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# The impact of climate change on the well-being and lifestyle of a First Nation community in the western James Bay region

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*Through the use of traditional environmental knowledge (TEK), the impacts of climate change on the Fort Albany First Nation community are explored. Thirty-nine community members were interviewed using a semi-directive interview format to gather knowledge about their observations of local environmental and climatic change and the significance of these changes. Thematic analysis, cluster analysis, and concept mapping were applied to analyze interview transcriptions. A second round of interviews was conducted to obtain feedback on the themes and concepts that emerged from the first round of interviews. Community members indicated that there have been noticeable changes in the timing of seasons, snow type, and total snowfall, with an increase in extreme weather events. These changes have impacted animal behaviour, traditional harvesting activities, and the winter road, which have led to socio-economic and well-being issues. The community has exhibited strength in adapting to ongoing changes in the environment; however, their ability to adapt to climate change in the future is not certain.*

Keywords: animal behaviour, climate change, First Nations peoples, traditional environmental knowledge, winter roads

**Les impacts des changements climatiques sur le bien-être et les modes de vie d'une communauté des Premières Nations de la région de l'ouest de la Baie-James**
*À partir de l'utilisation des connaissances environnementales traditionnelles, cette étude explore les impacts des changements climatiques sur la communauté des Premières Nations de Fort Albany. Des entrevues ont été réalisées auprès de trente-neuf membres de la communauté à l'aide d'un canevas d'entretien semi-directif afin de recueillir leurs connaissances et leurs observations sur l'environnement local ainsi que sur les changements climatiques et la signification qu'ils donnent à ces changements. Les comptes rendus d'entrevues ont fait l'objet d'une analyse thématique, d'une analyse par grappes et d'une cartographie conceptuelle. Une deuxième série d'entrevues a été réalisée pour recueillir leurs avis sur les sujets et les concepts qui ont émergé lors de la première série d'entrevues. Les membres de la communauté ont remarqué qu'il y a eu des changements considérables dans les cycles saisonniers, les types de neige et l'accumulation totale de neige, avec une augmentation des évènements météorologiques extrêmes. Ces changements se sont fait sentir dans le*

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*comportement des animaux, les activités traditionnelles d'exploitation et les sentiers d'hiver, ce qui a suscité des préoccupations concernant le e développement socio-économique et le bien-être. La communauté a été en mesure de s'adapter aux changements environnementaux en cours. Toutefois, les moyens dont ils disposent pour s'adapter aux futurs changements climatiques ne suffiront peut-être pas.*

Mots clés : comportement animal, changements climatiques, Premières Nations, connaissances environnementales traditionnelles, sentiers d'hiver

## Introduction

Climate change is attributed to the unprecedented increase in the Earth's average temperatures over recent years. Global average temperature has increased by 0.6°C over the past 100 years, and snow and ice areal cover has declined by 10 percent since the 1960s (Walther et al. 2002). In Canada, the effects of climate change are most acute in northern regions. Arctic temperatures have increased by 0.6°C per decade since 1981 (Comiso 2006), and sea ice extent in Hudson Bay has declined by approximately 5 percent from 1979 to 2010 (Cavalieri and Parkinson 2012). Observed regional changes include a decline in multiyear ice, thinner ice cover, greater variability in weather patterns, warmer seasons, and changes in wind and precipitation patterns (McDonald et al. 1997; Nichols et al. 2004; Comiso 2011). Snow and sea ice cover in particular are significant contributors of polar climate, as their high albedo cause much incoming solar radiation to be reflected back to the atmosphere. However, Arctic average temperatures have increased by nearly twice the global average temperature rate over the last century, causing a significant decline in permafrost, sea ice extent and thickness, snow cover, and the duration of ice seasons (Serreze et al. 2000; Gough and Leung 2002; Moritz et al. 2002; Gough et al. 2004; Johannessen et al. 2004; Gagnon and Gough 2005; Kattsov et al. 2005; IPCC 2007). A decline in snow and sea ice cover has led to an increase in total solar radiation absorbed at the Earth's surface, amplifying a rise in average temperatures. Such changes have direct impacts on Aboriginal (First Nations, Inuit, and Metis) communities residing in northern regions (Furgal and Seguin 2006; Guyot et al. 2006; Lemelin et al. 2010; Tam et al. 2011).

For many northern Aboriginal communities in Canada, climate change has significantly affected traditional harvesting practices and food sources (Ford et al. 2006; Guyot et al. 2006; Laidler et al. 2009; Lemelin et al. 2010). Aboriginal communities in Beaver Creek, Yukon; Fort Providence, Northwest Territories (NWT); and Peawanuk, Ontario have noticed changes in migration patterns of games species (Guyot et al. 2006; Lemelin et al. 2010), which have affected subsistence harvesting. Changes in sea ice patterns have affected seal and walrus hunting in an Inuit community in Igoolik, Nunavut (Laidler et al. 2009). Unstable ice conditions have increased incidences of hunters being stranded on drifting ice in an Inuit community in Arctic Bay, Nunavut (Ford et al. 2006). Changes in the natural environment (e.g., snow and ice cover) have increased the difficulty in traveling to hunting grounds and obtaining game meat. For many Aboriginal communities, these changes have increased financial burden, as there is a need to cover additional costs for hunting/traveling supplies and store-bought foods (Ford et al. 2006; Laidler et al. 2009). Despite the detrimental effects of climate change, many remote communities have learned to adapt to changes in the environment through various adaptive strategies such as community sharing of knowledge, necessities, and food, and the use of newer technology (Nickels et al. 2002; Laidler and Gough 2003; Ford et al. 2006; Furgal and Seguin 2006; Guyot et al. 2006; Laidler et al. 2009; Lemelin et al. 2010).

The main objective of the present study was to examine how Fort Albany, a western James Bay First Nation community, has been affected by climate change, focusing on various aspects including environmental changes, lifestyle (e.g., subsistence harvesting/diet), well-being, and community infrastructure. To our knowledge, there is a lack of literature concerning the implications of climate change on this community. Though past studies have conceptualized the risks to Aboriginal populations from climate change, understanding vulnerability at a local level is complex, as there are multiple factors that enhance or reduce exposure, along with factors that limit or strengthen adaptive capacity of a community. As each community is unique (e.g., geographically, culturally, economically, and/or

socio-politically), there is a continual need to examine the effects of climate change at a local level.

### Vulnerability framework

The effects of climate change on the Fort Albany community were analyzed through an integrated approach to vulnerability. Vulnerability, defined as a measure of one's susceptibility to external stressors and one's (in)ability to cope and adapt to perturbations, is influenced by multiple systems including socio-ecological, physical, economic, and/or political systems (Bohle et al. 1994; Cannon 1994; Klein and Nicholls 1999; Adger 2006). An integrated approach to vulnerability incorporates multiple perspectives of vulnerability, in that vulnerability may not only be associated to direct risks of a hazard (e.g., risk-hazard model), but also to societal implications through varying processes (Fussel 2007). For this article, vulnerability is conditioned by interrelating processes within the human-environment system at multiple spatial and temporal scales (Turner et al. 2003). This article follows the vulnerability framework described in Turner et al. (2003). Vulnerability is examined by (1) delineating the environmental/biophysical processes that affect the community; (2) describing perturbations that may arise from these processes; and (3) determining the community's risks and responses to these perturbations (including impacts and adaptation) (for more details, see Turner et al. 2003).

### Study area

Fort Albany is located in the western James Bay region of Ontario, Canada (52°15′N, 81°35′W), with a population of roughly 850 Cree (Tsuji et al. 2006) (Figure 1). Historically, the Cree of the western James Bay region lived nomadically, migrating seasonally to harvest traditional foods (George et al. 1987). The Cree started to reside along the coast of James Bay following the establishment of trading posts of the Hudson Bay Company (George and Preston 1987; McCarthy et al. 2011). In 1905, the Fort Albany First Nation reserve was established through Treaty No. 9 (Duhamel 1931). Fort Albany is a remote fly-in community, where the only means of year-round access is by air. From late spring to fall, this community is accessible by barge (Tsuji et al. 2006), and during winter, this community is accessible by a seasonal road referred to as "the winter road." Fort Albany is within the Mushkegowuk region, geographically classified as boreal and subarctic. The Mushkegowuk region is an essential area for the Fort Albany First Nation community, as it is a habitat for many species and provides the grounds for subsistence harvesting (Berkes et al. 1994). Traditional food species include waterfowl, fish, upland game species, and various mammals (Tsuji et al. 2001). Subsistence harvesting may be defined as the gathering of animals through hunting or trapping practices for personal/family consumption. Subsistence harvesting is part of the mixed-economy that exists in Fort Albany (other sectors include wage employment and government grants/transfer payments) (Berkes et al. 1994). Many members of the Fort Albany community partake in a subsistence lifestyle not only for economical reasons, but also for social and cultural reasons.

Past studies have shown evidence of warming in the James Bay region in recent years. In the Hudson-James Bay region, trends indicate significantly earlier ice break-up events by 0.8 days per year ($p \leq 0.05$), and significantly longer ice-free seasons by 0.32 to 0.55 days per year ($p \leq 0.05$) (Gough et al. 2004; Gagnon and Gough 2005). Ice break-up in the James Bay region has been found to occur in June, and the region remains ice free until December (Gagnon and Gough 2005). The Albany River and Attawapiskat River have significantly changed in break-up time ($p \leq 0.05$) over the past few decades, and a significant trend in earlier break-up ($p \leq 0.05$) was found for the Albany River. Regression analysis depicted a decline from approximately 128 Julian days in 1990 to approximately 120 Julian days in 2000 for the Albany River ($p \leq 0.05$) (Ho et al. 2005). Over recent years, spring melt and spring break-up events have changed in the James Bay area, resulting in less apparent break-up events. Cree Elders of the western James Bay region have found that ice freeze-up has been occurring later in the year, and that timing of freeze/thaw cycles has become less predictable (Ho et al. 2005). Moreover, average temperatures are projected to increase in the western James Bay region. By 2100, mean temperatures are projected to increase by 4.1°C in summer, and by 7.5°C in winter (Hori 2010).

## Methods

This study commenced with a partnership between the research team and the Fort Albany First Nation

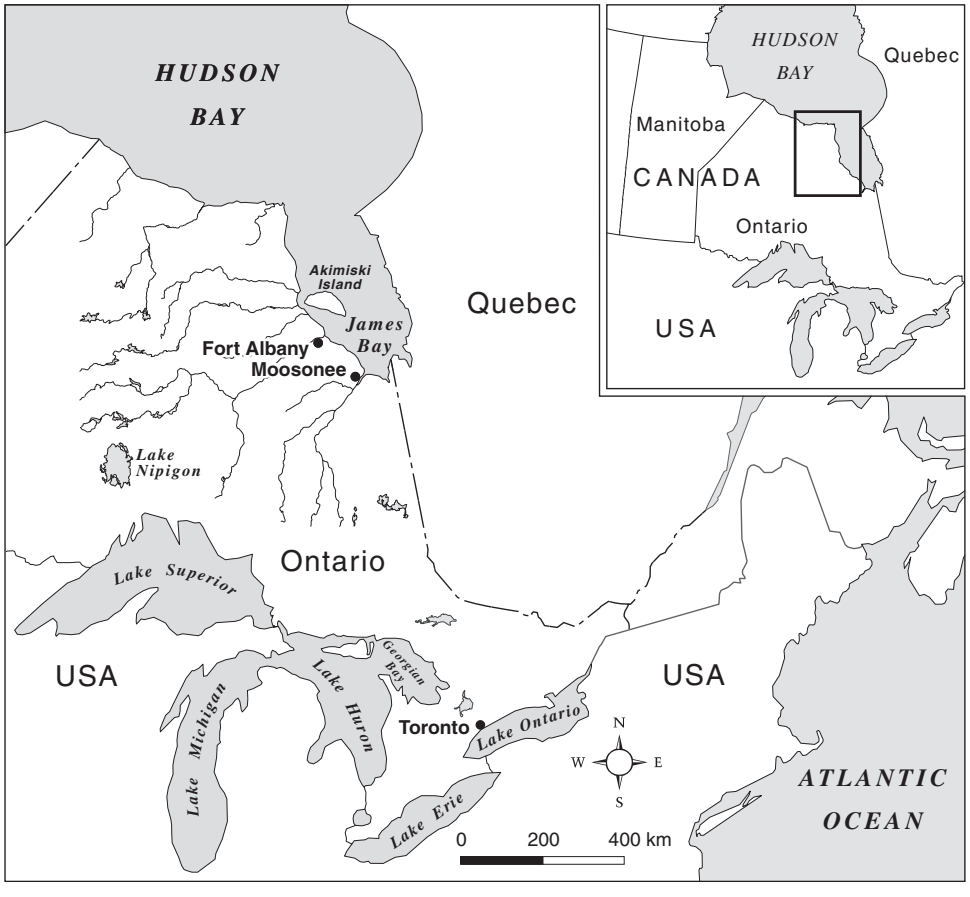


**Figure 1**
Map of Fort Albany, Ontario, Canada

community. Community partnerships create trust, community capacity, and support project sustainability. Community leaders (e.g., the Chief of Fort Albany, health care workers) and a community-based research coordinator oversaw every stage of the study to ensure that the study remained culturally appropriate and relevant to the community.

The implications of climate change for the western James Bay First Nation community were examined through the collection of traditional environmental knowledge (may also be referred to as traditional ecological knowledge [TEK]). TEK stems from indigenous knowledge (IK), which is "local knowledge unique to a given culture" (Berkes et al. 1995, p. 282). TEK is a knowledge set of the intrinsic interactions of living beings, communities, and ecosystems in a particular environment (Berkes et al. 2001). TEK may be derived from those who have a breadth of environmental observations and/or experiences gained over a long period of time, and thus have an understanding of how the environment has evolved over time. Aboriginal peoples have monitored changes within the environment using their own indigenous methods, cumulating knowledge over generations. TEK is similar to western science in that the collection of TEK is systematic; empirical observations are obtained through specific traditional activities (Tsuji and Ho 2002). On the other hand, TEK is a holistic set of knowledge, whereby TEK incorporates all aspects including cultural, spiritual, and social contexts (Johnson 1992; Berkes et al. 1995; Tsuji and Ho 2002). Such

knowledge and cultural insight can rarely be measured by modern science (Berkes et al. 2001). As an aim of the study was to understand the nuanced effects of climate change on the Fort Albany First Nation community, the collection and analysis of TEK was imperative.

Data collection occurred in the summer of 2010 and the fall of 2011. The community-based research coordinator was fundamental in contacting and recruiting participants for the study. In 2010, participants were interviewed (one-on-one) using an in-depth semi-directive interview format to gather information on their observations, experiences, and perceptions of local environmental and climatic change, with a Cree translator available if needed. A semi-directive interview is a qualitative method of gathering information through open-ended questions. Semi-directive interviews are commonly used when working with northern Aboriginal communities to understand local environmental and climatic changes (Huntington 1998; Ford et al. 2008; Laidler et al. 2009; Gearheard et al. 2010). The aim of the interviews was to document temporal changes in the environment/climate, and the associated impacts to the Fort Albany community. The main topics addressed in the interviews include (but were not limited to) environmental/climatic change (e.g., weather patterns/events, animals, fauna); impacts on lifestyle/well-being (e.g., hunting, diet); and impacts on community (e.g., infrastructure, winter road). All interviews were conducted in English. Sampling was purposive—as this study was part of a larger initiative— and participants were matched for age (±5 years) with an urban Aboriginal population. We only report our results for the remote population in this article. Moreover, purposive sampling was employed to recruit community members that were knowledgeable of local environmental/climatic changes. Additional eligibility criteria included the following: 1) the participant must be of Aboriginal descent; 2) the participant must have been living in Fort Albany for the majority of their lifetime; and 3) the participant must currently reside in Fort Albany at the time of their interview. A total of 39 community members (males, $n = 17$; females, $n = 22$) participated in the study. The ages of the participants ranged from 22 to 73 years old (mean = 42). Informed consent was obtained from all participants. All interviews were recorded using a voice recorder, and were subsequently transcribed verbatim. Interviews were coded both by hand and through use of NVivo. A thematic analysis was used to analyze the transcripts, identifying recurrent observations, impacts, experiences, and/or perceptions. Patterns that emerged from the transcriptions were categorized into themes and sub-themes. Dominant themes (those with a high recurrence value) were identified. Cluster analysis and concept mapping were then performed to organize and connect themes and sub-themes into general concepts. In 2011, a second round of interviews was conducted with the same community members to obtain feedback on the themes and concepts that emerged from the first round of interviews (Aronson 1994). The Chief of Fort Albany First Nation, the elected leader of the local government, and the Office of Research Ethics of the University of Toronto gave their approval for the study. As an additional measure of ethical consideration, the community-based research coordinator provided cultural insight to the research team that helped reduce or avoid misinterpretations of the data.

## Results and discussion

Results are presented in the sequence of the vulnerability framework and through a context of interrelatedness. TEK observations of climatic and environmental change are first presented, followed by the significant implications for the environment and community, and then the significant implications for community members. One of the themes that emerged from the interviews is the concept of interrelatedness. Participants viewed the effects of climate change as a domino effect, where one change in the environment resulted in numerous repercussions for the community: "I do see a lot of changes, and it's a domino effect. It's affecting everything. Vegetation to mammals that live here: birds, migratory birds, fish, everything; even the berries that we used to eat" (Participant #8, age 41). The theme of interrelatedness was highlighted in the interviews: from direct impacts of climate change (e.g., shorter colder seasons, longer warmer seasons, earlier spring melt, later freeze-up, less snowfall, abrupt seasonal change, and drastic weather conditions); to indirect impacts of climate change (e.g., changes in traditional harvesting and animal behaviour); to community and personal impacts (e.g., infrastructure, well-being, diet, and socio-economic status). As one participant stated,

> It [climate change] seems to affect everything, in the community … The migration of the birds, the geese … came but they couldn't stay because the ground was thawed out, so they must have went right through. So we didn't have our geese that would supplement our food. Like you know how much it cost in the stores. High costs to buy fresh meat. We supplemented those with whatever we kill in the spring time and we didn't have that chance this year. (Participant #7, age 58)

In keeping with this interrelatedness, the themes that emerged from the interviews—e.g., environmental changes, changes in animal behaviour, impact on harvesting practices, impact on the winter road, impact on well-being and the ability to adapt—will now be described, moving from direct impacts of climate change, through to effects on individuals and the community.

### Noticeable changes in seasons and weather patterns

Unanimously, participants stated that there have been changes in seasonal timing and climate variables. Seasonal timing and climate variable changes that were repeatedly identified were ones that had a significant impact on personal lifestyle, including subsistence harvesting and transportation via the winter road. The majority of participants ($n =$ 27 [69 percent]) related the term, "climate change," to their personal experiences with weather. In general, participants found that in the past weather patterns were more predictable. Now, weather has become more variable and severe. Participants referred to what the Elders have been saying, which was that weather has become unpredictable. This is an issue, as there is a reliance on predictable weather conditions for harvesting activities, as noted in other studies (McDonald et al. 1997). Unpredictable weather conditions, quick changing weather, and/or more extreme weather have also affected subsistence activity in other Aboriginal communities in Canada (Riedlinger 2001; Laidler et al. 2009; Weatherhead et al. 2010). Though specific traditional subsistence activities may differ in various Aboriginal communities, a common challenge is the effect of unpredictable weather conditions.

### Changes in fall and winter

In Fort Albany, participants unanimously felt that the winters have become milder, less cold, unpredictable, more humid, shorter in duration, and later in onset:

> It used to be that we had longer winters. Yes, cold, cold, cold: 40 below, 50 below. And it's just recent that not even 10 years ago that we are starting to have milder weather in the winter; and getting hotter in the summer too. Like those kind of changes. Since I was a child, I guess, to adult—older now. I see those changes. (Participant #7, age 58)

These temperature observations are in agreement with historical temperature data which indicate that mean annual temperatures have significantly increased in the western James Bay region (Barbeau et al. 2013; Hori et al. 2012). Four participants stated that it used to snow by Halloween, and that they were able to skate on a nearby lake in October years ago. Now they noticed that the lake only begins to freeze in December, and the ice is not frozen or thick enough to travel on. Participants noted that recently there have been rain, thunder, and lightning storms occurring in December, something they had not witnessed in the past. Thunderstorms occurring at unusual times of the year compared to the past have also been observed in other Aboriginal communities in northern Canada (Guyot et al. 2006). One participant, for example, stated that "I never seen rain in the middle of winter, nor lightning [before]" (Participant #13, age 31).

### Changes in spring and summer

The majority of participants ($n = 31$ [79 percent]) noted that spring has been occurring earlier in the year and at a faster rate. This is consistent with past research on the rate of spring melt in the western James Bay region (Ho et al. 2005). Similarly, in the western Hudson Bay region, statistical trends indicate that spring mean temperatures have significantly increased from $-12.4^{\circ}$C (1962) to $-9.8^{\circ}$C (2002); and spring break-up has been found to occur earlier (Ferguson et al. 2005).

Participants indicated that river break-up used to result in thick ice, but now they are finding that sometimes a major break-up does not even occur, and if it does, the ice is thin. For instance, one participant stated, "I think [spring] is early. It gets warmer. It doesn't even really get a chance to freeze, the ice is thinner. Last year, or the other year, it melted away—no major break up" (Participant #36, age 34). This coincides with past findings that have

found a significant trend in earlier and infrequent traditional break-ups in the western James Bay region (Ho et al. 2005). Furthermore, participants are finding spring and summer to be warmer than usual. In particular, they stated that summers are more hot and humid, and that the sun's rays feel stronger than previous years: "Like in the summer time, it is so hot now. Like one point it was 34 (°C). It wasn't like that before; we never used air conditioning before, but now it is a necessity" (Participant #37, age 50). This observation aligns with findings that depict an increase in summer mean temperatures in the western James Bay region over past years (Barbeau et al. 2013; Hori et al. 2012). Similarly, hotter summers and stronger sun have been observed by community members in North Slope, Alaska (McBeath and Shepro 2007); and hotter, longer, and drier summers have been observed by community members in Nunavik, Canada (Martin et al. 2007).

## Changes in animal behaviour and fauna

The majority of the participants ($n = 39$ [97 percent]) related changes in animal migratory patterns in the western James Bay area to the influence of climate change. A summary of these changes are listed in Table 1. Changes in animal patterns have been linked to climate change in other regions in Canada (Hersteinsson and MacDonald 1992), Norway (Sæther et al. 2000), Germany (Winkel and Hudde 1997), as well as other parts of the world (Hersteinsson and MacDonald 1992; Parmesan et al. 1999). Changes in animal patterns (e.g., an population) affect the diet and health of those who partake in a traditional subsistence lifestyle. Though not all participants were actively partaking in a subsistence lifestyle, they were all aware of the changes in animal patterns occurring in the western James Bay region and the related ramifications to the health of the community. Changes in animal behaviour and patterns have been observed in the past in the Hudson-James Bay region

**Table 1**
Perceived changes in fauna and flora patterns in Fort Albany, Ontario, Canada (this list only includes species mentioned in the interviews)

| ***Scientific name*** | **Common name *Fauna*** | ***Population*** | **Significance and observations** |
|---|---|---|---|
| *Rangifer tarandus* | Caribou | Decrease | Traditional game species |
| *Alces alces* | Moose | Stable | Traditional game species<br>Taste different now |
| *Lepus americanus* | Hare | Stable | Traditional game species<br>Taste different now |
| *Alopex lagopus* | White fox | Decrease | Traditional game species<br>Not seen anymore |
| *Canis lupus* | Wolf | Increase | Population is increasing, moving closer into the community |
| *Ursus maritimus* | Polar bear | Change in distribution | Population moving closer into the community |
| | ***Fish*** | | |
| *Perca flavescens* | Perch | Increase | Increased numbers being caught |
| | ***Birds*** | | |
| *Branta canadensis* | Canada goose | Apparent change | Traditional game species<br>Geese are smaller and they taste different<br>Flight patterns have changed, time of migration has changed |
| *Chen caerulescens* | Snow goose | Apparent change | Traditional game species<br>Geese are smaller and they taste different<br>Flight patterns have changed, time of migration has changed |
| *Tympanuchus phasianellus* | Sharptailed grouse | Decrease | Traditional game species<br>Not seen anymore |
| *Pelecanus spp.* | Pelican | Increase | New species in area<br>Increase in sightings |
| *Pteroglossus spp.* | Aracari | Rare sighting | New species in area |
| *Columbidae spp.* | Pigeon | Increase | New species in area |
| *Haliaeetus leucocephalus* | Bald eagle | Increase | Increase in population affects geese population residing in area |
| | ***Flora*** | | |
| *Vaccinium uliginosum* | Blueberry | Decrease | Traditional food |
| *Vaccinium oxycoccos* | Cranberry | Decrease | Traditional food |
| *Rubus idaeus* | Raspberry | Decrease | Traditional food |

(McDonald et al. 1997; Lemelin et al. 2010). The majority of the participants ($n = 32$ [82 percent]) reported that there had been an apparent decline in the Canada geese (*Branta canadensis*) population; that the geese are now smaller; and that they taste different. Similarly, Cree hunters in the eastern James Bay region have noticed a decline in the geese population in recent years (Peloquin and Berkes 2009; Sayles and Mulrennan 2010). In contrast, the geese population is reported to be stable in the western Hudson Bay region (Lemelin et al. 2010). Participants are also finding that the flight and migratory patterns of Canada geese have changed (see also McDonald et al. 1997). Likewise, changes in geese migratory patterns have been reported in the eastern James Bay region (Peloquin and Berkes 2009). In the past, changes in migratory patterns of snow geese (*Chen caerulescens*) in the western James Bay region have been observed (McDonald et al. 1997). Our participants stated that they no longer see snow geese (also known as wavies) and grouse (*Tympanuchus phasianellus*) in the area during hunting season:

> Well, the geese … last spring … [were] very scarce. It was a very bad season. We are not sure. Well they said that the spring came all of a sudden, and the birds don't like that, so they went right past this region. So that completely causes a lot of problems. Well food, we rely on the geese, and now there is hardly any. So we are going to rely on store bought stuff now, which is not what people want because they are so used to traditional foods. (Participant #37, age 50)

Similarly, Cree hunters in the eastern James Bay region have not been able to harvest snow geese since the 1980s (Sayles and Mulrennan 2010).

Changes in bird migratory patterns may not be solely attributable to climate change, as it has been documented that the Victor Mine transmission line has obstructed the flight paths of geese (McEachren et al. 2011). The power transmission line altered the migratory patterns of geese, and as a result, community members have not been able to harvest as many as before (McEachren et al. 2011). Furthermore, natural cyclic oscillations in the abundance of birds such as grouse have been well documented (Calder 1983; Williams et al. 2004). These factors may also account for the variable abundance of game birds in the western James Bay region; climate change may not be the sole factor. Nonetheless, climate change may indirectly affect animal populations as the animals' habitat and food sources may be directly affected by climate change (McCarty 2001).

Participants described a significant increase in novel bird species in recent years: "Pelicans. I don't know. They never used to be here a long time ago … But to us, our age group, we were surprised to see them because we never seen them before growing up here" (Participant #32, age 53). An increase in novel species may increase competition for the limited food supply in an area (Dukes and Mooney 1999), thereby affecting the native bird population residing in the area. This in turn has negative consequences for the diet of those who live a traditional subsistence lifestyle in the western James Bay region. Novel bird species include pelicans (*Pelecanus* spp.) and pigeons (*Columbidae* spp.) (refer to Table 1). One participant noted that they have also seen an aracari (*Pteroglossus* spp.) in Fort Albany.

Participants felt that the bald eagle (*Haliaeetus leucocephalus*) population, though not novel to the area, has increased over recent years:

> There are more bald eagles here. We never had as many bald eagles here before … Now we [have] lots of bald eagles here and it's affecting the geese out in the bay too, they are scared of bald eagles. You don't get much birds around if you see, if there is a bald eagle hanging around in the bay. You never see geese there. (Participant #10, age 45)

Similar observations have been reported in the western Hudson Bay region (Lemelin et al. 2010).

Many participants related changes in climate to changes in the bird population. As it has been documented, change in climate is a significant factor to changes in bird migratory patterns (Ball 1983; Prevett et al. 1983). Participants expressed a belief that, due to earlier springs and warmer seasons, birds' migratory patterns had been affected, leading to a decline in traditional species and an increase in novel species. It is projected that climate change will cause species native in the south to move northwards (Kerr and Packer 1998). With an abrupt breakup, Canada geese are able to migrate to their nesting areas quickly, and snow geese are less inclined to hang around the James Bay area (Prevett et al. 1983). Furthermore, participants relate the rising population of bald eagles to a continual decline in the geese population; many believe that the eagles are warding off the geese population from landing in the vicinity of Fort Albany.

Some participants noted an increase in perch (*Perca flavescens*), a species that was not plentiful in the past. Hori et al. (2012) projects that with climate change, fish diversity will change within the western James Bay region, as changes in water temperature may become more favourable for species of fish with a more southern distribution. Changes in the spatial distribution of fish species have been linked with changes in water temperatures and oxygen levels (Downing and Merkens 1957). Study participants echoed these findings, speaking of the effect of changing water temperatures, levels of precipitation, and water levels: "I think when it's really warm, the rivers dry up. You don't have any precipitation falling from the sky. The waters become warmer and the fish get cut off from their oxygen. So there will be no fish because the temperatures of the water are too warm for the fish to breathe in" (Participant #8, age 41).

Other traditional game species include caribou (*Rangifer tarandus*), moose (*Alces alces*), hares (*Lepus americanus*) and white fox (*Alopex lagopus*) (see Table 1). Changes in the caribou and moose populations in the western James Bay region have not been reported in previous studies. Participants noted that the moose population is stable, but described a decline in the caribou, white fox, and other populations. "In the 70s, I remember seeing white partridges [ptarmigans], you know the white ones, they are not here anymore. Or even the white foxes, used to chase, kill" (Participant #1, age 59). Participants reported the hare population being stable in the western James Bay region, though prior reports indicated that the hare population had greatly fluctuated in the Hudson-James Bay area (McDonald et al. 1997). Observed changes in animal abundance may be natural cyclic fluctuations. The abundance of hare, for example, naturally oscillates in a 10-year cycle (Calder 1983; Peterson et al. 1984). In northern Canada, the population of caribou has been found to naturally oscillate in a cycle of 60 to 80 years (Ferguson et al. 1998). The cyclic oscillation of the white fox population is related to the cyclic oscillation in population of their primary food source (Calder 1983). One primary food source of the white fox is lemming (*Lemus lemus*), which has a population cycle of three to five years (Calder 1983). While discussing the stability of the game species' populations, some participants mentioned that some of the game, specifically moose and hare, now taste different. One participant felt that all game meat now tastes different than before. Similarly, Aboriginal people in the Hudson-James Bay area have reported that animals taste differently (McDonald et al. 1997).

Participants stated that polar bears (*Ursus maritimus*) are moving closer to the community, affirming past reports that polar bears are becoming fearless of humans in the western James Bay region (McDonald et al. 1997). Increasing interaction between humans and polar bears may be due to the effects of warming in northern Canada (Barbeau et al. 2013). Earlier break-up and a longer ice-free season have forced polar bears to search for alternate food sources which tend to be in human settlements (Stirling and Parkinson 2006). It is projected that with climate change, polar bears will continue to search for food in human settlements and most likely decline in population (Stirling and Parkinson 2006). Those living in the western James Bay region may continue to see more polar bears entering the community during the ice-free seasons.

Participants are finding that there has been an increase in wolves (*Canis lupus*), which they relate to changes in snow conditions. They reasoned that less snowfall allows wolves to travel more easily throughout the western James Bay area and hunt moose. It is theorized that moose and wolves have related population oscillation cycles of 30 to 40 years (Mech 1966; Boutin 1992). The predation and number of wolves significantly affects the abundance of moose (Post et al. 1999; Post et al. 2002). Typically moose avoid shallow areas of snow to evade predators such as wolves (Dussault et al. 2005), but a decline in total snowfall reduces the effectiveness of this defense mechanism.

Other traditional foods include blueberries (*Vaccinium uliginosum*) and raspberries (*Rubus idaeus*) (see Table 1). Participants ($n = 17$ [44 percent]) indicated that there has been a decline in berries growing in the area, leading to a general decline in berry picking and consumption. As one participant described it, "Like I said, food is getting scarce. And berries, you can't find them anymore, and that always been a tradition to go and gather berries in the fall. Now there is, they are very scarce" (Participant #37, age 50). Some participants related warmer temperatures, stronger sun, and lack of precipitation to the change in berry volume. Other participants indicated that the decline in the berries may be due to soil contamination and an increase in pollution in the area. Observed changes in berries

have also been reported in other locations in Canada (Furgal et al. 2002). An Inuit community in Nain, Labrador found that, associated with increased temperatures, berries do not appear some years—and when they do, many are burnt and dried up (Furgal et al. 2002). Another factor that can affect flora is glacial isostatic adjustment (GIA) in James Bay, where GIA has caused sea-level to decline by approximately 1 cm/year (Tsuji et al. 2009). It may be that sea-level change is having a limiting effect on the availability of water to support growth of flora in the area.

### Implications for harvesting practices

Participants indicated that in the Fort Albany community, many families share game meat with each other; because of this, the decline in hunted game meat affects not just one family, but the entire community. Land-based activities such as hunting and fishing are an integral part of the Cree community in Fort Albany (Berkes et al. 1994; George et al. 1996). For this reason, changes in seasonal timing and weather patterns and changes in animal patterns have significant ramifications for those who partake in a traditional harvesting lifestyle, as well as those who do not (Guyot et al. 2006; Lemelin et al. 2010).

Participants find that the traditional harvesting lifestyle of the community is negatively impacted by shorter winters, earlier spring melt, less snowfall, different snow texture, thinner ice of frozen lakes, lower water levels or dry rivers, warmer seasons, unpredictable weather, increases in severe weather conditions, and a decline in traditional game species. This is consistent with past studies on the effects of climate change on northern Aboriginal communities (Furgal and Seguin 2006; Ford et al. 2008). Due to a decline in traditional game species, participants indicated that they, and/or someone they know, have only been able to harvest a fraction of what they used to harvest—including geese, caribou, and moose. As changes in climate alter migratory timing of geese (Prevett et al. 1983), participants find that they are no longer prepared for their arrival, causing them to miss their opportunity to hunt them: "… about the geese; the geese are early, earlier. Whereas everybody expects them in mid-April; they came in the end of March, as it is getting warmer, definitely, for sure" (Participant #36, age 34).

In addition to affecting animal populations, changes in the environment increase the difficulty and risks in traditional harvesting. Shorter and warmer winters, earlier snowmelt, less snow, and different snow texture shorten the hunting season and increase the difficulty for hunters travelling to their hunting grounds in the western James Bay region. Unpredictable and severe weather events increase the risks of hunting, forcing some hunters to change their hunting plans (Ford et al. 2008). When weather was more predictable, community members were able to plan out their hunting trips and follow through with those plans. Now, participants find that they are not able to fully rely on the weather patterns to plan out their hunting trips: "… this spring was kind of early. The snow just melted right away and we couldn't go to our hunting camp—spring camp—our hunting season, because the snow was gone already" (Participant #1, age 59). Furthermore, participants indicated that they require snow that is "crusty" and hard so they can travel on it by snow-machine. In recent years, the snow has become soft; it melts too quickly, making it very difficult to travel on. As a result, there has been an increase in related injuries or deaths. One participant shared about an accident that occurred when her family went hunting a couple of years ago:

> They go hunting in the Muskeg area, and I guess it was too, the ice was too thin. And, but a year before that, they had a hard time coming back and my father in-law went down with the skidoo. Then my husband had to jump in and try to save his father, then he went down. [Those] areas are deep spots, open spots, and he couldn't feel the ground. It was good for him because there was a twig under that water, and he had to hold on with the heel boots separators. So what happened then when my husband went down, my son grabbed a big stick, gave it to him so he could pull himself up. (Participant #31, age 33)

Similarly, unpredictable weather conditions and a rise in hunting related accidents have been reported in northern Aboriginal communities (Furgal and Seguin 2006; Downing and Cuerrier 2011). Some participants stated that, as an alternative, they could rent a helicopter to get to their hunting grounds, but such a form of transportation is costly.

Participants indicated that changes in river water levels and freeze-up have impacted traditional harvesting activity. Likewise, Aboriginal communities in the eastern James Bay region indicated that fluctuating water levels has increased the difficulty of travel (McDonald et al. 1997). Participants noted

that they are not able to trap when the rivers do not completely freeze, as they are not able to cross the creeks to get to their traplines. When rivers are dry or too low, respondents stated that they are not able to go upstream to their hunting grounds (where the moose population tends to be), decreasing the amount of hunted moose meat for the year: "If the rivers are dry, if the rivers are dry, you get less moose because you can't, you can't get to your hunting grounds. The rivers are too dry, you can't go up there. You go, the rivers are bone dry, you try to go up there, you won't get your moose" (Participant #10, age 45). Hunters from North Slope, Alaska face a similar situation, where climate change has affected their travel route; in their case, the effects of warming have increased the retreat of glaciers, forcing hunters to cross a larger area of water (Nuttall et al. 2004). Subsequent effects include an increase in time, distance travelled, and costs (e.g., fuel) (Nuttall et al. 2004).

## Implications for the winter road

The majority of participants ($n = 36$ [92 percent]) related changes to the winter road to the effects of climate change. The James Bay winter road is an ice road built during the cold season. This seasonal road connects fly-in Aboriginal communities such as Attawapiskat, Fort Albany, and Kashechewan, to Moosonee—the southern terminus of the winter road—and the northern terminus of the railroad (Kimesskanemenow Corporation 2011). The winter road has become an important asset to the Fort Albany community, as it is a cheaper means of transit for community members travelling to Moosonee. Many participants ($n = 22$ [56 percent]) use the winter road to travel to Moosonee to purchase cheaper necessities, such as food, furniture, and housing supplies. In other parts of Canada, climate change is projected to shorten the lifespan of winter roads in Mackenzie Value, Northwest Territories (Lonergan et al. 1993). To our knowledge, the impact of climate change on the James Bay winter road and the repercussions to nearby First Nation communities have not been directly addressed. Lemelin et al. (2010) briefly mentioned that the impact of climate change on infrastructure (including the winter road) would affect the Cree community in the western Hudson Bay area, but did not provide any further detail.

Participants noted that the winter road used to last longer, freezing by the end of November and lasting until the end of March. Respondents related the effects of warming, such as less snow, earlier spring melt, later freeze-up, and warmer winters to a less stable winter road. This supports the finding that spring melt has significantly changed in recent years (Ho et al. 2005). Due to a warmer climate, the winter road's usability is lessened as the road opens later in the cold season and thaws out earlier. Participants feel that due to a warmer climate, the stability of the road is declining, increasing the risk of injuries for those who travel across the winter road:

> Well we used that road primarily to get cheaper food and materials, and I know that this year Fort Albany was approved with a lot of money to get housing supplies, and they were dependant to use the winter road to get the supplies in, but it never happened. So now we have to wait for the barge. The winter roads are getting shorter every year. It is only going to get worse as well. (Participant #13, age 31)

Many Fort Albany community members travel to Moosonee to purchase cheaper necessities. Participants indicated that with a shorter winter-road season, they have less time to travel to Moosonee. As a result, a shorter winter road lifespan has resulted in financial strain for several participants ($n = 7$ [19 percent]). Lonergan et al. (1993) addressed the economic implications of a shorter winter road in northern Canada for western society, but did not explore the impacts on nearby Aboriginal communities. Lonergan et al. (1993) indicated that climate change may result in a shorter winter road, and therefore extend the barge season. However, in the western James Bay region, GIA affects the depth of water at the mouth of major river systems where barges often get stranded; thus, the extension of the barge season may be of little consequence. Furthermore, as indicated by participants, transporting items by air or barge is more costly than using the winter road.

## Climate change and well-being

Wellness for many Aboriginal groups is a holistic concept that encompasses a balance among four aspects of the human condition: spiritual, physical, emotional, and mental (Bopp et al. 1984; McCormick 1996). Based on the medicine wheel, wellness is achieved when there is a balance among these four dimensions within an individual. Aboriginal wellness is also achieved through harmony between the

individual and the environment (Bopp et al. 1984; McCormick 1996; Svenson and Lafontaine 1999). Changes in the environment, animal patterns, and climate have created an imbalance in resources in the environment, and an imbalance in well-being for many participants. Participants noted that partaking in a traditional lifestyle involves a lot of physical activity, and that a decline in traditional harvesting may lead to a decline in health. They conceptualize health as living a traditional lifestyle in which one hunts, fishes, and/or traps on a regular basis. For the Aboriginal community, partaking in traditional activities, such as hunting, not only provides physical health benefits, but also the connection to mental and spiritual health (Wilson 2003). Moreover, cultural and social values are rooted in obtaining and consuming game meat (George et al. 1996), which may increase the balance among the four aspects of well-being. This was one of the responses to the question, "what does it mean to be healthy?": "Stay in the bush" (Participant #6, age 52). Another participant related his own health to his level of physical activity and the benefits of hunting: "When you go hunting, you have to do a lot of physical work; so you get, so you are healthy" (Participant #17, age 56).

For the Cree, Aboriginal identity is significantly related to game meat and traditional activities (George et al. 1996). A decline in traditional foods decreases well-being and quality of life (Downing and Cuerrier 2011). Participants recognize that traditional foods are a lot healthier than the majority of store-bought foods, but due to circumstances such as the changing environment and decreasing numbers of traditional animals, a lot of community members are consuming more store-bought foods. Participants pointed out that foods sold at the local store are costly and typically unhealthy, and that the selection of healthy foods is limited and even more costly. Consequently, choices in store-bought foods tend to be unhealthy ones. Skinner et al. (2006) examined barriers to healthy eating for the Fort Albany First Nation community and found that community members felt disempowered when buying store-bought foods as a consequence of unsuccessful requests for certain foods, limited items, and produce that were not fresh. Other barriers include lack of resources, remoteness, and socio-economic status (Skinner et al. 2006). With the effects of climate change, such barriers to healthy eating may be exacerbated:

> Well we try to eat whatever we can get from the land, but mostly store bought foods. And the only people working full time are able to buy food from down south to be delivered here. The welfare people, they have to buy their food from the Northern Store and that causes problems because the costs are really high, so they have to decide if they want electricity or if they want food on the table. So it is mostly food I guess. (Participant #17, age 56)

The majority of participants ($n = 23$ [59 percent]) indicated that store-bought foods are part of their daily diet, which is why they rely on the winter roads to travel to Moosonee to purchase cheaper items. Many participants ($n = 22$ [56 percent]) indicated that a shorter-term winter road season decreases the opportunity to purchase cheaper necessities in Moosonee. Increased costs associated with purchasing local store-bought items, a shorter-term winter road, and hunting have led to greater financial strain:

> The food … it's too expensive in the Northern store. It's expensive food, so I don't shop from here, so that's the reason why I use the roads: the winter roads. That and stuff for, like furniture, I need to buy in Moosonee, it's cheaper in Moosonee. I can always bring it in my truck; mainly it's food. (Participant #10, age 45).

Ford (2009) found that food insecurity was a prominent issue for those who harvested off the land and were financially strained. For the Fort Albany community, increased financial strain due to the effects of climate change, coupled with challenges such as disempowerment, lack of resources, remoteness, and current socio-economic status (Skinner et al. 2006), may increase the risk of food insecurity. Food insecurity has been associated with higher odds of reporting heart disease, high blood pressure, diabetes, poor/fair health, depression, and food-related allergies (Vozoris and Tarasuk 2003). The effects of climate change on traditional foods may cause an imbalance in resources and well-being, putting many Fort Albany First Nation community members at greater risk for poorer health.

## Adaptation to climate change

There is a sense of adaptability occurring within the Fort Albany community. Participants who were actively subsisting off the land indicated that they are continually learning to adapt to ongoing changes in the environment: "We rely on hunting in the community, and the families are, if the environment

changes, then those things have an impact on us. It is hard to measure what the impact will be right now because we are constantly adapting" (Participant #11, age 42). Those who participate in hunting activities reported that they have altered their hunting skills and practices to adapt to changes in animal behaviour and weather patterns. Participants have recognized the risks associated with certain environmental conditions, and thus have learned to modify their hunting plans to reduce these risks. For example, hunters would plan shorter hunting trips if they suspected that the ice cover would deteriorate at a faster rate. Similarly, community members in Igloolik, Nunavut, manage risks in hunting activities through preparatory practices (e.g., carrying radios and extra supplies) and knowledge of survival strategies (Laidler et al. 2009).

Other participants indicated that though they are not able to participate in traditional activities, they are still able to consume traditional foods through sharing of game meat with family members and other community members. Community sharing of traditional foods is exemplified in other communities in northern Canada. Community members of Inuvialuit Settlement Region, Northwest Territories, share game meat with those who are no longer able to participate in traditional hunting practices (Nickels et al. 2002). To adapt to the effects of hotter summers and stronger sun, some participants reported wearing more sunscreen or specific articles of clothing to protect their skin, and others reported that they use air conditioners to reduce the risk of heat stress.

There is also a sense of resiliency within the Fort Albany community. The Cree believe the ability to adapt is focused on strengths, not vulnerability—and that good health includes both resiliency and strength (Lemelin et al. 2010). Though the effects of climate change are increasing the difficulty of adapting to environmental changes, this has not prevented the Fort Albany community from partaking in their traditional lifestyle (see also Ford et al. 2008; Lemelin et al. 2010). A participant acknowledged the strength of their community's ability to adapt to changes in the environment, but also brought forth the notion that the effects of climate change are nonetheless increasing the difficulty in subsisting off land:

> We are people that adapt. So with those changes then we just basically adapt to those changes. What is disturbing though is that patterns that we rely on, it's just the way nature behaves or the way animals behave; they change as well. Basically it's hard to predict weather now. It would appear that the weather is more severe as well. Hunting practices have to change because animals obviously behave differently. So it's a bit harder to rely on skills or animal behavior that have been constant for many many years, like generations and stuff; it has changed. So it almost we have to, it's harder to rely on that information to help you hunt and stuff. So it makes it tough that way. (Participant #11, age 42)

The ability to adapt to climate change is vital. The health implications of a warmer climate cannot be ignored (Downing and Cuerrier 2011). While study participants expressed confidence in their ability to adapt to climate change, the effects of increasing climate change on their traditional lifestyle and ability to hunt and harvest must be considered as an ongoing concern.

## Conclusion

Through a partnership with the Fort Albany First Nation community, we have been able to explore the explicit and nuanced evidence of climate change in the western James Bay region, and the significance of these changes to the Aboriginal community residing in the area. The main objective of this study was to understand the effects of climate change on the Fort Albany community through the collection of TEK. Semi-directive interviews were conducted to gather TEK on local environmental and climatic changes. The effects of climate change on this community are interrelated. Changes in the environment and climate have affected traditional subsistence activities and the winter road, which in turn affect community members' lifestyle and well-being. TEK observations brought forth in this study are consistent with scientific findings reported in past studies (Gagnon and Gough 2005; Ho et al. 2005; Hori 2010). The implications of climate change to the Fort Albany First Nation are also consistent with other studies, where the effects of climate change (e.g., changes in snow and ice, seasons, and animal behaviour), have had serious ramifications on northern Aboriginal communities (McDonald et al. 1997; Furgal and Seguin 2006; Ford et al. 2008; Lemelin et al. 2010; Downing and Cuerrier 2011). This study addresses a point not previously addressed in studies on climate

change: the repercussions of a shorter-term winter road to the well-being of the Fort Albany First Nation. The impact of shorter-term winter roads in other northern Aboriginal communities needs to be addressed, as there may be devastating socio-economic and health effects. The Fort Albany First Nation community has exhibited the ability to adapt to changes in the environment—but as climate change increases the difficulty in adaptation (Ford et al. 2008), community members may be forced to cope with detrimental health effects. An important next step will be to work with this community on effective adaptation strategies through a community-based research participatory approach. While TEK is a knowledge set that may enable Aboriginal communities "to cope with dynamic change in complex systems," TEK is also a foundation for adaptive management (Berkes et al. 2000, pp. 1259–1260). Adaptation strategies are the end goal, and through TEK, effective adaptive solutions can be formed for the Fort Albany First Nation community.

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