms used by

scientists to describe Inuit knowledge include: *traditional knowledge*, *traditional ecological knowledge*, *indigenous knowledge*, and *local knowledge*. These terms identify different components of Inuit knowledge, many which are overlapping. While this research focuses on Inuit knowledge systems, these terms have also been used to describe the knowledge of people from other cultural groups.

The term **traditional knowledge** is defined by Huntington (1998), Berkes (1999), Noongwook et al., (2007), and the Government of the Northwest Territories (2005), as a cumulative body of knowledge, practice and values, which have been acquired through experience, observation from the land or from spiritual teachings, and handed down from one generation to another. Other definitions similarly acknowledge the seamlessness of the concept: “(t)he knowledge held by Inuit that pertains to the dynamic interactions that occur among all elements, cultural as well as biophysical, within the northern ecosystem” (Wenzel, 1999). Traditional knowledge is built on personal experience and interaction with peers, including people from other communities (Huntington, 1998; Berkes, 1999) and passed on through stories (e.g. Cruikshank, 1998) and practice. Some academics (e.g. Stevenson, 1996) interpret the term *traditional* to imply ‘old’ knowledge that, while interesting, does not necessarily have a role in modern Inuit society (Bell, 2002). This perspective may be an interpretation of the vernacular definition of *tradition* – “a custom, opinion, or belief handed down to posterity especially orally or by practice” (Fitzgerald et al., 2006). However, Bell and others, in the context of Inuit Qaujimaqatunangit (IQ) (a term used in Nunavut to describe Inuit knowledge) as traditional knowledge, maintain that the term *traditional* is properly defined as “the Inuit way of doing things,” and includes the past, present and future knowledge of Inuit society (Inuit Qaujimaqatunanginnut (IQ) Task Force 2002; Simpson, 2004). Traditional knowledge is dynamic and is continually being updated and revised in light of new technologies (Berkes, 1999).

Initially, the scientific focus on Inuit traditional knowledge was highly contextualized. Traditional knowledge was explored relative to a larger Inuit belief system and much of the work related Inuit ways of interacting with their environment, namely subsistence activities, not only to environmental knowledge but also to forms of cultural and social organization (e.g. Feit, 1973; Cruikshank, 1981). In recent years, this embedded perspective has been overshadowed by a pragmatic focus on the application of traditional knowledge of the environment in environmental assessment and management (Stevenson, 1996; Usher, 2000), land-use planning (Freeman, 1976; Brice-Bennett, 1977; Riewe, 1992), and the creation of wildlife management and co-management boards (Ellis, 2005; Kristofferson and Berkes, 2005).

The term **traditional ecological knowledge** (TEK) has been used by various commentators, either as a synonym for traditional knowledge (e.g. Wenzel, 1999), or referring specifically to those aspects of traditional knowledge about the relationships of living beings (including humans) with one another and with their environment (Berkes et al., 1995). Usher (2000) defines TEK as “...all types of knowledge about the environment derived from the experience and traditions of a particular group of people.” Usher (2000) uses the term TEK in the same way as Wenzel (1999), in preference to traditional knowledge because it is more specific. However, TEK is nonetheless also a problematic descriptor of Inuit knowledge. As is the case with the use of traditional knowledge, by using the term *traditional*, there is a risk of implying a static or archaic form of knowledge that is inherently non-adaptive, when in fact the knowledge depicted by TEK is both evolving and current (Usher, 2000). TEK does not appear to be treated as static or archaic in the working of northern government policy (e.g. GNWT, 2005) or in most Canadian assessment panels and boards, but Nadasdy (1999) suggests that such attitudes toward Inuit knowledge may subtly reside with some non-indigenous actors. This is cause for concern, as the politicization of language could lead to the misinterpretation and/or dismissal of Inuit knowledge in contemporary policy debates on account of its historical foundations.

The terms traditional knowledge and TEK are often interchanged with **aboriginal knowledge** or **indigenous knowledge** but the use of TEK is not restricted by genetics or heritage to aboriginal persons (Usher, 2000). The term **local knowledge** is sometimes used to refer to community member's knowledge (e.g. TEK) regardless of inter-generational history (Neis et al., 1999). Irniq and Tester (2006) argue that definitions of Inuit knowledge reflect what the dominant society sees as important. For example, the use of TEK emphasizes the ecological component of Inuit knowledge rather than its spiritual foundations. TEK is often reduced to a source of data or factual information rather than being seen as a worldview, and system of values and processes. This has been described as a process of 'scientizing' indigenous knowledge for use in and the consumption of Euro-Canadian society (Simpson, 2004). Stevenson (1996) suggests that a more appropriate term for the knowledge, experiences, wisdom, and philosophies that indigenous people can possess is **indigenous knowledge**. It is argued that the term indigenous knowledge is less contentious, more inclusive (capturing TEK, traditional knowledge and local knowledge), and thus more empowering than the terms traditional knowledge or TEK (Stevenson, 1996). Indigenous knowledge can be viewed as having two sources: traditional knowledge and nontraditional knowledge (Stevenson, 1996). As described above, traditional knowledge refers to the cumulative, collective body of knowledge, experience, and values developed and refined by residents of the Arctic. Nontraditional knowledge is knowledge and experiences that may be derived from interaction with non-aboriginal people and institutions, exposure to foreign values, attitudes and philosophies, formal schooling, and/or television and other modern media (Stevenson, 1996).

In this research, Inuit environmental knowledge and land skills are treated as a complex in which practical knowledge and skills are considered together. Inuit environmental knowledge is inclusive of all sources of information, past and present, Inuit and non-Inuit derived, and is handed-down from one generation to another.

Chapter 3: Review and Critique of Climate Change Vulnerability and Adaptation Research in the Inuvialuit Settlement Region (ISR)

Publication details:

Pearce T, Ford J, Duerden F, Smit B, Andrachuk M, Berrang-Ford L and Smith T (2010a)

Advancing adaptation planning for climate change in the Inuvialuit Settlement Region

(ISR): a review and critique. *Regional Environmental Change*. doi: 10.1007/s10113-010-

0126-4

3.1 Introduction to Manuscript

The manuscript addresses objective one: review relevant literature addressing climate change vulnerability and adaptation in the Inuvialuit Settlement Region (ISR), identify knowledge gaps, and document priorities for future adaptation research and planning.

3.2 Manuscript

Advancing Adaptation Planning for Climate Change in the Inuvialuit Settlement Region (ISR): A Review and Critique

Abstract

This paper reviews scientific and grey literature addressing climate change vulnerability and adaptation in the Inuvialuit Settlement Region (ISR) in the western Canadian Arctic. The review is structured using a vulnerability framework. 420 documents related directly or indirectly to climate change are analyzed to provide insights on the current state of knowledge on climate change vulnerability in the ISR as a basis for supporting future research and long-term adaptation planning in the region. The literature documents evidence of climate change in the ISR which is compromising food security and health status, limiting transportation access and travel routes to hunting grounds, and damaging municipal infrastructure. Adaptations are being employed to manage changing conditions; however, many of the adaptations being undertaken are short term, ad-hoc, and reactive in nature. Limited long term strategic planning for climate change is being undertaken. Current climate change risks are expected to continue in the future with further implications for communities but less is known about the adaptive capacity of communities. This review identifies the importance of targeted vulnerability research that works closely with community members and decision makers to understand the interactions between current and projected climate change and the factors which condition vulnerability and influence adaptation. Research gaps are identified and recommendations for advancing adaptation planning are outlined.

Introduction

Canada's Arctic regions are at the forefront of changes in climate (IPCC 2007a; IPCC 2007b; Lawrence et al. 2008; Lemmen et al. 2008; Rinke and Dethloff 2008). Temperatures are increasing at twice the global average, recent years have witnessed an unprecedented reduction in summer sea-ice, and extreme weather conditions are more frequent and intense (McCabe et al. 2001; Macdonald et al. 2005; IPCC 2007b; Barber et al. 2008; Comiso et al. 2008; Graversen et al. 2008; Moline et al. 2008; Perovich et al. 2008; Stroeve 2008; Prowse et al. 2009). These changes are having implications for Canada's Inuit population, the majority of whom live in small, remote, coastal communities, and continue to depend on the harvesting of fish and wildlife for their livelihoods (AHDR 2004). This high dependence on the environment has made Inuit particularly susceptible to climate change (Nuttall et al. 2005; Anisimov et al. 2007; Lemmen et al. 2008). Compromised food security and health status, loss of life and serious injury, constrained transportation access and travel routes to hunting areas, and inability to practice traditional cultural activities, have been documented in all Inuit regions and can be expected to continue as the climate changes (Krupnik and Jolly 2002; ACIA 2005; Ford et al. 2006a; Ford et al. 2006b; Furgal and Seguin 2006; Gearheard et al. 2006; Nickels et al. 2006; Huntington et al. 2007; Krupnik and Ray 2007; White et al. 2007; Ford et al. 2008b; Ford 2009b; Hovelsrud et al. 2008; Huntington 2009; Loring and Gerlach 2009; Pearce et al. 2010e). Rising sea levels, coastal erosion, and permafrost thaw are also threatening the viability of some settlements, damaging important heritage sites, and affecting municipal infrastructure (i.e. buildings and roads) and water supply (Couture and Pollard 2007; Lynch and Brunner 2007; Martin et al. 2007; Alessa et al. 2008; Larsen et al. 2008). Benefits have also been noted as a result of climatic changes including a longer boating and shipping season, fewer days with extreme cold, and increased interest in resource development, but the balance of impacts is believed to be negative (ACIA 2005; IPCC 2007a).

In the Canadian Arctic, dramatic changes in climatic conditions have been documented in the Inuvialuit Settlement Region (ISR), Northwest Territories (NWT). The NWT, especially the Mackenzie Valley, is a global hot spot for climate change with average annual temperatures increasing about 2°C since the 1940s when meteorological data were first recorded (ACIA 2005). Temperature increases vary among locations; for example, annual temperatures in Inuvik, situated at the mouth of the Mackenzie River near the Beaufort Sea, have increased by 3°C in the last half-century (ACIA 2005; GNWT 2008a). These are some of the greatest temperature changes recorded globally in the past 50 years. Together with increases in temperature, local observations and instrumental measurements in the ISR have documented more frequent and intensive extreme weather events, more active geophysical processes, and changes in the health and availability of some species of wildlife important for subsistence (e.g. Barber and Hanesiak 2004; Nickels et al. 2006; Manson 2007; Carmack and Macdonald 2008; Lemmen et al. 2008). These changes are already affecting communities, and scientists project that they will continue in the future with further implications for the Arctic environment and people (Kattsov and Kallen 2005; Anisimov et al. 2007; Prowse et al. 2009; Ford and Pearce 2010). Given these observed changes and predicted future impacts, adaptation planning to maintain social and economic well being in a rapidly changing climate has been identified as a priority by the scientific community (Huntington et al. 2007; Furgal and Prowse 2008), Inuit Organizations (Nickels et al. 2006), and the Government of the Northwest Territories (GNWT 2008a). *Adaptation* in the context of human dimensions of climate change refers to a process, action or outcome in a system (e.g. individual, household, community, sector) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity (Smit and Wandel 2006).

In 2008 the GNWT released a report on climate change impacts and adaptations in the NWT that calls for the development of tools and best practices to assist communities and governments in developing long-range adaptation planning (GNWT 2008a). This includes research on adaptation

techniques, developing better resolutions of regional and sub-regional climate model projections, and research on how changes in climate affect the life cycle and maintenance costs for infrastructure (GNWT 2008a). Some adaptation planning is already being undertaken in the NWT: the City of Yellowknife and the Decho First Nation have begun to develop adaptation plans, and the private consortium that operates winter ice roads to diamond mine operations has begun to consider alternatives because of problems they have been experiencing due to shorter ice seasons (GNWT 2008a; Pearce et al. 2010b). To date, however, no formal long-term adaptation planning for climate change has been undertaken in the ISR.

To initiate pro-active adaptation plans at regional and/or community levels, decision makers need to know the nature of vulnerability in terms of who and what are vulnerable, to what stresses, in what way, and also the local capacity to adapt to changing conditions (Turner et al. 2003; Ford and Smit 2004; Smit and Wandel 2006). Considerable research on environmental and climatic risks and their determining factors have already been conducted in the ISR, providing insights on the vulnerability of communities (Ford and Pearce 2010). However, despite the long history of research projects and government studies, research on the human dimensions of climate change has often ignored this wealth of information (Duerden 2004). This is partly due to the difficulty in finding relevant studies: publication databases are limited, unpublished materials are often located in difficult to access locations (e.g. community organizations/libraries, government records), and there are few examples where the published literature has been synthesized or analyzed for insights on climate change vulnerability and adaptation. Consequently, researchers, policy makers, and community members are often unaware of what has been published and, in some cases, unnecessarily duplicate studies that have been completed, rather than building on what has already been done. Our understanding of climate change vulnerability in the ISR and opportunities for advancing future research on climate change adaptation thus remains limited.

Another feature of research in the ISR in general and on climate / environmental change in particular is the predominance of localized case studies. This is essential for vulnerability assessment and adaptation planning, but an understanding of vulnerability determinants, trends, and outcomes at a regional level is lacking, thereby limiting the potential to develop adaptation interventions at non-local levels. A similar lack of regional scale understanding has been noted elsewhere in Arctic Canada (Ford et al. 2010a) and in the general climate change literature (Adger et al. 2009; Ford et al. 2010a). Meta-analyses of multiple case studies offer a means of overcoming this barrier, enabling systemic or system-wide determinants of vulnerability to be identified and are increasingly common in the climate change literature (e.g. Turner et al. 2003; Polsky et al. 2007; Ford et al. 2010b). Importantly, such analyses are based on the synthesis of existing studies, requiring little additional data collection.

In this paper we review scientific and grey literature addressing climate change vulnerability and adaptation in the ISR. The purpose of the study is to identify and synthesize what is currently known about climate change vulnerability in the ISR and identify priorities for future adaptation research and planning. To achieve this, we first identify relevant literature using a search and review criteria that directs attention to studies that explicitly address climate change vulnerability in the ISR as well as others which provide insights into climatic and environmental risks in general. Secondly, the literature is reviewed for insights on current and future vulnerability following a widely used structure for vulnerability assessment. Where applicable, commonalities among case study and location specific research results are discussed relative to regional level responsibilities. Finally, recommendations for future research and planning are made based on the review findings and author experience.

The Inuvialuit Settlement Region (ISR)

The ISR was established as a result of the 1984 Inuvialuit Final Agreement (IFA) between six Arctic communities and the Government of Canada. The IFA was the first land settlement in Canada to include land ownership, both surface and sub-surface and the beds of water bodies. The ISR covers 906,430 km², of which the Inuvialuit own 90,643 km², with surface rights on 77,694 km² and both surface and sub-surface rights on the remaining 12,949 km² (Fast 2005) (Fig. 3.1). The region's population is dispersed over six communities: Aklavik (approx. pop. 630) and Inuvik (approx. pop. 3,590) located in the Mackenzie Delta; Tuktoyaktuk (approx. pop. 1,010) and Paulatuk (approx. pop. 312) on the mainland coast of the Beaufort Sea; Ulukhaktok (approx. pop. 420) on Victoria Island; and Sachs Harbour (*Ikahuak*) (approx. pop. 120) on Banks Island. Populations are dominantly Inuvialuit, who are Inuit peoples living in the western Canadian Arctic. Life is strongly oriented towards the marine and terrestrial resources of the near-shore Beaufort Sea, and dependency on the region's wildlife resources, such as seal, whale, fish, caribou, waterfowl, and muskox remains strong despite a range of incursions from industrial society over the past century (Condon et al. 1995; Usher 2002; IJS 2003). With the exception of Inuvik, with its commercial, government, and industrial functions, the economies of ISR communities largely depend on public administration, subsistence hunting, sporadic resource exploration and development, and to a limited extent, tourism. Social transfer payments and government payrolls also make substantive contributions to local economies (GNWT 2008b).

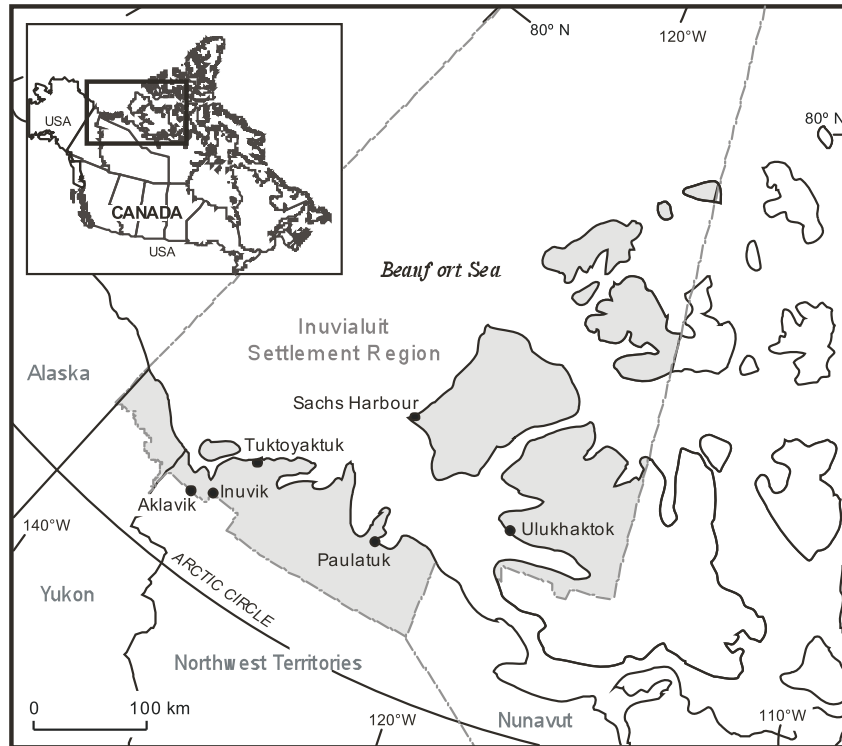


Figure 3.1 Map of ISR and the Inuvialuit communities

Under the IFA a series of federal government and Inuvialuit joint land-use and wildlife management bodies were established to uphold the goals of the agreement: “to preserve Inuvialuit cultural identity and values within a changing northern society; to enable Inuvialuit to be equal and meaningful participants in the northern and national economy and society; and to protect and preserve the Arctic wildlife, environment and biological productivity (Government of Canada 1984)”. As part of the IFA, the Inuvialuit received capital transfer payments from the Canadian federal government totaling \$152 million in 1997. These funds are not to replace government expenditure but have been used to develop economic and political bodies in each of the Inuvialuit communities. Inuvialuit bodies in each of the six communities (Hunters and Trappers Committees, and Community Corporations) are then represented by coordinated bodies at the regional level: Inuvialuit Game Council (IGC) and Inuvialuit Regional Corporation (IRC) (see Fast 2005). These institutional arrangements are not self-government, though the Inuvialuit

continue to work towards this goal, and nothing in the agreement prejudices the devolution or transfer of responsibility or powers from the Government of Canada to the Government of the NWT. The IFA does provide the Inuvialuit with a voice in any development that is proposed on Inuvialuit lands, partnership in the management of natural resources on Inuvialuit lands and means for seeking compensation for any damage that is incurred by development on these lands (Fast 2005). Given the long-standing, active role that Inuvialuit play in governance of the ISR, it is important to engage Inuvialuit communities (individuals and organizations), regional organizations (Joint Secretariat, Regional Corporation, Land Administration, etc.), and Territorial and Federal government agencies in assessments of vulnerability to climate change and the development and implementation of adaptation plans (Pearce et al. 2009).

Methods

Identifying the Literature

A systematic literature review was used to identify and organize scientific and grey literature publications addressing climate change vulnerability and adaptation in the ISR. The review began by defining a review strategy including, identifying key search terms and relevant publication databases through an iterative process, and developing criteria for including and excluding literature from the review (Centre for Reviews and Dissemination (CRD) 2001; Kitchenham 2004; Petticrew 2006; Julian et al. 2008). Elements of the review strategy include: the review focused on peer reviewed and grey literature published from January 1990 to March 2009 and was limited to publications in English. Reflecting the breadth of studies providing potential insights on vulnerability, the scope of the review covered many disciplines and areas of research. Importantly, the search terms used were much broader than ‘adaptive capacity’, ‘adaptation’ and ‘exposure-sensitivity’; many studies provide insights on these components of vulnerability

without explicitly using this terminology (Table 3.1). All literature relating to the processes and conditions that determine how climate change risks are manifested and experienced in the ISR and which influence vulnerability was considered eligible. This included publications on biophysical, social, economic, and political process and events that shape exposure-sensitivity, adaptation and adaptive capacity. Reflecting the focus of the research on vulnerability, literature regarding climate change mitigation strategies and policy debates, greenhouse gases, and renewable energies were excluded.

To ensure the collection of all relevant literature, electronic and in-field searches were conducted. The electronic search involved four main steps. The first step was a preliminary screening of key documents, including the IPCC Fourth Assessment Report, Arctic Climate Impacts Assessment (ACIA), and the Mackenzie Basin Impact Study (MBIS), to identify relevant topics and keywords to use in the search process (identifying search terms was an iterative process with new search terms being added throughout the search process). Secondly, selected scientific search engines (GEOBASE, ISI Web of Knowledge, and JSTOR) and specialized databases (Inuvialuit Settlement Region Database, Northern Climate Exchange Infosources Database, annual Compendium of Research in the Northwest Territories, Google Scholar) were searched using the search terms in various combinations. The in-field component involved visiting the ISR and gathering literature available in regional and community libraries and organization records (e.g. community Hunters and Trappers Committees, Aurora Research Institute library, Inuvik library). Thirdly, the collected literature was evaluated per the exclusion criteria outlined in Table 3.2. Finally, pertinent information related to current and future climate change vulnerability was extracted and analyzed following the vulnerability framework described next.

Table 3.1 Search terms identified through an iterative process and used to locate relevant literature

Search Terms					
Place Names	Inuvialuit Settlement Region; Mackenzie River Delta; Inuvik; Aklavik; Sachs Harbour; Holman (Ulukhaktok); Paulatuk; Tuktoyaktuk; Banks Island; Beaufort Sea; Northwest Territories; Arctic; Canada; Western Arctic				
Generic	Climate; Global warming; Climate change; Climate risks; Climate hazards; Dangers; Risks; Hazards; Environment; Vulnerability; Resilience, Adaptation; Adaptive Capacity; Coping; Inuvialuit; Gwich'in				
Biophysical	Sea ice; Sea level; Permafrost; Precipitation; Ocean; Freeze-thaw cycles; Temperature; Weather; Wind; Storms; Forecasts; Snow conditions; Erosion; Sedimentation; Ice Freeze-up; Ice Break-up; Forest fires; Algae; Ice Roads; Flooding; Extreme weather; Soil; Pingo; Glacier				
Sector	Health and well-being	Economy and Business	Infrastructure and Transportation	Subsistence Hunting, fishing and Trapping	Culture and Learning
Specific	Socio-economic status; Unemployment; Livelihood; Housing; Basic services; Drinking water; Education; stress; Death; Injury; Accidents; Food security; Food contamination; Disease; community; crime; suicide	Industry; Household economy; Oil; Gas; Tourism; Sport hunting; Tours; Public administration; Primary resources; Exploration; Development; Mining; Technology; Government; Energy	Infrastructure; Transportation networks; Buildings; Energy; Water; Sewage; Cultural sites; Hunting/harvesting trails/routes; Aggregate; Construction	Wildlife; Wildlife habitat; Wildlife migration; Youth; Technology; Country food	Traditional knowledge; Land skills; High school; Elementary; Certificate; Degree

Table 3.2 Criteria used in the systematic literature review to exclude literature from the study

Exclusion Criteria	
1	Duplicated in previous search
2	Irrelevant geographical location
3	Article written prior to search limit (1990)
4	Irrelevant content

Analyzing the Literature

The conceptualization of vulnerability and approach to vulnerability analysis described by Ford and Smit (2004) and Smit and Wandel (2006) were used to analyze the identified literature for insights on vulnerability to climate change in the ISR. Vulnerability is conceptualized as a function of exposure-sensitivity to climate-related risks and the adaptive capacity to deal with those risks. *Exposure-sensitivity* refers to the susceptibility of a community or other system of interest to climatic risks (and hence a changing climate). Exposure-sensitivity is a joint property of the characteristics of climatic conditions (e.g. magnitude, frequency, spatial dispersion, duration, speed of onset, and temporal spacing of climatic risks), and the nature of the system (i.e. location of community, timing of activities, etc). *Adaptive capacity* refers to the ability of individuals, households, communities, institutions, etc. to address, plan for, or adapt to these risks. Vulnerability is viewed as being determined by socio-economic, cultural, political, and climatic conditions and processes operating at multiple scales that affect exposure-sensitivity and adaptive capacity. When assessing the literature for what is known about vulnerability in the ISR, attention was given to studies that concern human-environment interactions in general and not just limited to climate change. This conceptualization is consistent with other descriptions of vulnerability in the climate change adaptation literature (Brooks 2003; Turner et al. 2003; McLeman and Smit 2005; Schröter et al. 2005; Adger 2006; Belliveau et al. 2006; Fussel and Klein 2006; Keskitalo 2008).

The analysis of the literature followed a two-step approach, similar to empirical assessments using a vulnerability framework (Ford et al. 2006a; Ford et al. 2008b; Pearce et al. 2010e). The first step involved characterizing what we know about *current vulnerability* to climate related risks, which fed directly to assess knowledge on future vulnerability to climate change. This

began by identifying current exposure-sensitivities to climatic conditions, and characterizing the nature of exposure-sensitivities in terms of the physical nature of the risks (spatial distribution, magnitude, frequency, and duration), local impacts, change over time, and determining factors. Assessment of current vulnerability also included the identification and characterization of adaptive strategies employed to manage climatic risks and the processes and conditions which affect their success. To this end we reviewed literature pertaining to all climate-related risks, adaptive strategies, and determining factors. Second, *future vulnerability* is concerned with future trends with analysis beginning by examining how climate change will affect existing exposure-sensitivities. Evaluating the extent to which institutional arrangements and socio-economic capacity will enable communities in the ISR to deal with future exposure-sensitivities completed the vulnerability assessment. In this review, we located literature concerning future socio-economic-biophysical trends and conditions in the ISR to provide insights on future vulnerability.

Results

First, the characteristics of the literature review are described in terms of the number of articles reviewed, how they are grouped, the geographic focus of the literature, how current the research is, and the type of literature. This provides a characterization of the extent and nature of literature pertaining to climate change vulnerability in the ISR. Second, following the vulnerability framework, a summary of current understanding on climate change vulnerability and adaption in the ISR is given, research gaps are identified, and opportunities for adaptation research and planning are discussed.

Characteristics of the Literature Review

420 documents were identified using the search criteria and reviewed based on their contribution to what is currently known about climate change vulnerability in the ISR. Out of the publications reviewed, 217 (52%) specifically examine climate change impacts and/or adaptations in the ISR (Table 3.3) and the remaining 203 (48%) focus on environmental risks in general. Among the publications that specifically address climate change impacts and/or adaptations in the ISR (n=217), research on physical impacts is most common (42%). Less work has focused on the socio-economic implications of climate change (7%) and even less work has addressed the affects of climate change for human health (5%). It is noteworthy that there are three times more publications focusing on climate change impacts (n=161) than adaptations (n=56), and is perhaps indicative of the adaptation deficit noted for Canada in general (Burton 2006), and the north in particular (Ford et al. 2007; Ford 2009b) (Table 3.3). During the literature review general themes related to vulnerability to climate change emerged and for organizational purposes, the literature was grouped within one or more of five identified sectors – subsistence hunting and trapping, culture and learning, infrastructure and transportation, business and economy, and health and well-being (Table 3.4).

Table 3.3 References specifically addressing climate change impacts and adaptation in the ISR

Impact on	References	Adaptation	References
1. General	51	1. General	36
2. Physical	67	2. Sectoral	8
3. Bio-physical	21	3. Political	5
4. Socio-economic	12	4. Cultural	4
5. Human Health/Well-being	8	5. Economic	2
6. Culture/Learning	2	6. Technological	1
Total	161	Total	56

Note: If a document referred to multiple types of impacts/adaptations, it was categorised as ‘general’. Some duplication of references occurred between sectors and sub-sectors.

Table 3.4 References by sector and sub-sector

Sector	References
1. Subsistence Hunting, Fishing and Trapping	105
a. Wildlife	87
b. Resource Management	68
c. Food	33
2. Culture	36
Education and learning	34
a. TEK	31
3. Infrastructure/Transportation	38
a. Granular Resources	5
4. Economy/Business	34
a. Traditional/Household	12
b. Energy (Oil and gas)	12
c. Tourism	12
5. Health and Well-being	35
6. Other	
a. Government/Policy	26
b. Inuvialuit (people)	88
c. Technology	12
d. Gender Issues	1

Note: The number of valid references is not the same as the number of records (420) because many records contained multiple references to different topics.

To date, research on climate change in the ISR has been concentrated in the Mackenzie River Delta and Beaufort Sea, and when communities are mentioned in the research they are most often Inuvik, Aklavik and Tuktoyaktuk (Table 3.5). This concentration of research in the Mackenzie River Delta may be the result of environmental and social impact assessments affiliated with the proposed Mackenzie Valley Gas Project and other resource development in the delta region. Other explanations for this concentration of research could be the larger populations in the delta communities, and/or the accessibility of the delta communities via seasonal roads and air transportation, which may attract researchers with limited time and/or funds. The amount of research conducted in or near each community, however, does not necessarily reflect the detail of information available on climate change impacts and adaptations. Some of the most comprehensive studies on climate change impacts and adaptations at the community level, and

which integrate both western scientific and traditional knowledge, have been undertaken in Sachs Harbour and Ulukhaktok (Berkes and Jolly 2002; Pearce et al. 2010e).

Table 3.5 Geographic focus of literature

Location	References
Mackenzie River Delta/Beaufort Sea	112
Inuvialuit Settlement Region (non-specified)	77
Tuktoyaktuk	57
Inuvik	26
Aklavik	24
Ulukhaktok	23
Sachs Harbour	23
Paulatuk	7
Total	349

Note: As some documents referenced more than one location, they were recorded more than once. This table does not represent the number of sources discretely referring to each community but rather how many documents discussed that community specifically.

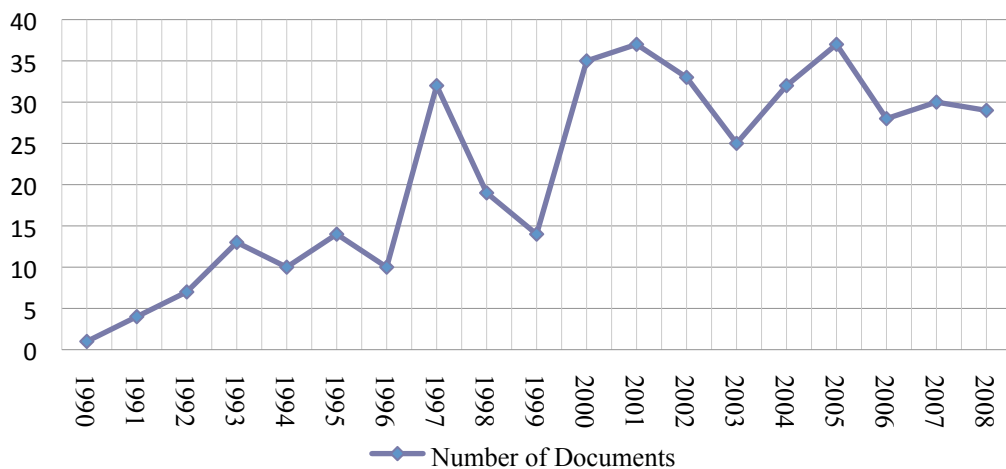
Table 3.6 Types of literature reviewed

Type	Number of Documents
Peer-reviewed journal articles, reports, and books.	352 (84%)
Non-peer reviewed (community reports, industry reports, popular press articles, grey literature etc.)	68 (16%)
Total	420

Over the time period covered by this review (January 1990 - March 2009) there has been an increase in the production of literature providing insights on climate change vulnerability in the ISR (Fig. 3.2). Three time periods stand out as peaks in the production of literature, particularly the impacts literature. Firstly, the peak in 1997 reflects the completion of the Mackenzie Basin Impact Study (MBIS) when several reports from this study were published (Cohen 1997). Secondly, the peak between 2001 and 2002 reflects the growing international interest in the Arctic and renewed interest in oil and gas development in the Mackenzie Delta. Thirdly, the peak

in 2005 may be the result of increased government expenditure on university-based research and activities related to the Mackenzie Gas Project. Something that is not captured in this graph but can be expected is another spike in literature production related to the International Polar Year (IPY) (2008 to 2010).

The majority, 352 (84%), of the documents reviewed can be regarded as ‘academic’, including articles published in peer-reviewed journals, reports, and books (Table 3.6). Non-peer reviewed grey literature including community and government reports, and articles in popular press complement the information found in academic articles (68 (16%).



Note: References from 2009 (7) are not included as this year has not completed.

Figure 3.2 Distribution of literature according to the date it was made available

State of Knowledge: what we know and don't know

Current and Future Exposure-Sensitivity

The literature contains considerable information about how the climate of the ISR is changing and implications for physical and biological systems. This scholarship largely focuses on one aspect of the physical or biological environment (e.g. permafrost, sea ice, hydrology, a specific species of plant or animal, etc.), and makes limited, if any, connections to other processes or human activities (e.g. Marsh and Lesack 1996; Wolfe et al. 2000; Dickson and Gilchrist 2002; Carmack and Macdonald 2008). Local observations of environmental changes are also well documented in each community, recorded in community workshops, by community members who presented their findings at conferences and meetings, and by university and government researchers (e.g. Berkes 1999; Riedlinger and Berkes 2001; Community of Aklavik et al., 2005; Community of Holman et al., 2005; Community of Inuvik et al., 2005; Community of Paulatuk et al., 2005; Community of Tuktoyaktuk et al., 2005; Nickels et al. 2006; Riewe 2006; Carmack and Macdonald 2008). These studies provide valuable insights on the nature of climatic changes but seldom examine how biophysical changes translate to affect human activities or the capacity to adapt.

Changes documented in each community include: more unpredictable weather, changing ice dynamics with thinner ice and earlier ice break up, decreasing snowfall on land, and accelerated coastal and/or riverine erosion. Also frequently noted are later ice freeze up, melting permafrost, ground slumping, increased sedimentation in rivers, new species of wildlife, decreased health of wildlife, warmer winters, less extreme cold, more freezing rain, and more intense sun. Several changes that have been documented elsewhere in the Arctic (Corell 2006; Gearheard et al. 2006; Ford et al. 2008b; Ford et al. 2009a,b; Ford et al. 2010a; Laidler et al., 2009) were noted less

frequently in the ISR. These include, more storm winds which have only been observed in Aklavik, more extreme weather and increasing temperature variability only in the High Arctic communities (Sachs Harbour, Ulukhaktok), warmer and longer autumns only in Inuvik and Tuktoyaktuk, more flooding in Aklavik and on the land near Ulukhaktok, and increased winter snowfall only in Sachs Harbour. This is indicative of the heterogeneous nature of Arctic climate change. Detailed community-specific physical science analysis of trends is available for permafrost, coastal erosion and some species of wildlife (e.g. Gunn et al. 1991; Bromley 1996; Larter 2001; Solomon 2002; Johnson et al. 2003) but less is known about wind regimes and weather patterns (IPCC 2007b; Furgal and Prowse 2008; Prowse et al 2009).

Changing climatic conditions are having implications for ISR communities and the literature documents evidence of compromised food security and health status of wildlife, constrained transportation access and travel routes to hunting areas, damage to municipal infrastructure, and affects on the ability to practice some traditional activities in all communities (e.g. Solomon 2005; Duerden and Beasley 2006; Furgal and Seguin 2006; Nickels et al. 2006; Ford et al. 2008a; Pearce et al. 2010e). Some studies have aimed to integrate both western scientific knowledge and traditional knowledge to generate insights on climate change and human vulnerability (e.g. Berkes and Jolly 2002; Duerden and Beasley 2006; Catto and Parewick 2008; Andrachuk 2009; Pearce et al. 2010e). These studies represent a movement towards integrated and applied research, which engages communities and assesses vulnerability in the context of multiple stresses, climate and non-climate related. These studies demonstrate, using case studies, how exposure-sensitivities are experienced differently between and within communities as a result of differing geographies, population attitudes, past experiences with change, cultural history, economic relationships, adaptive capacities, and livelihood activities. To date, however, few studies have drawn comparisons among case studies (e.g. Duerden and Beasley, 2006; Ford et al. 2008a).

Threats to infrastructure have been assessed, to some degree, in each community. Built infrastructure in communities located in the Mackenzie Delta is particularly sensitive to permafrost thaw due to its construction on ice rich flood plains (Hoeve et al. 2006). Threats to municipal and transportation infrastructure also come from coastal erosion, flooding, and warming in “shoulder seasons” (i.e. fall freeze up, spring melt) threatening the integrity of buildings and services, and of winter roads and trail networks. These threats operate at different scales, from events that may jeopardize entire communities, to events affecting highly localized access, such as degradation of hunting trails through multiple ATV traverses over vulnerable tundra. Permafrost degradation associated with warming temperatures has been documented across the region, and together with other events (e.g. increased storm surges in the Beaufort Sea, flooding in Aklavik) threatens to be costly and potentially disruptive (Zhou et al. 2009). In all communities melting permafrost threatens the integrity of transportation infrastructure, notably roads and airport runways as well as building foundations. Coastal erosion in Tuktoyaktuk, river erosion in Aklavik, and coastal erosion in Sachs Harbor are all critical events damaging and further threatening the integrity of infrastructure and in some cases community viability (Berkes and Jolly 2002; Community of Aklavik et al. 2005; Andrachuk 2008). There has been substantial documentation of threats to infrastructure in Tuktoyaktuk and Aklavik because of their long exposure to physical stresses (e.g. Reimnitz and Maurer 1979; Hamlet of Tuktoyaktuk 1984; Couture et al. 2002; Community of Aklavik et al. 2005; Manson et al. 2005). Somewhat less is known about the situation in other communities, and this is especially pertinent for Inuvik, where size, regional importance, and functional complexity are significant characteristics.

Exposure-sensitivities associated with subsistence hunting and fishing also vary between communities, depending on local biophysical conditions and human ecology of hunting, and between community members depending on access to financial resources and hunting knowledge (Betts 2005). For many Inuvialuit, subsistence hunting plays an important role in supporting

household food security. The collection and consumption of country food is also important to cultural identity and is manifest in the activity of harvesting, spending time with family members, the fulfillment, status, and the self-esteem associated with the harvest and in the sharing of country foods (Collings et al. 1998; Van Oostdam et al. 2005; Kuhnlein and Receveur 2007). Changing climatic conditions have been documented that are affecting subsistence activities including changes in temperature, seasonal patterns, weather variability, ice conditions (sea ice and river ice), wind dynamics and snowfall. For example, changing sea ice conditions have affected travel routes on the sea ice to seal and polar bear hunting grounds, and earlier and more rapid spring melts have affected travel inland by ATV to spring fishing and hunting areas (e.g. Berkes and Jolly 2002; Nickels et al. 2006; Pearce et al. 2006; Andrachuk 2008; Ford et al. 2008a). As a result of these changes, together with non-climatic changes affecting communities (e.g. economic stresses, rising cost of fuel and equipment), some harvesters face challenges in continuing to participate in subsistence harvesting, other harvesters are increasingly exposed to hazards on the land (e.g. thin ice during spring and autumn, unpredictable weather), and the health and food security of some people are being constrained as a result of compromised access, availability, and quality of country foods.

Understanding of future climate change exposure-sensitivities in the ISR is limited. The majority of research with relevance for characterizing future exposure-sensitivity focuses on projecting future climatic conditions and impacts on biophysical systems. This work is largely reported as part of broad climate impact assessments (e.g. ACIA 2005; IPCC 2007a; Lemmen et al. 2008) although focused studies on permafrost thaw and coastal erosion have been published (e.g. Anisimov et al. 2002; Hovee et al. 2006; Manson 2007; Zhang et al. 2008; Zhou et al. 2009). This work has significantly increased our understanding of the susceptibility of bio-physical systems in the ISR to climate change: accelerated warming, continued permafrost thaw, declining sea ice extent, enhanced coastal erosion, and changing wildlife health and abundance have all been

projected to continue into the future. Some studies have extrapolated how projections of climate change and associated impacts will interact with human systems at a community level (Bone 1997; Berkes and Jolly 2002; Kruse et al. 2004; Borsy 2006; Andrachuk 2008; Pearce et al. 2010e). For example, Andrachuk (2008) and Pearce et al (2010e) infer potential future vulnerabilities in Tuktoyaktuk and Ulukhaktok by evaluating current exposure-sensitivities and adaptive strategies under the lens of expected future climate change and socio-economic projections. This provides us with some information on what future vulnerabilities may be, but what degree of change will occur, how it will be manifested, and what capacity exists in communities to adapt remains unclear.

Current Adaptive Strategies and Future Adaptive Capacity

The literature indicates historically high adaptive capacity among communities in the ISR and a number of adaptations are documented as being employed today to manage the risks of current climate change and take advantage of new opportunities (Table VII). Examples of adaptive actions already being undertaken include the substitution of store foods for country foods when a hunting area or a species of wildlife is not accessible, using alternative modes of transportation (e.g. ATVs instead of snow machines to travel inland in the spring) and routes to access hunting grounds, switching species of wildlife harvested (e.g. in Ulukhaktok hunting muskox instead of caribou when caribou are less abundant or further from the community), taking extra precautions and supplies when traveling on the land (e.g. travel with VHF radios, satellite phones and/or GPS and take extra gas, fuel, food, etc.), the strengthening of municipal infrastructure to cope with altered climatic extremes (e.g. shoreline protection infrastructure in Tuktoyaktuk to protect against erosion), the development of youth-elder mentoring programs to facilitate the transmission of traditional knowledge and land skills, and the use of community freezers to store and make country foods more accessible to the greater community. In most cases adaptations are

autonomous to the individual or household and reactive in nature involving limited planning, are largely behavioural and technological, and are being developed to manage everyday challenges as opposed to long-term climate change: this is consistent with findings from other research elsewhere in Arctic Canada (Ford et al. 2006 a,b; Gearheard et al. 2006; Wolfe et al 2007; Pearce et al. 2010e) and the Arctic more generally (Lynch and Brunner 2007; Forbes and Stammerl al. 2009).

The literature highlights a diversity of practices that could underpin the ability of communities to cope with climatic change, including: livelihood and economic diversity to spread risks, ability to purchase needed hunting equipment and fuel, traditional knowledge allowing exploitation of risky environments and management of dangers, social networks through which risk is shared (e.g. food sharing networks), and acceptance of risk as part of everyday life and management practice (Collings et al. 1998; Berkes and Jolly 2002; Bates 2007; Pearce et al. 2010e). These factors represent strategic policy entry points for adaptation planning to climatic change (Ford et al. 2007). For example, research suggests that increasing the capacity of harvesters to purchase harvesting equipment, food, fuel and supplies, and supporting initiatives that promote the generation and transmission of environmental knowledge and land skills among younger generation community members would enhance adaptive capacity to current and future climate change (e.g. Ford et al. 2010a; Pearce et al. 2010e). In some cases efforts to increase access to harvesting equipment, fuel and supplies and to promote hunting/traveling knowledge and skills are already underway in communities (e.g. Inuvialuit Harvesters Assistance Program (IHAP); land skill camps, skills teaching). These are pragmatic entry points in which to consider integrating or mainstreaming adaptation planning initiatives. For example, the skills necessary to travel and navigate on the sea ice during different times of the year and insights on changing ice conditions could be included in skills teaching programs. The paths to mainstreaming initiatives such as these are already well established in communities and in many cases efforts to support

adaptation to climate change will not necessarily be directed at climate change alone but will be oriented to enhance adaptive capacity in general.

Considerable scientific effort has gone into documenting climatic changes in the ISR and evaluating current climate change risks in the communities. The potential strategic responses (e.g. relocation? live with the problem?) are also known, as are the techno-engineering fixes, including the use of thermo-siphons (to help reduce permafrost melt around buildings), application of increased volumes of aggregate to building foundations, and construction of rip-rap barriers to deal with coastal erosion. However, these ‘fixes’ are often short-term, potentially expensive, would be taking place in the context of a changing physical environment, and could be maladaptive depending on the nature of future change. Thus, increased demand for aggregates (e.g. gravel) would put pressure on a resource that is not always easily accessible at a time when transportation (winter roads) may be compromised, and the physical environments in which aggregates lie become more difficult to work (Borsy 2006). A ‘best guess’ estimate of the likely adaptation cost for building foundations in the ISR is approximately \$126,700,000 CDN (Hoeve et al. 2006). This raises the question, ‘who will pay?’ Furthermore, community infrastructure built today (e.g. new housing developments, roads, community buildings) will be exposed to very different climatic conditions in the future, yet the assumption that future climatic variability will be like past variability continues to guide community planning and construction. There are few examples in the reviewed literature of land-use planning guiding development away from areas susceptible to permafrost thaw, coastal flooding, or erosion. In some communities the opposite is occurring, with development taking place in high-risk areas (Catto and Parewick 2008). Given recent projections of climate change it is no longer safe to assume that the past will be a guide to the future, the so-called “death of stationarity” (Milly 2008). In those communities that have experienced long term threats to infrastructure, adaptive capacity may be enhanced because of their experiences and heightened awareness of the options open to them (e.g. Aklavik and flood

threat). In Tuktoyaktuk new buildings and a new road are being constructed further inland, which will make them less susceptible to coastal erosion (Andrachuk, 2008). This planning strategy was not designed to respond to climate change *per se* but it does reflect a recognition that development needs to better consider risks such as sea level rise and coastal erosion.

Table 3.7 documents barriers and limits to adaptation identified in the literature, where a barrier implies constraints that can be overcome and a limit implies an absolute barrier to adaptation (Ford 2009b). Financial resources are an important component of the means to adapt and are identified as one of the main barriers preventing adaptation from taking place (Nickels et al. 2006; Andrachuk 2008; Pearce et al. 2010e). Many adaptations are costly and exceed the financial ability of households, communities, businesses, regional governments, and regional institutions. Households for example, often do not have access to the capital resources to purchase new hunting equipment to take advantage of new conditions or replace equipment lost or damaged in climate-related hunting accidents, and municipalities often struggle to afford existing maintenance projects, let alone invest in climate-proofing infrastructure. Other adaptation barriers identified in the literature are social-cultural in nature including the erosion of traditional land skills among younger generations, substance abuse, and the cultural value of hunting and consuming certain country foods throughout the year (Condon et al. 1995; Berkes and Jolly 2002; Pearce et al. 2010e). These barriers are having implications for adaptive capacity and exposure-sensitivity of some groups within communities, particularly youth and those with limited household income and participation in social networks (e.g. equipment sharing). Limits to adaptation are also evident in the literature. For example, many landscape features are imbued with cultural significance (e.g. Herschel Island in the Beaufort Sea – traditional whaling camp), and damage to them would imply significant and irreplaceable cultural loss (Riedlinger 2001; Myers 2005; Nickels et al. 2006).

The literature identifies adaptations that have the potential to reduce future exposure-sensitivities and increase adaptive capacity, including integrated regional planning to anticipate future conflicts and stresses, enhanced harvester support assistance, skills training that meets local interests and priorities, improved search and rescue capacity, better weather and ice hazard forecasting, protection of cultural sites, and infrastructure strengthening and improved building practices (Duerden and Beasley 2006; Nickels et al. 2006; Pearce et al. 2010e). However, the majority of literature addresses future adaptation options as part of broader climate impact studies, lacking detailed policy analysis and often presenting adaptation responses as part of ‘wish lists.’ For example, few published studies have examined how adaptations would be developed and implemented, assessed support for various options among stakeholders and community members, or examined the performance and durability of adaptation options under different climate change scenarios or conditions not specified in climate change scenarios (e.g. weather patterns, wildlife migration routes). Moreover, while there are promising opportunities for adaptation to be mainstreamed into ongoing policy objectives in areas of social, cultural, and economic development, analysis of this has not been undertaken.

Table 3.7 Examples of current adaptive strategies and adaptation constraints to climate change in the ISR

Adaptive Strategies	Barriers and Limits to Adaptation
<p>Subsistence Hunting, Fishing and Trapping</p> <ul style="list-style-type: none"> • Travel with extra supplies (i.e. gas, fuel, food, etc.) (Nickels et al. 2006; Pearce et al. 2010e) • Travel with VHF radios, GPS and/or satellite phone (Pearce et al. 2010e) • Use alternative modes of transportation and travel via alternative travel routes in response to changing trail conditions (Berkes and Jolly 2002; Nickels et al. 2006; Pearce et al. 2010e) • Travel in groups and leave itineraries behind (Pearce et al. 2010e) • Wait for improved conditions (Riedlinger 2001) • Harvester assistance programs (e.g. IHAP) to provide harvesters with economic resources (Pearce et al. 2010e) • Community freezers to store foods (Nickels et al. 2006) • Read environmental signs and weather forecasts before traveling (Pearce et al. 2010e) • Substitute less accessible species with those more locally available (Riedlinger 2001; Berkes and Jolly 2002; Nickels et al. 2006; Pearce et al. 2010e) • Eat more store-bought foods (Nickels et al. 2006; Pearce et al. 2010e) • Inter and intra community trade of country foods (Collings et al. 1998; Berkes and Jolly 2002; Pearce et al. 2010e) • IFA wildlife and environmental resource co-management works to preserve diversity and availability of species (Usher 2002) • Empty fish from nets more frequently to avoid spoilage in warmer waters (Nickels et al. 2002; Andrachuk 2008) • Develop conservation plans and monitoring programs (e.g. FJMC 2000) 	<ul style="list-style-type: none"> • High costs (i.e. gas, fuel, communication and transportation equipment) (Berkes and Jolly 2002; Nuttall et al. 2005; Duerden and Beasley 2006; Pearce et al. 2010e) • Inability to access capital resources necessary to purchase harvesting equipment (i.e. boat, snowmobile, ATV) (Pearce et al. 2010e) • Substance abuse saps material resources and impairs decision making (Korhonen 2004; Ip 2007; Pearce et al. 2010e) • Costly maintenance of community freezers (Nickels et al, 2006) • Changing levels of traditional ecological knowledge and land skills (Usher 2000; Berkes and Jolly 2002; Pearce et al. 2010e) • Preference for certain species which may become less readily available (i.e. caribou) (Nagy 2005; Environment and Natural Resources 2006; Andrachuk 2008) • Employment effects the timing and duration of harvesting activities (Pearce et al. 2010e) • Inability to harvest country foods has social, cultural and health implications (Condon et al. 1995; Nuttall et al. 2005; Pearce et al. 2010e)
<p>Infrastructure and Transportation</p> <ul style="list-style-type: none"> • Build shoreline protection infrastructure to protect against erosion (Nickels et al. 2002; Johnson et al. 2003) • Greater insulation for roads, airstrips, and buildings to protect against permafrost thaw (Borsy 2006; Hoeve et al. 2006) • Design changes in offshore drilling structures to cope with altered wave action (McGillivray 1993; ACIA 2005) • Design changes in on-land buildings and structures to cope with permafrost thaw (Hayley 2004) • Trucks travel with lighter loads on ice roads (Lonergan et al. 1993) 	<ul style="list-style-type: none"> • Destruction of shoreline protection infrastructure as a result of wash-over, altered sedimentation, and erosion of tundra anchoring points (Shaw et al.2008) • High cost of climate proofing infrastructure (UMA Engineering Ltd. 1994; Hoeve et al. 2006) • Availability and cost of local aggregates (Borsy 2006)

<p>Culture and Learning</p> <ul style="list-style-type: none"> • Land skill camps and skills teaching programs (Community of Aklavik. Nickels et al. 2005; Pearce et al. 2010e) • Sharing networks, spreading, and reducing risk amongst community members (e.g. food sharing, equipment sharing) (Collings et al. 1998; Berkes and Jolly 2002; Bates 2007) 	<ul style="list-style-type: none"> • Institutional capacity (Schlag 2005) • Feelings of lost identity as the climate changes (Riedlinger 2001)
<p>Health and Well-Being</p> <ul style="list-style-type: none"> • Use of insect repellents (Nickels et al. 2006). • Pack drinking water/frozen fresh water on hunting/fishing trips (Nickels et al. 2002) • Hunters return home more frequently and new food preparation techniques are used (Nickels et al., 2002; Andrachuk, 2008) • Developing community evacuation and preparedness plans in case of extreme events (i.e. flooding) (Newton 1997) • Increased consumption store bought foods (Wein 1992; Collings et al. 1998) 	<ul style="list-style-type: none"> • Expense of fresh water and extra gas to carry the additional weight (Nickels et al. 2006). • Store bought foods are less nutritious and are causing health concerns (Collings et al. 1998; Leake et al.2008)
<p>Economy and Business</p> <ul style="list-style-type: none"> • Purchase expensive furs/skins from non-local sources and/or avoidance of hunting/trapping (Nickels et al., 2002; Nickels et al, 2006) • Purchase store-bought foods to compensate for less/more expensive country food (Nickels et al. 2006; Pearce et al. 2010e) 	<ul style="list-style-type: none"> • High prices and low incomes decrease purchasing power (Duerden and Beasley 2006; Pearce et al. 2010e)

Conclusions

The literature reviewed here provides considerable insights on current vulnerability in the ISR. We know that the climate of the ISR is changing with widespread implications for human activities. We also know that historically there has been a high level of adaptive capacity among Inuvialuit and that currently a number of adaptations are being utilized to deal with changing conditions. Despite traditionally high adaptive capacity, the literature identifies a number of barriers and limits to adaptation, which are undermining adaptive capacity, and provide insights for future vulnerability. However, research has tended to focus on the physical impacts of climate change with limited, if any, attention being given to the interactive effects of climate change with other social, cultural, and economic processes which influence how communities experience climate change and which condition adaptive capacity. This gap in knowledge limits decision

makers in their ability to make choices, which would help to reduce vulnerabilities and enhance adaptive capacity. Furthermore, while there is a well-developed understanding of the current vulnerability of key sectors including subsistence hunting and infrastructure and transportation, our understanding of current vulnerability would be improved by further research on Inuit health and well-being, economic sectors, and culture and learning. This is a priority given emerging health risks and cultural vulnerabilities predicted with climate change, and potential risks and opportunities for businesses (Furgal and Seguin 2006; Furgal 2008).

Few studies have directly assessed future vulnerability to climate change in the ISR and there is limited research from which insights on future vulnerability can be obtained. Concerning future exposure-sensitivity, the literature largely focuses on the output of global circulation models (GCMs) coupled with biophysical impact models and future emission scenarios. These studies highlight that climatic conditions associated with existing physical risks today are projected to increase in frequency and magnitude, including permafrost thaw, coastal erosion, and changing sea ice dynamics. However, to gain insights on human vulnerability it is important that research also examines how projected changes might interact with biological and human systems to affect exposure-sensitivity, and how socio-economic-demographic trends will affect how communities experience a changing climate. Moreover, location specific assessments of climate change effects would improve our understanding of future vulnerability, with the majority of biophysical studies focusing on regional level projections and impacts. For example, modeling studies project a loss of 40% or greater of summer sea ice for the Beaufort Sea by 2050 (Overland and Wang 2007), yet what communities need is an assessment of how local sea ice conditions might be affected, including ice-based transportation routes during freeze-up and break-up. This information needs to be communicated in plain language that is understandable to the people most affected by anticipated events (Pearce et al. 2009).

Adaptations can be manifested in several ways, at different scales, and take on a variety of forms. While some elements of adaptation planning are well suited to be addressed at the territorial or regional level (e.g. building codes, public infrastructure, health care), adaptation planning that is directed at supporting households and/or individuals to cope with and adapt to climate change is best undertaken at the community level with community members and other stakeholders actively engaged in the planning process. In many instances efforts to support adaptation to climate change will not necessarily be directed at climate change alone but will be oriented to enhance adaptive capacity in general. A few authors have offered broad prescriptive approaches to adapting to climate change but for the most part the reviewed works are perhaps best characterized as describing physical and human circumstances in the ISR. Although important gaps remain, a picture of the changing environment in the ISR and challenges facing the region's population is emerging. Physical scientists have identified ways in which the region's environment is changing and potential implications for infrastructure, biologists have recorded changes in fish and wildlife, and social scientists have demonstrated that the Inuvialuit are a highly adaptive people facing a range of challenges as climate change introduces new stresses while exacerbating existing ones and places increased pressure on already over-stretched community capacity. Taken together with the knowledge, observations and experiences of people living in the ISR, these insights could form the basis for advancing the adaptation research agenda, from analyses currently weighted heavily towards problem identification and description to the development and implementation of practical adaptive initiatives. In some cases adaptation will involve addressing already pressing concerns (e.g. building codes for the North) whereas in others it will mean supporting communities to obtain the resources and training needed to undertake autonomous adaptation (e.g. land skills training, economic resources). Moving from research that identifies climate change impacts and adaptation, to adaptation action is consistent with the GNWT's (2008a) call for pragmatically focused research. Preliminary efforts are currently underway to advance the adaptation planning agenda in the ISR through community-

level planning initiatives funded by the Department of Indian and Northern Affairs (INAC) Climate Change Impacts and Adaptation Program. This, and other programs are initial efforts to engage communities and researchers in processes that seek to translate research findings and federal funds into practical actions to help alleviate the negative effects of climate change in northern communities. These planning efforts will benefit from the wealth of information already available and suggested new research that will target priority issues.

Chapter 4: Community-Researcher Collaboration

Publication details:

Pearce T, Ford J, Laidler G, Smit B, Duerden F, Allarut M, Andrachuk M, Baryluk S, Dialla A, Elee P, Goose A, Ikummaq T, Inuktalik R, Joamie E, Kataoyak F, Loring E, Meakin S, Nickels S, Scott A, Shappa K, Shirley J and Wandel J (2009). Community research collaboration in the Canadian Arctic. *Polar Research*, 28: 10-27.

4.1 Introduction to Manuscript

This manuscript addresses objective two: contribute to an established approach to vulnerability analysis by identifying key considerations for effectively engaging arctic communities in collaborative research.

4.2 Manuscript

Community Collaboration and Climate Change Research in the Canadian Arctic

Abstract

Research on climate change impacts, vulnerability, and adaptation, particularly projects aiming to contribute to practical adaptation initiatives, requires active involvement and collaboration with community members, and local, regional, and national organizations that use this research for policy making. Arctic communities are already experiencing and adapting to environmental and socio-cultural changes, and researchers have a practical and ethical responsibility to engage communities who are the focus of the research. This paper draws on the experiences of researchers working with communities across the Canadian Arctic together with the expertise of Inuit organizations, northern research institutes, and community partners, to outline key considerations for effectively engaging arctic communities in collaborative research. These considerations include: initiating early and ongoing communication with communities, regional and national contacts; involving communities in research design and development; facilitating opportunities for local employment; and dissemination of research findings. Examples of each consideration are drawn from climate change research conducted with communities in the Canadian Arctic.

Introduction

An increasing number of research projects have identified climate change impacts and adaptations in the Canadian Arctic (e.g. Berkes and Jolly, 2002; Fox, 2002; ACIA, 2005; Nickels et al., 2006; Ford et al., 2008b; Furgal and Prowse, 2008). The experience of climate change in

arctic communities and their ability to adapt varies among regions and communities, and within communities, on account of different geographies, histories, and social, political and economic contexts (Duerden, 2004; Adger et al., 2005). Assessing the vulnerability and adaptive capacity of communities requires research in particular places, recognizing local social and cultural conditions, the broader economic and political environments, and involving the knowledge and experiences of local people (Turner et al., 2003; McCarthy and Martello, 2005; Smit and Wandel, 2006). Such research necessarily entails working with people in communities.

This paper explores challenges in involving arctic communities in research on climate and other environmental changes and outlines opportunities for the effective engagement of local people in community-environment research. In this paper, the term, “community-environment research” is used to refer to research on climate and other environmental changes and their human implications that actively involves the knowledge and experiences of local people. The aim of the paper is to draw from the experiences of projects in the Canadian Arctic, particularly three case studies, to identify key considerations for effectively engaging arctic communities in community-environment research.

The paper begins with a short summary of the issue of climate change in the Arctic, followed by a review of the rationale for community involvement in research. A summary of the main types of community-environment research in the Arctic provides an indication of some of the challenges in such research and strategies adopted to facilitate community engagement. Four key considerations for effective community engagement are outlined, relating to communication, research design, employment, and dissemination of findings. These are illustrated in turn with reference to three case studies, and insights from other community-environment research projects. The case studies, conducted in Nunavut and the Northwest Territories (NWT) between 2002 and

2006, examined relationships between aspects of climate change and people, and involved members of the community.

The Canadian Arctic, Climate Change and Communities

The Canadian Arctic is defined in this paper as the three territorial administrative regions of the Yukon, NWT, and Nunavut plus the Inuit settlement regions of Nunavik and Nunatsiavut (Fig. 4.1). Together these regions cover nearly 60% of the Canadian landmass, encompassing an area that is rich in geographic and biological diversity. Approximately half the population living in the Canadian Arctic is indigenous and belongs to distinct cultural and political groups (Furgal and Seguin, 2006).

People living in the Canadian Arctic have experienced rapid social, economic and political changes in the last half of the twentieth century including: settlement in communities; compulsory education; introduction of new technologies; signing of land claim agreements; development of new political institutions and co-management arrangements (e.g. wildlife management); and increasing natural resource extraction and development. In recent years, arctic communities have also been exposed to hazards associated with climate change. Local observations and instrumental measurements have recorded an increase in the frequency and magnitude of hazardous conditions in the Arctic including permafrost thaw, coastal erosion, ice instability, and increases in average temperatures and precipitation (Nickels, 2006; Furgal and Prowse, 2008). These changes have increased risks associated with traveling on the sea ice, affected access to hunting and fishing areas, and have damaged community infrastructure (e.g. buildings, roadways, trails, airports, cultural sites) (Instanes, 2005; Furgal and Seguin, 2006; Tremblay et al., 2006). Changes have also been documented in the health of wildlife species important for subsistence hunting (Nuttall, 2005; Nickels, 2006). These changes are expected to

continue into the future with further implications for the arctic environment and arctic communities (ACIA, 2005; Furgal and Prowse, 2008).

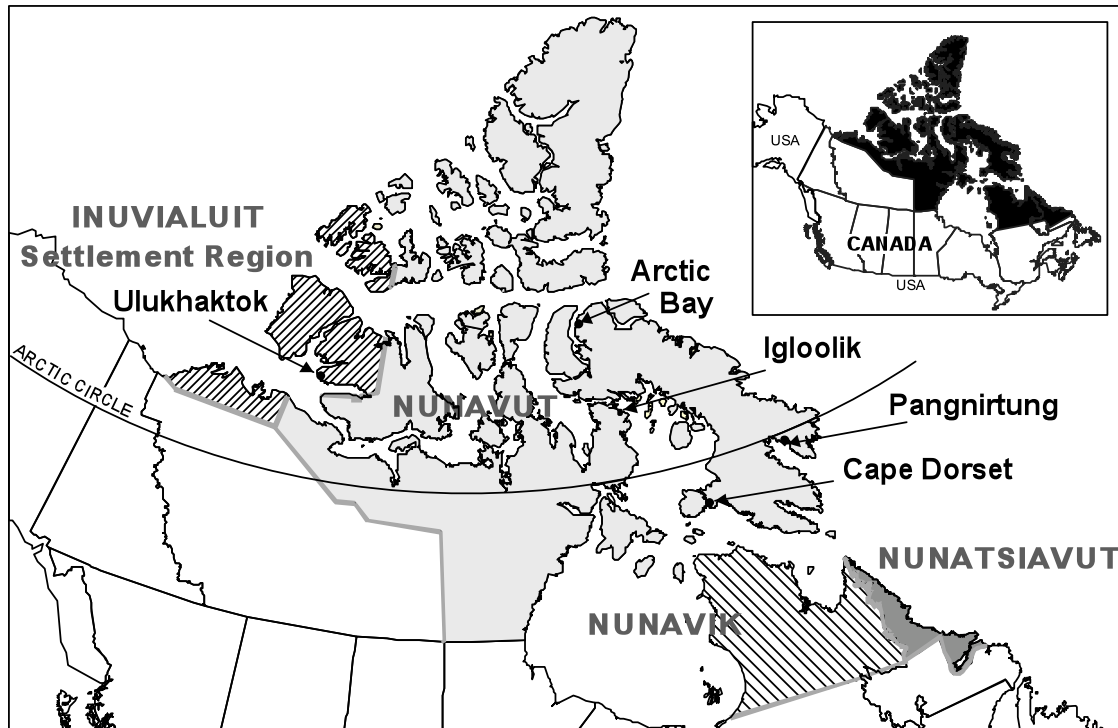


Figure 4.1 Location of case study communities: Ulukhaktok, Arctic Bay, Igloolik, Cape Dorset and Pangnirtung

In many instances, social change and climate change have acted synergistically to affect arctic livelihoods and the resources on which they depend. Due to the interdependence between arctic communities and global markets, arctic communities are exposed to changes in market processes, technologies and public policies, and to outside political and economic situations. Whereas in the past, people often relocated or changed resource use activities in response to environmental changes, today people do not have such flexibility due to living in permanent communities and their involvement in wage employment and resource management arrangements (e.g. quota systems) (McCarthy and Martello, 2005). Current and future climate change impacts have created a growing urgency amongst communities, governments, and regional and national indigenous

organizations to improve our collective understanding of how arctic communities will be affected by climate change, and how they might deal with, or adapt to these changes (GeoNorth, 2000; GN, 2003; Shirley, 2005; Watt-Cloutier et al., 2005; Handley et al., 2007).

Given this interest in the effects of climate change on arctic environments and communities, several, sometimes complementary, research foci have been adopted, including: global climate modeling (IPCC, 2001; ACIA, 2005); recording indigenous observations of environmental change (Fox, 2002; Nichols et al., 2004; Nickels et al., 2006); analyses of community sustainability (Kruse et al., 2004; Crate, 2006); studies of social ecological resilience (Berkes and Jolly, 2002; Chapin et al., 2006; Chapin et al., 2009); and assessments of community vulnerability (Tyler et al., 2007; Ford et al., 2008b). Common findings from these bodies of work are that changes are occurring that have significant implications for arctic peoples, and that there is a need for an enhanced understanding about the human dimensions of environmental change. It is also apparent that community-environment research necessitates input from local people, and several projects have actively involved community members in the research process.

Why Involve Communities In Community-Environment Research?

The rationale for, and importance of community engagement are summarized here according to practical, ethical, and regulatory considerations.

i) Practical considerations

Community collaboration in community-environment research is important because effective research cannot be done without community involvement; it is difficult, if not impossible, to identify who is vulnerable, to what stresses, in what way and why, without community collaboration. Furthermore, adaptations to climate change are not isolated from other decisions,

but occur in the context of local demographic, cultural, and socio-economic conditions. Adaptations are more likely to be successful and meaningful to individuals and communities if they are identified and developed in collaboration with communities (Sallenave, 1994; Chapin et al., 2006; Ford et al., 2007; Wolfe et al., 2007). The knowledge and information that arctic peoples hold and the importance of local involvement in policy driven research is reflected in the inclusion of traditional knowledge in environmental assessment (Stevenson, 1997; Usher, 2000), climate change assessment (GN, 2003; GY, 2006; GNWT, 2008a), and land and resource management across Canada's arctic regions (Duerden and Kuhn, 1998; Berkes et al., 2001; Ellis, 2005). Research approaches that are inconsistent with northern expectations or community involvement can result in faulty data collection, misinterpretation, community dissatisfaction, and in some cases prohibition of research by communities (Gearheard and Shirley, 2007).

ii) Ethical considerations

Researchers have an ethical obligation to engage the people who are the focus of the research. Since northerners are the individuals experiencing the conditions being researched and those living with the impact of the research, researchers have a responsibility to involve community members. However, researchers and community members do not necessarily have the same views about appropriate research objectives and methods. What may be perceived as culturally acceptable in an academic or professional culture may not be considered acceptable in the local community culture (Wiita, 2006). Researchers can work with local people on developing the research foci, objectives and methods to ensure that the research is being undertaken in a locally acceptable fashion. Several publications outline ethical principles for the conduct of research involving people in northern Canada (e.g. ACUNS, 2003; CIHR, 2007; ITK and NRI, 2007). These principles relate to respecting local laws, protocols, cultural norms, language, traditions, knowledge, confidentiality, acknowledgement, consent, and ensuring the privacy and dignity of people (ACUNS, 2003). Just as researchers clearly benefit from the knowledge collected in the

research process, many communities in northern Canada also regard scientific research as a useful tool to help provide the information needed to publicize issues of importance to them, to raise awareness, and inform policy initiatives (ITK and NRI, 2007). They often seek partnerships in the research process to serve these purposes, to influence the chosen foci of research, to maintain a degree of ownership, and to provide employment and skills development opportunities for community members.

iii) Research regulations

With the signing of land claim agreements across the Canadian Arctic, indigenous peoples have gained significant control over decisions affecting their environment and communities, including the type and nature of research conducted in their communities and regions. Northern research institutes require researchers to engage communities in the design and development of research as a part of the protocol for research licensing. For example, under the Nunavut Land Claim Agreement of 1993, the Nunavut Research Institute (NRI) licenses all research undertaken in Nunavut. Among other requirements for applications, researchers are strongly encouraged to engage Nunavut community authorities and other local and regional agencies that may be affected by and/or have an interest in the proposed research, to discuss their research plans, and incorporate feedback and suggestions (NTI, 2008). Elsewhere in Canada, funding agencies, government departments, universities, and northern research institutes increasingly recognize the importance of involving communities in research, and have developed requirements and licensing procedures and protocols for conducting research with northern communities (CYFN, 2000; ACUNS, 2003; ARCUS, 2004; ARI, 2004; CIHR, 2007; Eamer, 2006; NCP, 2007).

Community-Environment Research in the Arctic

Researchers continue to develop and refine methods for involving northern people and their knowledge in research (Sallenave, 1994; Cohen, 1997; Huntington, 2000; Nickels et al., 2002; Brooks et al., 2006; Gearheard and Shirley, 2007; Wolfe et al., 2007). Despite an increasingly common claim by researchers that their projects engage local people and knowledge, few studies in the Arctic report the methods they use to engage communities. This section outlines some ways that northern people have been engaged in community-environment research, and identifies key issues and challenges in facilitating this engagement. With the proliferation of research on climate change impacts, vulnerability, resilience, and adaptation in the Arctic, different interpretations of community engagement are evident. For some, community engagement may involve hiring a local assistant, or attending a community meeting, whereas for others it may involve community collaboration in research design and development, inclusion of traditional knowledge, or participatory action research. Ultimately, each research project will necessitate or incite different levels of community interest and involvement based on the topic and goals (ITK and NRI, 2007), and thus will have different experiences and various degrees of success in engaging communities (Gearheard and Shirley, 2007).

A common situation in which communities are engaged in research is through measuring changes in the Arctic environment (i.e. measuring sea ice characteristics, seal monitoring, etc.). In this context, community engagement often takes the form of hiring and training local people as field researchers. It may also include involving local people as informants, interpreters, guides, and research partners. Communities have also been invited to share traditional knowledge of arctic human-environment systems, and the complex social and environmental factors that underpin them. The term “traditional knowledge” is used here, consistent with its use by Huntington (1998), Berkes (1999), Noongwook et al., (2007), and the Government of the NWT, to mean

“knowledge and values, which have been acquired through experience, observation, from the land or from spiritual teachings, and handed down from one generation to another” (GNWT, 2005). The term “traditional ecological knowledge” (TEK) has been used by various commentators, either as a synonym for traditional knowledge, or referring to those aspects of traditional knowledge that relate to ecosystems and human interactions with the environment (Wenzel, 1999). The term traditional knowledge is sometimes interchanged with “aboriginal knowledge” or “indigenous knowledge” when pertaining to specific cultural groups (Stevenson, 1996; GNWT, 2005; Usher, 1999); and sometimes “local knowledge” is used to refer to information from community members regardless of culture or inter-generational history.

Researchers working in northern Canada, particularly projects that document traditional knowledge have a long history of engaging arctic communities. Boas’ (1888) work on the relationship between sea ice types, ringed seal abundance and Inuit settlement patterns represents an early example of systematic research done among Canadian Inuit (Wenzel, 1999). Traditional knowledge and community involvement are explicit in the ethnographies produced by Steffansson (1913), Jenness (1922), Rasmussen (1931), and Birket-Smith (1929). Arctic communities have been engaged to share their knowledge in land-use studies (Freeman, 1976; Brice-Bennett, 1977; Riewe, 1992), harvest studies (IJS, 2003; Gamble, 1984), and in research on subsistence (e.g. Kemp, 1971; Freeman, 1976; Keene, 1985; Smith and Wright, 1989; Noongoowak et al., 2007). Cultural anthropologists, archaeologists, and other social scientists have involved arctic communities in research (e.g. Bielawski, 1984; Condon, 1995; Collings et al., 1998; Damas, 1963; Wenzel, 1981; Tester, 2006), and several researchers working in the sub-Arctic regions of Canada (e.g. Cree and Athabaskan societies) have also engaged communities (e.g. Brody, 1981; Fiet, 1973; Fienup-Riordan, 1983; Nelson, 1969, 1973; and Ohmagari and Berkes, 1997).

In the more recent work on community-environment issues, numerous researchers have engaged communities to document traditional knowledge related to changing environmental conditions. These studies have used participatory research methods including community workshops (Nickels et al., 2006), semi-directed interviews and focus groups (Huntington, 1998; Noongwook et al., 2007), mapping (Tremblay et al., 2006; Laidler and Elee, 2008), stakeholder meetings (Woo et al., 2007), and guided trips on the land/sea-ice (Berkes et al., 2000; Gearheard et al., 2006). In some studies, community engagement is limited to meetings in which scientific information is shared and feedback is sought from local representatives. In other studies community engagement involves the collection of traditional knowledge with minimal local involvement in other aspects of the research such as topic selection, interpretation and application. Traditional knowledge is treated as one source of data contributing to western scientific research. If communities are the intended end-users of the research, such studies may have limited relevance to local concerns or interests (Kruse et al., 2004). To address this challenge, researchers are increasingly involving communities throughout the research process, including in research design and application, and in the interpretation and verification of results (Berkes and Jolly, 2002; Nickels et al., 2006). In doing so, researchers are attempting to incorporate both traditional knowledge and western scientific knowledge to help direct the research process and inform decision-making.

However, the integration of scientific knowledge and traditional knowledge in research is difficult in practice (Freeman, 1992; Usher, 2000; Noongwook et al. 2007; Wolfe et al. 2007). The process of community engagement has proven to be complex, and researchers and communities face challenges when forging community-research relationships. Key challenges include local employment trends and attitudes, revolving membership and leadership of community organizations, concurring local activities at the time of research, cultural differences, poor historical research community-researcher relations, economic subtext of many community-research relationships, financial limitations, time constraints, and communicating results to

stakeholders (Wiita, 2006; ITK and NRI, 2007; Gearheard and Shirley, 2007; Wolfe et al., 2007). Some of these challenges are inevitable given the contexts in which community-research relationships are often developed (e.g. government and university funding structures; timing constraints in academic programs; resource development pressures, and new political arrangements). However, efforts are continually being made to reflect upon, and improve, the ways in which community-researcher relations are established and maintained.

Several frameworks and methodologies for participatory research and community-research collaboration have been applied in the Arctic. Wolfe et al. (2007) developed a conceptual framework for interdisciplinary community-environment research that is participatory, iterative, and promotes ongoing communication between researchers and community members. The framework was applied in Fort Resolution and the Slave River Delta, NWT to understand how ecosystems and human communities respond to environmental change. Researchers were flexible with the timing, duration, and nature of research activities and data collection in the community was adjusted to accommodate local activities and respond to community feedback. The methods used by Berkes and Jolly (2002) and Nickels et al. (2006) drew on a series of techniques based on the ZOPP (Ziel Orientierte Projekt Planung, or Objectives Oriented Planning) or GOPP (Global Oriented Project Planning) approach, and approaches such as Participatory Rural Appraisal (PRA) to document Inuit traditional knowledge of environmental change (see GTZ, 1988; Chambers, 1994). GOPP was used to structure and manage community workshops in which community members identified priority issues, and established research questions and methodologies with researchers. In Berkes and Jolly (2002), researchers made multiple trips to the study community focused on data collection and on reporting results back to the community. A variety of complementary participatory methodologies were used including workshops, focus groups, video interviews, semi-directive interviews, and participant observation.

Several documents exist to help guide researchers and northerners through the process of undertaking studies in Canada's northern regions. Eamer (2006) summarizes procedures for research licensing in Northern Canada (including NWT, Yukon, Nunavut, and in the Northern provinces), and ITK and NRI (2007) provide advice to assist researchers working with Inuit communities in the Inuvialuit Settlement Region (ISR), Nunavut, Nunavik (northern Quebec), and Nunatsiavut (Labrador). Gearheard and Shirley (2007) discuss sources of community-research conflict in physical science research in Nunavut and opportunities to avoid such conflicts. Messages in these documents are generally consistent with this paper, which focuses upon community collaboration (not licensing) for research that directly involves northerners and their communities, and that is intended to have both scientific and community relevance.

Case Studies Illustrating Considerations for Community Engagement

This paper draws on the experiences of academic and community researchers, as well as representatives of northern and Inuit organizations who have been involved in community-environment research in the Arctic. Organizations include Inuit Tapiriit Kanatami (ITK), Inuvialuit Joint Secretariat (IJS), Inuit Circumpolar Council (ICC), Nunavut Research Institute (NRI), and Aurora Research Institute (ARI). Key considerations for effectively engaging arctic peoples in community-environment research are identified, and illustrations of each consideration are drawn from case studies of community-environment research in the Canadian Arctic. The cases are from i) Ulukhaktok, NWT (i.e. the Ulukhaktok case study); Arctic Bay and Igloolik, Nunavut (i.e. the Arctic Bay-Igloolik case study); and iii) Cape Dorset, Pangnirtung, and Igloolik, Nunavut (i.e. the Dorset-Pang-Igloolik case study) (Figure 4.1). While the case studies are specific to the Canadian Arctic, the broad elements of doing community research are likely to be applicable in other northern regions, and on other topics involving communities and/or their lands and resources.

The Ulukhaktok Case Study

A study was conducted with the community of Ulukhaktok (formally Holman), a coastal Inuvialuit community of approximately 420 people located on the west coast of Victoria Island in the ISR of the NWT (StatsNWT, 2007). The study aimed to identify and describe the ways in which the community is vulnerable to changing environmental conditions. This involved documenting exposure-sensitivities and associated adaptive responses employed in the community to deal with variations and changes in physical and socio-economic forces (see Pearce, 2006). Data were collected in the community over a four-month period between May and September 2005 through 62 semi-structured interviews with community members, participant observation, and an analysis of secondary sources of information (e.g. existing research, wildlife harvest data and economic reports). Research findings were disseminated and feedback provided in the community during an additional two-month visit between mid July and mid September 2006.

The Arctic Bay-Igloolik Case Study

The Arctic Bay-Igloolik case study refers to collaborations with the Nunavut communities of Arctic Bay and Igloolik over the period 2002-2006. Arctic Bay is a coastal community of approximately 700 people located in a mountainous region of north Baffin Island, and Igloolik is a community of 1500 people located on a small island in northern Foxe Basin (StatsCan, 2006). Researchers worked with Inuit in the communities to identify and characterize vulnerabilities to climate change and to identify entry points for policy to increase community adaptive capacity or resilience. A total of 112 semi-structured interviews and 6 focus group sessions were conducted for the project, which were followed-up with discussion sessions to review the project results (see Ford et al., 2006a; Ford et al., 2006b; Ford et al., 2007; Ford et al., 2008b).

The Dorset-Pang-Igloolik Case Study

This study was undertaken with three coastal Inuit communities around Baffin Island, Nunavut: Cape Dorset, Pangnirtung, and Igloolik. Cape Dorset is located on a small island of the same name on the southwestern tip of Baffin Island with a population of 1236 (StatsCan, 2006). Pangnirtung is located on the southeastern shore of Pangnirtung Fjord on Cumberland Peninsula off the northern shore of Cumberland Sound, with a population of 1325 (StatsCan, 2006). This research project aimed to characterize the importance of sea ice processes, use and change in the three communities, based on Inuit knowledge of local and regional sea ice conditions. These results can form baseline contributions to more comprehensive vulnerability assessments, as well as provide recommendations for linking Inuit and scientific sea ice knowledge in a complementary manner. In total, 84 semi-structured interviews with community members (including participatory mapping), 14 experiential sea ice trips, and 4 focus groups were conducted over several trips to each community, totaling nearly nine months spent in the communities) (see Laidler and Elee, 2008; Laidler and Ikummaq, 2008; Laidler et al., 2008).

These communities are all predominantly Inuit and have economies based on wage employment and subsistence harvesting. The researchers involved in these case studies sought to work collaboratively with local people, went through the licensing and approval processes, and established local research partnerships. In all three studies the main information sources were the community members themselves, supplemented with data from records, documents, and existing research reports. In each case study, researchers, representatives of northern organizations, and community members faced challenges in building collaboration. Lessons from these experiences are drawn on to illustrate considerations for engaging communities in community-environment research in the Canadian Arctic. As illustrated in Fig. 4.2, these issues are interrelated, but here they are addressed under four categories: 1) initiating early and ongoing communication with

community, regional and national contacts; 2) involving communities in research design and development; 3) facilitating opportunities for local employment; and 4) dissemination of research findings.

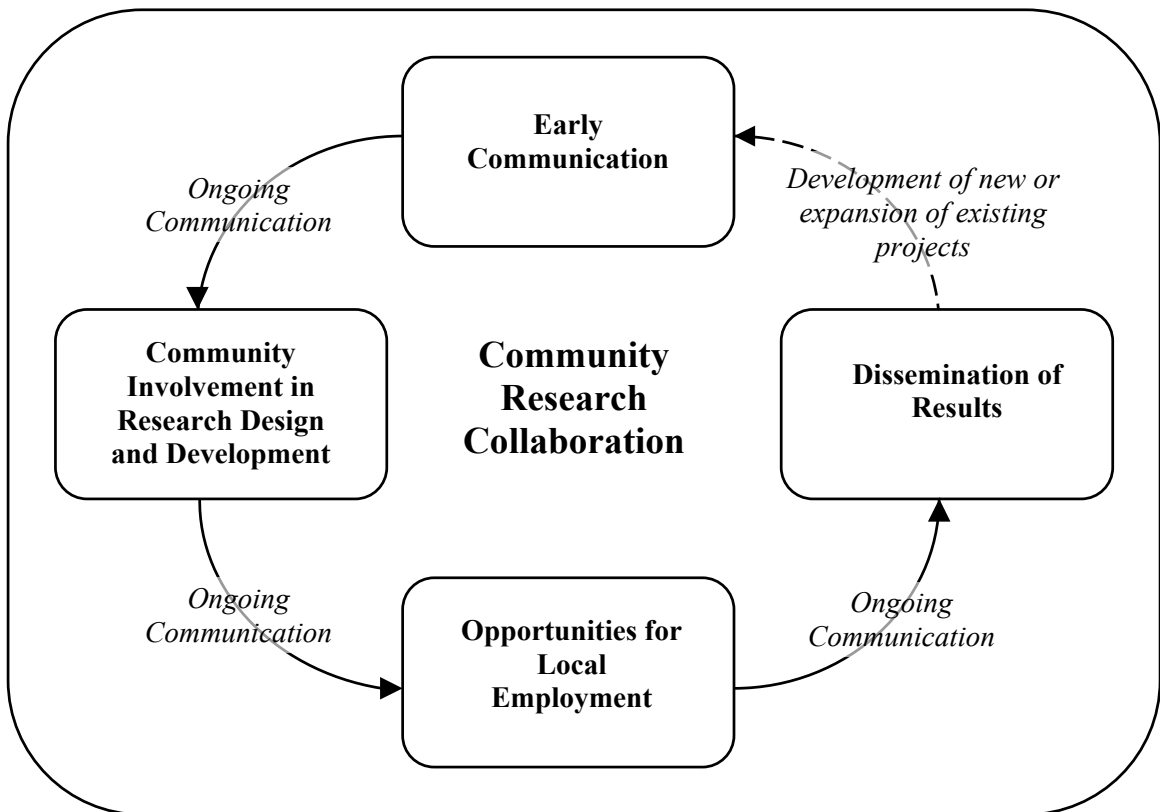


Figure 4.2 Key considerations for engaging Arctic communities in collaborative research

Early and Ongoing Communication

Effective early and ongoing communication is essential in developing strong community-research relationships. Effective communication provides opportunities to identify interested community partners, link with existing research projects, develop community-researcher relationships, and communicate research progress and findings in the community. The Canadian Arctic has an

extensive network of indigenous organizations and northern research institutions that are prepared to (and have a mandate to) assist researchers in communicating their project ideas to communities. Early communication can be done via any of several routes (e.g. direct contact with communities through established contacts) but many problems can be avoided by going through arctic indigenous organizations and northern research institutions, in order to establish research legitimacy by following accepted protocols for contacting and engaging communities.

In the Dorset-Pang-Igloodik case study, the university researcher was interested in understanding and documenting long-term, detailed, experiential Inuit knowledge of the dynamic sea ice environment to provide a more comprehensive assessment of implications of sea ice change. But before pursuing this research, confirmation was sought regarding whether this might be of interest to prospective community partners. After conducting extensive literature reviews on the topic of sea ice from both Inuit and scientific perspectives, as well as discussing the project idea with ITK, NRI, Nunavut Tunngavik Inc. (NTI), and Qikiqtani Inuit Association (QIA) representatives, gaps in this area of research were identified. Inuit and northern associations also confirmed that the issue was of great importance to nearly all Nunavut communities. Therefore, three collaborating communities (Cape Dorset, Pangnirtung, and Igloodik) were selected to be approached with the research idea, in consultation with the above-mentioned organizations, as well as through efforts to collaborate with another researcher proposing to work in these locations.

In the Ulukhaktok study, early communication with national and regional Inuit organizations was crucial for identifying local research partners. Early in the planning, researchers contacted ITK for assistance in communicating research ideas to prospective case-study communities. Following recommendations from ITK, researchers provided representatives of the Inuvialuit Joint Secretariat (IJS), Inuvialuit Game Council (IGC), and Aurora Research Institute (ARI) with a written summary broadly outlining the proposed research. These initial communications led to an

invitation from the IGC to present the research ideas at an IGC meeting – an opportunity to meet with representatives from each of the six Inuvialuit communities. At this meeting, representatives from Ulukhaktok expressed interest in having the research conducted in their community, citing changes in the environment and community concern for impacts on subsistence activities.

Researchers did not select a community *a priori* but identified, with community representatives, a case study that suited both the research needs and those of the community.

It is not uncommon for multiple research projects to be underway simultaneously (or recently completed) in a community, or a region. In some cases, research projects may be complementary, offering the possibility for collaboration and sharing among researchers. Initiating early communication with community and regional stakeholders provides an opportunity to identify and link with existing research projects or build on earlier studies. Identifying the research that has been conducted and the projects that are underway offers researchers the chance to advance what has been done, explore certain themes in detail, and avoid common concerns expressed by communities that researchers are unaware of other projects and are “always asking the same questions.”

In the Arctic Bay-Igloodik study, Arctic Bay was selected because the community was the focus of the Unikkaaqtigiit study being conducted by ITK to document local observations of climate change (Nickels et al., 2006). Recognizing the complementary features of the two studies, researchers used the Unikkaaqtigiit focus groups to introduce their project to community members, obtain feedback, and to identify key themes and concerns of the community. By linking with the existing study, researchers avoided repeating the focus group exercise, were able to focus the research on concerns already identified by the community (and consistent with the project’s aims), and gained community interest and support in the research. Of course, a balance needs to be found here, as most researchers have only a limited range regarding research topics.

Community-research collaboration has been described as a relationship-building exercise based on mutual trust and respect (Wiita, 2006). Formal and informal communications between researchers and community members play important roles in developing this relationship. In the Ulukhaktok case study, the researcher spent time participating in daily community activities during research visits to the community: visiting public buildings such as the hotel restaurant, Co-op and Northern stores, school, and Hamlet office, and developed rapport with many community members. Similarly in the Arctic Bay-Igloolik and Dorset-Pang-Igloolik studies, the researchers gained familiarity in the communities by billeting with local households during research visits and participating in community activities such as sports and traditional games. By expressing an interest in and a willingness to learn about local culture and customs the researchers were welcomed into people's homes for tea and conversation, to join community members on daily excursions on the land, and community events including hunting trips, drum dances, sporting activities, and feasts. It was these informal, often subtle communications between researchers and community members that helped develop the mutual trust and understanding needed for effective community research. It is difficult to systematically evaluate these aspects of communication but, as well known by cultural anthropologists and other social scientists (Gearheard et al., 2006; Huntington et al., 2006), informal communications are undoubtedly critical to the success of collaborative endeavours as they underlie the way that community members perceive a researcher and thus influence how they wish to work with someone.

A key element in effective ongoing communication in the case studies was the involvement of local researchers - people from the study community who were employed as members on the research teams. These people identified appropriate means of communicating with community residents, and often facilitated the information sharing. In the Arctic Bay-Igloolik study, radio, information pamphlets, and posters were jointly established by the researchers, research assistants, and interpreters to be appropriate mediums for communicating research updates. Radio

was especially useful as it is a primary mode of daily communication in the communities. Project updates were broadcasted on the community radio stations to keep community members informed of the projects as they evolved, encourage participation in the research, and solicit community feedback (people called in to make comments and suggestions). Information pamphlets and posters were distributed to individuals and organizations to summarize the goals of the project (in early stages) and to summarize project results (in later stages). These short, ongoing updates were appreciated by communities and effective at keeping communities informed on the progress of the research.

Communication with community members, organizations, and local researchers was sometimes difficult to maintain when the academic researchers were not in the community. This was mostly related to local collaborators not having easy access to a telephone, fax or the Internet; miscommunication over the phone due to language barriers; difficulties in discussing the content of publications and other written documents due to the limitations of phone and/or e-mail communications; high turn-over rate in local organizations; and/or lack of availability due to cultural events, hunting activities, etc. However, through the persistent use of multiple mediums of communication, community members and organizations in all the studies were routinely updated on post-fieldwork activities, progress, and preliminary results. In addition, opportunities were identified for local researchers to attend and present findings at conferences, pursue follow-up research activities independently, and co-author publications.

Community Involvement in Research Design and Development

Involving communities in research design and development is necessary in respect for the community in which the research is to be undertaken, and to learn from the knowledge and experiences of community members in designing feasible, practical, and comprehensive research

programs. However, it may require a resolution of differences that may exist between what the researchers aim to investigate, and issues that community members want addressed. In the case studies, preliminary consultation visits by researchers were important steps in this process. These meetings helped to develop research foci, research methodologies, appropriate times of year to conduct fieldwork, and positive working relationships between communities and researchers.

In the Ulukhaktok case the importance of researcher flexibility in conducting a preliminary community consultation was particularly important for negotiating the design and timing of the research. Early in the process, the researcher accepted an invitation from the Ulukhaktok Hunters and Trappers Committee (HTC) to visit the community to discuss the proposed research.

Depending on the nature of the proposed research, researchers may also choose to initiate early contact with, for example, the Hamlet Council, Community Corporation, health centre, cultural resource centre, school administration, elders and/or youth councils. During the two-week visit, the researcher held several formal and informal meetings with community representatives to discuss the research and gain familiarity in the community. The visit was planned to coincide with regularly scheduled meetings of the HTC, Community Corporation, and Hamlet Council. As is commonly the case, meeting dates changed and the researcher had to extend the stay to accommodate the schedules of local participants.

This experience serves as a lesson for the planning of consultations and other visits. Communities comment that researchers too often fly into a community for a short duration of time (e.g. one day) and expect to meet with community representatives at that time (what some communities call “storm trooper” consultation). This does not provide enough time for adequate discussion of a research project, nor does it give enough time for community members to give feedback on the research. Visits from researchers are but one of many activities occurring in arctic communities at

any given time and researchers wanting to engage communities in research sometimes need to be flexible and accommodating with their time.

During the consultation visit in Ulukhaktok, the researcher established partnerships with local collaborators, addressed language barriers by working with collaborators and interpreters, and began learning about the local culture and community dynamics. Community members and organizations made several recommendations for the research design and development and confirmed methods already proposed by the researcher, including conducting field research during sea-ice freeze-up and/or break-up when community members are not as busy traveling and harvesting; conducting data collection with a local Inuinnaqtun interpreter; training and employing local high school graduates; sharing research results in the community regularly and translate documents in Inuinnaqtun; and disseminating research findings at the local school. Ongoing feedback from local collaborators helped to integrate these recommendations into the research design, building trust in the community, increasing participation in the research, and ensuring that information was being collected using locally appropriate methods.

Many research design issues required making compromises. For example, in Ulukhaktok community representatives suggested fieldwork take place in the spring and fall during sea ice freeze-up and/or break-up when community members would be spending more time in the community. However, these times of year did not necessarily match the periods available to the researcher who had to work around academic requirements and constraints. As a compromise, field work was conducted between May and September. Although the summer was not an optimal time to conduct research (many community members were out “on the land”), the researcher adapted by dividing time between conducting interviews with elders (who did not travel) and community members who are employed in the community, and participating in experiential trips

on the land. These trips helped the researcher contextualize the information people shared in interviews related to the environment, environmental change and subsistence.

In the Arctic Bay-Igloolik case, linking with an existing research project in Arctic Bay helped frame the research foci and provided researchers with an opportunity to identify the most appropriate time to conduct the research in the community. Researchers attended community focus groups conducted by ITK in which many of the climate risks identified by community members concerned the late spring floe-edge narwhal hunt. The hunt is conducted during late spring when the ice is in the final stages of melting prior to break-up. Ice leads, cracks, and pools of water on the ice make travel time consuming and dangerous. Hunters are also at risk of being caught on drifting ice which is detached from the floe-edge by a southerly wind. After discussions with community members, it was decided to focus the vulnerability assessment on conditions related to subsistence hunting and the central field research was timed to occur during the narwhal hunt in July. Also, during initial meetings with community members, a preliminary list of local hunters and sea ice experts was developed, both for information sources and to assist with field research planning.

Preliminary research visits were critical to the initiation of the Dorset-Pang-Igloolik study. Conducted in the fall of 2003 and the winter of 2004, the researcher spent one to one and a half weeks in each study community, meeting with the Hamlet Councils, Hunters and Trappers Associations, Elders Groups, QIA representatives, local high schools, Nunavut Arctic College coordinators, Visitor's Centres, and Research Centres (where possible – not all the communities have the same number of local organizations). These visits included formal and informal meetings with community members to establish research foci that were of local interest and a research design that was appropriate. Existing reports of changing ice had mostly relied on scientific measurements, often limited in attributes considered and local/regional coverage.

Community organizations were interested in having local Inuit expert's knowledge of ice recognized in reports and programs, so this became a central component of the research and the foundational support from which to plan future visits and objectives.

Also during the Dorset-Pang-Igloolik consultation meetings, community members and organizations emphasized that results must be frequently communicated and made accessible to a community audience. To address these concerns, interim trip reports were developed after each field visit, to provide preliminary results as well as to elicit feedback throughout the project instead of the community having to wait four years for the "final" results. Furthermore, these consultations helped refine research foci and interview questions, develop a list of local sea ice experts to interview during subsequent research trips, and the times of year to return for field research (during all stages of sea ice formation and decay). These interactions helped establish positive working relationships with the communities from the outset. Community members were engaged in the development and design of the research project and research methods were updated and refined based on local feedback.

Preliminary consultation visits are an opportunity to facilitate local involvement in research design and development. However, the duration and nature of community consultations may be limited by funding and/or time constraints. Travel in the Arctic can be expensive and time consuming, which can be limiting factors for even the best-intentioned researcher. It is therefore important for researchers to factor a preliminary consultation visit into their research plans and budget. Funding agencies are calling for greater community engagement in research and now often provide funding for consultation visits. In all the case studies, consultation visits to potential partner communities provided opportunities to identify research foci, agree on research methodologies, and for the community to get to know the researchers. The consultation visits also

allowed the researchers to become more familiar with the social and environmental contexts in which the research is to be conducted.

Opportunities for Local Employment

Most arctic research projects attempting to understand the connections between livelihoods and environmental change are feasible only with the collaboration of local partners and assistants. These partnerships are also important for the communities, both for providing employment and for providing opportunities for developing research skills. Local employment is important for building community support for and participation in the research, facilitating communication between researchers and communities, and for interpreting and verifying data.

By employing local people, researchers in each study gained greater support for the research and received the participation of some community members who would have otherwise not been as willing to participate. For example, in the Arctic Bay-Igloodik study, local researchers were hired based on their knowledge and involvement in hunting, a focus of the research. These researchers were able to identify a list of potential interviewees and local experts, and through their relationships in the community were able to solicit the participation of several key informants. Local researchers guided the research in the community and they taught researchers about local customs, language, and how to best conduct interviews and focus groups. At the same time, local researchers report learning research skills including interviewing, information recording, report writing, and summarizing and presenting findings. Some local researchers report that their experience working on the research project has helped them obtain employment on other research projects, and has given them confidence to initiate their own research activities and to pursue additional skills training (e.g. land-based skills, college, vocational training courses, etc.).

In all case studies, interpreters were employed as part of the research team. Interpreters played vital roles in the case study research, including translator, research assistant, community liaison, guide, and teacher. Not only did they interpret language, they also interpreted concepts that vary greatly between cultures, societies, and languages. Interpreters also helped facilitate interpersonal linkages between the researcher and community members, and collaborated in the refinement of research questions and methods to more adequately reflect locally accepted practices. Their language and interpersonal skills were essential for both collaboration and communication.

With different languages factoring into all case studies effective interpreters were essential for communication. When dealing with Inuktitut or Inuinnaqtun and English, it is not only a matter of translating a word, as literal translations almost never make sense when translating in either direction. The concepts and mind frames incorporated into speech and word selection in each language are completely different, requiring a skilled interpreter to adequately communicate what is meant by statements in either language. In each case study ample time was spent with interpreters to discuss the concepts of the research project and how they could be explored in the local culture, perceptions, and language. Interpreters reviewed and commented on the interview/focus group questions prior to conducting any interviews to ensure that the questions were appropriate and that their interpretation of the questions was consistent with the goals of the research. The challenge of avoiding misinterpretation is ever-present, making ongoing communication and positive working relationship a necessary iterative element in community-environment research, if the knowledge shared is to be clearly understood and accurately portrayed.

In the Dorset-Pang-Igloolik study, the willingness of Inuit elders and hunters to participate in interviews and focus groups and to take the researcher on experiential sea-ice trips was essential in developing detailed and comprehensive results. Community members were more than

informants in the conventional sense. Paid local researchers helped design the projects around the expertise of community members in an effort to accurately convey their knowledge in a manner that was locally acceptable. Through focus groups and sea ice trips, several key individuals helped to refine and verify Inuktitut terminology, link terminology to photos of ice conditions, and review maps created during interviews. In each community, additional local experts were hired following the fieldwork, to further verify Inuktitut terminology and linkages (facilitated by local researchers). This helped to ensure higher accuracy of results, and more meaningful presentations within the community context.

Notwithstanding the benefits of employing community members, there are challenges in achieving this engagement. These include difficulties identifying suitable candidates, community collaborators struggling to balance employment obligations with other priorities (i.e. land-use activities, family roles, other seasonal employment), and the economic subtext of employment relationships (Wolfe et al., 2007). The challenge of identifying suitable candidates was evident in the Ulukhaktok study, where the aim was to employ people with the necessary skills, willing and available, and with good rapport with community members. The researcher's two-week preliminary visit helped with gaining acceptance and appreciating characteristics of the community, its livelihoods, and institutions, but it was insufficient for identifying suitable local researchers. Using the Hamlet office and posting job positions encountered difficulties with uncertainty over impartiality. Eventually, following discussions with community representatives, the Elder's Council and Inuvialuit Cultural Resource Centre (ICRC) served as the decision-making bodies and two candidates were selected.

Many community members and organizations in arctic Canada believe that researchers should provide the maximum local economic benefit (local purchases and employment) possible through their research. These expectations have become a central factor in evaluating the quality of

community-research relationships and have caused conflict where there are differences between community and researcher perceptions of what is acceptable monetary compensation. Beyond payment for lodging, food, local transportation, etc., economic relationships in community-environment research encountered in the case studies relate mainly to payment for: a) work as a researcher, interpreter, and/or guide (local collaborators), and b) compensation for interviews and participation in meetings. In all case studies, work undertaken as employment was financially compensated. For example, work as an interpreter, translator or guide involved payment for services. Financial compensation rates for local collaborators were based on communication with the northern research institute in the study regions. In communities that are being affected by rapid resource exploration and development, including Igloolik and Ulukhaktok, finding people willing to work for ‘research wages’ as opposed to ‘mine and exploration wages’ can be difficult, and suitable candidates tend to be those who wish to benefit from the experience and skill development as well as the income.

Guidelines to financial compensation for interviews and meetings are not as clear as they are for employment, and they vary among regions and communities, and over time. In the Ulukhaktok study community representatives did not request financial compensation for interviewees or honoraria for participants in meetings, and because the research was being developed with the community, community representatives suggested that the research budget be used to hire two local high school graduates to work as research assistants. In the Arctic Bay-Igloolik study, interview participants were compensated based on rates established by community organizations. In these communities, even though the research was developed in communication with the communities, it was expected that interviewees be paid in compensation for their time. In the Dorset-Pang-Igloolik study interviewees were also paid, as the convention was that people take time out of their schedules to participate and payment offsets the money they are not making if they interrupt their employment, carving, hunting, or fishing schedules. Since the increase in

mining activity in the Igloolik region, some community members who previously participated in the research subsequently expressed dissatisfaction at the level of payment and declined to be interviewed further. This emerging conflict points to the importance of continued re-assessment and negotiation of acceptable financial compensation for a participant's time in rapidly changing communities (ITK and NRI, 2007).

Dissemination of Results

Dissemination of results in the partner community serves to inform community members of the status of the project, help ensure accuracy of results, lets a broader audience know of the results, and provides an opportunity for community members to provide feedback on the research. For research that aims to connect with policy and decision-making, results can be disseminated to other potential end-users or parties interested in the research (i.e. regional decision makers, government representatives). The experiences of the case studies show that effective dissemination requires a suitable time of year, the use of communication techniques that are well suited in a community context, and an appropriate duration of time to allow people to provide feedback on the research.

In the Dorset-Pang-Igloolik study, dissemination and verification of preliminary results were conducted on each field research trip to the communities (four to each of Cape Dorset and Pangnirtung between April, 2004 and May, 2005; two to Igloolik between October, 2004 and June, 2005), using some of the communication methods described in the section, "early and ongoing communication." In addition, to communicate finalized results and pursue further verification, reporting trips were arranged to Pangnirtung and Igloolik. The final Cape Dorset trip was cancelled due to weather delays and researcher illness, but all materials were mailed to the community and organizations were contacted by phone. Results were shared with the

communities using bilingual summary reports, public meetings, a radio show, hard copy maps, school presentations, and copies of the original audio/video/transcript data that were stored in the community. Researchers worked closely with local researchers in each community to generate bilingual summary reports that were distributed to each individual who had participated in the project (via interviews or sea ice trips) as well as local organizations who had supported the project with their interest and feedback. These provided a good overview of results that had been refined by community feedback in the previous field work trips in each community; however, some community members preferred oral communication. Thus, public meetings were organized to complement written communications. Interestingly these drew more interest more from people who had not been involved in the project, and thus represented basic information sessions. While the 10-20 person sessions addressed those who were particularly interested (and not out on the land) and allowed detailed information exchange, to engage larger numbers of community members, information sessions would ideally be timed outside the spring hunting periods or to coincide with other public meetings being held at the same time.

Additionally, a radio show was conducted in Igloodik to highlight key findings (the radio station air time was strictly limited in Pangnirtung because of local community event planning at the time). This again helped to reach a broad audience, noted by people who would mention to the researcher the next day that they were happy to hear the results on the radio. School presentations and the provision of hard copy maps were other ways of giving back to the community. These techniques, especially the maps, sparked discussions of results, their potential uses in the community, and future directions for research. However, it is difficult to evaluate the lasting utility of these methods of reporting, as it is less evident how a presentation influences a student, or how young hunters use the maps, for example, in times following the departure of the researcher. From the general feedback received, the more personal, interactive, and visual aspects of results dissemination were most appreciated by community members, and thus should be

emphasized as important elements of any communication or dissemination strategy, alongside the more academic reporting and outputs that are expected of researchers (e.g. thesis, journal publications, book chapters, and summary reports).

Project results were disseminated in Ulukhaktok between mid July and mid September 2006, a year following the main data collection trip. The timing of this visit was established with community representatives to correspond with the start of the new school year in August and the return of most families to the community from camping on the land. The researcher worked with the local researchers and interpreter to develop dissemination materials (bilingual summary reports) and shared the research findings in the community through household visits, presentations at the school and to community organizations (e.g. Hamlet Council, HTC), and at an elder's lunch and drum dance. The bilingual summary reports incorporated pictures and other visual elements with simple text, and were made available to community members at the Hamlet office and during individual household visits. Initial attempts by the researcher and an interpreter to conduct household visits were not effective. Household visits to collect feedback were more effective when conducted by the local researchers and interpreter themselves, both because the communication was smoother and because people felt more comfortable sharing their thoughts on the research with people they knew.

An elder's lunch and drum dance was organized to show appreciation for the community's involvement in the research, and inform community members on the status of the research and the availability of dissemination materials. Summary booklets were distributed, the researcher was available to answer questions, and a slide show presentation was given. School presentations were made to share research findings with younger generation community members. Staff at Helen Kalvak Elihakvik School in Ulukhaktok were exceptionally welcoming and supportive of the research and they invited the researcher and research assistants to share project updates and

project findings with students. School presentations facilitated further discussions on how results can be used in the community, community research needs, and youth involvement in future research. Following these presentations, four students pursued their interest in the research topic and engaged in a discussion on ‘youth perspectives’ on environmental change. These discussions developed into a presentation, which was given by the youth at the Coastal Zone Canada Youth Forum in August 2006 in Tuktoyaktuk, NWT.

In the Arctic Bay-Igloolik study dissemination trips of one and half weeks were made to each community in March and April 2005. Although this is a busy time of year for hunting in the communities, it was identified as a good time period to share results as people hunt close to the communities at this time of year, and it is prior to the spring hunting season when most community members travel further out on the land. In each case study, researchers together with ITK and local collaborators developed a variety of accessible dissemination media including town-hall style presentations, follow-up interviews with people interviewed for the project, radio shows, leaflets, and an information CD. Bilingual summary reports were designed by researchers and community collaborators to be free of jargon, concise and emphasize key findings using both text and pictures.

Feedback was encouraged throughout dissemination visits in all the partner communities and community members had the opportunity to share their thoughts on the research in English or Inuinnaqtun/Inuktitut. Community feedback was incorporated into final project results through an additional review and verification stage of research findings and an element of local critique of the research process. For example, in the Dorset-Pang-Igloolik study, elders and hunters expressed their interest in having the documented sea ice terminology, features, and conditions more accessible in an educational format for use in the communities. This has been acted upon, in the development of follow-up research that is part of an International Polar Year project, the

“Inuit Sea Ice Use and Occupancy Project,” to render previously documented materials more accessible and interactive in an online educational atlas framework for use in Nunavut schools and curriculum. In addition, communities expressed interest in learning what climatic changes are being experienced by other communities and in other arctic regions, and what adaptation strategies are being used to cope with these changes. Another International Polar Year project, “Community Adaptation and Vulnerability in Arctic Regions (CAVIAR),” is building upon existing community-environment research and community-research relationships to conduct vulnerability studies with communities across the Circumpolar North, to better understand how arctic communities are affected by environmental changes, and to help inform adaptive strategies and policies. The communities involved in the case studies have remained actively involved in one or more of these projects, and it was the foundation of the earlier relationship-building, communication, and results dissemination that enabled these collaborations to continue.

Conclusions

Community-environment research requires active collaboration with community members. Developing a research project with an arctic community is a shared process that will evolve from mutual trust and an understanding of the cultural context in which the research is being conducted. It is a negotiation between researchers and community members to identify and balance the needs, interests, and expectations of both parties (ITK and NRI, 2007). The four considerations described in this paper for involving communities in community-environment research are intended to help facilitate these negotiations. Early and ongoing communication provides opportunities to identify interested community partners, link with existing research projects, develop community-researcher relationships, and communicate research progress and findings in the community. Involving community members in research design and development through pre-research consultation visits allows for the mutual development of research foci,

methodologies, research timing and duration, mediums and channels for communication, and community-researcher relationships. Providing employment as local researchers and interpreters is important for building community support for, and participation in the research, facilitating communication between researchers and communities, and for interpreting and verifying data. Dissemination of results in the partner communities serves to inform community members of the status of the project, ensure accuracy of results, share the results, and provides an opportunity for community members to give feedback on the research. Ongoing and effective communication is important in each of these considerations and throughout the entire research process from initial planning, to the start of the project, during field work, and reporting on final project results. Strong communication between researchers and the partner community throughout the research process provides opportunities to develop, monitor, evaluate, and improve the research as it progresses.

The nature of community-research relationships will differ among research projects and will evolve based on the type of research and the particular characteristics of each community. There is no one 'right' set of methods for engaging arctic communities in collaborative research; however, there are well-established protocols for undertaking research with communities in the Canadian Arctic. These protocols have been documented by northern governments, northern research institutes, Inuit organizations, and researchers in research licensing guides and reports. Together with these and other resources, the experiences described in this paper are offered as considerations for effectively engaging arctic communities in collaborative community-environment research. These considerations are applied in the case study research described in Chapter 5.

Chapter 5: Transmission of Environmental Knowledge and Land Skills

Publication details:

Pearce T, Wright H, Notaina R, Kudlak A, Smit B and Ford J (In Review). Transmission of environmental knowledge and land skills among Inuit men in Ulukhaktok, Northwest Territories and adaptation to climate change. *Human Ecology*.

5.1 Introduction to Manuscript

This manuscript addresses objective four: document and explain how land skills are being transmitted among Inuit men in Ulukhaktok; and objective five: draw key lessons and implications from the research findings for climate change adaptation planning. The manuscript is an empirical case study and applies considerations identified in Chapter 4 for engaging communities in research to analyze the transmission of 83 land skills among Inuit men in Ulukhaktok. Transmission rates, learning age and teachers, skill competency, changes in the present system of transmission, and aids and constraints to transmission are documented and described.

5.2 Manuscript

Transmission of Environmental Knowledge and Land Skills among Inuit Men in Ulukhaktok, Northwest Territories and Adaptation to Climate Change

Abstract

The transmission of environmental knowledge and land skills was studied with Inuit men in Ulukhaktok, Northwest Territories. A list of 83 skills important for safe and successful harvesting was generated with 14 active hunters and elders, and tested with a sample of 47 men. Just over half of all skills were being transmitted through ‘hands-on’ learning among younger respondents. Some skills including general hunting, traveling, fishing and camp-related skills, and skills related to caribou, musk ox, seal (summer) and duck hunting were transmitted well. Others such as fur preparation, dog team handling, winter seal hunting, traveling on the sea ice, and some traditional navigation and weather forecasting skills, were not. Despite similar learning ages between generations, there has been a loss of certain skills and an incomplete transmission of others among younger respondents with implications for hunting involvement, safety and success. This is attributable to factors including changes in the educational environment, loss of native language, absence of skills teachers, and declining levels of involvement in some subsistence activities.

Introduction

Numerous studies conducted in the Canadian Arctic and elsewhere in the Circumpolar North have documented Inuit sensitivities to climate change risks and have identified the importance of adaptation (e.g. Berkes and Jolly, 2002; Furgal and Seguin, 2006; Gearheard et al., 2006; Lynch and Brunner, 2007; White et al., 2007; Furgal and Prowse, 2008; Ford et al., 2008a; Ford et al., 2008b; Ford et al., 2010a; Pearce et al., 2010e). In the context of subsistence hunting, changes in seasonal patterns, precipitation, sea ice dynamics and weather variability have exacerbated risks associated with hunting and travel on the land and ice, and have affected the health and availability of some species of wildlife important for subsistence. These changes, together with social, economic and political changes already affecting Inuit, have implications for food security and health status, travel safety and harvest success, and the ability of Inuit to practice traditional cultural activities (e.g. Laidler et al., 2009; Ford, 2009a,b; Pearce et al., 2010e). Climate change is expected to continue into the foreseeable future, with further affects on Inuit in the social, health, and economic sectors of arctic communities (Anisimov et al., 2007; Lemmen et al., 2008). These expected changes will require Inuit to continue to undertake some level of adaptation. *Adaptation* in the context of human dimensions of climate change refers to an adjustment in human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007a).

Inuit have a long history of coping with and adapting to the arctic ecosphere and are already adapting to emerging climatic risks. As Ford et al. (2008a) note Inuit hunters are managing climatic risks using several adaptive strategies including risk management, risk avoidance, and risk sharing. Hunters are responding to changing ice and snow conditions by adjusting the timing of their seasonal hunting calendars, using alternative modes of transportation (e.g. ATV or boat instead of snow machine in the spring) and travel routes, and are sometimes traveling and hunting

in unfamiliar areas (Berkes and Jolly, 2002; Nickels et al., 2006; Ford et al., 2006b; Andrachuk, 2008; Ford et al., 2008b; Pearce et al., 2010e). Hunters are taking extra precautions before and during travel – checking weather forecasts prior to traveling, packing extra fuel and supplies, traveling closer to the community and in groups, and some hunters are using technologies including GPS, satellite phones, and VHF radios to be prepared in case they encounter hazardous conditions (Aporta and Higgs, 2005; Gearheard et al., 2006; Ford et al., 2009a). However, some adaptation technologies such as GPS can increase sensitivity to hazards by encouraging risk-taking behavior (Aporta and Higgs, 2005; Ford et al., 2006a).

Key determinants of adaptation and associated policy initiatives to help realize adaptive capacity and overcome barriers have also been identified (Ford et al., 2007; Dowlatabadi et al., 2009; Ford et al., 2010a; Pearce et al., 2010a). The ability to adapt is often associated with a profound knowledge of the arctic ecosphere and land skills, which affords Inuit dynamic and flexible use of the environment and its resources. Hunters manage the risks associated with hunting by knowing what equipment to take along and what preparations to make and being sensitive to critical signs in the environment and knowing how to respond. Inuit are astute observers of the sea ice and their knowledge and understanding of ice, sea, and weather conditions, assures safe travel and successful hunting (Nelson, 1969; Wenzel, 1991; Krupnik, 2002; Laidler, 2006; Laidler and Elee, 2008). Knowledge of animal behavior enables hunters to adapt to changing animal numbers and location, while knowledge of the land underpins the ability to do this (e.g. Collings, 1997; Berkes and Jolly, 2002; Ford et al., 2006a; Peloquin and Berkes, 2009). Traditionally, environmental knowledge and land skills were developed and transmitted between generations through on-the-land education or hands-on, practical engagement with the environment (Wenzel, 1987; Condon, 1996; Takano, 2004). The rate of social, economic, and political change in the Canadian Arctic, however, has had a profound effect upon younger generation Inuit, most of whom have been exclusively raised in the context of fixed settlements and Eurocentric education. Unlike their

parents and/or grandparents, younger generation Inuit are generally spending less time involved in subsistence activities beyond organized land-camps and occasional hunting trips but comparatively more time engaged in formal education, wage employment, and community socialization (e.g. sports, Internet, television). As a result, many younger and inexperienced hunters are not as well equipped to cope with the risks of hunting (MacDonald, 1998; Aporta and Higgs, 2005; Ford et al., 2007). There have been several cases of young Inuit encountering dangers on the land, and changing climatic conditions are making it even more hazardous for them (Aporta and Higgs, 2005; Ford et al., 2006a). Subsistence hunting and fishing are valued activities among Inuit and others (e.g. Canadian Military Rangers Program) and are expected to continue to play roles in the lives and livelihoods of future generations (Condon et al., 1995; Nuttall et al., 2005). The rate of climate change coupled with the dramatic social changes already proceeding in arctic communities, however, has some Inuit concerned about the capacity of younger generations to cope with and adapt to future climate change risks.

If young people do not take that skill from their family trees it will be difficult for them to survive on the land... Young people need to learn how to survive in the weather changes, even when their elders are gone so that they can pass the knowledge onto their grandchildren and teach them how to survive. Walter Olifie, Inuit elder (translated from Inuinnaqtun)

Supporting the transmission of environmental knowledge and land skills has been identified by Inuit, northern educators, researchers and governments as an important policy intervention to enhance Inuit adaptive capacity to deal with changes affecting the subsistence sector in arctic communities (Ford et al., 2010; Pearce et al., 2010a; Pearce et al., 2010e). To initiate action, decision makers need to know what skills are important for safe and successful hunting under changing conditions, what skills are being transmitted incompletely or not at all, what factors aid or impede transmission, and also what is the capacity of the community to facilitate these efforts. Despite this, few studies have examined the transmission of Inuit knowledge and land skills

limiting our understanding of Inuit adaptability and an important policy entry point to support adaptation.

This paper first conceptualizes the relationships among the transmission of environmental knowledge and skills, adaptive capacity, and adaptation to climate change. The environmental knowledge and land skills discussed are treated as a complex and practical knowledge and skills are considered together in this research (Ohmagari and Berkes, 1997). The term ‘land skills’ is used hereafter to refer to both environmental knowledge and land skills together. The paper then documents how land skills are transmitted among Inuit men in the community of Ulukhaktok, Northwest Territories (NWT) Canada. The focus on men reflects one side of the gendered nature of Inuit harvesting activities, in which men and women both have roles. The community of Ulukhaktok is briefly described and the empirical methodology employed is outlined. The results are presented first for the transmission status of the tested land skill items, and then for learning age, learning level, and teachers. Trends in the data are discussed, factors that influence transmission are identified, and policy interventions to support the transmission of land skills are outlined. In the paper transmission refers to the process of transferring cultural items, such as a skill, among individuals through experience and participation in an environment and where transmission success depends on the level of mastery of a particular item (Ohmagari and Berkes, 1997; Ingold, 2000).

Land Skills, Adaptive Capacity and Adaptation

In a climate change context, adaptive capacity can be defined as the ability of a system (e.g. a community, region, sector) to address, plan for, or adapt to climate change to moderate potential damages and/or take advantage of new opportunities (IPCC, 2007a). Adaptive capacity is often conceptualized as a function of certain characteristics of human systems that influence the

propensity or ability to adapt, known as the determinants of adaptive capacity (Smit and Pilifosova, 2001; Adger, 2006; Smit and Wandel, 2006). These determinants may include: the range of available technological options for adaptation, availability of resources and their distribution across the population, structure of critical institutions and decision-making, human capital including education and personal security, social capital including property rights, the system's access to risk-spreading processes, ability of decision-makers to manage information, and the public's perceived attribution of the source of stress (Yohe and Tol, 2002). These and other attributes will differ among regions, communities, and individuals and will vary over time, translating into different capacities to adapt (Cutter, 1996; Adger and Kelly, 1999; Duerden, 2004; Smit and Wandel, 2006).

A common perspective on the relationship among adaptive capacity, its determinants, and the process of adaptation itself focuses on 'the realization of adaptive capacity' (Brooks, 2003) or 'manifestation of adaptive capacity' as adaptation (Smit and Wandel, 2006). Adaptive capacity is described as a set of resources that represent an asset base from which adaptations can be made (Smit et al., 2000; Brooks, 2003; Vincent, 2007). The question is whether or not adaptive capacity will be drawn upon to bring about adaptation, something that depends on a range of uncertain variables (Vincent, 2007). Before traveling on the sea ice, experienced hunters closely observe the weather, clouds and wind, and look for subtle warning signs that are precursors to hazardous conditions. Drawing on past knowledge, lessons and experiences traveling on the ice, hunters determine when and where it is safe to travel (Aporta, 2002; Laidler and Ikummaq, 2008; Laidler et al., 2009). To assess adaptive capacity we must understand the adaptation process – how adaptive capacity is constituted and how it is translated into adaptation (Smit et al., 2000).

The Arctic is a highly variable environment and Inuit have long known about and coped with this variability. Anthropologists and other social scientists have identified several groups of cultural

practices that are considered to be adaptive responses to the changing arctic environment, including mobility and flexibility in terms of group size, flexibility with regard to seasonal cycles of harvest and resource-use supported by oral traditions to provide social memory, detailed local environmental knowledge and land skills, sharing networks to provide mutual support and minimize risk, and intercommunity trading (Balikci, 1968; Krupnik, 1993; Freeman, 1996; Berkes and Jolly, 2002; Ford et al., 2006a). However, the types of changes being witnessed in the Arctic today are unprecedented, and how Inuit have responded up to now may not be a reliable indicator of their ability to adapt in the future (Berkes and Jolly, 2002; Wenzel, 2009). Inuit adaptive capacity to changing environmental conditions will likely depend in part on their ability to learn and reorganize and in part on culturally available options (Berkes and Jolly, 2002). Some traditional adaptive strategies are clearly less feasible, namely mobility and flexibility in terms of group size since Inuit across the Canadian arctic now live in fixed settlements. Other traditional adaptive strategies such as 'flexibility' in terms of harvesting techniques, locations, timings and species sought continue to be an important source of adaptive capacity in Inuit society (Wenzel, 1995; Damas, 2002).

Flexibility and skills of improvisation and adaptability are associated with Inuit knowledge of the local environment and land skills. Developed, applied, and tested through personal interaction with the environment and from knowledge and skills handed down through generations by cultural transmission, this collective, dynamic, and cumulative social memory represents both competence on the land and in skills and technology necessary for safe and successful hunting. Land skills also represent an asset base from which adaptation actions can be made to deal with both routine and novel events. Rather than trying to predict or plan for the future, Inuit deal with the present and respond to each situation as, and when it presents itself (Bates, 2007). Having adequate knowledge of the present is more important than predicting what might happen next as adaptability is a process of continual learning and readjustments. Innovation and improvisation

skills are gained through personal experience in the environment, and are transmitted among generations to generate a wealth of flexibly utilized opportunities at any given point in time. Inuit knowledge is dynamic, continually evolving and being updated and revised in light of observations, new experiences, and the incorporation of non-traditional knowledge alongside the traditional (Stevenson, 1996; Berkes, 1999; Usher, 2000; Takano, 2004; Bravo, 2009). Ford et al. (2006a), working with hunters in the community Igloodik, Nunavut, documented how Inuit knowledge is evolving with changing climate conditions through social learning, moderating the risks of a changing environment. As a reservoir of accumulated knowledge of changing conditions and experiences of adaptation, environmental knowledge and land skills allow 'response with experience' to climatic risks (Ford et al., 2006b); this increases adaptive capacity (Gunderson and Holling, 2002; Berkes et al., 2003).

Transmission of Land Skills

The transmission of land skills entails a thorough experience of, and interaction between, human beings and their natural environment (Berkes, 2009; Ingold, 2000). Transmission can occur through imprinting, conditioning, imitation, active teaching and learning, or any combination of these. Transmission may occur between individuals of different generations but within genealogy (vertical transmission), between individuals of the same generation (horizontal transmission), or between genealogical lines (oblique transmission), from one individual to many (one-to-many), or from many individuals to one (concerted or many-to-one) (Cavalli-Sforza et al., 1982).

Traditionally, skills among Inuit were developed and transmitted hands-on through on-the-land education, and from listening to and learning from elders and other experienced individuals (Barnhardt and Kawagley, 2005; Takano, 2005). In traditional Inuit education, learning and living were the same things, and knowledge, judgment, and skill were not separated (Nunavik Educational Task Force, 1992). This style of learning is consistent with Ingold (2000) who

suggests that skills are grown, incorporated into the human organism through practice and training in an environment. Studying the generation and transmission of skills thus calls for an approach that situates individuals in the context of an active engagement with the constituents of their surroundings (Ingold, 2000).

There is evidence however that the traditional modes of skills transmission are not functioning as they were in the past, particularly for younger generation Inuit (Irwin, 1989; Condon et al., 1995; MacDonald, 1998; Takano, 2005; Ford et al., 2009b). Some skills have been lost, some are being transmitted incompletely or to elementary levels, and others are new skills (e.g. navigate using a GPS, read a weather report, start and tend a naptha stove, etc.) that the older generation did not possess (Berkes and Jolly, 2002; Ford et al., 2006b). This ‘deskilling’ is linked to a gradual disengagement of younger generations from the land and subsistence activities, beginning with the settlement of Inuit in communities in the 1960s and accelerating over generations. Older generation Inuit grew up at a time when there were few economic or food supply alternatives to hunting. A young man learned the knowledge and skills of hunting and trapping or he became a burden to his family or community (Condon et al., 1995). Younger generation Inuit however are growing-up in a much different economic and social environment, in which harvesting and spending time on the land while important is challenged by a number of other activities and new priorities. Disengagement from the land and subsistence activities has been linked to several factors including: requirements of formal schooling, increased dependence on wage employment, alternative activities (e.g. sports), increasing intergenerational separation between young and older generations, new technologies (e.g. Internet, video games, television), a decline in the prestige of being a hunter, and the desire among youth to follow ‘western’ rather than ‘traditional’ social norms (Condon et al., 1995; Collings et al., 1998; Ford et al., 2006b).

Ulukhaktok is one of several arctic communities where people are concerned about the potential erosion of land skills among younger generation community members (e.g. Berkes and Jolly, 2002; Takano, 2005; Ford et al., 2006a; Pearce et al., 2010e; Pearce et al., 2010c). This concern has become more immediate with the passing of many community elders, a growing youth population and the rate of climatic change. Northern educators and decision makers have expressed interest in identifying ways to support the transmission of land skills among younger generations and have already instituted some actions. These include offering skills courses in communities (e.g. *alliak* (Inuit sled) building and other tool making), on-the-land camps for youth, and integrating Inuit knowledge, language, and skills into educational curricula (Inuit Subject Advisory Committee, 1996; ITK, 2005). To extend existing information on skills transmission and Inuit adaptation to climate change, the transmission of land skills was empirically studied with a sample of Inuit men in Ulukhaktok using an approach adapted from Ohmagari and Berkes (1997).

Ulukhaktok Case Study

Ulukhaktok, formerly Holman, is a coastal Inuit community of approximately 400 people (99% Inuit) located on the west coast of Victoria Island in the Inuvialuit Settlement Region (ISR), Northwest Territories (NWT) (GNWT, 2008b) (Fig. 5.1). Like many indigenous communities in Canada, Ulukhaktok has a growing youth population with 49% of residents under 25 years old (NWT Bureau of Statistics, 2008). Ulukhaktok evolved as a permanent settlement starting in 1939 with the establishment of a Hudson's Bay Company (HBC) trading post and a Roman Catholic mission near the location of the current settlement. Prior to moving into the settlement, Inuit families lived on the land and followed seasonal hunting patterns (Condon, 1996). In 1967 the last Inuit family to remain on the land moved into the settlement and the community has since expanded considerably in terms of infrastructure, services and local economy (Condon, 1987).

Some Inuit families lived between the settlement and outpost camps until the late 1980s, maintaining some of their traditional seasonal hunting patterns.

Similar to other communities in the Canadian Arctic, Ulukhaktok has a mixed economy composed of waged employment and subsistence harvesting. Wage employment is based mostly on government and municipal services, seasonal employment (e.g. sport hunting, wildlife monitoring), arts and crafts, social transfer payments, and occasional employment in resource exploration industries, and research (Condon, 1987; Pearce et al., 2010e). Subsistence hunting, fishing and trapping continue to be valued activities for Inuit in Ulukhaktok with 76% of community members participating in subsistence (Bureau of Statistics GNWT, 2008b). Common species harvested include *iqalukpik* (Arctic char) (*Salvelinus alpinus*), *natic* (ringed seal) (*Phoca hispida*), *ugyuk* (bearded seal) (*Eringnathus barbatus*), *ihuuhuk* (Lake trout) (*Salvelinus namaycush*), *tuktu* (Peary caribou) (*Rangifer trandus*), *tuktu* (Dolphin-Union caribou) (*Rangifer traandus groenlandicus* x *pearyi*), *omingmak* (musk ox) (*Ovibos moschatus*), *kingalik* (King Eider ducks) (*Somateria specabilis*), *kanguq* (snow geese) (*Chen caerulescens*), *tirigannia* (Arctic fox) (*Vulpes lagopus*), *nanuk* (Polar bear) (*Ursus maritimus*), *amagok* (Arctic wolf) (*Canis lupus arctos*) and *kelalugak* (beluga whale) (*Delphinapterus leucas*). Harvesting, sharing and consuming country foods (locally harvested fish and wildlife) are important for food security and household economy, and are fundamental aspects of Inuit culture and identify (Wein et al., 1996; Collings et al., 1998; Pearce et al., 2010e).

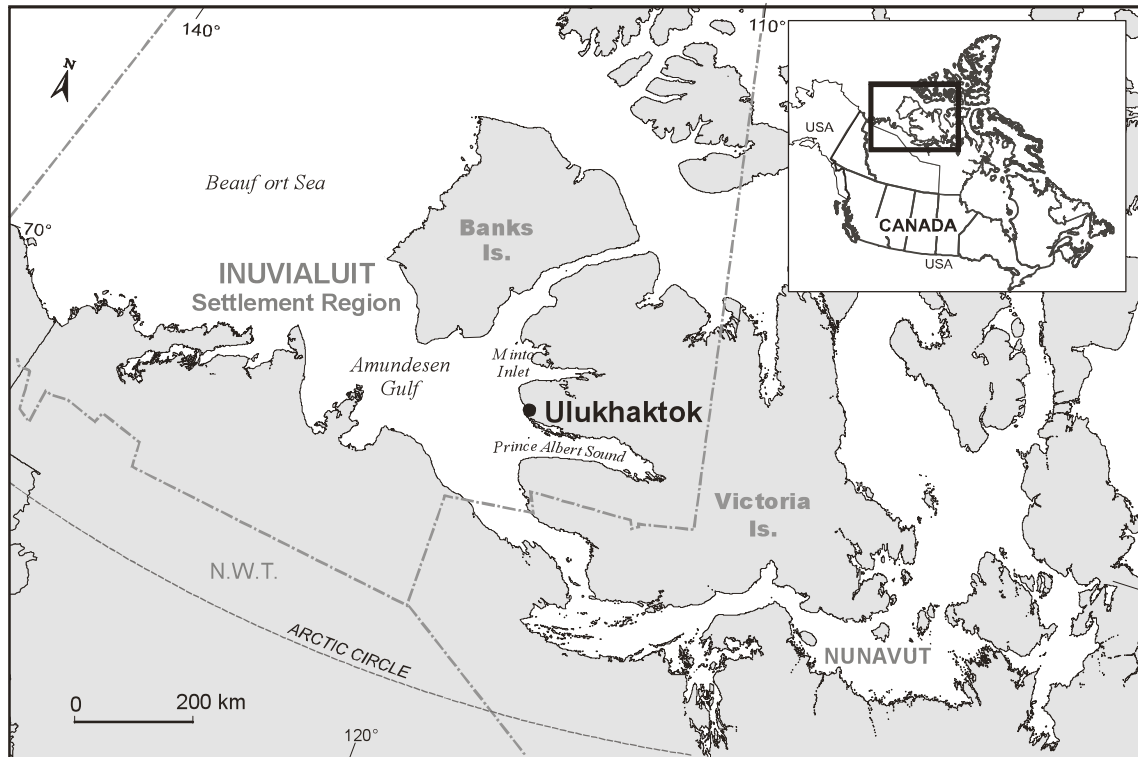


Figure 5.1 The location of Ulukhaktok in the Inuvialuit Settlement Region (ISR), Northwest Territories in relation to the Western and Central Canadian Arctic

Methods

Research in Ulukhaktok was conducted over three visits totaling approximately six and a half months spent in the community and followed recommendations for community engagement outlined by ITK and NRI (2007) and Pearce et al. (2009). A pre-research consultation visit to the community was conducted over a one-month period in November 2008 including meetings with community representatives, the Ulukhaktok Community Corporation (UCC), and the Hunters and Trappers Committee (HTC). Community feedback was integrated into the research design, including the research foci, timing of fieldwork, remuneration to research participants, and data collection techniques. The support of local organizations was obtained, a NWT scientific research license was acquired and data collection was conducted over three and a half months between

January and May 2009. The researcher worked together with several Inuit researchers who live in the community to design interview questions and guides, facilitate and conduct interviews, and interpret the data. In particular, three local researchers played integral roles. Two local researchers, men age 36 and 64, were selected for their hunting knowledge and experience, strong rapport with elders, and previous experience conducting research with the lead author. These researchers guided the development of the research (e.g. research foci, interview questions) and oversaw data collection in the community. The lead author had daily conversations with these individuals to discuss and critique the research, interpret the data and refine interview questions and technique. A third local researcher, male age 28, was employed for his ability to conduct interviews in English and Inuinnaqtun, his hunting and traveling experience, and his strong rapport with other men in the community. This researcher was integral for the recruitment of research participants, and for the collection and interpretation of interview data. Three interpreters, including the aforementioned local researcher, facilitated interviews in Inuinnaqtun and provided cultural guidance while working in the community. The practical assistance and intellectual input from local researchers was essential for conducting this research. A six-week follow-up visit was made to Ulukhaktok between February and March 2010, during which time the lead author worked with local researchers to interpret the data and develop results, communicate research findings in the community, and prepare this manuscript. Research results were disseminated in the community over two-weeks in September 2010. Research summary reports (text and photographs) were shared with all research participants (communicated to participants individually in English and Inuinnaqtun) and with key community organizations (Hunters and Trappers Committee, Community Corporation, Helen Kalvak Elihakvik (school), District Education Authority), and a research summary poster was put on long-term display in the community. Feedback on the research was documented and plans were made to communicate results to regional decision makers in Inuvik and Yellowknife.

Data Collection

First, semi-structured interviews were conducted with 14 experienced hunters and elders between 36 and 93 years of age, to generate a list of land skills and related environmental knowledge deemed important for safe and successful harvesting. Semi-structured interviews are a standard method used in ethnographic research for collecting information in an open-ended format and have been widely applied in northern research (e.g. Ferguson and Messier, 1997; Huntington, 1998; Noongwook et al., 2007; Eisner et al., 2009; Laidler et al., 2009). This comprehensive list of skills was condensed, for practical reasons, to a list of 83 items. The list included both traditional skills, such as meat and fur preparation, and more recent skills such as setting-up and operating a VHF radio, driving a snow machine pulling an *alliak*, and starting and tending to a naptha stove.

Second, semi-structured interviews were conducted with 41 Inuit men, 29 respondents between 18-34 years old and 12 respondents between 35-49 years old, representing 51% of the available male population in these age groups. The categorization of respondents into these two age groups was done in consultation with local researchers to broadly reflect two generations of respondents. The categorization allows for comparison between the two age groups and with elders. A census was used to recruit respondents between 18 and 34 years of age. A comprehensive list of male community members and their ages was obtained, individuals not currently residing in the community were removed from the list, and all other subjects aged 18-34 years were approached to participate in the research. 29 individuals agreed to participate in the research and another 18 individuals declined. A purposive sampling strategy was used to recruit respondents between 35-49 years of age. Respondents were recruited from different kinship groups, ages, and employment histories. 15 individuals were approached to participate in the research, 12 agreed to participate and three declined. Some of the reasons given for choosing not to participate in the research included: not comfortable sharing their information; too busy; and not interested in the research

foci. Two respondents, one from each age group, were eventually removed from the sample because of their delayed learning capabilities as a consequence of developmental health issues. Eight respondents 50 years old and older were also purposively recruited for their hunting knowledge and land skills expertise and were interviewed for the purpose of comparison.

In the interviews, questions firstly focused on collecting data on basic household demographics and economy, relative involvement in subsistence, and general attitudes concerning the importance of subsistence harvesting (see Condon et al., 1995). Each interviewee was then asked three fixed questions on each of the 83 skill items on the list: (1) did you learn the particular skill? (2) If yes, who was your main teacher? And (3) how old were you when you learned the skill? The research used the framework described by Ruddle and Chesterfield (1977), and adapted by Ohmagari and Berkes (1997), to analyze the learning sequences for traditional skills. Ruddle and Chesterfield (1977) identified eight stages of the learning complex: 1) familiarization of the skill to be learned; 2) observation of the teacher performing the skill; 3) helping with simple steps; 4) helping with the entire skill complex; 5) performing the skill complex under supervision; 6) becoming an assistant or apprentice to the instructor; 7) independent performance of the skill complex by the apprentice and ability to experiment with the task; and 8) becoming an equal partner to the teacher (Fig. 5.2). Key informants confirmed that the steps in the learning complex were consistent with the sequence for learning Inuit land skills. Like Ohmagari and Berkes (1997), the researchers also tried to avoid potential respondent fatigue and used an abbreviated version of the framework involving three key stages: (1) learned by hands-on experience; (2) learned by observation only; and (3) not learned. If a respondent answered that they learned a skill by hands-on experience, further questioning was undertaken to elaborate on their learning experience and to identify where on the 8-stage learning complex the respondent was.

Semi-structured questions were also used to identify the depth of knowledge a respondent had about a particular skill. For example, if a respondent answered that ‘yes’ they knew how to hunt an animal they were then asked if they knew ‘where’ to go to hunt the animal and why that is a good habitat for that species. Interviews were often complemented at the end by more open-ended questioning and informal conversation regarding hunting knowledge and skills. Participant observation of several skill items and experiential trips on the land with community members helped contextualize information shared by respondents (including summer and winter seal hunting, musk ox hunting, ice fishing, sled making, tool making, re-loading ammunition, navigation and weather prediction, polar bear hunting, and meat and fur preparation).

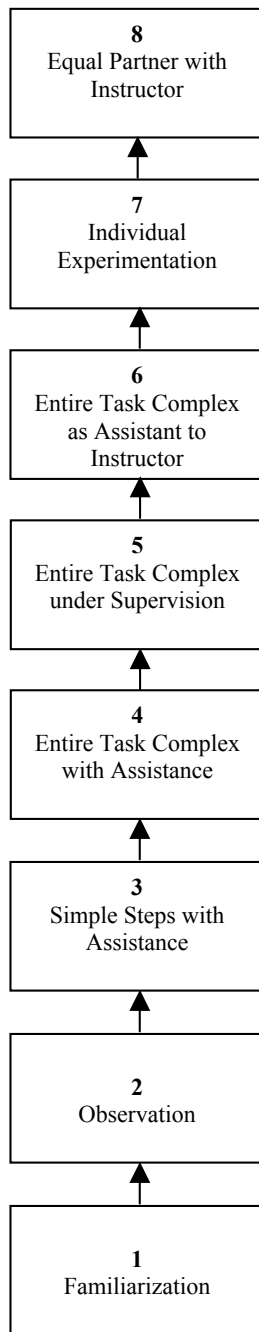


Figure. 5.2 8-stage learning complex for environmental knowledge and land skills. After Ruddle and Chesterfield (1977) and Ohmagari and Berkes (1997).

Results

Transmission of Land Skills in Ulukhaktok

The transmission status of land skills by group of skills is shown in Table 5.1. Among respondents 18-34 years of age, 56% of 83 skills were learned by hands-on experience and another 17% were learned by observation only. For respondents 35-49 years of age, 87% were learned by hands-on experience and another 6% by observation only. 27% of the 83 skills were not learned among 18-34 year old respondents and 7% were not learned among 35-49 year olds.

General hunting, traveling and camp-related skills, and skills related to fishing (all seasons), caribou, musk ox, seal (summer), and duck hunting were transmitted well among respondents 18-34 years of age, and completely among 35-49 year old respondents (level 7 or 8). Skills including using a rifle and shotgun, pulling an *alliak* behind a snow mobile, setting up a canvass wall tent, starting and tending to a naphtha stove, getting ice for drinking water, duck hunting skills, setting fish nets in the summer, and ice fishing skills were transmitted 100% by hands-on learning among respondents in both age groups. The high transmission success for duck hunting skills is attributable to strong participation in the hunt as a result of the hunt taking place in close vicinity to the community, low cost, availability of time since the hunt takes place in June when school is not in session, long day light hours and relatively warm weather, and the high level of success that can be achieved hunting ducks. 91% of respondents 18-34 years of age and 93% of respondents 35-49 years of age participated in duck hunting over the past year (between February 2009 and February 2010) (Fig. 5.3). Setting fishnets in the ocean in the summer and ice fishing at inland lakes that are close to the community also had high levels of participation and correspondingly, the associated skills have been transmitted well. High participation in fishing

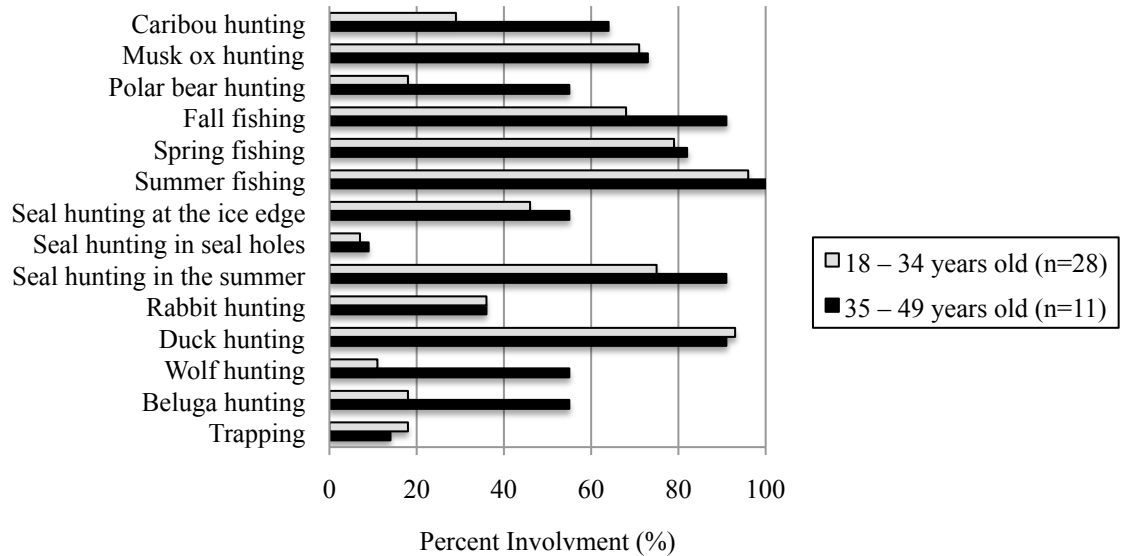
can be attributed to the accessibility of fisheries, with the ocean and several lakes easily accessed from the community.

Table 5.1 Transmission of land skills, mean scores by groups of skills, by percentage

	Percentage Reporting the Skills					
	18-34 years (n=28)			35-49 years (n=11)		
Groups of Land Skills	HO	O	N	HO	O	N
General hunting and traveling skills (x=5)	95	4	1	100	0	0
<i>Re-load bullets (x=1)</i>	18	43	39	64	27	9
Dog team skills (x=2)	39	19	42	73	27	0
Camp-related skills (x=8)	87	8	5	100	0	0
<i>Light and tend a kulliq^a (x=1)</i>	11	64	25	27	18	55
Fishing skills (x=3)	94	1	5	100	0	0
Caribou hunting skills (x=4)	84	6	10	100	0	0
Muskox hunting skills (x=4)	74	14	12	100	0	0
Seal hunting skills (x=7)	43	29	28	79	9	12
Duck hunting skills (x=3)	100	0	0	100	0	0
Polar bear hunting skills (x=3)	23	12	65	91	6	3
Wolf hunting skills (x=3)	26	14	60	85	0	15
Trapping skills (x=3)	50	11	39	88	0	12
Fur preparation skills (x=6)	25	46	29	79	16	5
Navigation and wayfinding skills (x=7)	45	14	41	94	0	6
Travel on the sea-ice (x=3)	54	8	38	97	3	0
Weather forecasting (x=5)	39	25	36	64	7	29
Equipment making and repair (x=15)	51	17	31	82	10	8
Average (x = 83)	56%	17%	27%	87%	6%	7%

HO: learned by hands-on experience, O: learned by observation only, N: not learned, x: number of skill items, n: number of respondents, ^a Inuit stone lamp

Figure. 5.3 Hunting, fishing and trapping involvement for the period February 2009-February 2010 by percentage based on respondent interviews, Ulukhaktok, NWT



Caribou and musk ox hunting skills (e.g. how to approach the animal, where to shoot the animal, how to butcher the animal) were also transmitted well among respondents in both age groups and can be attributed to the continued participation of several families in seasonal caribou hunting (spring, summer and/or fall) and the close proximity of musk ox to the community (day hunting trips for musk ox can be made throughout the year). Several respondents strongly identified with caribou hunting and took pride in their family’s caribou hunting activities. There is prestige and community recognition associated with getting your first caribou that several respondents identified with. 57% of respondents 18-34 years of age and 73% of 35-49 year olds self-reported their level of involvement in caribou hunting during one or more seasons as ‘high’ or ‘very high’ but only 29% of 18-34 year olds and 64% of 35-49 year olds participated in caribou hunting over the past year (Fig. 5.3). Respondents indicated that their lower level of involvement in caribou hunting was the result of the caribou now migrating further from the community, the high costs associated with taking boats or snow machines to the end of Prince Albert Sound to hunt caribou,

lack of equipment (e.g. boat or snow machine), and/or the absence of anyone to travel with. Caribou hunting is a family activity and if a respondent's family does not participate, their options to be involved are limited.

Skills related to setting fish nets in the fall under lake ice (at *Amoakatahuk* – Fish Lake) were transmitted well among 18-34 year olds (82% learned by hands-on) and completely among older respondents. Fall fishing provides an important source of meat over the winter months (Arctic Char and Lake Trout) and has a high level of participation. In recent years the school has facilitated fall fishing trips for students, further supporting participation among younger respondents. 68% of respondents 18-34 years of age and 91% of respondents 35-49 years of age participated in fall fishing during the past year (Fig. 5.3). Skills for hunting seals in the summer were also transmitted well among respondents in both age groups - 93% among 18-34 year olds and 100% among 35-49 year olds. Respondents learned how to shoot seals from boats and the shore, and to use an *egikhak* (floating throw hook) and a *kiviyokhout* (sinking seal hook) to retrieve seals.

A respondent's depth of knowledge about a particular skill became evident when asked if they knew where to hunt a certain species of wildlife and why? It is one thing to be able to approach, shoot, and butcher a caribou and another to know where to find the animals and understand why that is a good habitat for that species. This knowledge is particularly important in light of climate change which is affecting ecosystems and wildlife patterns requiring hunters to adapt and sometimes hunt in less familiar locations. Unlike respondents 35-49 years of age, several respondents 18-34 years of age did not know where to hunt caribou, musk ox, wolf, or polar bear, or where to set fox traps; nor did they know why they went to the hunting areas they used (Table 5.2). For example, only 14% of respondents 18-34 years old knew where to hunt caribou and why, and for polar bear hunting the figure was a mere 11%. This is because for the most part, if

younger respondents hunt, they do so with their teachers (e.g. fathers or grandfathers) and skills have yet to be fully transmitted.

Table 5.2 Depth of knowledge about selected hunting activities, by percentage

Questions	Percentage Reporting YES	
	18-34 years (n=28)	35-49 years (n=11)
Where to go to hunt caribou and why?	14	91
Where to go to hunt muskox and why?	25	82
Where to go to hunt ducks and why?	68	100
Where to go to hunt wolves and why?	21	55
Where to go to hunt polar bear and why?	11	91
Where to set fox traps and why?	46	91

Among respondents 18-34 years old some skills including lighting and tending a *kulliq* (Inuit stone lamp), caching meat, re-loading ammunition, making fish nets, keeping and running a dog team, and hunting seals in the winter with harpoon have been replaced by other skills or have become obsolete. The *kulliq* has been replaced by naphtha burning stoves, ammunition is purchased at the store, meat is stored in electric freezers, fish nets are purchased rather than made, snow machines have replaced dog teams for winter transportation, and seal hunting in the winter is not as important as it was in the past because people have fewer, if any, dogs to feed and can purchase food from the store when needed, and selling pelts is not as lucrative as it was in the past. Older respondents, however, believe that some of these skills, namely lighting and tending a *kulliq*, re-loading ammunition, caching meat, and dog team skills could be important in the future and should be transmitted to younger generations: the price of naphtha fuel has increased rapidly in recent years (\$3.41CDN/L); some ammunition readily used by hunters is not always available; due to warmer temperatures in the summer hunters need to know how to cache meat securely to prevent it from spoiling; and rising gasoline (\$1.61 CDN/L) and oil prices (\$7.99 CDN/L) are

causing some older respondents to discuss the possibility of keeping dogs again for some winter travel.

Skills related to hunting wolves were transmitted poorly among 18-34 year olds (26% hands-on) but well among 35-49 year olds (85% hands-on). Wolves are hunted for their pelts, which are sold on international fur markets and used for clothing (e.g. *kamiks* (Inuit shoes), *pauluks* (mitts), *pogotaks* (fur collar on parkas)). A wolf pelt fetches \$200 CDN in advance from the local Environment and Natural Resource Officer (ENR) and the hunter usually earns an additional \$200-300 CDN when the pelt is sold at a southern fur auction depending on the quality of the fur (C. Okheena, Renewable Resource, Wildlife and Environment Officer, pers. comm. 2010). Few hunters travel exclusively to hunt wolves because of the low percentage chance of a successful hunt and the specialized skills needed to track, locate and kill wolves. With the exception of a few knowledgeable wolf-hunters, wolf hunting is for the most part based-on opportunity and chance.

Polar bear are also hunted for their hide, which are sold or sometimes kept and used to make clothing, and on trophy sport-hunts which generates income for the outfitter, local guide, and helpers (Freeman and Wenzel, 2006). There is also a strong cultural importance to polar bear hunting and killing your first bear is a pivotal achievement in the lives of young men. 23% of respondents 18-34 years of age had learned how to hunt polar bear in comparison to 91% of 35-49 year old respondents. Freeman and Wenzel (2006) suggest that the United States (U.S) ban on the importation of polar bear products and consequent downturn in the Canadian polar bear sport hunting industry could have negative effects on the transmission of polar bear hunting knowledge and skills to young Inuit. Lacking the economic incentive and/or capacity, fewer Inuit would participate in polar bear hunting. This appears to be the case in Ulukhaktok, which has witnessed a sharp decline in polar bear sport hunts in the past two years. Furthermore, the younger respondents who had participated in a polar bear hunt and had learned some polar bear hunting

skills had yet to learn the detailed knowledge about polar bear hunting held by elders (e.g. how to track a bear and how to identify a bear's gender and size from tracks).

The low transmission of skills related to trapping and seal hunting (in the winter) among younger respondents is the result of a declining role of trapping and selling furs in the community economy. There was a rapid drop in fur prices in international markets in the 1980s and several younger respondents grew-up during a period when there was limited incentive or opportunity to participate in trapping or winter seal hunting. Some trapping of Arctic fox continues today but only a few individuals (50+ years of age) have active trap lines and these are much shorter than during the height of trapping (three people were actively trapping fox in winter 2009 and only two in winter 2010). Low participation in trapping is reflected in the low transmission of trapping skills among younger generations. 50% of respondents 18-34 years of age had learned some trapping skills (e.g. how to set a trap) but they had only acquired these skills to an average of level 4 (entire task complex with assistance) on the learning sequence and a mere 14% had participated in trapping (assisted) in the past year. Furthermore, fur preparation skills (including fox and seal pelts) were transmitted well among 35-49 year old respondents (79% hands-on) but poorly (25% hands-on) among younger respondents. Older respondents had learned the skills needed to prepare skins but several respondents commented that women were more likely to perform these skills. This, together with the decline in fur prices, may explain why fur preparation skills have been transmitted incompletely to younger generation respondents.

In the context of changing climatic conditions, it is of interest that some traditional navigation, way-finding, and weather forecasting skills were, on average, poorly transmitted among 18-34 year old respondents. 93% of respondents 18-34 years of age could navigate by remembering land-forms but few could navigate using snow drifts (29%) or the stars (21%) - skills which are important for navigating in poor visibility or unfamiliar areas. Furthermore, only 57% knew the

different types of sea ice (including what is safe and unsafe to travel over) and had learned how to travel on the ice during the winter (Table 5.3). Even fewer 18-34 year old respondents knew how to forecast weather from cloud type (18%) or wind patterns (21%) but 96% could read a weather forecast. Interviews revealed that 79% of 18-34 year old respondents chose to travel when weather conditions were optimal and consulted weather forecasts before traveling. In contrast, 75% of 35-49 year old respondents were more likely to consult elders before traveling and relied on a combination of traditional weather forecasting skills and new technologies such as Global Positioning System (GPS). 82% of 35-49 year olds learned how to navigate using handheld GPS. Inuit in Ulukhaktok, and in other arctic communities, have expressed that weather patterns are changing and as a consequence, some traditional ways of navigation and weather prediction are less accurate and applicable than in the past. However, older respondents stressed that traditional navigation and weather prediction skills continue to be important particularly when technologies fail, and that these skills have, and will adapt to accommodate new conditions.

Table 5.3 Transmission of navigation, way-finding, sea ice travel and weather forecasting skills, by percentage

	Percentage Reporting the Skills					
	18-34 years (n=28)			35-49 years (n=11)		
Land Skills	HO	O	N	HO	O	N
Navigate using snow-drifts	29	18	53	100	0	0
Celestial navigation	21	11	68	91	0	9
Navigate using the sun and moon	32	11	57	91	0	9
Navigate by remembering land-forms	93	4	3	100	0	0
Navigate by GPS	54	14	32	82	0	18
Travel on the sea ice in the fall	22	14	64	91	9	0
Travel on the sea ice in the winter	57	7	36	100	0	0
Travel on the sea ice in the spring	82	4	14	100	0	0
Forecast weather by cloud type	18	39	43	73	0	27
Forecast weather by wind pattern	21	25	54	91	0	9
Read a weather forecast	96	4	0	82	18	0

HO: learned by hands-on experience, O: learned by observation only, N: not learned, n: number of skill items, x: number of respondents

In skills related to equipment making and repair, there was a mix of well-transmitted and poorly transmitted items. Basic snow machine repair skills were transmitted well as were knife and *ulu* (Inuit Knife) sharpening skills, basic rifle and shotgun maintenance, and *alliak* building and repair. 82% of respondents 18-34 years of age and 91% of respondents 35-49 years of age had learned how to build an *alliak* through hands-on experience (Table 5.4). 59% of younger respondents reported learning hands-on how to build an *alliak* through skills-training courses offered by the local school and Aurora College. These respondents had learned the entire skill complex under supervision, but few had experience building or repairing an *alliak* outside of the skills training program. Some specialized skills including repairing an outboard boat motor or an ATV, building a *oinakhuit* (open water boat), and fixing fishnets were transmitted poorly among 18-34 year old respondents. As in the past, some individuals have acquired specialized equipment making and repair skills that their peers have not. For example, when the respondents needed their rifles fixed they relied on one individual who has specialized tools and the skill to operate them (e.g. metal lathe and drill press). Similarly, when a snowmobile, ATV or boat motor needs to be repaired, several people would collaborate to fix it, drawing on various skill-sets and levels of expertise.

Learning Age, Level and Teachers

Table 5.4 shows the mean age of skill acquisition, transmission of selected land skills (hands-on learning), and the level of learning achieved based on the 8-stage learning sequence (see Fig. 5.2). There were variations by skill type and between age groups. Most general hunting, traveling and camp-related skills, and seal hunting (summer) were learned by both age groups between the ages of 11 and 14. Duck and caribou hunting skills were learned under supervision slightly earlier by 10 or 11 years old. These ages are consistent with the accounts of older generation respondents (50+ years) who had learned these skills by 10 or 11 years old and had started to perform them on

their own and master them (skill level 7 or 8) by 14 or 15. Skills including, polar bear hunting and travel on the sea ice were learned later among respondents in both age groups and were not acquired to a level of individual experimentation or higher until 17 to 19 years of age. These ages are also consistent with older generation respondents (50+ years) who had mastered these skills by 16-20 years of age. Newer skills including, navigating using a GPS, reading a weather forecast, using the Internet to get satellite images of the sea ice, and fixing an ATV were on average acquired at a later age among older respondents due to the recent availability of some of these technologies. Skills specific to hunting musk ox were also learned at a later age among respondents 35-49 years old (16 years) as a result of musk ox not being actively harvested by the community until the early 1990s because a wildlife management law prohibited it.

Table 5.4 Age of skill acquisition, transmission of selected land skills (hands-on learning) and level achieved on the learning sequence (Fig. 4.2)

Land Skills	18-34 years (n=28)			35-49 years (n=11)		
	Mean age	Transmission (HO)	Level	Mean age	Transmission (HO)	Level
Use a rifle	8	100%	8	9	100%	8
Pack an <i>alliak</i> ^a for travelling	14	96%	7	14	100%	8
Drive a snow machine with an <i>alliak</i>	14	100%	7	14	100%	8
Run a dog team	14	39%	3	11	73%	6
Set-up a canvass wall tent	13	100%	7	11	100%	8
Set fish nets in the summer	14	100%	6	11	100%	8
Build a snow house	15	61%	4	13	91%	6
Set fish nets in the fall (under the ice)	14	82%	5	12	100%	8
Hunt caribou	11	86%	5	11	100%	8
Hunt muskox	12	78%	6	16	100%	8
Hunt seals (summer)	12	93%	6	12	100%	8
Hunt seals (winter)	12	39%	4	14	82%	7
Hunt polar bear	15	25%	5	19	100%	8
Hunt ducks	10	100%	7	11	100%	8
Navigate using land forms	14	93%	7	15	100%	8
Navigate using snowdrifts	14	29%	5	18	100%	7
Navigate by GPS	18	54%	5	30	82%	7
Read a weather report	17	96%	7	33	82%	6
Weather forecast using clouds	14	18%	5	17	73%	7
Travel on the sea ice in spring	16	82%	6	17	100%	7
Travel on the sea ice in the winter	15	57%	4	16	100%	7
Fix a snow mobile	15	89%	5	16	100%	7
Build an <i>alliak</i>	16	82%	5	19	91%	7

HO: learned by hands-on experience, x: number of respondents, ^a Inuit sled

Although the age at which respondents learned skills ‘hands-on’ is similar between age groups, the level of skill mastery differed. Respondents 18-34 years of age had yet to master most hunting, travel, navigation, and equipment making and repair skills and continued to learn from their teachers. On the other hand, respondents 35-49 years of age and elders had reached levels of individual experimentation and/or skill mastery by a similar age (level 7 or 8). For example 18-34 year old respondents on average acquired caribou hunting skills to level 5 (entire task complex

under supervision) by 11 years of age, whereas 35-49 year olds acquired the same skills to level 8 (equal partner to instructor) by 11 years of age. Similarly, the skill of traveling on the sea ice in the winter was acquired to level 4 by age 15 among 18-34 year olds (entire task complex with assistance) whereas 35-49 year olds had mastered the skill by 16 years of age. This difference in the level of skill acquisition is indicative of most of the skills tested with the exception of basic hunting (e.g. use a rifle and shotgun) and camp-related skills. Younger generation respondents learned skills at similar ages to older respondents, and sometimes at earlier ages, but learning was incomplete (mostly stages 4 - 6). This finding suggests that if younger generations are going to master these skills, they will not do so until an older age. Ohmagari and Berkes (1997) in their study on the transmission of bush skills among Cree women also found that learning was incomplete or at the elementary levels among younger generation respondents.

Consistent with elders, fathers were the principal teachers for respondents in both age categories (Table 5.5). 67% of 18-34 year old respondents and 73% of 35-49 year old respondents identified their father or both parents as their principal skills teachers. Grandfathers or both grandparents, and uncles were also important teachers for respondents in both age groups. Nine of the 28 respondents aged 18-34 years did not have their biological fathers in their lives (deceased or absent from infancy). Three of these respondents had been adopted by their grandfathers and identified them as their 'fathers' when asked who their principal teacher was. The remaining six respondents did not have father figures in their lives and hence identified someone other than a father as their principal teacher. Interestingly, the respondents who were adopted by their grandfathers had learned most hunting and travel skills as a result of having older and more experienced teachers - 71% of knowledge and skills were transmitted by hands-on experience (Table 5.6). In fact, these respondents were among the individuals in the younger age group who had learned the most skills, at the earliest ages, and to advanced levels on the learning sequence. Transmission success was second highest among respondents who identified their biological

father as their primary teacher – 61% of skills were transmitted by hands-on experience. In contrast, respondents who did not have a father in their lives reported some of the lowest levels of skill transmission success – 36% of skills were transmitted by hands-on experience. These data suggest that the absence of a father (biological or adopted by a grandfather) hinders the transmission of land skills. This highlights an important policy opportunity to direct land skills programs and initiatives at individuals who do not have an active teacher in their lives.

Table 5.5 Primary and secondary teachers in the transmission of land skills, by number of respondents and by percentage

Teacher	18 – 34 years old (n=28)		35 – 49 years old (n=11)	
	Primary	Secondary	Primary	Secondary
Father-in-law	4			
Father	60	3	73	8
Mother		14		8
Both parents	7			
<i>Subtotal (parents)</i>	<i>67</i>	<i>17</i>		<i>16</i>
Grandfather	11	21	27	17
Both grandparents		7		8
<i>Subtotal (grandparents)</i>	<i>11</i>	<i>28</i>		<i>25</i>
Uncle	7	28		33
Brother		14		17
Brother-in-law	4			
Cousin	7	3		8
CND Rangers		3		
Others (e.g. friends, school teacher)		7		
Total	100%	100%	100%	100%

Table 5.6 Transmission success (hands-on learning): Adopted by grandfather as active teacher (GF) vs. father as active teacher (F) vs. no father/grandfather as active teacher (No F/GF)

	18-34 years (n=28)		
	GF (n=3)	F (n=19)	No F/GF (n=6)
Groups of Land Skills	HO	HO	HO
General hunting and traveling skills (x=5)	100	98	87
<i>Re-load bullets (x=1)</i>	67	16	17
Dog team skills (x=2)	100	40	0
Camp-related skills (x=8)	100	88	79
<i>Light and tend a kulliq^a (x=1)</i>	0	16	0
Fishing skills (x=3)	89	100	78
Caribou hunting skills (x=4)	100	99	29
Muskox hunting skills (x=4)	100	78	50
Seal hunting skills (x=7)	57	48	19
Duck hunting skills (x=3)	100	100	100
Polar bear hunting skills (x=3)	33	28	0
Wolf hunting skills (x=3)	44	32	0
Trapping skills (x=3)	78	58	11
Fur preparation skills (x=6)	33	33	0
Navigation and wayfinding skills (x=7)	71	48	24
Travel on the sea-ice (x=3)	67	65	11
Weather forecasting (x=5)	53	41	27
Equipment making and repair (x=15)	65	54	36
Average (x = 83)	71%	61%	36%

HO: learned by hands-on experience, x: number of skill items, n: number of respondents, ^a Inuit stone lamp

Changes in the Transmission of Land Skills

Changes in the transmission status of some skills, the depth of knowledge acquired, and the level of learning achieved may be the consequence of a synergy of factors which have affected the traditional mode of learning, learning by observation and apprenticeship. In addition to access to a teacher (e.g. father, grandfather), and declining levels of participation in some subsistence activities these factors include: competing Eurocentric educational environment and modes of

learning, and loss of native language. Efforts in the community to support the transmission of land skills are then described and opportunities to enhance these and other initiatives are discussed.

Inuit and Education

Formal education came to the Canadian Arctic in the 1940s and 1950s in the form of mission schools, introducing a new way of learning that was in direct conflict with traditional Inuit modes of transmitting knowledge across generations. These schools were residential and operated on Eurocentric social rules. Only English could be spoken in schools; native languages were forbidden. Many Inuit children were sent from their home communities or camps for long periods of time to attend schools that aimed to assimilate them into contemporary Euro-Canadian lifestyle (Irwin, 1989; Damas, 2002; ITK, 2005). They spent the winters in school and the summer out on the land with their parents. Essentially, Inuit children spent their school years alternating between a southern education and enculturation experience and an Inuit education and enculturation experience (Irwin, 1989). During the 1950s, Inuit started to move from the land into communities. It is suggested that the removal of Inuit children from their parents for school had a profound influence on Inuit choosing to remain in or within close vicinity to settlements where they would wait for their children to be returned to them in the summer (Damas, 2002). In the early 1960s, schools began to be built in communities across the Canadian Arctic and Inuit children were able to live with their parents while they attended grade school, and those Inuit who continued on to high school were able to stay in the North among their peers at schools located in regional centers (e.g. Yellowknife, Rankin Inlet, Frobisher Bay (Iqaluit)). In the 1970s, control of education was transferred from the federal government to the Government of the Northwest Territories. Since the settling of four land claims across the Canadian Arctic, control over education has been transferred to respective territorial and land claim organizations (e.g. Nunavut Government).

While the Euro-Canadian form of education continues to operate in communities across the Canadian arctic, greater local control over education has resulted in changes to the development and delivery of school curricula (Nunavik Educational Task Force, 1992). For example, in Ulukhaktok, students can now study up to grade 12 in the community.

Even though changes have been made in Inuit educational systems (e.g. Inuit Subject Advisory Committee, 1996; Vick-Westgate, 2002), formal education in the Arctic has been historically disruptive, and continues to be in conflict with Inuit worldviews and modes of transmitting knowledge across generations (Stairs, 1988). In formal education, Inuit students are removed from their ecology and social networks and are isolated from each other in time and space (Stairs, 1992). Inuit ecology refers to the natural environment in which Inuit acquire livelihood skills. Inuit clearly recognize the difference between formal education and traditional learning. Based on Wenzel's (1987) work with Inuit on Baffin Island (Nunavut), "traditional learning (*isumaqsayuq*) is the way of passing along knowledge through observation and imitation embedded in daily family and community activities, with integration into immediate, shared social structure and ecology as the principal goal." In contrast, formal education (*ilisayuq*) "is teaching that involves a high level of abstract verbal mediation in a setting removed from daily life, with the skill base for a future specialized occupation as the principal goal."

Traditional learning and formal education are premised on differing worldviews and may be understood as leading to different cultural identities. In traditional learning the focus is on values developed through the learner's relationship to other persons and to the environment – this may be understood as education leading to eco-centric identity ("eco" encompassing human, animal, and material). In contrast, formal education may be understood as leading to egocentric identity ("ego" referring to the individual) for success in an egocentric contractual culture (Stairs, 1992). These conflicting values and models of learning can cause "tremendous internal conflict...when

an individual tries to live according to two value systems that in some ways contradict each other” (Henze and Vanett, 1993: 124). The conflict between these forms of education is highlighted by the dramatically low level of educational achievement among Inuit youth compared with their counterparts in southern Canada (ITK, 2005). The generations of Inuit who were born, grew up and went to school in communities have, for the most part, acquired neither a mastery of environmental knowledge and land skills nor the quality of education necessary to succeed in a Euro-centric world.

We learned from our elders, parents and grandparents, and we carried these teachings with us. Even though [formal] education is important, the kids go from morning all day and the connection with the parents is lost. They [kids] are in a new learning system. It is good to learn the modern age but the traditions and culture are being lost at a fast rate. They [kids] don’t know about being out on the land and don’t know the language [Inuinnaqtun]. Although they take our kids out on language programs and land camps, this is not enough. The teaching must be ongoing. Mabel Nigiyok, Inuit elder (translated from Inuinnaqtun)

The Nunavut Social Development Council wrote that schooling in Nunavut leaves young people “aimlessly stranded between the English and Inuit cultures” (NSDC 2000: 82). Many young Inuit have not acquired the knowledge and skills necessary to live on the land, to develop a career, or to complete a program of higher education. Two decades ago, Irwin (1989) wrote that Inuit youth “are a lost generation, whose education and enculturation provides them with little more than the skills required to live out their lives as wards of the state” (6). The same issue continues to be of great concern to Inuit today (ITK, 2005).

Three respondents 35-49 years of age (46%) completed formal schooling to an intermediate grade level at a residential school. The other eight respondents (64%) completed formal schooling to grade seven or a grade level below (e.g. one respondent completed up to grade three). The transmission of several skill items was delayed among the respondents who attended residential school as a result of these individuals being removed from the traditional learning environment for long periods of time each year. One respondent described finding himself being caught

between two worlds when he returned to the community after schooling, neither of which he felt completely comfortable in. In this study, the respondents who attended residential school did eventually learn land skills but not until later ages (19 plus years of age) once they returned to the community. In each of these cases, the respondent's families were actively engaged in subsistence harvesting and the respondents had opportunities to learn land skills when they moved back to the community. This may not be the case, however, for all individuals who attended residential school and as such, this observation must be taken in context to the research sample. In contrast, respondents who did not pursue formal schooling past elementary grade levels joined their fathers or grandfathers hunting, trapping, and traveling on the land (consistent with the way of life prior to the introduction of formal schooling). As a result, these respondents learned harvesting and traveling skills to advanced levels on the learning sequence at young ages.

Only 5 respondents 18-34 years of age (18%) attended residential school for a portion of their intermediate schooling before school was offered in the community up to grade 12. Transmission success did not differ among these and the respondents who did not attend residential school most likely because those individuals who attended residential school only did so for one or two years before continuing school in the community. At the time of the research, all of the respondents had completed school to at minimum of grade 8 and 39% of respondents had completed grade 12.

There is not a clear relationship between the level of schooling achieved and transmission success of land skills among the respondents. Rather, the determining factor as to whether respondents learned land skills, regardless of the level of formal schooling achieved, was the availability of a teacher, namely a father (or grandfather). Some families have encouraged their children to participate in formal schooling and have also remained engaged in subsistence activities, which generate learning opportunities. Although in many ways formal schooling works against traditional modes of learning, the school has also helped to facilitate the transmission of some

skills to students, some who without the school would not have had this learning opportunity. These and other skill training programs are outlined in Table 5.7 and described below.

Incomplete Transmission of Native Languages

Language comprehension is an important component of skills transmission, particularly when knowledge and skills are being transmitted in a native language. Inuit knowledge and skills are often passed between generations by oral history requiring students to understand the language of their teachers. Inuinnaqtun and Inuvialuktun are the native languages spoken by Inuit in Ulukhaktok and are the first languages for older generation community members and for some younger people. As a result of external influences such as residential and local schooling, missionaries, and television, English is now widely spoken in Ulukhaktok and is the primary language used at the school and in community operations. Although some Inuinnaqtun language is taught at the school, these efforts at best can be described as ‘cultural add-ons’ to an Anglophone education system.

To identify a respondent’s proficiency in Inuinnaqtun or Inuvialuktun each respondent was asked to self-report their ability to communicate based on a modified version of the Interagency Language Roundtable (ILR). The ILR scale consists of descriptions of five levels of language proficiency: Level 1-Elementary proficiency; Level 2-Limited working proficiency; Level 3-Professional working proficiency; Level 4-Full professional proficiency; and Level 5-Native or bilingual proficiency. On average, Elder respondents reported being at level 5, respondents 35-49 years of age self-reported to be at level 4, and respondents 18-34 years of age reported to be at level 1. This finding, although based on self-reporting, shows a progressive erosion of native language skills between generations. 82% of respondents 18-34 years of age explained that they had a basic understanding of Inuinnaqtun from their parents and/or grandparents but did not have

a strong enough understanding of the language to fully comprehend or speak it confidently. As a result, they chose to converse in English, even when they communicated with elders. Inuit elder Andy Akoaksion shares the sentiments of several elders, that the inability of many young people to communicate effectively with their elders inhibits the transmission of knowledge and skills through oral history and explanations.

Because of the language barrier, young people here do not really understand Inuinnaqtun anymore, just parts of it or maybe most of them don't even know it at all. So it is much more difficult for elders to teach them because of the language barrier. Andy Akoaksion, Inuit elder (translated from Inuinnaqtun)

Efforts to Support Knowledge and Skill Transmission

Despite limitations in the present system of education, language challenges, and other barriers to the transmission of land skills, efforts are being made to help facilitate the transmission of skills in the community. For some community members who do not have regular teachers in their lives, these training opportunities are especially important. For others who already travel and hunt with their families, these are opportunities to further hone skills, learn new skills, and bond with their peers. Table 7 describes some of the skills training and land camps currently offered in the community.

The Hamlet together with community organizations (e.g. Community Corporation, Elders Committee), facilitate on-the-land camps for youth each summer (July). Camps are one to two weeks in duration and involve traveling by boat to traditional summer camping locations with elders and other experienced Inuit teachers where youth learn hunting, fishing, traveling, and camp-related skills. This style of land-camp has been well-received in the community and local suggestions to improve the camps include: limiting what non-traditional foods participants take to camp; lengthening the time spent at camps; offering camps in all seasons (in particular spring and winter); and including a stronger focus on Inuinnaqtun language training. Summer camps are

complemented with ongoing seal monitoring activities at a location near the community. Local Inuit seal monitors take a couple youth with them to the camp weekly to learn seal hunting and camp-related skills.

Helen Kalvak Elihakvik (School) and the Canadian Forces Rangers Programs also play important roles in facilitating the teaching of land skills. Helen Kalvak Elihakvik coordinates fall and spring musk ox hunts, a fall boat trip, fall and summer fishing, and several skills teaching programs including *alliak* and *igloo* (snow house) building with local Inuit teachers. For several respondents, these experiential learning experiences were important and sometimes crucial for transmission success. Sr. Canadian Rangers and Jr. Rangers programs operate in the community and also contribute to the teaching of some land skills. The Canadian Rangers are part-time reservists who provide a military presence in Ulukhaktok and other remote, isolated, and coastal communities of Canada. Part of their responsibilities are to conduct surveillance or sovereignty patrols and provide local assistance to search and rescue activities. For Sr. Rangers this involves engaging in one or more ‘exercises’ per year, usually in the winter, for four-plus days. These are opportunities for Rangers (already experienced hunters and travelers) to hone skills such as marksmanship, navigation and way finding, and to train in newer skills like GPS navigation, mapping, equipment repair, and rifle maintenance. Rangers are also issued a rifle and free ammunition, which encourages them to practice marksmanship and use the rifle for subsistence hunting. Jr. Rangers are also provided with opportunities to learn rifle skills and engage in day trips on the land with Sr. Rangers. The intention of the Jr. Ranger program is to help facilitate the teaching of land skills among youth so that they are equipped to join the Sr. Rangers when they are eighteen years of age. The Jr. Ranger program has not replaced traditional skills teachings, but rather modestly complements them by providing younger generation Inuit opportunities to practice some skills (e.g. marksmanship), learn new skills (e.g. emergency planning and

response), and engage in on the land activities. There are approximately 28 Sr. Rangers and 60 Jr. Rangers in Ulukhaktok.

Table 5.7 Skills training and land camps offered in Ulukhaktok

Skills Training / Land Camp	Skills Taught	Target age groups	Provider	Duration and Time of Year
Summer camps	Seal and muskox hunting, meat and hide preparation, fishing with nets and rods, shooting rifles and shotguns, navigation to the camp, boating skills, basic camp skills	10-13 years 14-18 years	Ulukhaktok Community Corporation (UCC), Hamlet, Elders Group, Youth Council, Aboriginal Healing Foundation (AHF)	1-2 weeks July
Muskox hunt	Muskox hunting, rifle and bow and arrow skills, meat and hide preparation, packing an alliak, travel by snow machine	Grade 9-12 (ages 13 – 18)	Helen Kalvak Elihakvik (School)	Day trip Fall: Nov/Dec Spring: Mar/Apr
Boat Trip	Boating skills, navigation to the camp, seal hunting, fishing with nets and rods, fish preparation, basic camp skills	Grade 9-12 (ages 13 – 18)	Helen Kalvak Elihakvik	Day trip September
Summer fishing	Fishing with rods, fish preparation	K-Grade 12 (ages 5-18)	Helen Kalvak Elihakvik	Day trip August
Fall fishing	Setting fish nets under lake ice, fish preparation, navigation to the camp, packing an alliak, basic camp skills	Grade 9-12 (ages 13 – 18)	Aboriginal Healing Foundation (AHF), Helen Kalvak Elihakvik	5 days October/November
Seal monitoring at Masoyak	Seal hunting, meat and hide preparation, boating skills, rifle skills, basic camp skills	All ages	Department of Fisheries and Oceans and local seal monitors	1 week July-September
Sled building	Build alliaks	Grade 10-12 (ages 14-18)	Aurora College, Helen Kalvak Elihakvik	Daily for one week
Igloo building	Identify snow for cutting snow blocks, cut snow blocks, build an igloo	Grade 9-12 (ages 13-18)	Helen Kalvak Elihakvik	Daily for 3 days
Skills teaching	Sewing, alliak building, ulu and other tool making	All ages	Brighter Futures	Evenings Weekly during winter months
Rangers exercise	Rifle skills, navigation – GPS, mapping	19+ years	Canadian Rangers	4 days Winter
Jr. Rangers exercise	Air-rifle skills	9-18 years	Canadian Rangers	Day trip

Conclusions

In this paper the transmission of land skills is studied among Inuit men in Ulukhaktok and the connection between skills transmission and adaptation to climate change is made. The paper builds upon previous research that documented Inuit sensitivities and adaptations to changing environmental conditions to further our understanding of a key determinant of Inuit adaptive capacity, environmental knowledge and land skills. Adaptive capacity is conceptualized as a function of certain characteristics of a human system (in this case the transmission of knowledge and skills) that influence the ability to adapt. In this context, adaptive capacity is realized as adaptation when a hunter draws upon their knowledge and skill to cope with a climatic stress (e.g. changes in the sea which compromise a travel route). Thus, supporting the transmission of land skills inadvertently enhances adaptive capacity. This detailed understanding of the state of skills transmission in Ulukhaktok can help northern decision makers and educators make informed decisions regarding the development and implementation of skills training programs and northern relevant education curricula.

In Ulukhaktok and over much of the Canadian Arctic and Subarctic, harvesting fish and wildlife is an integral component of the culture and society. Subsistence harvesting is important for food security, health, household economy, and cultural continuity and wellbeing. Until approximately 50 years ago, Inuit had few economic or food supply alternatives to hunting, fishing and trapping and Inuit acquired the knowledge and skills necessary to be a producer for their family and community through hands-on experience and observation of their elders in daily life. Young Inuit today, however, are growing-up in a much different economic and social environment in which hunting and spending time on the land is challenged by a number of other activities, new priorities, and food options. Nevertheless, some degree of hunting, fishing, and traveling continue to be valued among Inuit in Ulukhaktok and are expected to continue to be important in the lives and livelihoods of future generations. A pressing concern among older generation Inuit is that as a

result of young people spending less time traveling and hunting they are not learning the skills important for safe and successful harvesting particularly in light of recent and expected future climate change. With limited knowledge of changing sea ice and other environmental conditions, weather patterns, and wildlife movements some young Inuit are less confident to hunt and travel, and are at higher risk of encountering dangers on the land. In this regard, the findings of this research help to substantiate and contextualize these concerns and identify opportunities to support the transmission of land skills in a changing Arctic environment and society.

First, several skills including general hunting, traveling, fishing, and camp-related skills were transmitted well among respondents. The majority of respondents 18-34 years of age had acquired these skills to at least level 5 on the learning sequence (entire task complex under supervision). Despite changing societal conditions, there are still benefits to participating in subsistence hunting (e.g. food and nutrition, psychological benefit, cultural bonding, social status, etc.) and there is a social momentum that tends to keep people engaged in subsistence to at least a moderate level. As a result, most of the respondents had learned basic hunting, fishing, and camp skills by age 14.

Second, given the dramatic societal and economic changes and introduction of new technologies in the Arctic, it is not surprising that some skills were poorly learned among younger respondents. Skills such as lighting and tending a *kulliq* and running a dog team have been largely replaced by newer technologies, naphtha burning stoves, snow machines and all-terrain-vehicles (ATV). Other skills such as hunting seals in the winter and trapping Arctic fox were poorly transmitted among 18-34 year olds because selling pelts is not as desirable since the fur market declined. While price fluctuations are common in the fur market, one major decline, such as when seal pelts were targeted by animal rights groups in the 1980s, can break the chain of learning between generations. The income generated from the sale of furs was often put back into equipment and

other resources important for participating in subsistence activities. Without this needed income, many people traveled and hunted less resulting in fewer opportunities for youth to learn land skills. Some skills, which are particularly important in light of rapidly changing climatic conditions, have yet to be learned as a result of the respondents spending less time engaged in hunting and travel. In the case of navigation and weather prediction, most young respondents have not learned the detailed knowledge and skills needed to navigate when the weather is *niptiaktuk* (poor visibility), how to anticipate and cope with changes in weather, or how to travel on the sea ice in different seasonal conditions. This is of concern because weather patterns, land, and sea ice conditions are changing rapidly requiring travelers to have the knowledge and skills necessary to be flexible and cope with changing conditions.

Thirdly, skills had been acquired to a lower level of mastery among respondents 18-34 years of age than among older respondents. For several skills, younger respondents had learned them to stage 4 or 5 on the learning sequence (entire task complex with assistance; entire task complex under supervision) whereas older respondents had mastered the skills by the same age. Moreover, most 18-34 year old respondents had not learned detailed knowledge of animal behaviour or habitat preference and relied on others to lead them to hunting areas. Younger respondents had also not mastered important emergency survival skills like how to build a snow shelter (*igloo* or *nalaaqtaq* (small snow shelter)). The incomplete transmission of many skills could have a profound effect on the capacity of younger respondents to continue to hunt and travel under changing climatic and environmental conditions. As habitats and wildlife movements change in response to climate change it will be increasingly important for hunters to understand changes to travel routes on the land and ice, and wildlife patterns. Without this knowledge the success of hunts could be compromised and hunters could be at greater risk of encountering hazards. It is important to note, however, that although there has been an incomplete transmission of some skills among younger respondents these skills may still be acquired at a later age. It is possible

that as a respondent's life situation changes and they become responsible for more dependents (e.g. children, taking over a hunting role from a parent or grandparent) their level of participation in subsistence activities may increase as will their level of skill mastery.

Fourthly, some factors that have affected transmission success include, access to teachers, declining participation in some subsistence activities, competing Eurocentric educational environment and modes of learning, and loss of native language. The modes of learning used in formal schooling conflict with traditional modes of skill transmission, observation and apprenticeship, and have led to conflicting values and cultural identities. There is an expressed need for a greater integration of Inuit modes of learning, knowledge and skills, and language into the current education system. Furthermore, the inability of many young people to communicate effectively with their elders in Inuinnaqtun inhibits knowledge and skill transmission through oral history and explanations. Having a father or grandfather who was an active harvester and teacher was a key variable influencing transmission success among 18-34 year old respondents.

Respondents were nearly 50% more likely to learn the tested skills if they had a father (biological or adopted by grandfather) than if they did not have a biological father in their lives. Interventions are therefore important to facilitate the transmission of land skill among individuals who do not have an active teacher in their life.

Community members and northern representatives recognize that traditional modes of skill transmission are not functioning as they were in the past and intervention is needed to ensure that some hunting and traveling skills are not lost (Pearce et al. 2010e). Several programs have been initiated to help address this concern but more needs to be done. To date, most programs have been directed at youth 18 years of age and younger, and youth who are enrolled in school. As a consequence, few skill development opportunities have been made available to individuals 19 years and older who may not have had similar skill learning opportunities as younger generations

(e.g. attended residential school). This has resulted in a group of young adults who have not completely learned the knowledge and skills necessary to actively participate in subsistence and who, at present, have limited opportunities to do so. Furthermore, multi-day on-the-land programs have been exclusive to the summer yet there is a need for skills specific to the fall, winter and spring to also be learned. Incomplete skill transmission has, and if not addressed, will continue to have negative consequences for the community. For some Inuit, incomplete skill transmission will increase their sensitivity to changing climatic conditions and for others it will reduce or prevent participation in subsistence.

Traditional education is much more than acquiring hunting skills. Land-based skills encompass many of the skills needed to survive in a turbulent modern world: patience, forbearance, observation skills, control over one's physical reactions and one's emotions, the ability to be controlled under pressure and overcome adversity, and the ability to develop strategy and to efficiently execute it. Subsistence hunting is more than just getting 'meat.' Participation in subsistence pursuits is also about being a producer and a provider, and gaining respect in the community by providing vital, tangible benefits as well as maintaining a central position in cultural heritage. Some of the social ills that exist in Ulukhaktok and elsewhere in the Arctic - homelessness, dependence on social transfer payments, poor health, and suicide can be partially attributed to feelings of low self-worth and position in society that many young Inuit struggle with. Having skills important for safe and successful harvesting under changing conditions provides young Inuit with the opportunity to engage in productive activities that continue to have value economically and socially. The importance of both formal and traditional models of education to Inuit is well established; however, many challenges have been identified for the brokerage between the two educational models including developing and transmitting culturally appropriate curricula. A greater integration of environmental knowledge and land skills, native language, and traditional modes of learning (e.g. experiential) into formal educational curricula

would help youth to acquire skills relevant to their local surroundings and culture. The status quo of incomplete skill transmission should not be acceptable. There is a trend among young Inuit towards dependence, and supporting the transmission of land skills is an important action in reversing this trend.

Chapter 6: Conclusions

This chapter serves to summarize and explain what has been learned in the thesis research and its contributions to knowledge and practice. The aim of the research was to investigate the relationships between skills transmission and human adaptation to climate change. A conceptual model was developed for interpreting these relationships that is grounded in recent theoretical developments in climate change vulnerability and adaptation research. Elements of the relationships were empirically examined in an arctic community to document how land skills were transmitted among Inuit men and what role, if any, land skills transmission plays in adaptation to climate change with respect to subsistence harvesting. Key considerations for engaging arctic communities in collaborative research were identified and applied in the case study. The chapter is organized according to the nature of contribution: empirical, practical, methodological, and theoretical.

The documentation of the transmission of land skills among Inuit men in Ulukhaktok is a sizeable **empirical contribution** of the thesis. This research found that there is a difference in the rate of land skills transmission among generations, with average transmission rates lowest among younger respondents. Some skills had been transmitted well among younger respondents, but others had not been or had been transmitted incompletely.

The research shows that subsistence harvesting continues to be important in the lives of Inuit men in Ulukhaktok. Several skills including general hunting, traveling and camp-related skills, and skills and knowledge related to fishing (all seasons), caribou, musk ox, seal (summer) and duck hunting were transmitted well among respondents 18-34 years of age, and completely among respondents 35-49 years of age and 50+ years of age. The successful transmission of these skills

is associated with high levels of involvement in these subsistence activities, which provided opportunities for hands-on learning. Respondents 18-34 and 35-49 years of age had acquired most general hunting, traveling and camp-related skills, and seal hunting (summer) skills to a level of individual experimentation or higher (level 7 or 8 on the learning sequence), between 11 and 14 years of age. Skills, which had lower levels of participation including polar bear hunting and travel on the sea ice, were not acquired to these levels of mastery until 17 to 19 years of age. These ages are consistent with the age of skills transmission among elder respondents (50+ years of age). However, although the age at which respondents learned skills 'hands-on' is similar between age groups, respondents 18-34 years of age had learned most skills to a *lower level of mastery* than older respondents at an equivalent age. Younger generation respondents also had not learned the depth of knowledge about wildlife habitat choice and behavior that older respondents had acquired at the same age. The lack of acquisition of knowledge depth could affect the capacity of younger respondents to adapt their harvesting practices to accommodate changes in wildlife patterns and hunting locations.

Some skills were poorly learned among younger respondents, partly a result of changing societal conditions and the introduction of new technologies. Skills such as lighting and tending a *kulliq*, running a dog team, caching meat on the land, making fishnets, and reloading ammunition have been largely replaced by newer technologies, naphtha burning stoves, snow machines, freezers, and manufactured fishnets and ammunitions. Older respondents, however, stressed that some of these skills, namely lighting and tending a *kulliq*, re-loading ammunition, caching meat, and dog team skills could be important in the future and should be transmitted to younger generations: the price of naphtha fuel has increased rapidly in recent years (\$3.41CDN/L); some ammunition readily used by hunters is not always available; due to warmer temperatures in the summer hunters need to know how to cache meat securely to prevent it from spoiling; and rising gasoline (\$1.61

CDN/L) and oil prices (\$7.99 CDN/L) are causing some older respondents to discuss the possibility of keeping dogs again for some winter travel.

Other skills that were poorly transmitted among younger respondents included seal hunting in the winter, wolf and polar bear hunting, trapping and fur preparation skills, traveling on the sea ice in the fall and winter, and some traditional weather forecasting and navigation skills. In the context of adaptation to changing climatic conditions, it is of interest that few younger respondents had learned how to navigate using snowdrifts or the stars, how to forecast weather by cloud type or wind pattern, how to travel on the sea ice in fall or winter, or how to build an igloo or *nalaaqtaq* (small snow shelter) (in times of emergency). Some of these skills have been supplemented by new technologies including GPS, weather and sea ice reports, and canvas tents. Respondents 35-49 years of age reported using items from both skill-sets depending on the situation at hand.

However, adaptation technologies such as GPS can also increase sensitivity to hazards by encouraging risk-taking behavior (Aporta and Higgs, 2005; Ford et al., 2006a). Moreover, older respondents stressed that traditional navigation and weather forecasting skills continue to be important for safe travel despite new technologies. For instance, when new technologies fail (e.g. a weather report is incorrect, the GPS battery dies, it is too windy to set up a canvas tent, etc.) hunters must depend on traditional skills. Having knowledge of both traditional skills and new technologies provides a harvester with more options and flexibility if they encounter hazardous conditions.

Some factors that influenced the transmission of land skills include changes in the educational environment, access to teachers and equipment, and loss of native language, which have ultimately led some respondents to spend less time engaged in subsistence activities. Formal schooling has been historically disruptive for traditional modes of learning and continues to clash with Inuit values and ways of learning. The erosion of native language - *Inuinnaqtun* - has also

negatively affected skills transmission because many younger generation respondents are unable to communicate confidently with elders. In many instances, Inuinnaqtun terminology is a more accurate representation of the skills being taught (e.g. types of snow or ice), but most young respondents had not learned this terminology, inhibiting skills transmission. Fathers and grandfathers were identified as the primary teachers for respondents, and uncles were also important teachers. Having a father figure who was an active harvester and teacher was a key variable influencing transmission success among 18-34 year old respondents. In fact, skill transmission rates were the highest among respondents who were adopted to their grandfathers. This is most likely the result of having older and more experienced teachers. This cohort of younger respondents, adopted by their grandfathers, had learned most of the land skills examined and to levels of mastery consistent with the older respondents. This finding suggests a potential future social change in which there could be fewer all-season-harvesters than in the past raising questions about future food security, health, cultural dynamics, and the integrity of food sharing networks.

The research findings make **practical contributions** to the advancement of adaptation planning for climate change in Ulukhaktok and in communities elsewhere in the Canadian Arctic. Specifically, the empirical findings inform efforts to support the transmission of land skills among generations as a means of enhancing adaptive capacity to climate change risks that affect subsistence harvesting. The research findings are specific to Ulukhaktok but there may be applicability to the transmission of land skills in other arctic communities with similar histories, livelihoods, and social structures (Ford et al. 2010b).

The research makes a practical contribution to the advancement of land skills training programs in Ulukhaktok by identifying what skills have not been transmitted well and thus require attention. These skills include: understanding wildlife behaviour and habitat choice (e.g. know

where to hunt a species and why?); navigating by snowdrifts and stars; traveling and navigating by boat; traveling on the sea ice in the fall and winter; understanding weather patterns from clouds and wind direction; building a snow shelter (*igloo* or *nallaaqtaq*); meat and fur preparation; storing meat on the land (cache); tracking wildlife; hunting seals in the winter; trapping skills; and equipment making and repair (e.g. fix fish nets, repair sleds, small engine repair).

Recommendations to improve the transmission of land skills at community-led land camps were also identified. These include: offering land camps in all seasons including the winter and spring; extending the duration of land camps; limiting what non-traditional foods participants take to camp; and including a stronger focus on Inuinnaqtun language training.

Other recommendations for improving the transmission of land skills in Ulukhaktok include: a greater integration of environmental knowledge and land skills, Inuinnaqtun language, and hands-on learning into formal educational curricula; providing skill training programs for individuals 19 years and older, youth who are not attending school, and youth who do not have skills teachers in their lives (e.g. father, grandfather, uncle); and a greater involvement of skills teachers (experienced and active harvesters, and elders) in school education. Taken together, these recommendations call for a re-negotiation of formal schooling in the community. There is a need for greater integration of Inuit values, native language, modes of teaching and learning, and subject content into the existing formal education system.

The thesis makes important **methodological contributions** to an approach to vulnerability assessment described by Ford and Smit (2004) and Smit and Wandel (2006), and that has been applied in the International Polar Year (IPY) CAVIAR (Community Adaptation and Vulnerability in Arctic Regions) project. This approach to vulnerability assessment requires

research in particular places, and involves the knowledge and expertise of local people to identify who is vulnerable, to what stresses, in which ways, and why. Such research necessarily entails working with people in communities. Drawing on the experiences of researchers working with communities across the Canadian Arctic, together with the expertise of Inuit organizations, northern research institutes and community partners, the thesis outlines key considerations for effectively engaging arctic communities in collaborative research. These considerations include: (a) initiating early and ongoing communication with communities, and regional and national contacts, (b) involving communities in research design and development, (c) facilitating opportunities for local employment, (d) and disseminating research findings. Each recommendation is described using examples from climate change research conducted in Ulukhaktok and elsewhere in the Canadian Arctic. Together with other resources - e.g. Gearheard and Shirley 2007; ITK and NRI 2007; Wolfe et al. 2007, these considerations for effectively engaging arctic communities in collaborative research were applied to study the transmission of land skills among Inuit men in Ulukhaktok.

The thesis contributes to a **theoretical understanding** of the relationships between skills transmission and human adaptation to climate change. Elements of the relationships were examined among Inuit men in Ulukhaktok. In a climate change context, adaptive capacity can be defined as the ability of a system (e.g. a community, region, sector) to address, plan for, or adapt to climate change to moderate potential damages and/or take advantage of new opportunities (IPCC, 2007a). It is theorized that adaptive capacity is a function of certain characteristics of human systems that influence the propensity or ability to adapt, known as the determinants of adaptive capacity. In the context of Inuit subsistence harvesting, this research theorizes that Inuit environmental knowledge and land skills are key determinants of adaptive capacity to deal with changing climatic conditions. This research has shown that Inuit hunters in Ulukhaktok have, and

continue to draw upon, a reservoir of accumulated knowledge and experiences to cope with and adapt to changing environmental conditions.

The theoretical idea that adaptive capacity and its determinants are dynamic has also been demonstrated in this research. Inuit knowledge and skills are continually being updated and revised in light of new observations and experiences, and the incorporation of new technologies alongside the traditional. For example this research found that hunters used a combination of new navigation technologies – GPS, satellite imagery of the sea ice, etc., together with traditional navigation skills such as remembering landforms, navigating by snowdrifts and/or stars to navigate on the land and ice. Knowledge of wildlife behaviour and habitat choice was also being continually updated and revised in light of new observations. This finding demonstrates the dynamism of Inuit knowledge and land skills in the face of changing environmental conditions.

The ability of an individual to draw on this reservoir of knowledge and land skills for adaptation depends on whether or not the skills have been transmitted, and transmission success depends on the level of mastery of a particular skill. Traditionally, land skills were transmitted from the older generations to the younger through hands-on learning on the land and under the tutelage of a teacher. This research found that the traditional mode of skills transmission continues to function for the transmission of land skills among Inuit men. Transmission success depended on whether a respondent had learned a skill through hands-on experience in the environment and from an older teacher. In fact, the presence of a skills teacher was a key factor influencing skills transmission among younger respondents.

The research found that there is a difference in the rate of land skills transmission among generations, with average transmission rates lowest among younger respondents. Several skills had not been transmitted, or were transmitted incompletely among younger respondents.

Consequently, many younger and inexperienced hunters are not well equipped to cope with the risks of hunting, particularly in changing climatic conditions. Lower rates of skills transmission among young Inuit, together with changing socio-economic and societal conditions, have already reduced some individuals' involvement in subsistence (e.g. traveling and hunting on the sea ice in the fall and winter) and increased the sensitivity of those who continue to travel and hunt to changing climatic conditions.

Environmental knowledge and land skills provide young Inuit with the opportunity to engage in productive activities that continue to have value economically and socially. This research suggests that land skills also enhance an individuals' capacity to manage and adapt to changing environmental conditions. Supporting the transmission of land skills, while not directed at climate change adaptation specifically, is an important action that will enhance the adaptive capacity of Inuit to deal with current and expected future climate change risks that affect subsistence harvesting.

Bibliography

- ACIA (2005). Arctic Climate Impacts Assessment Scientific Report. C Symon (ed.). Cambridge: Cambridge University Press.
- ACUNS (Association of Canadian Universities for Northern Studies) (2003). Ethical Principles for the Conduct of Research in the North. ACUNS. Ottawa, 9 p.
- Adger N (1999). Social vulnerability to climate change and extremes in coastal Vietnam. *World Development* 27: 249-269.
- Adger N and Kelly M (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change* 4: 253-266.
- Adger N (2000). Institutional adaptation to environmental risk under the transition in Vietnam. *Annals of the Association of American Geographers* 90(4): 738-758.
- Adger N, Kelly M and Ninh N (2001). *Living with environmental change: social vulnerability, adaptation and resilience in Vietnam*. London: Routledge.
- Adger N (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography* 79(4): 387-404.
- Adger N, Arnell N and Tompkins E (2005). Successful adaptation to climate change across scales. *Global Environmental Change* 15: 77-86.
- Adger N (2006). Vulnerability. *Global Environmental Change* 16: 268-281.
- Adger N, Dessai S, Goulden M, Hulme M, Lorenzoni I, Nelson D, Otto Naess L, Wolf J, Wreford A (2009). Are there social limits to adaptation to climate change? *Climatic Change* 93(3-4): 335-354. doi: 10.1007/s10584-008-9520-z
- AHDR (2004). Arctic Human Development Report. Akureyri: Stefansson Arctic Institute.
- Alessa L, Kliskey A, Busey R, Hinzman L and White D (2008). Freshwater vulnerabilities and resilience on the Seward Peninsula: Integrating multiple dimensions of landscape change. *Global Environmental Change-Human and Policy Dimensions* 18(2): 256-270. doi: 10.1016/j.gloenvcha.2008.01.004
- Allen K (2003). Vulnerability reduction and the community-based approach. In M Pelling (ed.), *Natural disasters and development in a globalising world*. London: Routledge, pp 170-184.
- Andrachuk M (2008). An assessment of the vulnerability of Tuktoyaktuk to environmental and socio-economic changes. Master of Arts, University of Guelph.
- Anisimov O, Velichko A, Demchenko P, Eliseev A, Mokhov I, and Nechaev V (2002). Effect of climate change on permafrost in the past, present, and future. *Izvestiya - Atmospheric and Ocean Physics* 38(1): 25-39.

- Anisimov O, Vaughan D, Callaghan T, Furgal C, Marchant H, Prowse T, Vilhjalmsson H and Walsh J (2007). Chapter 15: polar regions (Arctic and Antarctic). In: M Parry, J Palutikof, P van der Linden and C Hanson (eds.), *Climate change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press: 653-685.
- Aporta C (2002). Life on the ice: understanding the codes of a changing environment. *Polar Record* 38(207): 341-354.
- Aporta C and Higgs E (2005). Satellite culture: global positioning systems, Inuit wayfinding, and the need for a new account of technology. *Current Anthropology* 46: 729-753.
- ARCUS (Arctic Research Consortium of the United States) (2004). Guidelines for improved cooperation between Arctic researchers and northern communities. Fairbanks, Alaska: ARCUS, 20 p.
- ARI (Aurora Research Institute) (2004). Doing research in the Northwest Territories: A guide for researchers. Inuvik, Northwest Territories: ARI, 50 p.
- Balikci A (1968). The Netsilik Eskimos: adaptive processes. In: RB Lee and I Devore (eds.), *Man the Hunter*. Chicago: Aldine Publishing Company: 78-82.
- Barber D and Hanesiak J (2004). Meteorological forcing of sea ice concentrations in the southern Beaufort Sea over the period 1979 to 2000. *Journal of Geophysical Research* 109: 1-16. doi: 10.1029/2003JC002027
- Barber D, Lukovich J, Keogak J, Baryluk S, Fortier L and Henry G (2008). The changing climate of the Arctic. *Arctic* 61 (suppl. 1): 7-26.
- Barnhardt R and Kawagley A (2005). Indigenous knowledge systems and Alaska native ways of knowing. *Anthropology and Education Quarterly* 36(1): 8-23.
- Bates P (2007). Inuit and scientific philosophies about planning, prediction, and uncertainty. *Arctic Anthropology* 44(2): 87-100.
- Bell M (2002). Nunavut literacy development in the context of Inuit Qaujimajatuqanginnut (IQ): A discussion paper. [online] <http://www.nunavutliteracy.ca/english/resource/reports/paper/cover.htm> (accessed 3 November 2010).
- Belliveau S, Smit B and Bradshaw B (2006). Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change* 16: 364-378.
- Berkes F, Folke C and Gadgil M (1995). Traditional ecological knowledge, biodiversity, resilience, and sustainability. In: C Perrings, K Mahler, C Folke, C Holling and B Jansson (eds.), *Biodiversity conservation: problems and policies*. Kluwer Academic, Dordrecht (The Netherlands), pp 281-299.

- Berkes F (1999). *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. London: Taylor and Francis.
- Berkes F, Colding J and Folkes C (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10(5): 1251-1262.
- Berkes F, Mathias J, Kislalioglu M and Fast H (2001). The Canadian Arctic and the Oceans Act: The development of participatory environmental research and management. *Ocean & Coastal Management* 44: 451-469.
- Berkes F and Jolly D (2002). Adapting to climate change: social-ecological resilience in a Canadian Western Arctic community. *Conservation Ecology* 5(2): [online] <http://www.consecol.org/vol5/iss2/art18/> (accessed 3 November 2010).
- Berkes F, Colding J and Folke C (2003). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.
- Berkes F (2009). Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand* 39(4): 151-156.
- Berman M and Kofinas G (2004). Hunting for models: Rational choice and grounded approaches to analyzing climate effects on subsistence hunting in an Arctic community. *Ecological Economics* 49(1): 31-46.
- Betts M (2005). Seven focal economies for six focal places: The development of economic diversity in the western Canadian Arctic. *Arctic Anthropology* 42(1): 47-87.
- Bielawski E (1984). Anthropological observations on science in the North: The role of the scientist in human development in the Northwest Territories. *Arctic* 37(1): 1-6.
- Birket-Smith K (1929). *The Caribou Eskimos, Parts I and II. Report of the Fifth Thule Expedition 1921-24*. Copenhagen: Gyldendalske Boghandel.
- Blaikie P and Brookfield H (1987). *Land degradation and society*. London: Methuen.
- Blaikie P, Cannon T, Davis I and Wisner B (1994). *At risk: natural hazards, people's vulnerability and disaster*. London: Routledge.
- Boas F (1888). *The Central Eskimo. 6th Annual Report of the Bureau of American Ethnography for the Years 1884-1885*. Washington, D.C. 399-669.
- Bohle H, Downing T and Watts M (1994). Climate change and social vulnerability. Towards a sociology and geography of food security. *Global Environmental Change* 4: 37-48.
- Bone R, Long S and Mcpherson P (1997). *Settlements in the Mackenzie Basin: Now and in the Future 2050*. In: Cohen S (ed.), *Mackenzie Basin Impact Study (MBIS)*. Downsview, Ontario: Atmospheric Environment Services, Environment Canada: 265-271.
- Borsy E (2006). *The Impacts of Climate Change on the Availability of Granular Resources in the Inuvialuit Settlement Region, Northwest Territories*. Master of Applied Science, Ryerson University.

- Bravo, M. (2009). Voices from the sea ice: the reception of climate impact narratives. *Journal of Historical Geography* 35: 256–278.
- Brice-Bennett C (ed.) (1977). *Our footprints are everywhere: Inuit land use and occupancy in Labrador*. Nain, Labrador: Labrador Inuit Association.
- Brody H (1981). *Maps and dreams: Indians and the British Columbia frontier*. Vancouver, British Columbia: Douglas and McIntyre.
- Bromley R (1996). Characteristics and management implications of the spring waterfowl hunt in the western Canadian arctic, Northwest Territories. *Arctic* 49(1): 70-85.
- Brooks N (2003). *Vulnerability, Risk and Adaptation: A Conceptual Framework*. Norwich, Tyndall Centre for Climate Change Research: Working Paper 38.
- Brooks N, Adger N and Kelly M (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15(2): 151-163.
- Brooks R, M'Lot M and McLachlan S (2006). Pitfalls to avoid when linking traditional and scientific knowledge. In: R Riewe and J Oakes (eds.), *Climate Change: Linking Traditional and Scientific Knowledge*. Winnipeg, Manitoba: Aboriginal Issues Press, University of Manitoba: 13-20.
- Burton I, Huq S, Lim B, Pilifosova O and Schipper E (2002). From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy* 2(2-3): 145-159.
- Burton I (2006). Adapt and thrive: options for reducing the climate-change adaptation deficit. *Policy Options* (December 2005-January 2006): 32-38
- Cannon T, Twigg J and Rowell J (2003). *Social vulnerability, sustainable development and disasters*. Department for International Development. UK.
- Carmack E and Macdonald R (2008). Water and ice-related phenomena in the coastal region of the Beaufort Sea: Some parallels between native experience and western science. *Arctic* 61(3): 265-280.
- Carter T, Parry M, Harasawa H and Nishioka S (1994). *IPCC Technical guidelines for assessing climate change impacts and adaptations with a summary for policy makers and a technical summary*. London: Department of Geography, University College and Japan: Centre for Global Environmental Research, National Institute for Environmental Studies. 59 p.
- Catto N and Parewick K (2008). Hazard and vulnerability assessment and adaptive planning: mutual and multilateral community-researcher communication, arctic Canada. In: Liverman D, Pereira C and Marker B (eds), *Communicating environmental geoscience*. Geological Society, London: 123-140. doi: 10.1144/SP305.12
- Cavalli-Sforza L, Feldman M, Chen K and Dornbusch S (1982). Theory and observation in cultural transmission. *Science* 218(4567): 19-27.

- Centre for Reviews and Dissemination (CRD) (2001). Undertaking systematic reviews of research on effectiveness: CRD's guidance for those carrying out or commissioning reviews, York University, Toronto.
- Chambers R (1994). The Origins and Practice of Participatory Rural Appraisal. *World Development* 22(7): 953-969.
- Chapin III F, Kofinas G and Folke C (eds.) (2009). *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World*. New York: Springer.
- Chapin III F, Hoel M, Carpenter S, Lubchenco J, Walker B, Callaghan T, Folke C, Levin S, Maler K, Nilsson C, Barrett S, Berkes F, Crepin A, Danell K, Rosswall T, Starrett D, Xepapadeas A and Zimov S (2006). Building Resilience and Adaptation to Manage Arctic Change. *AMBIO: A Journal of the Human Environment* 35(4): 198-202.
- CIHR (Canadian Institute for Health Research) (2007). *CIHR Guidelines for Health Research Involving Aboriginal Peoples*. CIHR. Ottawa 46.
- Cohen S (1997). What if and so what in northwest Canada: Could climate change make a difference to the future of the Mackenzie basin? *Arctic* 50(4): 293-307.
- Collignon B (2006). *Knowing Places: The Inuinait Landscapes, and the Environment*. Edmonton, Alberta: Canadian Circumpolar Institute (CCI) Press.
- Collings P and Condon R (1996). Blood on the ice: status, self-esteem, and ritual injury among Inuit hockey players. *Human Organization* 55(3): 253-262.
- Collings P (1997). Subsistence hunting and wildlife management in the central Canadian arctic. *Arctic Anthropology* 34(1): 41-56.
- Collings P, Wenzel G and Condon R (1998). Modern food sharing networks and community integration in the Central Canadian Arctic. *Arctic* 51(4): 301-314.
- Collings P (2000). Aging and life course development in an Inuit community. *Arctic Anthropology* 37(2): 111-125.
- Collings P (2005). Housing policy, aging, and life course construction in a Canadian Inuit community. *Arctic Anthropology* 42(2): 50-65.
- Condon R (1987). *Inuit Youth: Growth and Change in the Canadian Arctic*. New Brunswick: Rutgers University Press.
- Condon R (1990). The rise of adolescence: change and life stage dilemmas in the Central Canadian Arctic. *Human Organization* 49(3): 266-279.
- Condon R (1995). The rise of the leisure class: adolescence and recreational acculturation in the Canadian Arctic. *Ethos* 23(1): 47-68.

- Condon R, Collings, P. and Wenzel, G. (1995). The best part of life: subsistence hunting, ethnicity, and economic development among young adult Inuit males. *Arctic* 48(1): 31-46.
- Condon R (1996). *The Northern Copper Inuit: A History*. Toronto: University of Toronto Press.
- Comiso J, Parkinson C, Gertsen R and Stock L (2008). Accelerated decline in the Arctic sea ice cover. *Geophysical Research Letters* 35, L01703, doi: 10.1029/2007GL031972
- Community of Aklavik, Nickels S, Furgal C, Castleden J, Armstrong B, Buell M, Dillion D, Fonger R and Moss-Davies P (2005). *Unikkaaqatigiit - Putting the Human Face on Climate Change - Perspectives from Aklavik, Inuvialuit Settlement Region*. Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization, Ottawa.
- Community of Holman Island, Fonger R, and Moss-Davies P (2005). *Unikkaaqatigiit - Putting the Human Face on Climate Change - Perspectives from Holman Island, Inuvialuit Settlement Region*. Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization, Ottawa.
- Community of Inuvik, Nickels S, Furgal C, Castleden J, Armstrong B, Binder R, Buell M and Dillion D, Fonger R and Moss-Davies P (2005). *Unikkaaqatigiit - Putting the Human Face on Climate Change - Perspectives from Inuvik, Inuvialuit Settlement Region*. Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization, Ottawa.
- Community of Paulatuk, Fonger R and Moss-Davies P (2005). *Unikkaaqatigiit - Putting the Human Face on Climate Change - Perspectives from Paulatuk, Inuvialuit Settlement Region*. Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization, Ottawa.
- Community of Tuktoyaktuk, Nickels S, Furgal C, Castleden J, Armstrong B, Binder R, Buell M, Dillion D, Fonger R and Moss-Davies P (2005). *Unikkaaqatigiit - Putting the Human Face on Climate Change - Perspectives from Tuktoyaktuk, Inuvialuit Settlement Region*. Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization, Ottawa.
- Corell, R (2006). Challenges of climate change: An Arctic perspective. *Ambio* 35(4): 148-152. doi: 10.1579/0044-7447(2006)35[148:COCCAA]2.0.CO;2
- Couture N and Pollard W (2007). Modelling geomorphic response to climatic change. *Climatic Change* 85: 407-431. doi: 10.1007/s10584-007-9309-5
- Couture R, Robinson S, Burgess M and Solomon S (2002). *Climate Change, Permafrost, and Community Infrastructure: A Compilation of Background Material from a Pilot Study of Tuktoyaktuk, Northwest Territories*. Geological Survey of Canada Open File 3867: 83.

- Cruikshank J (1981). Legend and landscape: Convergence in oral and scientific traditions in the Yukon Territory. *Arctic Anthropology* 17(2), 67-93.
- Cruikshank J (1998). *The social life of stories*. Lincoln: University of Nebraska.
- Cutter S (1996). Vulnerability to environmental hazards. *Progress in Human Geography* 20(4): 529-539.
- Cutter S, Boruff B and Shirley W (2003). Social vulnerability to environmental hazards. *Social Science Quarterly* 84(2): 242-261.
- CYFN (Council of Yukon First Nations) (2000). *Traditional Knowledge Research Guidelines: A Guide for Researchers in the Yukon*. Whitehorse, Yukon: CYFN.
- Damas D (1963). *Igluligmiut kinship and local groupings - a structural approach*. Ottawa, ON: National Museum of Canada.
- Damas D (2002). *Arctic migrants / Arctic villagers*. Montreal: McGill-Queens University Press.
- Dickson D and Gilchrist H (2002). Status of marine birds of the southeastern Beaufort Sea. *Arctic* 55(Supp. 1): 46-58.
- Dilley M and Boudreau T (2001). Coming to terms with vulnerability: a critique of the food security definition. *Food Policy* 26(3): 229-247.
- Dowlatabadi H, Boyle M and Rowley S (2009). Understanding and planning for climate change in Nunavut. *Meridian Fall/Winter*: 4-11.
- Downing T and Patwardhan A (2003). Assessing vulnerability for climate adaptation. In: Lim, B., Spanger-Siegfried, E. (eds.), Chapter 3: *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies, and Measures*. Cambridge: Cambridge University Press.
- Dreze J and Sen A (1990). *The Political Economy of Hunger*. UK: Clarendon Press.
- Duerden F and Kuhn R (1998). Scale, context, and application of traditional knowledge of the Canadian north. *Polar Record* 34: 31-38.
- Duerden F (2004). Translating climate change impacts at the community level. *Arctic* 57(2): 204-212.
- Duerden F and Beasley E (2006). Assessing community vulnerabilities to environmental change in the Inuvialuit region In: Riewe R and Oakes J (eds.), *Climate Change: Linking Traditional and Scientific Knowledge*, Aboriginal Issues Press, Winnipeg: 81-94.
- Eamer C (2006). *Research Licensing in Northern Canada: An Overview*. Daley Networks. Whitehorse, Yukon 31.
- Eisner W, Cuomo C, Hinkel K, Jones B and Brower R (2009). Advancing landscape change research through the incorporation of Inupiaq knowledge. *Arctic* 62(4): 429-442.

- Ellis S (2005). Meaningful consideration? A review of traditional knowledge in environmental decision making. *Arctic* 58(1): 66-77.
- Environment and Natural Resources NWT (2006). *Caribou Forever - Our heritage, our responsibility: a barren-ground caribou management strategy for the Northwest Territories 2006 - 2010*, Yellowknife, 38 p.
- Fast, H, Mathias J and Baniyas O (2001). Directions towards marine conservation in Canada's Western Arctic. *Ocean & Coastal Management* 44: 183-205.
- Fast H, Chipperzak D, Cott K and Elliott G (2005) Integrated management planning in Canada's western Arctic: An adaptive consultation process. In: Berkes F, Fast H, Manseau M and Diduck A (eds) *Breaking ice: renewable resource and ocean management in the Canadian north*, University of Calgary Press, Calgary, pp 95-119.
- Fienup-Riordan A (1983). *The Nelson Island Eskimo: Social structure and ritual distribution*. Anchorage, Alaska: Alaska Pacific University Press.
- Feit H (1973). Ethno-ecology of the Waswanipi Cree - Or how hunters can manage their resources. B. Cox. *Cultural ecology readings on the Canadian Indians and Eskimos*. Carleton Library No. 65. Toronto, Ontario: McClelland and Stewart: 115-125.
- Ferguson M and Messier F (1997). Collection and analysis of traditional ecological knowledge about a population of Arctic tundra caribou. *Arctic* 50(1): 17-28.
- Fitzgerald H, Howell T and Ponisso R (eds.) (2006). *Compact Oxford Canadian dictionary*, second edition. Don Mills, Ontario: Oxford University Press.
- FJMC (2000). *Tuktoyaktuk Community Conservation Plan*. Fisheries Joint Management Committee, Tuktoyaktuk, Northwest Territories, 168p.
- Forbes B and Stammler F (2009). Arctic climate change discourse: the contrasting politics of research agendas in the West and Russia. *Polar Record* 28: 28-42. doi: 10.1111/j.1751-8369.2009.00100.x
- Ford J and Smit B (2004). A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic* 57(4): 389-400.
- Ford J, MacDonald J, Smit B and Wandel J (2006a). Vulnerability to climate change in Igloodik, Nunavut: What we can learn from the past and present. *Polar Record* 42(2): 1-12.
- Ford J, Smit B and Wandel J (2006b). Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16(2): 145-160.
- Ford J, Pearce T, Smit B, Wandel J, Allurut M, Shappa K, Ittusujurat H and Qrunnut K (2007). Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. *Arctic* 60(2): 150-166.
- Ford J, Pearce T, Gilligan J, Smit B and J Oakes (2008a). Climate change and hazards associated with ice use in Northern Canada. *Arctic, Antarctic and Alpine Research* 40(4): 647-659.

- Ford J, Smit B, Wandel J, Allurut M, Shappa K, Ittusarjuat H and Qrunnut K (2008b). Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *Geographical Journal* 174: 45-62.
- Ford J (2009a). Vulnerability of Inuit food systems as a consequence of climate change: a case study from Igloodik, Nunavut. *Regional Environmental Change* 9(2): 83-100. doi: 10.1007/s10113-008-0060-x
- Ford J (2009b). Sea ice change in arctic Canada: are there limits to Inuit adaptation? In: Adger N, Lorenzoni I, O'Brien K (eds.), *Adapting to climate change: thresholds, values, and governance*. Cambridge: Cambridge University Press, pp 114-128.
- Ford J, Gough B, Laidler G, MacDonald J, Qrunnut K and Irgaut C (2009). Sea ice, climate change, and community vulnerability in northern Foxe Basin, Canada. *Climate Research* 37: 138-154.
- Ford J and Pearce, T (2010) What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic: a systematic literature review. *Environmental Research Letters* 5: 1-9. doi:10.1088/1748-9326/5/1/014008
- Ford J, Keskitalo C, Smith T, Pearce T, Berrang-Ford L and Smit B (2010b). Case study and analogue methodologies in climate change vulnerability research. *Wiley Interdisciplinary Reviews*. doi: 10.1002/wcc.48
- Ford J, Pearce T, Duerden F, Furgal C and Smit B (2010a). Climate change policy responses for Canada's Inuit population: the importance of and opportunities for adaptation. *Global Environmental Change* 20: 177-191.
- Ford J, Pearce T, Prno J, Duerden F, Berrang Ford L, Beaumier M, Smith T and Marshall D (2010c). Perceptions of climate change risks in primary resource use industries: A survey of the Canadian mining sector. *Regional Environmental Change*, 10: 65-81 doi:10.1007/s10113-009-0094-8
- Fox S (2002). These are things that are really happening: Inuit perspectives on the evidence and impacts of climate change in Nunavut. In: Krupnik I and Jolly D (eds.), *The Earth is Faster Now: Indigenous observations of climate change*. Fairbanks: Arctic Research Consortium of the United States: 12-53
- Fraser EDG, Mabee W and Slaymaker O (2003). Mutual vulnerability, mutual dependence: The reflexive relation between human society and the environment. *Global Environmental Change* 13(2): 137-144.
- Freeman M (ed.) (1976). *Inuit land use and occupancy project*. 3 vols. Ottawa, Ontario: Department of Indian and Northern Affairs.
- Freeman M (1992). The nature and utility of traditional ecological knowledge. *Canadian Arctic Resource Committee - Northern Perspectives* 20(1), 7.
- Freeman M (1996). Identity, health and social order. In Foller, M. and Hansson, L. (eds.), *Human Ecology and Health: Adaptation to a Changing World*. Gothenburg University, Gothenburg: 57-71.

- Freeman M and Wenzel G (2006). The nature and significance of polar bear conservation hunting in the Canadian Arctic. *Arctic* 59(1): 21-30.
- Furgal C and Seguin J (2006). Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities. *Environmental Health Perspectives* 114(12): 1964-1970.
- Furgal C, Buell M, Chan L, Edge V, Martin D and Ogden N (2008). Health impacts of climate change in Canada's north. In: Sequin J (ed.), *Human health in a changing climate: a Canadian assessment of vulnerabilities and adaptive capacity*, Health Canada, Ottawa.
- Furgal C and Prowse T (2008). Northern Canada. In: Lemmen D, Warren F, Bush E and Lacroix J (eds.), *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Natural Resources Canada, Ottawa: 57-118.
- Fussler H and Klein R (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Global Environmental Change* 17(3): 301-329. doi: 10.1007/s10584-006-0329-3
- Fussler H (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change* 17: 155-167.
- Gamble R (1984). A preliminary study of the Native harvest of wildlife in Keewatin Region, Northwest Territories. Technical Report No. 1282. Winnipeg, Manitoba: Fisheries and Oceans Canada.
- Gearheard S, Matumeak W, Angutikjuaq I, Maslanik JA, Huntington H, Leavitt J, Matumeak D, Tigullaraq G and Barry RG (2006). "It's not that simple": comparison of sea ice environments, observed changes, and adaptations in Barrow Alaska, USA, and Clyde River, Nunavut, Canada. *Ambio* 15(4): 203-211. doi: 10.1579/0044-7447(2006)35[203:INTSAC]2.0.CO;2
- Gearheard S and Shirley J (2007). Challenges in community-research relationships: Learning from natural science in Nunavut. *Arctic* 60(1): 62-74.
- GeoNorth (2000). *Climate Change Impacts and Adaptation Strategies for Canada's Northern Territories: Final Workshop Report*. Prepared for Natural Resource Canada and Environment Canada. Yellowknife, Northwest Territories, 59p.
- Gibbs M (2001). Toward a strategy for undertaking cross-cultural collaborative research. *Society and Natural Resources* 14: 673-687.
- GN (Government of Nunavut) (2003). *Nunavut climate change strategy*. Iqaluit, Nunavut: GN, 26p.
- GNWT (2005). *Policy: traditional knowledge*. Yellowknife, Northwest Territories: Government of the Northwest Territories, 6p.
- GNWT (2008a). *NWT Climate Change Impacts and Adaptation Report*. Yellowknife, Northwest Territories: Department of Environment and Natural Resources.

- GNWT (2008b). "NWT Community Profiles." [online] <http://www.stats.gov.nt.ca/> (accessed 3 November 2010).
- Gornitz V, Daniels R, White T and Birdwell K (1994). The development of a coastal risk assessment database: Vulnerability to sea-level rise in the U.S. southeast. *Journal of Coastal Research*, Special Issue 12: 327-338.
- Government of Canada (1984). *The Western Arctic Claim: The Inuvialuit Final Agreement*.
- Graversen R, Mauritsen T, Tjernstrom M, Kallen E and Svensson G (2008). Vertical structure of recent Arctic warming. *Nature* 451(7174): 53-56. doi: 10.1038/nature06502
- GTZ (1988). *ZOPP: An Introduction to the Method*. Deutsche Gesellschaft Fur Technische Zusammenarbeit. Eschborn, Germany.
- Gunderson LH and Holling CS (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington: Island Press.
- Gunn A, Shank C and McLean B (1991). The history, status and management of muskoxen on Banks Island Arctic 44(3): 188-195.
- GY (2006). *Government of Yukon Climate Change Strategy*. Whitehorse, Yukon: Government of Yukon, 10p.
- Hamlet of Tuktoyaktuk (1984). *Community Plan for the Hamlet of Tuktoyaktuk, N.W.T*
- Handley J, Fentie D and Okalik P (2007). *A Northern Vision: A Stronger North and a Better Canada*. Whitehorse, Yukon: Premier's Office Yukon Government; Premier's Office Government of the Northwest Territories; Premier's Office Government of Nunavut, 20p.
- Handmer J, Dovers S and Downing T (1999). Societal Vulnerability to Climate Change and Variability. *Mitigation and Adaptation Strategies for Global Change* 4: 267-281.
- Hare W and Meinshausen M (2006). How much warming are we committed to and how much can be avoided? *Climate Change* 75 (1 -2): 111-149.
- Hayley D (2004). *Climate Change: An Adaptation Challenge for Northern Engineers*. Association of Professional Engineers, Geologists and Geophysicists of Alberta, Alberta.
- Henze R and Vanett L (1993). To walk in two worlds - or more? Challenging a common metaphor of native education. *Anthropology and Education Quarterly* 24(2): 116-134.
- Hewitt K and Burton I (1971). *The hazardousness of a place: a regional ecology of damaging events*. Research Publication No. 6, University of Toronto.
- Hewitt K (1983). The idea of calamity in a technocratic age. In: Hewitt. K (ed.), *Interpretations of calamity from the viewpoint of human ecology*. Boston: Allen and Unwin, pp 3-32.
- Hewlett B and Cavalli-Sforza L (1986). Cultural transmission among Aka Pygmies. *American Anthropologist* 4(88): 922-934.

- Hinzman L, Bettez N, Bolton R, Chapin III F, Dyurgerov M, Fastie C, Griffith B, Hollister R, Hope A, Huntington H, Jensen A, Jia G, Jorgenson T, Kane D, Klein D, Kofinas G, Lynch A, Lloyd A, McGuire D, Nelson F, Oechel W, Osterkamp T, Racine C, Romanovsky V, Stone R, Stow D, Sturm M, Tweedie C, Vourlities G, Walker M, Walker D, Webber P, Welker J, Winker K and Yoshikawa K (2005). Evidence and implications of recent climate change in northern Alaska and other arctic regions. *Climatic Change* 72: 251-298. doi: 10.1007/s10584-005-5352-2
- Hoeve E, Zhou F and Zhang A (2006). Potential cost impacts for adaptation of building foundations in the Northwest Territories. *EIC Climate Change Technology IEEE*, pp 1-9
- Holland M, Serreze M and Stroeve J (2010). The sea ice mass budget of the arctic and its future change as simulated by coupled climate models. *Climate Dynamics* 34: 185-200.
- Homer-Dixon T and Blitt J (1998). *Ecoviolence: links among environment, population, and security*. Lanham, Maryland: Rowan & Littlefield Publishers, Inc.
- Hovelsrud G, McKenna M and Huntington H (2008). Marine mammal harvests and other interactions with humans. *Ecological Applications* 18(2): S135-S147. doi: 10.1890/06-0843.1
- Huq S, Rahman A, Konate M, Sokona Y and Reid H (2003). *Mainstreaming Adaptation to Climate Change in Least Developed Countries*. London: International Institute for Environment and Development (IIED) Climate Change Programme.
- Huntington H (1998). Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. *Arctic* 51(3): 237-242.
- Huntington H (2000). Using traditional ecological knowledge in science: Methods and applications. *Ecological Applications* 10(5): 1270-1274.
- Huntington H, Trainor S, Natcher D, Huntington O, DeWilde L and Chapin III F (2006). The significance of context in community-based research: Understanding discussions about wildfire in Huslia, Alaska. *Ecology and Society* 11(1): 1-40.
- Huntington H, Hamilton L, Nicholson C, Brunner R, Lynch A, Ogilvie A and Voinov A (2007). Toward understanding the human dimensions of the rapidly changing arctic system: insights and approaches from five HARC projects. *Regional Environmental Change* 7: 173-186. doi: 10.1007/s10113-007-0038-0
- Huntington H (2009). A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades. *Marine Policy* 33(1): 77-82. doi: [10.1016/j.marpol.2008.04.003](https://doi.org/10.1016/j.marpol.2008.04.003)
- IJS (Inuvialuit Joint Secretariat) (2003). *Inuvialuit Harvester Survey: Data and Methods Report, 1988-1997*. Inuvik, Northwest Territories: Inuvialuit Joint Secretariat.
- Ingold Tim (2000). *The perception of the environment: essays on livelihood, dwelling and skill*. London; New York: Routledge.

- Inuit Subject Advisory Committee (1996). Inuuqatigiit: The Curriculum from the Inuit Perspective. Yellowknife, Northwest Territories: Northwest Territories Education, Culture and Employment.
- Inuit Quajimajatuqanginnut (IQ) TaskForce (2002). First annual report. Iqaluit, Nunavut: Government of Nunavut.
- Ip J (2007). We don't live in igloos - Inuvik youth speak out. Canadian Family Physician 53: 864-870.
- IPCC (2001). Climate change 2001: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel Climate Change. Cambridge: Cambridge University Press
- IPCC (2007a). Climate change 2007: impacts, adaptation and vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Cambridge: Cambridge University Press.
- IPCC (2007b). Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.
- Irniq P and Tester F (2006). Inuit Quajimajatuqangit: community history, politics and the practice of resistance. Coastal Zone Canada 2006 Conference, Tuktoyaktuk, NWT, 21p.
- Irwin C (1989). Lords of the Arctic: wards of the state. The growing Inuit population, Arctic resettlement and their effects on social and economic change - a summary report. Ottawa: Canadian Arctic Resource Committee. Northern Perspectives 17(1).
- ITK (2005). State of Inuit Learning in Canada. Prepared for the Canadian Council on Learning. Ottawa: Inuit Tapiriit Kanatami, Socio-Economic Department.
- ITK and NRI (2007). Negotiating Research Relationships with Inuit Communities: A Guide for Researchers. Iqaluit and Ottawa: Inuit Tapiriit Kanatami and Nunavut Research Institute.
- ITK (2008). Inuit Statistical Profile. Ottawa: Inuit Tapiriit Kanatami.
- Jenness D (1922). The Life of the Copper Eskimos. Report of the Canadian Arctic Expedition, 1913-18, Vol. 12. Ottawa: F.A. Acland. 12 part B.
- Erosion progression and adaptation strategy in a northern coastal community. 8th International Conference on Permafrost, Zurich.
- Jones R (2001). An environmental risk assessment/management framework for climate change impacts assessment. Natural Hazards 23: 197-230.
- Jones R and Boer R (2003). Assessing current climate risks. New York: United Nations Development Programme.

- Joss S and Inuktalik B (2000). Effects of climate change on wildlife on Holman Island. Climate Change Impacts and Adaptation Strategies for Canada's Northern Territories: Final Workshop Report. February 27-29, 2000, Explorer Hotel, Yellowknife. Prepared for Natural Resource Canada and Environment Canada by GeoNorth Ltd.
- Julian P, Higgins T and Green S (eds.) (2008). Cochrane handbook for systematic reviews of interventions, Version 5.0.1. [online] <http://www.cochrane-handbook.org/> (accessed 3 November 2010).
- Kattsov V and Kallen E (2005). Future climate change: Modeling and scenarios for the Arctic. In: Hassol S (ed.), Arctic climate impact assessment scientific report. Cambridge: Cambridge University Press, pp 99-150
- Kasperson R, Kasperson J and Turner B (1995). Regions at risk: comparisons of threatened environments. Tokyo: United Nations University Press.
- Kasperson R and Kasperson, J (2001). Climate Change, Vulnerability, and Social Justice. Stockholm, Sweden: Stockholm: Risk and Vulnerability Programme; Stockholm Environment Institute, 15p.
- Keene A (1985). Nutrition and economy: models for the study of prehistoric diet. In: Gilbert R and Mielke J (eds.), The analysis of prehistoric diet. New York: Academic Press, pp 155-190.
- Kelly P and Adger N (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change* 47: 325-352.
- Kemp W (1971). The flow of energy in a hunting society. *Scientific American* 224(3): 104-115.
- Keskitalo EC (2008). Climate change and globalization in the Arctic: an integrated approach to vulnerability assessment. London: Earthscan Publications.
- Kitchenham B (2004). Procedures for Performing Systematic Reviews, Joint Technical Report, Software Engineering Group, Department of Computer Science, Keele University, Eversleigh.
- Klein R, Nicholls R and Mimura N (1999). Coastal adaptation to climate change: can the IPCC technical guidelines be applied? *Mitigation and Adaptation Strategies for Global Change* 4: 239-252.
- Klein R, Schipper EL and Dessai S (2005). Integrating mitigation and adaptation into climate and development policy: three research questions. *Environmental Science & Policy* 8(6): 579-588.
- Klein R, Eriksen S, Naess L, Hammill A, Tanner T, Robledo C and O'Brien K (2007). Portfolio screening to support the mainstreaming of adaptation to climate change into development assistance. *Climatic Change* 84 (1): 23-44.
- Kofinas G, Chapin III F, BurnSilver S, Schmidt J, Fresco N, Kielland K, Martin S, Springsteen A and Rupp T (2010). Resilience of Athabascan subsistence systems to interior Alaska's changing climate. *Canadian Journal of Forest Research* 40(7): 1347-1359.

- Korhonen M (2004). Alcohol problems and approaches: theories, evidence and northern practice. Ottawa: Ajunnginiq Centre, National Aboriginal Health Organization.
- Kristofferson A and Berkes F (2005). Adaptive co-management of Arctic char in Nunavut Territory. In: Berkes F (ed.), *Breaking Ice: renewable resource and ocean management in the Canadian North*. Calgary, AB: University of Calgary Press, pp 249-268.
- Krupnik I (1993). *Arctic Adaptations: Native Whalers and Reindeer Herders of Northern Eurasia*. Hanover, New Hampshire: University Press of New England.
- Krupnik I (2002). Watching ice and weather our way: some lessons from Yupik observations of sea ice and weather on St. Lawrence Island, Alaska. In: Krupnik, I. and Jolly, D. (eds.), *The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change*. Arctic Research Consortium of the United States in cooperation with the Arctic Studies Center, Smithsonian Institution, Fairbanks, Alaska: 156-197.
- Krupnik I and Jolly D (eds.) (2002). *The Earth is faster now: indigenous observations of arctic environmental change*. Fairbanks: Arctic Research Consortium of the United States.
- Krupnik I and Ray G (2007). Pacific walruses, indigenous hunters, and climate change: bridging scientific and indigenous knowledge. *Deep-Sea Research Part II-Topical Studies in Oceanography* 54(23-26): 2946-2957. doi: 10.1016/j.dsr2.2007.08.011
- Kruse J, White R, Epstein H, Archie B, Berman M, Braund S, Chapin III F, Charlie J, Daniel C, Eamer J, Flanders N, Griffith B, Haley S, Huskey L, Joseph B, Klein D, Kofinas G, Martin S, Murphy S, Nebesky W, Nicolson C, Russell D, Tetlich J, Tussing A, Walker M and Young O (2004). Modeling sustainability of arctic communities: An interdisciplinary collaboration of researchers and local knowledge holders. *Ecosystems* 7(8): 815-828. doi: 10.1007/s10021-004-0008-z
- Kuhnlein H and Receveur O (2007). Local cultural animal food contributes high levels of nutrients for Arctic Canadian indigenous adults and children. *Journal of Nutrition* 137(4): 1110-1114.
- Ladio AH and Lozada M (2004). Patterns of use and knowledge of wild edible plants in distinct ecological environments: a case study of a Mapuche community from northwestern Patagonia. *Biodiversity and Conservation* 13: 1153-1173.
- Laidler G (2006). Inuit and scientific perspectives on the relationship between sea ice and climate change: the ideal complement? *Climatic Change* 78(2-4): 407-444.
- Laidler G and Elee P (2008). Human geographies of sea ice: freeze/thaw processes around Cape Dorset, Nunavut, Canada. *Polar Record* 44(228): 51-76.
- Laidler G and Ikummaq T (2008). Human geographies of sea ice: freeze/thaw processes around Igloodik, Nunavut, Canada. *Polar Record* 44(229): 127-153.
- Laidler G, Dialla A, and Joamie E (2008). Human geographies of sea ice: Freeze/thaw processes around Pangnirtung, Nunavut. *Polar Record* 44(231): 335-361.

- Laidler G, Ford JD, Gough WA, Ikummaq T, Gagnon, A, Kowal S, Qrunnut K and Irngaut C (2009). Travelling and hunting in a changing Arctic: assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic Change* 94(3-4): 363-397.
- Larsen P, Goldsmith S, Smith O, Wilson M, Strzepek K, Chinowsky P and Saylor B (2008). Estimating future costs for Alaska public infrastructure at risk from climate change. *Global Environmental Change* 18(3): 442-457. doi: [1016/j.gloenvcha.2008.03.005](https://doi.org/10.1016/j.gloenvcha.2008.03.005)
- Larter N and Nagy J (2001). Calf production, calf survival, and recruitment of Muskoxen on Banks Island during a period of changing population density from 1986-99. *Arctic* 54(4): 394-406.
- Lassiter R, Box E, Wiegert R, Johnston J, Bergengren J and Suarez L (2000). Vulnerability of ecosystems of the mid-atlantic region, USA, to climate change. *Environmental Toxicology and Chemistry* 19(4(2)): 1153-1160.
- Lawrence D, Slater A, Tomas R, Holland M and Deser C (2008). Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss. *Geophysical Research Letters* 35(11). doi: 10.1029/2008gl033985
- Leake J, Jozzy S and Uswak G (2008). Severe dental caries, impacts and determinants among children 2-6 years of age in Inuvik Region, Northwest Territories, Canada. *Journal of the Canadian Dental Association* 74(6): 519-519G.
- Leichenko R and O'Brien K (2002). The dynamics of rural vulnerability to global change: the case of southern Africa. *Mitigation and Adaptation Strategies for Global Change* 7: 1-18.
- Lemmen D, Warren F, Lacroix J and Bush E (2008). *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Ottawa: Government of Canada.
- Lim B and Spanger-Siegfried E (2005). *Adaptation policy frameworks for climate change: Developing strategies, policies and measures*. Cambridge: Cambridge University Press.
- Liverman D (1990). Vulnerability to global environmental change. In: Kaspersen R (ed.), *Understanding a global environmental change*. Worcester, Massachusetts: Center for Technology, Environment, and Development, Clark University, pp 27-44.
- Lomborg B (2007). *Cool it: the skeptical environmentalist's guide to global warming*. Alfred A. Knopf, a division of Random House, New York, pp 247
- Loneragan S, Difrancesco R and Woo M (1993). Climate Change and transportation in Northern Canada - An Integrated impact assessment *Climatic Change* 24(4): 331-351. doi: 10.1007/BF01091854
- Loring P and Gerlach S (2009). Food, culture, and human health in Alaska: an integrative health approach to food security. *Environmental Science & Policy* 12(4): 466-478. doi: [10.1016/j.envsci.2008.10.006](https://doi.org/10.1016/j.envsci.2008.10.006)
- Lozada M, Ladio A and Weigandt M (2006). Cultural transmission of ethnobotanical knowledge in a rural community of northwestern Patagonia, Argentina. *Economic Botany* 60(4): 374-385.

- Lynch A and Brunner R (2007). Context and climate change: An integrated assessment for Barrow, Alaska. *Climatic Change* 82(1-2): 93-111.
- McCabe G, Clark M and Serreze M (2001). Trends in Northern Hemisphere surface cyclone frequency and intensity 14: 2763-2768.
- McCarthy J and Martello M (2005). Chapter 17: Climate change in the context of multiple stressors and resilience. In: Symon C (ed.), *Arctic Climate Impact Assessment (ACIA) scientific report*. Cambridge: Cambridge University Press, pp 945-988.
- McGillivray D, Agnew T, McKay G, Pilkington G and Hill M (1993). Impacts of climatic change on the Beaufort Sea-ice regime: implications for the arctic petroleum industry. Environment Canada, Ottawa
- McLeman R and Smit, B (2006). Migration as a human adaptation to climate change. *Climatic Change* 76 (1-2): 31-53.
- MacDonald J (1998). *The Arctic Sky: Inuit Astronomy, Star Lore, and Legend*. Iqaluit and Toronto: Nunavut Research Institute and the Royal Ontario Museum.
- Macdonald R, Harner T and Fyfe J (2005). Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. *Science of the Total Environment* 342(1-3): 5-86.
- Metzger MJ, Rounsevell MDA, Acosta-Michlik L, Leemans R and Schroter D (2006). The vulnerability of ecosystem services to land use change. *Agriculture, Ecosystems & Environment* 114(1): 69-85.
- Manson G and Solomon S (2007). Past and future forcing of Beaufort Sea coastal change. *Atmosphere-Ocean* 45(2): 107-122. doi: 10.3137/ao.450204
- Manson G, Solomon S, Forbes D, Atkinson D and Craymer M (2005). Spatial variability of factors influencing coastal change in the Western Canadian Arctic. *Geo-Marine Letters* 25(2-3): 138-145.
- Marsh P and Lesack L (1996). The hydrologic regime of perched lakes in the Mackenzie delta: Potential responses to climate change. *Limnology and Oceanography* 41(5): 849-856.
- Martin D, Belanger D, Gosselin P, Brazeau J, Furgal C and Dery S (2007). Drinking water and potential threats to human health in Nunavik: Adaptation strategies under climate change conditions. *Arctic* 60(2): 195-202.
- Milly P, Betancourt J, Falkenmark M, Hirsch R, Kundzewicz Z, Lettenmaier D and Stouffer R (2008). Climate change: stationarity is dead: whither water management? *Science* 319(5863): 573-574. doi: 10.1126/science.1151915
- Mitchell J, Devine N and Jagger K (1989). A contextual model of natural hazard. *Geographic Review* 79(4): 391-409.

- Moline M, Karnovsky N, Brown Z, Divoky G, Frazer T, Jacoby C, Torrese J and Fraser W (2008). High latitude changes in ice dynamics and their impact on polar marine ecosystems. *Annals of the New York Academy of Sciences* 1134(The Year in Ecology and Conservation Biology): 267-319. doi: 10.1196/annals.1439.010
- Moss R, Brenkert A and Malone E (2001). Vulnerability to climate change: a quantitative approach. Report prepared for the U.S. Department of Energy. Springfield, Virginia, 70p.
- Myers H, Fast H, Berkes M and Berkes F (2005), Feeding the family in times of change. In: Berkes F, Fast H, Manseau M and Diduck A (eds.), *Breaking ice: renewable resource and ocean management in the Canadian north*. University of Calgary Press, Calgary, pp 23-47.
- Nagy J, Wright W, Slack T and Veitch A (2005). Seasonal ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East barren-ground caribou herds. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife. [online]
<http://www.srrb.nt.ca/registry/ENR/9%20Seasonal%20Ranges%20of%20CB%20BW%20BE%20Herds%20MR%20167.pdf> (Accessed 3 November 2010).
- NCP (Northern Contaminants Program) (2007). Northern contaminants program guidelines for responsible research. [online] <http://www.ainc-inac.gc.ca/nth/ct/ncp/pub-eng.asp> (accessed 3 November 2010).
- Nelson R (1969). *Hunters of the Northern Ice*. Chicago: University of Chicago Press.
- Nelson R (1973). *Hunters of the northern forest: Designs for survival among the Alaskan Kutchin*. Chicago, Illinois: University of Chicago Press.
- Newton J (1997). Coping with floods: an analogue for dealing with the transition to a modified climate in the northern sector of the Mackenzie basin. In: Cohen S (ed) *Mackenzie basin impact study (MBIS)*. Downsview, Ontario: Atmospheric Environment Services, Environment Canada, pp 219-224.
- Nichols T, Berkes F, Jolly D, Snow N and The Community of Sachs Harbour (2004). Climate Change and Sea Ice: Local Observations from the Canadian Western Arctic. *Arctic* 57(1): 68-79.
- Nickels S, Furgal C, Castleden J, Moss-Davies P, Buell M, Armstrong B, Dillon D and Fonger R (2002). Putting the human face on climate change through community workshops: Inuit knowledge, partnerships, and research. In: Krupnik I and Jolly D (eds.), *The Earth is faster now: indigenous observations of arctic environmental change*. Fairbanks: Artic Research Consortium of the United States, pp 301-333.
- Nickels S, Furgal C, Buell M and Moquin H (eds.) (2006). *Unikkaaqatigiit - Putting the Human Face on Climate Change: Perspectives from Inuit in Canada*. Joint Publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Universite Laval and the Ajunnginiq Centre at the Nataional Aboriginal Health Organization, Ottawa.

- Neis B, Felt L, Haedrich R and Schneider D (1999). An interdisciplinary method for collecting and integrating fishers' ecological knowledge into resource management. In: Newell D and Ommer R. Fishing places, fishing people. Toronto: University of Toronto Press, pp 217-238.
- NLCA (1993). Nunavut Land Claim Agreement: An agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada. [online] www.nucj.ca/library/bar_ads_mat/Nunavut_Land_Claims_Agreement.pdf (accessed 25 May 2008).
- Noongwook G, The Native Village of Savoonga, The Native Village of Gambell, Huntington H and George J (2007). Traditional knowledge of the Bowhead Whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. *Arctic* 60(1): 47-54.
- NTI (Nunavut Tunngavik Incorporated) (2008). Licensing process. [online] http://www.nri.nu.ca/lic_process.html (accessed 3 November 2010).
- Nunavik Educational Task Force (1992). *Silatunirmut: The Pathway to Wisdom*. Final report of the Nunavik Educational Task Force. Laval: Makivik Corporation.
- Nunavut Social Development Council (NSDC). (2000). *On Our Own Terms: the State of Inuit Culture and Society*. Iqaluit: NSDC.
- Nuttall, M, Berkes F, Forbes B, Kofinas G, Vlassova T and Wenzel G (2005). Hunting, herding, fishing and gathering: indigenous peoples and renewable resource use in the Arctic. In Hassol S (ed.), *Arctic Climate Impact Assessment*. Cambridge: Cambridge University Press, pp 650-690.
- NWT Bureau of Statistics (2008). *Summary of NWT community statistics*. Bureau of Statistics, Yellowknife: Government of the Northwest Territories.
- O'Brien K, Leichenko R, Kelkar U, Venema H, Aandahl G, Tompkins H, Javed A, Bhadwal S, Barg S, Nygaard L and West J (2004). Mapping vulnerability to multiple stressors: climate change and economic globalization in India. *Global Environmental Change* 14(4): 303-313.
- O'Brien K, Sygna L and Haugen J (2004). Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. *Climatic Change* 64 (1): 193-225.
- Ohmagari K and Berkes F (1997). Transmission of indigenous knowledge and bush skills among the western James Bay Cree women of subarctic Canada. *Human Ecology* 25(2): 197-222.
- Overland J and Wang M (2007). Future regional Arctic sea ice declines. *Geophysical Research Letters* 34: L17705.
- Parkins J and MacKendrick N (2007). Assessing community vulnerability: a study of the mountain pine beetle outbreak in British Columbia, Canada. *Global Environmental Change* 17: 460-471.

- Pearce T (2006). Vulnerability and adaptation to environmental change in Ulukhaktok. MA thesis, University of Guelph.
- Pearce T, Smit B, Duerden F, Katayoak F, Inuktalik R, Goose A, Ford J and Wandel J (2006). Travel routes, harvesting and climate change in Ulukhaktok, Canada. Northern Research Forum Open Meeting - the Borderless North, Oulu, Finland and Lulea, Sweden.
- Pearce T, Ford J, Laidler G, Smit B, Duerden F, Allarut M, Andrachuk M, Baryluk S, Dialla A, Elee P, Goose A, Ikummaq T, Joamie E, Kataoyak F, Loring E, Meakin S, Nickels S, Shappa K, Shirley J and Wandel J (2009). Community collaboration and environmental change research in the Canadian Arctic. *Polar Research* 28(1): 10-27. doi: 10.1111/j.1751-8369.2008.00094.x
- Pearce T, Ford JD, Duerden F, Smit B, Andrachuk M, Berrang-Ford L and Smith T (2010a). Advancing adaptation planning for climate change in the Inuvialuit Settlement Region (ISR): a review and critique. *Regional Environmental Change*. REC-D-09-00082R1
- Pearce T, Ford J, Prno J, Duerden F, Pittman J, Beaumier M, Berrang-Ford L and Smit B (2010b). Climate change and mining in Canada. *Mitigation and Adaptation Strategies for Global Change*. doi: 10.1007/s11027-010-9269-3
- Pearce T, Notaina R, Wright H, Kudlak A, Ford J and Smit B (2010c). Transmission of environmental knowledge and land skills in adaptation planning for climate change in the Arctic. *Meridian* (Spring/Summer 2010): 6-11.
- Pearce T, Notaina R, Kudlak A and Wright H (2010d). Transmission of environmental knowledge and land skills among men in Ulukhaktok: research summary report for the community of Ulukhaktok. Guelph, Ontario: Department of Geography, University of Guelph, 8p. ISBN: 97809865908-3-2
- Pearce T, Smit B, Duerden D, Ford JD, Goose A and Kataoyak F (2010e). Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Record* 46(237): 157-177.
- Peloquin C and Berkes F (2009). Local knowledge, subsistence harvests, and social-ecological complexity in James Bay. *Human Ecology* 37: 533-545.
- Perovich D, Richter-Menge J, Jones K and Light B (2008). Sunlight, water, and ice: extreme arctic sea ice melt during the summer of 2007. *Geophysical Research Letters* 35(11): 4. L11501. doi: 10.1029/2008gl034007
- Petticrew M and Roberts H (2006). *Systematic reviews in the social sciences: a practical guide*. Blackwell, Oxford,
- Polsky C, Neff R and Yarnal B (2007). Building comparable global change vulnerability assessments: The vulnerability scoping diagram. *Global Environmental Change* 17(3-4): 472-485. Doi: 10.1016/j.gloenvcha.2007.01.005
- Prno J, Bradshaw B, Pearce T, Wandel J, Smit B and Tozer L (In Press). Community vulnerability to climate change in the context of other risks in Kugluktuk, Nunavut. *Polar Research*.

- Prowse M (2003). Towards a clearer understanding of 'vulnerability' in relation to chronic poverty. Chronic Poverty Research Centre, Working Paper No. 24. School of Economic Studies/IDPM, Graduate School of Social Sciences and Law, University of Manchester.
- Prowse T, Furgal C, Bonsal B and Edwards T (2009). Climatic conditions in northern Canada: past and future. *AMBIO* 38(5): 257-265. doi: 10.1579/0044-7447-38.5.257
- Rasmussen K (1932). Intellectual culture of the Copper Eskimos. Report of the Fifth Thule Expedition 1921-24, Vol. 9. Copenhagen: Gyldendalske Boghandel.
- Reimnitz E and Maurer D (1979). Effects of storm surges on the Beaufort Sea coast, northern Alaska. *Arctic* 32: 329-344.
- Riedlinger D (2001). Responding to climate change in northern communities: impacts and adaptations. *Arctic* 54(1): 96-98.
- Riedlinger D and Berkes F (2001). Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. *Polar Record* 37(203): 315-328.
- Riewe R (ed.) (1992). Nunavut atlas. Edmonton, Alberta: Canadian Circumpolar Institute.
- Riewe R and Oakes J (eds.) (2006). Climate change: linking traditional and scientific knowledge. Winnipeg: Aboriginal Issues Press.
- Rinke A and Dethloff K (2008). Simulated circum-Arctic climate changes by the end of the 21st century. *Global and Planetary Change* 62(1-2): 173-186. doi: 10.1016/J.GLOPLACHA.2008.01.004
- Rogelj J, Chen C, Nabel J, Macey K, Hare W, Schaeffer M, Markmann K, Hohne N, Andersen K and Meinshausen M (2010). Analysis of the Copenhagen Accord pledges and its global climatic impacts-a snapshot of dissonant ambitions. *Environmental Research Letters* 5(3): 034013.
- Ruddle K (1993). The transmission of traditional ecological knowledge. In: Inglis, JT (ed.), *Traditional ecological knowledge: concepts and cases*. Ottawa: Canadian Museum of Nature and International Development Research Centre.
- Ruddle K and Chesterfield R (1977). *Education for Traditional Food Procurement in the Orinoco Delta, Ibero-Americana*. Berkley: University of California Press.
- Sakakibara C (2008). "Our home is drowning": Inupiat storytelling and climate change in Point Hope, Alaska. *The Geographical Review* 98(4): 456-475.
- Sallenave J (1994). Giving Traditional Ecological Knowledge Its Rightful Place in Environmental Impact Assessment. *Canadian Arctic Resource Committee - Northern Perspectives* 22(1), 7p.
- Schlag M and Fast M (2005). Marine stewardship and Canada's oceans agenda in the western Canadian Arctic: a role for youth. In: Berkes F, Fast H, Manseau M and Diduck A (eds.), *Breaking ice: renewable resource and ocean management in the Canadian north*. University of Calgary Press, Calgary, pp 119-141.

- Schroter D, Polsky C and Patt A (2005). Assessing vulnerabilities to the effects of global climate change: An eight step approach. *Mitigation and Adaptation Strategies for Global Change* 10: 573-596. doi: 10.1007/s11027-005-6135-9
- Serreze M (2010). Understanding recent climate change. *Conservation Biology* 24: 10-17.
- Sen A (1981). *Poverty and famines: an essay on entitlement and deprivation*. Oxford: Claredon Press.
- Shaw J, Taylor R, Solomon S, Christian H and Forbes D (2008). Potential impacts of global sea level rise of Canadian coasts. *The Canadian Geographer* 42(4): 365-379. doi: 10.1111/j.1541-0064.1998.tb01352.x
- Shirley J (2005). *C-CIARN North: Nunavut Community Research Needs Survey*. Iqaluit, Nunavut: Nunavut Research Institute.
- Simpson L (2004). *An Inuit way of knowing and the making of Nunavut*. Policy Options.
- Smit B, Burton B, Klein RJT and Wandel J (2000). An anatomy of adaptation to climate change and variability. *Climate Change* 45: 223-251.
- Smit B and Pilifosova O (2001). Adaptation to climate change in the context of sustainable development and equity. In: McCarthy J, Canziani OF, Leary NA, Dokken DJ and White KS (eds.), *Climate Change 2001: Impacts, Adaptation, Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, pp 876-912.
- Smit B and Wandel J (2006). Adaptation, adaptive capacity, and vulnerability. *Global Environmental Change* 16: 282-292.
- Smith T and Wright H (1989). Economic status and role of hunters in a modern Inuit Village. *Polar Record* 25(153): 93-98.
- Solomon S (2002). Tuktoyaktuk erosion risk assessment, 2001. Report prepared for the Government of the North West Territories and EBA Engineering. Geological Survey of Canada (Atlantic), Natural Resources Canada, Dartmouth. [online] http://nome.colorado.edu/HARC/members/Scanned_docs/Solomon_2001.pdf (accessed 27 September 2009).
- Solomon S (2005). Spatial and temporal variability of shoreline change in the Beaufort-Mackenzie region, northwest territories, Canada. *Geo-Marine Letters* 25(2-3): 127-137. doi: 10.1007/s00367-004-0194-x
- Spink J (1969). Historical Inuit awareness of past changes in sea level. *Muskox* 5, 37-40.
- Stairs A (1988). Native models of learning. *Educational Researcher* 17(6): 4-6.
- Stairs A (1992). Self-image, world-image: speculations on identity from experiences with Inuit. *Ethos* 20(1): 116-126.

- StatsCan (2006). Statistics Canada: 2006 Community Profiles. [online]
<http://www12.statcan.ca/english/census06/data/profiles/community/Index.cfm?Lang=E>
 (accessed 3 November 2010).
- StatsNWT (2007). Summary of NWT Community Statistics. Northwest Territories: Government of the Northwest Territories Bureau of Statistics. 5p.
- Stefansson V (1913). *My Life with the Eskimos*. New York: Collier Books.
- Stevenson MG (1996). Indigenous Knowledge in Environmental Assessment. *Arctic* 49(3): 278-291.
- Stroeve J, Serreze M, Drobot S, Gearheard S, Holland M, Maslanik J, Meier W and Scambos T (2008). Arctic sea ice extent plummets in 2007. *Eos, Transactions American Geophysical Union* 89(2): 13-14. doi: 10.1029/2008EO020001
- Susman P, O'Keefe P and Wisner B (1984). Global disasters: a radical interpretation. In: Hewitt K (ed.), *Interpretations of Calamity*. Boston: Allen and Unwin, pp 264-283.
- Takano T (2005). Connections with the land: land skills courses in Igloodik, Nunavut. *Ethnography* 6(4): 463-486.
- Tester F (2006). *IGLUTAQ: The Implications of Homelessness for Inuit – A case study of housing and homelessness in Kinngait, Nunavut Territory*. Vancouver, UBC, 160p.
- Timmerman P (1981). *Vulnerability, resilience and the collapse of society*. Toronto: Institute for Environmental Studies.
- Tremblay M, Furgal C, Lafortune V, Larrivee C, Savard J, Barrett M, Annanack T, Enish N, Tookalook P and Etidloie B (2006). Communities and ice: Linking traditional and scientific knowledge. In: R. Riewe and J. Oakes (eds.), *Climate Change: Linking Traditional and Scientific Knowledge*. Winnipeg, Manitoba: Aboriginal Issues Press, University of Manitoba, pp 123-138.
- Tschakert P (2007). Views from the vulnerable: understanding climatic and other stressors in the sahel. *Global Environmental Change* 17: 381-396.
- Turner B, Kasperson RE, Matson P, McCarthy J, Corell R, Christensen L, Eckley N, Kasperson, JX, Luers A, Martello M, Polsky C, Pulsipher A and Schiller A (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences* 100(14): 8074-8079.
- Tyler N, Turi J, Sundest M, Bull SK, Sara M, Reinert E, Oskal N, Nellemann C, McCarthy J, Mathiesen S, Martello M, Magga O, Hovelsrud G, Hanssen-Bauer I, Eira N, Eira I and Corell R (2007). Saami reindeer pastoralism under climate change: applying a generalized framework for vulnerability studies to a sub-arctic social-ecological system. *Global Environmental Change* 17: 191-206.

- UMA Engineering Ltd. (1994). Tuktoyaktuk shoreline protection study, phases 2 and 3. Interim Report No. 2 [online]
http://nome.colorado.edu/HARC/members/Scanned_docs/UMAEngineering_1994.pdf
 (accessed 3 November 2010).
- UNFCCC (1992). United Nations Framework Convention on Climate Change. Bonn: Climate Change Secretariat.
- Usher P (2000). Traditional ecological knowledge in environmental assessment and management. *Arctic* 53(2): 183-193.
- Usher P (2002). Inuvialuit use of the Beaufort Sea and its resources, 1960-2000. *Arctic* 55(Supp. 1): 18-28.
- Van Oostdam J, Donaldson S, Feeley M, Arnold D, Ayotte P, Bondy G, Chan L, Dewailly E, Furgal C, Kuhnlein H, Loring E, Muckle G, Myles E, Receveur O, Tracy B, Gill U and Kalhok S (2005). Human health implications of environmental contaminants in Arctic Canada: a review. *Science of the Total Environment* 351: 165-246. doi: 10.1016/S0048-9697(99)00036-4
- Vick-Westgate A (2002). *Nunavik: Inuit-Controlled Education in Arctic Quebec*. Calgary: University of Calgary Press and Arctic Institute of North America.
- Vincent K (2007). Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change* 17(1): 4-7.
- Wall E and Marzall K (2006). Adaptive Capacity for Climate Change in Canadian Rural Communities. *Local Environment* 11(4): 373-397.
- Wasserman S and Faust K (1994). *Social network analysis*. Cambridge: Cambridge University Press.
- Watts M and Bohle H (1993). The space of vulnerability: the causal structure of hunger and famine. *Progress in Human Geography* 17(1): 43-67.
- Watt-Cloutier S, Fenge T and Crowley P (2005). Responding to global climate change: The perspectives of the Inuit Circumpolar Conference on the Arctic Climate Impact Assessment. Inuit Circumpolar Conference. Ottawa.
- Wein E and Freeman M (1992). Inuvialuit food use and food preferences in Aklavik, Northwest Territories, Canada. *Arctic Medical Research* 51: 159-172.
- Wein E, Freeman M and Makus J (1996). Use of an preference for traditional foods among the Belcher Island Inuit. *Arctic* 49(3): 256-264.
- Wellman B (1988). Structural analysis: From method and metaphor to theory and substance. In: Wellman B and Berkowitz S (eds.), *Social structures: A network approach*. Cambridge: Cambridge University Press. pp 19-61.
- Wenzel G (1981). *Clyde Inuit adaptation and ecology: The organization of subsistence*. Ottawa, Ontario: National Museum of Man.

- Wenzel G (1987). I was once independent: the southern seal protest and Inuit. *Anthropologica* 29: 195-210.
- Wenzel G (1991). *Animal Rights, Human Rights*. Toronto: University of Toronto Press.
- Wenzel G (1995). Ningiqtuq: Resource sharing and generalized reciprocity in Clyde River, Nunavut. *Arctic Anthropology* 32(2): 43-60.
- Wenzel G (1999). Traditional ecological knowledge and Inuit: reflections on TEK research and ethics. *Arctic* 52(2): 132-124.
- Wenzel G (2009). Canadian Inuit subsistence and ecological instability- if the climate changes, must the Inuit? *Polar Research* 28(1): 88-89.
- Wesche S and Armitage D (2006). Adapting to environmental change in a northern delta system. In: Riewe R and Oakes J (eds.), *Climate change: linking traditional and scientific knowledge*. Winnipeg: Aboriginal Issues Press, University of Manitoba, pp 105-120.
- Whilhite D and Easterling W (eds.) (1987). *Planning for drought*. Boulder, Colorado: Westview Press.
- White D, Gerlach SC, Loring P, Tidwell AC and Chambers MC (2007). Food and water security in a changing arctic climate. *Environmental Research Letters* October-December: 045018, 4p. doi: 10.10898/1748-9326/2/4/045018
- Wiita A (2006). The culture of community-based research and a borderless north. Presented at the 4th Northern Research Forum Open Meeting. 5-8 October, Oulu, Finland and Lulea, Sweden.
- Wolfe B, Armitage D, Wesche S, Brock B, Sokal M, Clogg-Wright K, Mongeon C, Adam M, Hall R and Edwards T (2007). From isotopes to TK interviews: Towards interdisciplinary research in Fort Resolution and the Slave River Delta, Northwest Territories. *Arctic* 60(1): 75-87.
- Wolfe S, Kotler E and Nixon F (2000). Recent warming impacts in the Mackenzie Delta, Northwest Territories, and northern Yukon Territory coastal areas. *Current Research 2000-B1*, Geological Survey of Canada, Natural Resources Canada, Ottawa, 9p.
- Woo M, Modeste P, Martz L, Blondin J, Kochtubajda B, Tutcho D, Gyakum J, Takazo A, Spence C, Tutcho J, Di Cenzo P, Kenny G, Stone J, Neyelle I, Baptiste G, Modeste M, Kenny B and Modeste W (2007). Science meets traditional knowledge: Water and climate in the Sahtu (Great Bear Lake) Region, Northwest Territories, Canada. *Arctic* 60(1): 37-46.
- Yohe G and Tol R (2002). Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change* 12(1): 25-40.
- Zhang Y, Chen W and Riseborough D (2008). Transient projections of permafrost distribution in Canada during the 21st century under scenarios of climate change. *Global and Planetary Change* 60(3-4): 443-456. doi: 10.1016/j.gloplacha.2007.05.003

Zhou F, Zhang A, Li R and Hove E (2009). Spatio-temporal simulation of permafrost geothermal response to climate change scenarios in a building environment. *Cold Regions Science and Technology* 56(2-3): 141-151. doi: 10.1016/j.coldregions.2008.12.004

Appendix 1: Transmission of Environmental Knowledge and Land Skills in Adaptation Planning for Climate Change

Publication details:

Pearce T, Notaina R, Wright H, Ford J and Smit B (2010d). Transmission of environmental knowledge and land skills in adaptation planning for climate change. Meridian: 6-11.

Introduction to Manuscript

This manuscript addresses ‘objectives three and four’ and provides an overview of some of the key research findings from knowledge and skill transmission research reported on in Chapter 4. Meridian is published by the Canadian Polar Commission and is popular among northern policy makers. This publication is a means of communicating research findings on the transmission of environmental knowledge and land skills in adaptation to climate change in the Arctic among decision makers who may be engaged in northern adaptation planning and other related initiatives.

Manuscript

Transmission of environmental knowledge and land skills in adaptation planning for climate change

Introduction

Research on climate change impacts, vulnerability, and adaptation in the Arctic has shown that Inuit are exposed to climate change risks. Changes in seasonal patterns, precipitation, sea ice dynamics, and weather variability have affected the health and availability of some food species and have worsened risks associated with hunting and fishing. These changes have implications for food security and health, travel safety, and cultural activities. Climate change is expected to continue into the foreseeable future, with further effects on the social, economic, and political sectors of arctic communities (Anisimov et al. 2007; Lemmen et al. 2008). Inuit have a long history of coping with and adapting to the arctic ecosphere. They are already adapting to emerging climatic risks, and will need to continue to do so (Ford et al. 2006a; Pearce et al. 2010).

Crucial to the ability to adapt is a profound knowledge of the arctic environment, which affords Inuit dynamic and flexible use of the land and sea and their resources. Hunters manage risk by careful planning and preparation, bringing the right equipment, taking precautions, and by noting critical signs in the environment and responding appropriately. Knowledge of animal behaviour enables them to adapt to changing animal numbers and location, while knowledge of the land underpins the ability to do this. Environmental knowledge and land skills are transmitted between generations through practical engagement with the environment. However, younger Inuit are spending considerably less time in subsistence activities beyond organized land-camps and occasional hunting trips, but more time in formal education and wage employment. As a result,

many younger and inexperienced hunters are not as well equipped to cope with the risks of hunting. More than a few young Inuit have encountered hazards and some have been seriously injured because of their poor understanding of dangers on the land. Changing climatic conditions are making it even more dangerous for them.

There is a need for policy that supports the teaching and transmission of environmental knowledge and land skills in order to strengthen the competence of young Inuit, and therefore Inuit capacity to adapt to climate change. To plan for adaptation decision makers need to know what skills are important for safe and successful hunting under changing conditions, to what degree they are being transmitted, and what factors facilitate or impede transmission. Few studies have formally addressed this, and broad understanding of Inuit adaptability and how policy could assist adaptation is therefore limited. Our study conceptualizes the relationships between Inuit environmental knowledge and land skills, adaptive capacity, and adaptation planning in arctic communities. We have drawn upon research that empirically documented how environmental knowledge and land skills were transmitted among Inuit men in Ulukhaktok, Northwest Territories. We use the Ohmagri and Berkes (1997) definition of transmission: the process of transferring cultural items, such as skills, among individuals, where transmission success depends on the level of mastery of a particular item.

Adaptation and Inuit Environmental Knowledge and Land Skills

Adaptability is a process of continual learning and readjustment. Innovation and improvisation skills, gained through personal experience in the environment, are passed down through generations. Inuit knowledge is continually evolving, updated and revised in light of observations, new experiences, and the incorporation of non-traditional knowledge alongside the traditional (Stevenson 1996; Berkes 1999). As a reservoir of accumulated knowledge of changing

conditions and experiences of adaptation, environmental knowledge and land skills allow “response with experience” to climatic risks (Ford et al. 2006a); this increases adaptive capacity (Berkes et al. 2003). In Igloodik, Nunavut, for instance, Inuit knowledge is evolving with changing climate conditions through social learning, moderating the risks of a changing environment (Ford et al, 2009).

Transmission of Environmental Knowledge and Land Skills

Traditionally, knowledge and skills among Inuit were developed and transmitted through on-the-land education, and from listening to and learning from elders and other experienced individuals. In traditional Inuit education, learning and living were the same things, and knowledge, judgment, and skill were not separated (Nunavik Educational Task Force 1992). However, there is evidence that the traditional modes of knowledge transmission and learning are not functioning as they were in the past, particularly for younger generations (Irwin 1989; Condon et al. 1995; MacDonald 1998; Takano 2004).

This “deskilling” results from a gradual disengagement of younger generations from the land and subsistence activities, beginning with the settlement of Inuit in communities in the 1960s and accelerating since. Disengagement has been linked to several factors: requirements of formal schooling, increased dependence on wage employment, alternative activities (e.g. sports, television, video games), increasing separation between younger and older generations, new technologies, a decline in the prestige of being a hunter, and the desire among youth to follow “western” rather than “traditional” social norms (Condon et al. 1995; Ohmagari and Berkes 1997; Ford et al. 2006b).

Knowledge and Skills Transmission in Ulukhaktok

We studied the transmission of environmental knowledge and land skills among Inuit men in Ulukhaktok using an approach described by Ohmagari and Berkes (1997) and following recommendations for community engagement outlined by Pearce et al. (2009). Ulukhaktok, on the west coast of Victoria Island in the Inuvialuit Settlement Region (ISR), has a population of about 400, of whom 99% are Inuit (Fig. 5.1). This research responded to community concerns about the erosion of environmental knowledge and land skills, and the consequent disengagement of some youth in subsistence and increased risk of accident among young people.

First, the study used semi-structured interviews and free lists, with active harvesters recognized by the community as experts and with elders, to generate a comprehensive list of necessary land skills and related environmental knowledge. For practical reasons we condensed this to 83 items, including traditional skills like meat and skin preparation, and others such as setting up and operating a VHF radio, and using a naptha stove. We then conducted structured interviews with 39 Inuit men: 28 between 18 and 34 years old, and 11 between 35-49 years old, representing 51% of the available male population in these age groups.

Each interviewee was asked three questions on each item on the list: 1) Did you learn this skill? 2) If yes, who was your main teacher? 3) How old were you when you learned the skill?

Following the framework described by Ruddle and Chesterfield (1977) to analyze the learning sequences for traditional skills, we asked respondents whether, if they learned a skill, they learned it by hands-on experience or by observation only (Figure 5.2). We used more detailed questions to gauge respondents' level of knowledge about a particular skill. For example, if an interviewee said he knew how to hunt caribou, he was then if he knew where to go to hunt it and if so, why

was that a good place to go? Semi-structured interviews were conducted with eight elders (50 years or older) for comparative purposes.

Results

The transmission status of environmental knowledge and land skills by group of knowledge/skills is shown in Table 5.1. Among respondents 18-34 years of age, 56% of 83 items were learned by the respondents by hands-on experience and another 17% were learned by observation only. Among respondents 35-49 years of age, 87% were learned by hands-on experience and another 6% by observation only. Twenty-seven percent of the 83 items were not learned by 18-34 year old respondents, and seven percent were not learned among 35-49 year olds.

General hunting, travelling and camp-related skills, and skills related to fishing (all seasons), caribou hunting, muskox hunting and duck-hunting were transmitted well among respondents 18-34 years of age, and completely among 35-49 year old respondents. Skills including using a rifle and shotgun, pulling an alliak (sled) behind a snowmobile, setting up a frame tent, starting and tending a naphtha stove or fire, and getting ice for drinking water were transmitted 100% among respondents in both age groups.

In the context of changing climatic conditions it is significant that some traditional navigation, way-finding, and weather forecasting skills were, on average, poorly transmitted among 18-34 year old respondents. Ninety-three percent of respondents 18-34 years of age could navigate by remembering landforms but few could navigate using snowdrifts (29%) or the stars (21%) - skills which are important for navigating in poor visibility or unfamiliar areas. Furthermore, only 57% knew the different types of sea ice (including what is safe and unsafe to travel over). Even fewer knew how to forecast weather from cloud type (18%) or wind patterns (21%) but 96% could read

a weather report. Interviews revealed that most 18-34 year old respondents chose to travel when weather conditions were optimal and consulted weather reports before travelling. Respondents 34-49 years of age were more likely to consult elders before travelling and relied on traditional weather forecasting skills. Inuit in Ulukhaktok, and in other arctic communities, have said that weather patterns are changing (Nickels et al. 2006). Consequently, some traditional ways of navigation and weather prediction are less accurate and applicable than in the past (Ford et al. 2009). However, older respondents stressed that traditional navigation and weather prediction skills, adapted as necessary to accommodate new conditions, remain important.

A respondent's level of knowledge about a particular skill became more evident when asked if he knew where to hunt a species and why. It is one thing to be able to approach, shoot, and butcher a caribou, and another to know where to find the animals and understand why. This knowledge is particularly important in light of climate change which is affecting ecosystems and wildlife patterns, requiring hunters to adapt and sometimes hunt in less familiar locations. Although they had good duck hunting skills, respondents 18-34 years of age most often did not know where to hunt caribou, muskox, wolf, or polar bear, or where to set fox traps; nor did they know why they went to the hunting areas they used. For example, only 14% of respondents 18-34 years old knew where hunt caribou and why, and for polar bear hunting the figure was a mere 11%. This is because for the most part, these respondents still hunt with their teachers (older family members) and skills have yet to be fully transmitted.

It is important to note that some respondents within each age group had acquired more knowledge and skills than others (e.g. 96% of 83 skills were learned by hands-on experience by some respondents) and to higher learning levels. It appears that some respondents were better positioned to acquire environmental knowledge and land skills than others. Factors which may

influence learning include birth order, family structure, education history, and access to equipment. This and other trends will be explained in detail in future publications.

Learning Age

Table 5.4 shows the mean age of skill acquisition, transmission of selected environmental knowledge and land skills (hands-on learning), and the level of learning achieved. Most general hunting and camp-related skills were acquired by both age groups by the age of 13 or 14. Skills for traveling on the sea ice were on average acquired later at age 15-17 among respondents in both age groups. These ages are consistent with the accounts of older respondents (50 years and over) who had learned and mastered general hunting and camp-related skills by the age of 13 or 14 and more advanced skills such as navigation on the sea ice by 15-16. However, although the age at which skills were learned “hands-on” by respondents is similar among age groups, the level of skill mastery differed. For example 18-34 year old respondents on average had learned caribou hunting skills to level 5 (entire task complex under supervision) whereas 34-49 year olds acquired the same skills to level 8. Similarly, competence in travelling on the sea ice in winter was acquired to level 4 by 18-34 year olds (entire task complex with assistance) whereas 34-49 year olds had mastered the skill by 16 years of age. This difference is found with most of the skills tested with the exception of basic hunting, travelling, and camp-related skills. Younger respondents are learning at similar ages to older respondents but their level of acquisition is lower, which suggests that they will not master them until a later age.

Conclusions

The results of this research support policy initiatives that promote the teaching and transmission of environmental knowledge and land skills in arctic communities. Societal changes have altered

traditional methods of knowledge and skill transmission in the Arctic, requiring policy intervention. Detailed understanding of the transmission process can help northern decision makers and educators make informed decisions regarding the development and implementation of skills-training programs and educational curricula. Consistent with the learning ideology of, for example, the Piqqsilirivvik cultural school in Clyde River, Nunavut, this research shows that hands-on learning is important for the complete transmission (level 7 or 8 in the learning sequence) of environmental knowledge and land-based skills - including the detailed knowledge and experience that allows harvesters to adapt to changing climatic conditions. Initiatives to support the teaching and transmission of environmental knowledge and land skills, while not directed at climate change adaptation specifically, will also enhance the adaptive capacity of communities to deal with current and future climate change risks.

References

- Adger, W and P Kelly (1999) Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change* 4: 253-266.
- Andrachuk, M (2008) An Assessment of the Vulnerability of Tuktoyaktuk to Environmental and Socio-Economic Changes. Master of Arts, University of Guelph.
- Anisimov, O, D Vaughan, T Callaghan, C Furgal, H Marchant, T Prowse, H Vilhjalmsson and J Walsh (2007) Chapter 15: polar regions (Arctic and Antarctic). In: M. Parry, J. Palutikof, P. van der Linden and C. Hanson *Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK: 653-685.
- Aporta, C and E Higgs (2005) Satellite culture: Global Positioning Systems, Inuit wayfinding, and the need for a new account of technology. *Current Anthropology* 46: 729-753.
- Balikci, A (1968) The Netsilik Eskimos: Adaptive processes. In: R. B. Lee and I. Devore *Man the Hunter*, Aldine Publishing Company, Chicago: 78-82.
- Bates, P (2007) Inuit and scientific philosophies about planning, prediction, and uncertainty. *Arctic Anthropology* 44(2): 87-100.
- Berkes, F (1999) *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. Taylor and Francis, London.
- Berkes, F (2000) Indigenous knowledge and resource management systems in the Canadian subarctic. In: F. Berkes and C. Folke *Linking social and ecological systems: management practices and social mechanisms for building resilience*, Cambridge University Press, Cambridge, UK: 98-128.
- Berkes, F, J Colding and C Folke (2003) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge.

- Berkes, F and D Jolly (2002) Adapting to climate change: Social-ecological resilience in a Canadian Western Arctic community. *Conservation Ecology* 5(2): [online] <http://www.consecol.org/vol5/iss2/art18/>.
- Berkhout, F, J Hertin and A Jordan (2002) Socio-economic futures in climate change impact assessment: using scenarios as "learning machines". *Global Environmental Change* 12(2): 83-95.
- Bohle, H, T Downing and M Watts (1994) Climate change and social vulnerability. *Global Environmental Change* 4(1): 37-48.
- Brooks, N (2003). *Vulnerability, risk and adaptation: A conceptual framework*. Norwich, Tyndall Centre for Climate Change Research: Working Paper 38: 20.
- Cavalli-Sforza, L, M Feldman, K Chen and S Dornbusch (1982) Theory and observation in cultural transmission. *Science* 218(4567): 19-27.
- Condon, R, P Collings and G Wenzel (1995) The best part of life: Subsistence hunting, ethnicity, and economic development among young adult Inuit males. *Arctic* 48(1): 31-46.
- Cutter, S (1996) Vulnerability to environmental hazards. *Progress in Human Geography* 20(4): 529-539.
- Dowlatabadi, H, M Boyle and S Rowley (2009) Understanding and planning for climate change in Nunavut. *Meridian* Fall/Winter: 4-11.
- Duerden, F (2004) Translating climate change impacts at the community level. *Arctic* 57(2): 204-212.
- Ford, J, T Pearce, F Duerden, C Furgal and B Smit (2010) Climate change policy responses for Canada's Inuit population: the importance of and opportunities for adaptation. *Global Environmental Change* 20: 177-191.
- Ford, J., B Gough, G Laidler, J MacDonald, K Qrunnut, and C Irngaut (2009) Sea ice, climate change, and community vulnerability in northern Foxe Basin, Canada. *Climate Research* 37: 138-154.

- Ford, J, J MacDonald, B Smit and J Wandel (2006a) Vulnerability to climate change in Igloolik, Nunavut: What we can learn from the past and present. *Polar Record* 42(2): 1-12.
- Ford, J, T Pearce, B Smit, J Wandel, M Allurut, K Shappa, H Ittusujurat and K Qrunnut (2007) Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. *Arctic* 60(2): 150-166.
- Ford, J, B Smit and J. Wandel (2006b) Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16(2): 145-160.
- Ford, J, B Smit, J Wandel, M Allurut, K Shappa, H Ittusarjuat and K Qrunnut (2008) Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *Geographical Journal* 174: 45-62.
- Freeman, M (1996) Identity, health and social order. In: M. Foller and L. Hansson *Human ecology and health: adaptation to a changing world*, Gothenburg University, Gothenburg, Sweden: 57-71.
- Furgal, C and T Prowse (2008) Northern Canada In: D. Lemmen, F. Warren, E. Bush and J. Lacroix *From Impacts to Adaptation: Canada in a Changing Climate 2007*, Natural Resources Canada, Ottawa
- Furgal, C and J Seguin (2006) Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities. *Environmental Health Perspectives* 114(12): 1964-1970.
- Gearheard, S, W Matumeak, I Angutikjuaq, J Maslanik, H Huntington, Leavitt J., D Matumeak, Tigullaraq G. and R Barry (2006) "It's not that simple": Comparison of sea ice environments, observed changes, and adaptations in Barrow Alaska, USA, and Clyde River, Nunavut, Canada. *Ambio* 35(4): 203-211.
- GNWT. (2008). "NWT Community Profiles." from <http://www.stats.gov.nt.ca/>.
- Ingold, T and T Kurttila (2000) Perceiving the environment in Finnish Lapland. *Body & Society* 6: 183-196.

- IPCC (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Cambridge University Press, Cambridge, UK.
- Irwin, C (1989) *Lords of the Arctic: wards of the state. The growing Inuit population, Arctic resettlement and their effects on social and economic change - a summary report*. Ottawa: Canadian Arctic Resource Committee. *Northern Perspectives* 17(1).
- Krupnik, I (1993) *Arctic Adaptations: Native Whalers and Reindeer Herders of Northern Eurasia*. University Press of New England, Hanover, New Hampshire.
- Lemmen, D, F Warren, J Lacroix and E Bush (2008). *From impacts to adaptation: Canada in a changing climate 2007*. Ottawa, Government of Canada: 448.
- Lynch, A and R Brunner (2007) *Context and climate change: An integrated assessment for Barrow, Alaska*. *Climatic Change* 82(1-2): 93-111. 10.1007/s10584-006-9165-8
- MacDonald, J (1998) *The Arctic Sky: Inuit Astronomy, Star Lore, and Legend*, Nunavut Research Institute, Iqaluit, and the Royal Ontario Museum, Toronto.
- Nickels S, Furgal C, Buell M and Moquin H (eds) (2006). *Unikkaaqatigiit - Putting the human face on climate change: perspectives from Inuit in Canada*. Joint Publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Universite Laval and the Ajunnginiq Centre at the Nataional Aboriginal Health Organization, Ottawa.
- Nunavik Educational Task Force, (1992). *Silatunirmut: the pathway to wisdom. Final report of the Nunavik Educational Task Force*. Laval, Quebec, Makivik Corporation.
- Ohmagari, K and F Berkes (1997) *Transmission of Indigenous Knowledge and bush skills among the western James Bay Cree women of subarctic Canada*. *Human Ecology* 25(2): 197-222.
- Parry, M, C Rosenzweig, A Iglesias, G Fischer and M Livermore (1999) *Climate change and world food security: a new assessment*. *Global Environmental Change* 9: 51-67.

- Pearce, T, B Smit, D Duerden, J Ford, A Goose and F Kataoyak (2010) Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Record*. doi: 10.1017/S0032247409008602
- Pearce, T, J Ford, G Laidler, B Smit, D Duerden, M Allarut, M Andrachuk, S Baryluk, A Dialla, P Elee, A Goose, T Ikummaq, E Joamie, F Kataoyak, E Loring, S Meakin, S Nickels, K Shappa, J Shirley and J Wandel (2009) Community collaboration and environmental change research in the Canadian Arctic. *Polar Research* 28(1): 10-27.
- Smit, B, B Burton, RJT Klein and J Wandel (2000) An anatomy of adaptation to climate change and variability. *Climate Change* 45: 223-251.
- Smit, B and J Wandel (2006) Adaptation, adaptive capacity, and vulnerability. *Global Environmental Change* 16: 282-292.
- Stevenson, MG (1996) Indigenous Knowledge in Environmental Assessment. *Arctic* 49(3): 278-291.
- Takano, T (2004) Connections with the land: land skills courses in Igloodik, Nunavut. *Ethnography* 6(4): 463-486.
- Vincent, K (2007) Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change* 17(1): 4-7.
- White, D, S Gerlach, P Loring, A Tidwell and M Chambers (2007) Food and water security in a changing arctic climate. *Environmental Research Letters* October-December: 045018.

Appendix 2a: Consent Form

Prior to the interviews, the objective and purpose of the research were described and the rights of the respondent were outlined. An option of confidentiality was provided to the respondent as was the option to be recorded. The consent form was communicated orally in English or Inuinnaqtun and was signed by the respondent.

Interview Consent Form

Transmission of Environmental Knowledge and Land Skills in Ulukhaktok

What is the research about?

Objective: to document the transmission of environmental knowledge and land skills among community members.

Who is involved?

Research team: Roland Notaina, Adam Kudlak, Harold Wright, Jerry Sr. Akoaksion and Tristan Pearce – Nakimayak

Your rights: I have been fully informed of the objectives of the project being conducted. I understand these objectives and consent to participating in an interview for the project. I understand that steps will be undertaken to ensure that my information will remain confidential unless I consent to being identified. I also understand that if I wish to withdraw from the study, I may do so without repercussions.

I want my identity to be **non-confidential**

OR

I want my identity and the information I provide to be **confidential**

I give permission for **audio and video recording**

I give permission for a **copy of the audio and video tape** to be left securely in the community

NAME (please print): _____

Signature: _____

Date: _____

Signature of witness: _____

Date: _____

Appendix 2b: Interview Guide

INTERVIEW GUIDE

Environmental Knowledge and Land Skills: Ulukhaktok Winter 2009

Name:

Age:

Date:

INVENTORY ONE: Household Economy/Educational Attainment

The aim of this interview is to determine what the current sources of income are for the respondent (e.g. employment history), living arrangements (including dependents) and educational attainment and training.

- A. List members of household, relationships:
- B. Current employment of household adults (husband, wife, and attached relative):
 - B1. How long have you been married or shacked up?
 - B2. How long have you been shacked up (or living) in a separate house from parents?
- C. List all current sources of income (for at least past year):
- D. Employment history of respondent (over past 5 years):
 - D1. Employment history of partner (over past 5 years):
- E. Educational attainment:
 - E1. School in the community or residential school:
- F. College or other training:
- G. Sports hunting certification and number of sport hunts (over past five years):
- H. Estimation of income for 2008-2009:

INVENTORY TWO: Hunting/Fishing/Trapping History

This interview should be administered in an unstructured manner. Try to get answers to the following open-ended questions, but probe other avenues when available.

- A. Who was the person who taught you the most about travelling and hunting on the land?
- B. Who else was responsible for teaching these skills (e.g. uncles, brothers, grandfather, other)?
- C. How old were you when you went on your first major winter hunting trip?
- D. Who took you out and where did you go?

E. How old were you when you shot your first

Caribou:

Seal:

Ducks:

Muskox:

Rabbit:

Polar Bear:

Wolf:

F. Which of these events was the most important for you, the one that you remember the best and why?

G. When you were growing up, did you do much hunting or trapping with your father (or other relative)? How often did you go out?

H. At about what age did you start going out hunting on your own?

I. Is there any person that you now hunt with on a regular basis?

J. Rate your overall involvement in the following hunting activities, using young people your own age as a basis of comparison (very high, high, medium, low, very low)

1. fall fishing at Fish Lake:
2. fall caribou hunting:
3. spring caribou hunting:
4. summer caribou hunting (by boat):
5. muskox hunting:
6. seal hunting at the ice edge:
7. seal hunting in the winter (seal holes):
8. seal hunting in the summer (by boat):
9. duck hunting in spring:
10. polar bear hunting:
11. spring ice fishing:
12. summer rod fishing:
13. summer net fishing:
14. rabbit hunting (anytime of year):
15. trapping:
16. wolf hunting:

K. Overall, how would you rate your level of knowledge regarding hunting and travelling on the land (very high, high, medium, low, very low)

L. When you were growing up, did your (parents or other relatives) ever take you out to summer seal/fish camp away from town for long periods of time. If so, where did you go and how long did you stay?

M. When you were growing up, did your parents take you out often for spring fishing?

N. What are the most important things you remember being taught about hunting and survival on the land?

O. Over the past year, what hunting activities have you engaged in, how often, and with whom?

1. caribou hunting:
2. muskox hunting:
3. polar bear hunting:
4. fall fishing:
5. spring fishing:
6. summer fishing:
7. a. seal hunting at the ice edge:
b. seal hunting in seal holes:
c. seal hunting in the summer:
8. rabbit hunting:
9. duck hunting:
10. wolf hunting:
11. whale hunting:
12. trapping

P. What is the farthest distance you have travelled this year to go hunting? **(LABEL ON MAP)**

Snowmobile:

Boat:

ATV (Honda):

Q. How many overnight hunting trips did you make this past year?

R. Do you think that you spent enough time in school as a kid?

S. Do you think that you went out on the land enough?

T. Have you traveled on your own (or as the leader of a group) in the

Winter:

On the sea ice:

Spring:

Summer:

Fall:

U. Is hunting important to you? Why?

V. Do you think that it is important to take your kids out on the land? Why?

INVENTORY THREE: Transmission of Environmental Knowledge and Land Skills

The aim of this interview is to document what skills a respondent has learned, how they learned these skills, who was their main teacher and at what age did they learn the skill. Part of this interview is structured to document this information about each skill listed and part is unstructured to document information on the learning process, if this skill has been mastered, how the respondent values this skill, and factors that aided or impeded the learning of these skills. It is important to record the interviewees' stories about learning and using land skills to understand what stage they are at on the learning process. This will require probing some questions further to get more details on the interviewees' knowledge of a skill.

Each interviewee will be asked to answer three questions on each of the items on the list:

1. Did you learn the particular skill?
2. If yes, who was your major teacher?
3. How old were you when you learned this skill?

Note: When possible try and avoid repetitive questions or questions that have already been answered previously to avoid interviewee fatigue. You may want to ask whether the interviewee had one key teacher for hunting, fishing, trapping and traveling skills. If so, you can avoid repetitive questioning by recording this and proceeding with other questions.

A. Hunting, fishing and trapping skills

- **GENERAL**

1. Speak Inuinnaqtun
2. Understand Inuinnaqtun
3. Use a rifle
4. Use a shotgun
5. Re-load bullets
6. Keep dogs
7. Run a dog team
8. Pack a sled for traveling
9. Pack a boat for traveling
10. Drive a snowmobile with a sled (alliak)
11. Store meat (keeping the meat from rotting and away from predators)

- *CAMP-RELATED SKILLS*

12. Set-up a frame tent:
13. What direction to set-up camp (based on the winds)
14. Start and tend a naptha stove
15. Start a fire (using wood or geeqook)
16. Set-up and operate a VHF radio
17. Build a snow house:
 - (if yes) Cut snow blocks – know what type of snow to use
18. Light and tend a kulliq
19. Do you know how to get ice (for drinking)

- *FISHING*

20. Set fish nets in the summer
21. Set fish nets in the fall (under the ice)
22. (if yes) Make nets
23. (if yes) Fix nets
24. Prepare a hole in the ice and jig for fish

- *HUNTING CARIBOU (tuktu)*

25. How to hunt caribou
26. (if yes) Know where the caribou are during each time of the year
 - (if yes) Why the caribou go there?
27. (if yes) How to approach caribou
28. (If yes) How to shoot a caribou
29. Butcher a caribou
30. Prepare a caribou skin

- *HUNTING MUSX-OX (omingmak)*

31. How to hunt muskox
32. (if yes) Know where the muskox are during each time of the year
 - (if yes) Why the muskox go there?
33. (if yes) How to approach muskox
34. (if yes) How to shoot a muskox
35. Butcher a muskox

36. Prepare a muskox hide
 - *HUNTING SEALS (Natiq; Ugiuq)*
37. How to hunt seals in the winter
38. *(if yes)* Find seal holes in the ice
39. *(if yes)* Set seal hooks
40. *(if yes)* Hunt seals with a harpoon
41. Hunt seals at the ice edge with a oinakhiut
42. Hunt seals in the summer
43. Butcher a seal
44. Prepare a seal skin
- *HUNTING DUCKS (kingalik)*
45. How to hunt ducks
46. *(if yes)* Know where to go to hunt ducks
(if yes) why that is a good place to hunt ducks?
47. *(if yes)* How to shoot ducks
48. Butcher a duck
49. How to travel on the sea-ice in the spring
- *HUNTING POLAR BEAR (nanuq)*
50. How to hunt polar bear
51. *(if yes)* Know where to go to hunt polar bear
(if yes) why that is a good place to hunt polar bear?
52. Track polar bear
53. How to shoot a polar bear
54. Skin a polar bear (to sell)
- *HUNTING WOLVES (amaroq)*
55. How to hunt wolves
56. Know where to go to hunt wolves
(if yes) why that is a good place to hunt wolves?
57. Track wolves
58. Skin a wolf (to sell)

- *TRAPPING*

59. How to trap
60. (if yes) Where to set your traps
(if yes) why that is a good place to set traps?
61. Set an old style trap
62. Set a new style trap (conibear)
63. Skin a fox (to sell)

Have you taught anyone else these skills? If yes, which skills and to who?

B. Navigation skills and Weather prediction

How do you navigate when you travel? *(check-off skills below)*

Who was your teacher and how old were you when you learned these skills?

Do you know how to navigate by:

64. Snow drifts
65. Stars
66. Sun and Moon
67. Remembering land forms
68. GPS
69. Ocean swells travel by boat
70. Where the currents are
71. Know the different types of sea ice
72. Navigate on the sea ice in the fall
73. Navigate on the sea ice in the winter
74. Know the different types of snow

How do you tell what the weather is going to be like? *(check-off from list below)*

Can you read the weather using:

75. Clouds
76. Wind patterns
77. Know when the weather is going to change
78. Read a barometer

79. Read a weather report (know where to get one)
80. Use the Internet to get satellite images of the sea ice

Have you taught anyone else these skills? If yes, which skills and to who?

C. Equipment Making, Maintenance and Repair

81. Do you know how to carve (artwork)
82. Fix a snowmobile
83. Fix a sled
84. Build a sled
85. Fix a Honda
86. Fix an outboard motor
87. Fix a boat
88. Fix a rifle/shotgun
89. Fix a stove
90. Sharpen a knife/ulu
91. Build a wenakhiut
92. Make seal hooks
93. Make an unuk/harpoon

Have you taught anyone else these skills? If yes, which skills and to who?

Appendix 3: Publishers Permission to Reproduce Manuscripts

1. Journal: Regional Environmental Change (Chapter 2)

Date: 15 August 2010 08:45
From: Regional Environmental Change Editorial Office <rec@pik-potsdam.de>
To: Tristan Pearce <tpearce@uoguelph.ca>
Subject: RE: Publisher's Permission to Reproduce Manuscript

Dear Tristan,

For publication in a compilation of papers without commercial distribution as a new book, as is usually the case, you do not need my permission - this is done routinely.

Best wishes,

Wolfgang Cramer

Dr. Wolfgang Cramer
Potsdam Institute for Climate Impact Research
PO Box 60 12 03, 14412 Potsdam, Germany
Tel: +49-331-288-2637
E-mail: rec@pik-potsdam.de
<http://www.pik-potsdam.de/~cramer>

2. Journal: Polar Research (Chapter 3)



Date: 19 May 2010 08:18
From: Helle Goldman <helle.goldman@npolar.no>
To: Tristan Pearce <tpearce@uoguelph.ca>
Subject: RE: Publisher's Permission to Reproduce Manuscript

Hello,

Yes, please go ahead.

See the Exclusive License Form that you signed, where it explains (under "After acceptance") that as long as full bibliographic reference for the original article is provided, and appropriate acknowledgement made to the Journal and Blackwell, it may be used for this purpose.

Regards,

Helle

Dr Helle V. Goldman
Chief Editor, Polar Research
Norwegian Polar Institute
Polar Environmental Centre
NO-9296 Tromsø, Norway
Fax (+ 47) 77 75 05 01
goldman@npolar.no

Exert from Polar Research: *Exclusive License Form*

“After acceptance: Provided that you give appropriate acknowledgement to the Journal and Blackwell Publishing, and full bibliographic reference for the Article when it is published, you may use the accepted version of the Article as originally submitted for publication in the Journal, and updated to include any amendments made after peer review, in the following ways:

- you may share print or electronic copies of the Article with colleagues;
- you may use all or part of the Article and abstract, without revision or modification, in personal compilations or other publications of your own work;
- you may use the Article within your employer's institution or company for educational or research purposes, including use in course packs;
- 24 months after publication you may post an electronic version of the Article on your own personal website, on your employer's website/repository and on free public servers in your subject area.

Electronic versions of the accepted Article must include a link to the published version of the Article together with the following text: ‘The definitive version is available at www.blackwell-synergy.com’.”

3. Journal: Meridian (Appendix 1)



Canadian
Polar Commission

Commission canadienne
des affaires polaires

Date: 18 May 2010 14:06
From: John Bennett <bennettj@polarcom.gc.ca>
To: Tristan Pearce <tpearce@uoguelph.ca>
Subject: RE: Publisher's Permission to Reproduce Manuscript

Dear Tristan,

You are welcome to reproduce the article "Transmission of Environmental Knowledge and Land Skills in Adaptation Planning for Climate Change in the Arctic" published in the Spring/Summer 2010 volume of *Meridian*, as an Appendix in your doctoral dissertation.

Sincerely,

John Bennett
Editor, Meridian

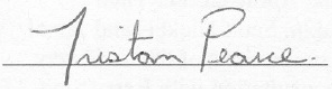
Canadian Polar Commission | Commission canadienne des affaires polaires
360 Albert Street, Suite 1710 | 360, rue Albert, pièce 1710
Ottawa, ON K1R 7X7 Canada
bennettj@polarcom.gc.ca
Telephone | Téléphone 613-943-0716 / Facsimile | Télécopieur 613-943-8607

Appendix 4: Co-Authors' Statement


Chapter 2

The manuscript that appears in Chapter 2 of this thesis is authored by Tristan Pearce, James Ford, Frank Duerden, Barry Smit, Mark Andrachuk, Lea Berrang-Ford and Tanya Smith.

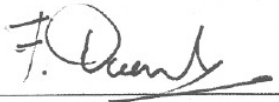
Tristan Pearce developed the initial concept for the manuscript after confirmation with James Ford on the scope and purpose. The literature search was designed and conducted by Tristan Pearce with assistance from Tanya Smith and Lea Berrang-Ford. The review drew upon concepts and ideas of numerous scholars, including Barry Smit and James Ford. Tristan Pearce produced the first full length draft, which included his own original ideas and lines of reasoning. The draft was reviewed and commented on by James Ford, Frank Duerden, Barry Smit and Mark Andrachuk. Tristan Pearce completed the final draft, integrating the co-author's comments, and submitted the manuscript to the journal *Regional Environmental Change*. After consultation with James Ford, Tristan Pearce addressed the reviewer's comments and re-submitted the revised manuscript to the publisher.



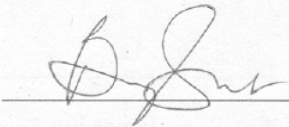
Tristan Pearce



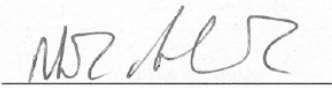
James Ford



Frank Duerden



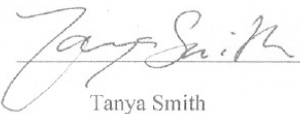
Barry Smit



Mark Andrachuk



Lea Berrang-Ford

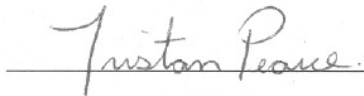


Tanya Smith

Chapter 3

The manuscript that appears in Chapter 3 of this thesis is authored by Tristan Pearce, James Ford, Gita Laidler, Barry Smit, Frank Duerden, Mishak Allarut, Mark Andrachuk, Steven Baryluk, Andrew Dialla, Pootoogoo Elee, Annie Goose, Theo Ikummaq, Eric Joamie, Fred Kataoyak, Eric Loring, Stephanie Meakin, Scott Nickels, Kip Shappa, Jamal Shirley and Johanna Wandel.

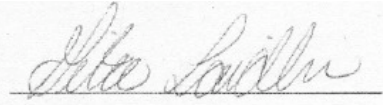
Tristan Pearce developed the initial concept for the manuscript after confirmation with Barry Smit and James Ford on the scope and purpose. The paper drew upon the concepts and ideas of numerous scholars, community members and decision makers, including all of the authors. Tristan Pearce produced the first full length draft, which included his own original ideas and lines of argument. The draft was reviewed and commented on by James Ford and Barry Smit. These comments included, inviting other researchers who had conducted community-environment case studies to share their experiences in the paper. The Arctic Bay-Igloolik case study was prepared by James Ford in cooperation with Tristan Pearce, and the Dorset-Pang-Igloolik case study was prepared by Gita Laidler in cooperation with Tristan Pearce. Tristan Pearce prepared a second full-length draft, which was reviewed and commented on by Barry Smit, James Ford and Gita Laidler. Tristan Pearce completed a third draft, integrating the comments of Barry Smit, James Ford and Gita Laidler. The third draft was reviewed and commented on by Barry Smit, James Ford, Gita Laidler, Frank Duerden, Mark Andrachuk, Steven Baryluk, Annie Goose, Theo Ikummaq, Eric Joamie, Fred Kataoyak, Eric Loring, Stephanie Meakin, Scott Nickels and Jamal Shirley. Tristan Pearce completed the final draft, incorporating the suggestions of the reviewers, and submitted the manuscript to the journal Polar Research. After consultation with Barry Smit, Tristan Pearce addressed the reviewer's comments and re-submitted the revised manuscript to the publisher.



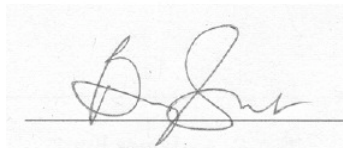
Tristan Pearce



James Ford



Gita Laidler



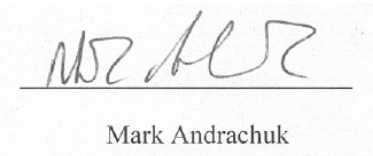
Barry Smit



Frank Duerden



Mishak Allarut



Mark Andrachuk



Steven Baryluk



Andrew Dialla

Pootoogoo Elee

Annie Goose

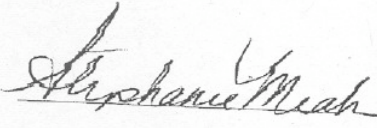
Theo Ikummaq

Eric Loring

Eric Joamie

Fred Kataoyak

Eric Loring

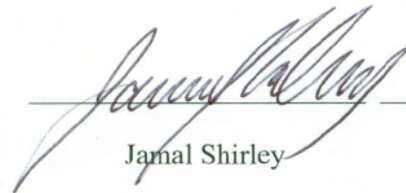


Stephanie Meakin

Scott Nickels

Kip Shappa

Johanna Wandel

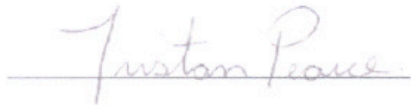


Jamal Shirley

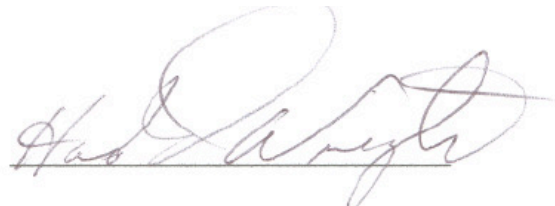
Chapter 4

The manuscript that appears in Chapter 4 of this thesis is authored by Tristan Pearce, Harold Wright, Roland Notaina, Adam Kudlak, Barry Smit and James Ford.


Tristan Pearce developed the initial concept for the manuscript after confirmation with Barry Smit, James Ford, Chris Furgal and Benjamin Bradshaw on the scope and purpose. The fieldwork was undertaken by Tristan Pearce in collaboration with Harold Wright, Roland Notaina and Adam Kudlak. The paper drew upon concepts and ideas of numerous scholars, including Harold Wright, Barry Smit and James Ford. Tristan Pearce produced the first full length draft, which included his own original ideas and lines of reasoning. The draft was reviewed and commented on by Harold Wright, Roland Notaina and James Ford. Tristan Pearce completed the final draft, integrating the co-author's comments, and submitted the manuscript to the journal Human Ecology.



Tristan Pearce



Harold Wright




Roland Notaina



Adam Kudlak



Barry Smit



James Ford

Appendix 1

The manuscript that appears in Appendix 1 of this thesis is authored by Tristan Pearce, Roland Notaina, Harold Wright, Adam Kudlak, James Ford and Barry Smit.

Tristan Pearce developed the initial concept for the manuscript after confirmation with Barry Smit, James Ford, Chris Furgal and Benjamin Bradshaw on the scope and purpose. The fieldwork was undertaken by Tristan Pearce in collaboration with Harold Wright, Roland Notaina and Adam Kudlak. The paper drew upon concepts and ideas of numerous scholars, including Harold Wright, Barry Smit and James Ford. Tristan Pearce produced the first full length draft, which included his own original ideas and lines of reasoning. The draft was reviewed and commented on by Harold Wright, Roland Notaina and James Ford. Tristan Pearce completed the final draft, integrating the co-author's comments, and submitted the manuscript to Meridian. In consultation with Roland Notaina and Harold Wright, Tristan Pearce addressed the editor's comments and re-submitted the revised manuscript for publication.

Tristan Pearce

Roland Notaina

Harold Wright

Adam Kudlak

James Ford

Barry Smit