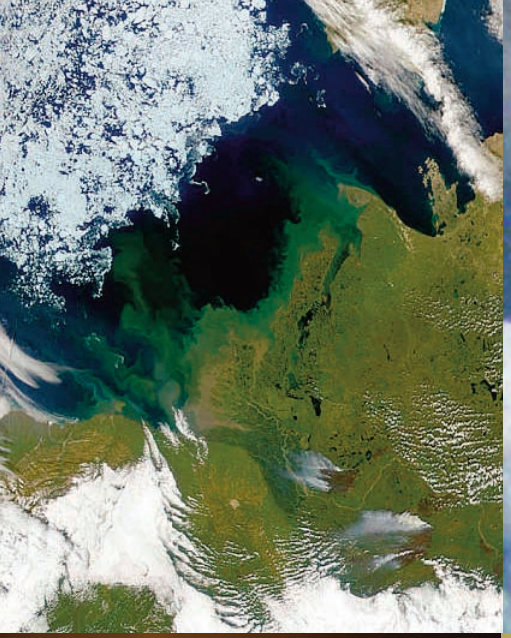
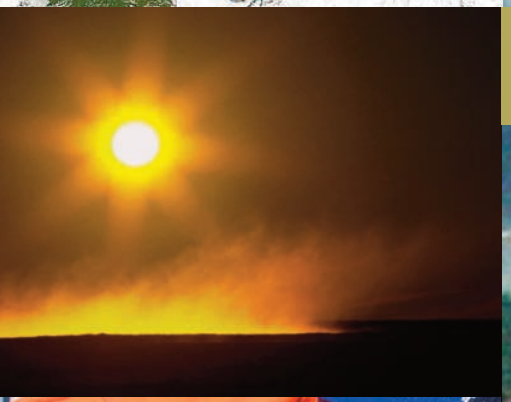




On The Frontlines of Climate Change

What's really happening in the Northwest Territories?

Prepared by Jamie Bastedo, Cygnus Environmental, Yellowknife

For The Honourable Nick G. Sibbeston, Senator for the Northwest Territories

ACKNOWLEDGEMENTS

I am grateful to Senator Nick Sibbeston who provided the original inspiration and leadership for this report. To distill the latest developments in northern climate change is a big challenge given how rapidly it is advancing and how diverse are its many signs. For help in finding and packaging the most relevant stories from the "frontlines", I thank Senator Sibbeston's Policy Advisor, Hayden Trenholm. I am also grateful to David Malcolm, Former Executive Director, Arctic Energy Alliance, and Doug Ritchie of Ecology North for their substantial contributions to my research. I also thank Weledeh MLA Bob Bromley and GNWT climate change expert Jim Sparling for their research advice. Funding for this project was provided from Liberal Senate Caucus Research Funds.

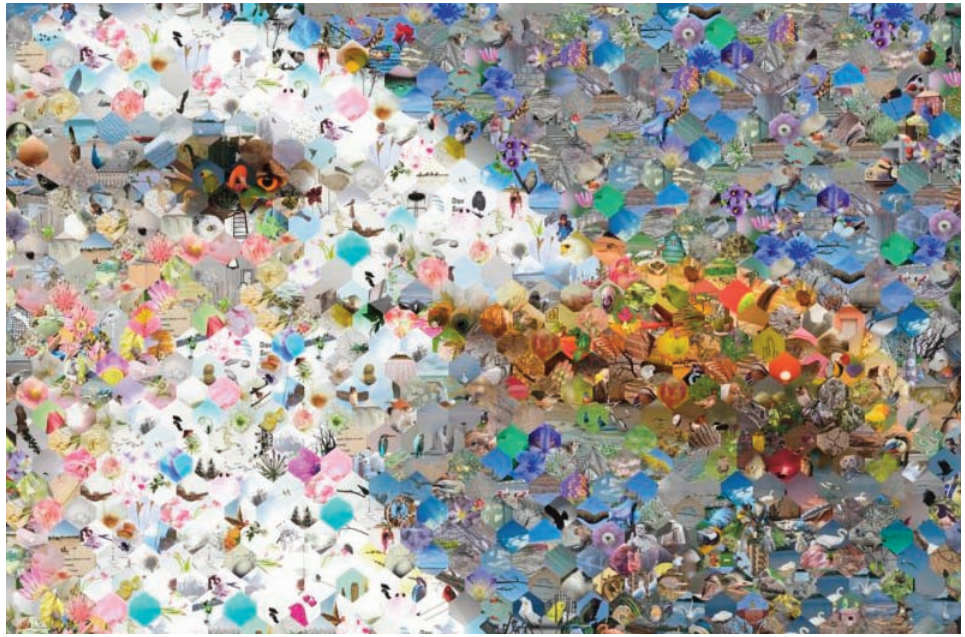
- Jamie Bastedo, Yellowknife, December 2007

Main cover photo: A massive forest fire licks at the outskirts of Tulita during the summer of 1995. The 1990s witnessed a marked increase in the frequency of forest fires in the NWT as well as longer burning seasons, associated with earlier springs and later falls. Photo courtesy Jim LeFleur, Tulita.

Secondary cover photo: Satellite view of Mackenzie Delta and Beaufort Sea coast (NASA); Blazing sun over tundra pond (Chris O'Brien); Apprentice beluga whale hunter, Edwin Rogers and his dog Snoop, Whitefish Station (Jamie Bastedo)

THE PUZZLE OF NORTHERN CLIMATE CHANGE: PUTTING THE PIECES TOGETHER

While this paper was being prepared, former U.S. Vice President Al Gore received the world's most prestigious award for his efforts in raising awareness on climate change: the Nobel Peace Prize. CBC National News declared that Gore's award clearly shows that climate change is a "planetary emergency" and hailed his work as a catalyst for changing global consciousness on the issue.[10] On the other hand, the National Post cynically greeted Gore's accomplishment as "a coup for junk science" and branded his Oscar winning movie, *An Inconvenient Truth*, as a "Snake Oil Road Show and Climate Terror Machine."[11] Are such conflicting headlines about climate change merely part of a media circus designed to sow controversy and sell newspapers? If climate change is indeed a planetary crisis, what can we possibly do about it? How real is this issue for Canadians anyway? For answers to these kinds of questions, there's no better place to look than Canada's North.



The puzzle of northern climate change is like this image of a gull. You can only see the big picture by putting the pieces together, in this case, smaller scenes of birds and flowers. (Wikimedia Commons)

Our northern land is huge and climate change is happening faster here than anywhere else in Canada – some would say, than anywhere else *in the world*. But its impacts are widely scattered across diverse ecosystems, communities, and cultures. Most people, wherever they live, can't grasp the enormity of climate change because they only see their little piece of the bigger picture.

The stories that follow are like a cluster of disconnected puzzle pieces, each showing a unique, local face of climate change. Only by putting these pieces together can we see the grand scale at which climate change is taking place in Canada's North and begin to understand what it means for the rest of the country, and for the wider world.

PURPOSE OF THIS PAPER

This paper is meant to raise awareness about what's happening "on the ground" with respect to climate change impacts in the Northwest Territories. It begins with a big picture look at northern climate change on the global stage and summarizes some of the main impacts. The focus is on concrete stories that combine community observations with recent scientific discoveries to provide a vivid, up to date picture of how the NWT's climate is changing and how it is already impacting people and the land in many ways.

Aimed at decision makers and the general public, it is hoped that this paper will ultimately raise awareness of the urgent need to make climate change a national policy imperative. It also aims to bolster ongoing programs which will help northerners reduce climate change impacts and prepare for the many changes ahead.

TABLE OF CONTENTS

Foreword

Over the last few years, in my travels to northern communities and conversations with Northerners, the reality of climate change has been brought home. It's real, it's happening now and it's going to get worse. Warmer winters and wilder weather have already affected our ability to travel on the land and sea and impacted both traditional and modern economies. From slumping river banks to receding sea ice, the effects of global warming are affecting northerners right now. I've become convinced that we all have to act both to slow down climate change and to adapt to the changes that have and will inevitably occur. I hope that this "primer" on climate change in the Northwest Territories will help stimulate debate and transform the way governments, industries and ordinary people deal with global warming.

- Nick Sibbeston

Introduction

Arctic climate change has become front page news not only across the North but in major southern media. Melting permafrost, shrinking sea ice, endangered wildlife, violent storms, threatened livelihoods and traditional rights – all these issues are widely publicized. But how real are they for decision-makers who are bombarded daily with climate change reports from around the world? Where does the NWT fit into the larger picture of global climate change? How are northerners experiencing climate change right now and what are they doing about it? What key scientific findings point to the urgency of this issue? These are the kinds of questions addressed by this paper.

The North's Changing Climate

The Earth's climate has been changing naturally for millions of years. But human activities which release carbon dioxide and other heat-trapping gases are quickly warming the planet like never before through the "greenhouse effect." Scientists predict that the North could heat up over the next fifty years by 5°C or more, with the most dramatic warming happening in winter. On top of that, average temperatures in the North are rising over twice as fast as the rest of the world. No one has ever seen changes like this.

Major landslide in the Mackenzie Delta caused by melting permafrost. (Jamie Bastedo)

Coastal communities are losing ground and infrastructure to violent storms. Unusual floods have caused widespread damage in some Mackenzie Delta communities. Melting permafrost is costing many communities lots of money in extra road and building repairs. Unpredictable ice patterns make winter travel more dangerous and less reliable for industries that depend on ice roads. The list goes on. Climate change affects each community in different ways. But none are free from its impacts.

This summer has been really hot so far, and it's too early for this warm weather. The sun came up early this year, I haven't seen it like this before. I didn't get a chance to get on the land this spring, it all happened so fast.

- Elias Aviugana, Inuvik Elder [12]

None of the elders have seen this in their lifetime. We should be skating and ski-dooing out on the bay like we were doing last [October].

- Merven Gruben, Tuktoyaktuk [13]

Perennial ice cover continued to decline at an even faster rate of 9.2% per decade, which is faster than previously reported. The most rapid retreat in the perennial ice cover has been occurring in the Beaufort Sea region while the [land] surface temperature has been steadily going up in adjacent regions.

– Josefino Comiso, *Impacts of a 2°C Global Warming on Arctic Sea Ice Cover*

The Big Picture

In a recent international bestseller about global climate change, *Heat: How to Stop the Planet from Burning*, British author George Monbiot lists some of the many perils faced by the people of northern Canada.

> *While in the temperate parts of Europe the graver impacts of climate change will be slow to arrive, in Canada they are already knocking on your door. The Arctic is warming much more rapidly than lower latitudes, with serious consequences for the culture and subsistence of your native peoples; for biodiversity and for infrastructure: already roads and airstrips which will cost billions of dollars to replace are beginning to sag and split as the permafrost melts. As the tundra warms, it could release the massive store of carbon dioxide it contains, greatly accelerating global warming.*[14]

Sweeping statements like this are scattered widely across the popular media but they often ignore what is actually happening "on the ground" in different parts of the North. Just as climate change is expressed in different ways and degrees across the planet, so is there much variability across the circumpolar world. For instance, summers in some parts of Canada's eastern arctic are actually *cooler* than they were decades ago. On the other hand, Canada's western Arctic, much of which falls within the Northwest Territories, is one of the fastest warming regions on earth. In some cases, these changes are happening at a pace that outstrips science's ability to accurately predict them. For instance, the decline of perennial sea ice off the NWT's arctic coast is declining much faster than the most accurate climate models had predicted just ten years ago.

The focus of this paper is on climate change in the NWT. However it also includes impacts from other parts of northern Canada which shed light on the NWT situation. To understand these impacts, it's first useful to view them broadly in the context of the wider world.

Summary of Northern Climate Change Impacts[15]

- Warmer winter temperatures
- Less predictable ice conditions
- Shorter winter road seasons
- Invasive species (eg. white-tailed deer, magpies, cougars)
- More insect pests
- Thawing of permafrost
- Higher sea levels
- Increased forest fires
- Melting sea ice
- Impacts on fish and wildlife (eg. lake trout, caribou, polar bear)
- Less predictable weather patterns
- Shifting vegetation zones (shrub and tree encroachment on tundra)

Massive cement barriers piled high on the fragile shores of Tuktoyaktuk where rising seas and more violent storms have cast a shadow over the town's long term future. (Jamie Bastedo)

The Big Picture

What's our carbon count?

Greenhouse gases at an all-time high

- Ice cores from ancient glaciers show that levels of greenhouse gases in the atmosphere such as carbon dioxide and methane are now higher than they have been for 650,000 years.[16]

CO_2 rising faster than ever

- Carbon dioxide levels have been rising over the past century faster than at any time over the past 20,000 years.[17]

...and temperatures too

- The Earth is heating more rapidly than it has at any other time during the past 10,000 years.[18]

Arctic emissions among highest

- While carbon emissions across much of Europe are falling, in Canada they have been rising for over 10 years.[19]
- Canadians emit an average of 22 tonnes of carbon a year. In the NWT, the carbon released from all activities is almost twice that, at over 40 tonnes per person.[20] This represents 40 times the level that the United Nations says we need to slow down climate change.[21]

We're already over the top

- The sustainable limit for carbon dioxide emissions per capita is 1.2 tonnes, one sixteenth of what most Canadians now produce.[22]

Today's impacts

North warming faster

- The average global temperature has climbed by 0.6 degrees C in the past 100 years.[23] Meanwhile, in northwestern Canada, winter temperatures have risen 4 to 7 degrees in just half that time.[24]
- Human emissions of carbon dioxide and other greenhouse gases are causing temperatures in much of northern Canada to rise 2 to 3 times faster than the global average.[26]

Shrinking sea ice

- Arctic sea ice has shrunk to the smallest area ever recorded by satellites.[27] Declining at approximately 10% per decade since the 1970s, it is now well over a million square kilometers smaller than the historic average.[28]

Rising seas

- Sea levels around the world have been rising by around 2 millimetres a year, partly because of melting ice and snow, partly because water expands as it warms.[30]

Rising storms

- The number of extreme weather events of all kinds has increased by 5 times since the 1950s.[31] Storms along the Arctic coast are often more violent due to lack of sea ice.

Thawing permafrost releases greenhouse gases

- Permafrost is already warming or melting across much of the North, causing the release of stored carbon in the form of methane which, in turn, contributes to more warming. Methane is a very powerful greenhouse gas because it retains 21 times more heat than CO_2.[32]

Changes of this magnitude will irrevocably alter arctic ecosystems, leaving behind a natural world that will be nearly unrecognizable to today's arctic residents.

– Lynn Rosentrater and Aynslie Ogden, *Building Resilience in Arctic Ecosystems*[25]

We saw several polar bears quite close to the ship. Polar bears must wait out the summer melt season on land, using their stored fat until they can return to the ice. But if winter recovery and sea ice extent continue to decline, how will these beasts survive?

– Roger Barry, Director, National Snow and Ice Data Centre[29]

Reductions in sea ice will drastically shrink marine habitat for polar bears, ice-inhabiting seals, and some seabirds, pushing some species toward extinction.

- Arctic Climate Impact Assessment[39]

Forests invade a great deal of the Arctic in the scenarios of global 2°C warming, largely at the expense of tundra area. In the most extreme warming scenario, tundra is reduced to less than half its present-day extent. These changes in habitat are likely to have far-reaching consequences for animal and plant distributions and ecologies, human activities in the Arctic, and important feedbacks to the climate system.

- Jed Kaplan, *Climate Change and Arctic Vegetation*[46]

Health impacts

- The World Health Organization estimates that 150,000 people a year are now dying as a result of climate change from more rapid spread of disease, altered storm patterns, new contamination pathways, and heat-related health problems.[33] Arctic people face new dangers traveling over weak or unpredictable ice.

Tomorrow's impacts

Hotter faster

- Most climate models predict that, on average, the earth's temperature will rise 2°C above pre-industrial levels by the middle of this century. The same models predict that Arctic winters will be significantly warmer, rising by 4° to 10°C. Arctic warming in summer will be less pronounced but would still exceed southern latitudes.[34]

Good-bye permafrost

- 50% of the top 3 meters of permafrost - which supports much northern infrastructure - could thaw across the North by the year 2050 and as much as 90% by 2100. This thawing would alter ecosystems, damage buildings and roads, alter streamflows, destabilize tundra lakes, and release vast amounts of carbon into the atmosphere.[35]

Ice-free Arctic Ocean

- If sea ice continues to shrink at current rates, the Arctic summer will be completely ice-free well before the end of this century, causing widespread ecological change.[36]
- Multi-year sea ice is now melting at a rate of nearly 10% per decade. If current trends continue, polar bears and other species that require a stable ice platform for survival could become extinct well before the end of this century.[37]
- In the Arctic Ocean, temperature varies only a few degrees (-2 to +3° C), so any increase in temperature could have major impacts on the marine ecosystem.[38]

Wetter, snowier North

- Climate models predict a general increase in precipitation across the North for all seasons. This will lead to greater snow depths and more summer rainfall. These changes will in turn have a pronounced effect on river hydrology and fish ecology.[40]

Altered pollution pathways

- The pathways by which chemical pollutants enter Arctic food chains are strongly influenced by climate change. Some northern regions will experience drops in contaminants while others will see them rise.[41]
- Polar bears and other marine mammals stressed by climate change will be more susceptible to the impacts of chemical contamination.[42]

Vegetation changes

- Up to two thirds of tundra vegetation could disappear with a 2 degree global warming scenario during the next 200-300 years.[43,44]
- Heat-sensitive arctic plants may become extinct because they will be unable to adapt to the Arctic's rapidly changing climate or compete with invasive species.[45]

Carbon legacy

- Regardless of plans to reduce greenhouse gas emissions, the carbon released now will stay in the atmosphere for 100 to 300 years causing climate change impacts far into the future. But it is never too late to act. Whatever we do, the greater the cuts we make, the lesser will be those impacts. And the sooner we act, the more effective the cuts. [47]

What's Happening? - Part 1

Most people in southern Canada experience less direct impacts from climate change than Northerners. This can be a major obstacle to developing strong, nationwide programs to tackle climate change, especially when the most powerful decision-makers live in the south. Many politicians who could take such action - and the public whom they represent - just don't feel it the same way Northerners do.

Global climate models and stirring headlines in major newspapers can't speak to the daily challenges most Northerners face in their own fast-changing backyards. The following 18 "stories" blend the voices of field scientists and local residents who know the land best. They are presented here from south to north, reaching from northern Alberta to the high Arctic islands. Together, these stories paint a vivid picture of what's actually happening on Canada's frontlines of climate change.

Climate change alters levels of Canada's second largest lake

When water levels go way up or down on Great Slave Lake, or its main feeder, the Slave River, talk on many northern streets is about what's causing it. Is it BC Hydro's Bennett Dam which controls the flow of the Peace River, the Mackenzie basin's largest tributary? Is it the Alberta Tar Sands project which siphons large volumes of water from the Athabasca River, another major tributary? Or is it climate change, which is bringing altered rain and snow patterns to northern Canada? According to a recent study[48] by scientists at the National Water Research Institute in Victoria, the answer is likely: "All of the above."

At over 450 kilometres long and 80 wide, Great Slave Lake is the second largest lake entirely within Canada and the 10th largest in the world. About 75% of the water entering this massive lake comes from the Slave River which, in turn, is fed by the Peace-Athabasca system.

By analyzing river flows, lake levels, hydro dam releases, and climate data as far back as 1938, this study showed that, soon after the Bennett Dam started operating in the early 1970s, it caused yearly high water levels in Great Slave to *drop* by about 15 centimetres. It also shifted the arrival of high water to about a month earlier - reducing the natural flow of water in springtime and increasing it in winter when electrical demands are highest. Meanwhile, climate change has brought more precipitation to the region which has tended to *raise* yearly high water levels by about 10 centimetres. At the same time, shorter winters have contributed to earlier peak flows. The upshot: climate change and the Bennet Dam have had a counterbalancing effect on water levels, partly offsetting each other. On the other hand, both tend to shift the high water season away from spring towards winter.

Paddlers on Great Slave Lake. A water body this huge is not immune to the pervasive touch of climate change. (Jamie Bastedo)

The amount and timing of peak flows are critical to the maintenance of healthy fish and wildlife habitats along the North's great rivers and lakes. These factors also play a big role in the safety and viability of water-based transportation. Clearly, climate change is one of several complex factors to consider when managing northern waters.

I've got a trapline here on the [Slave] river too, and I've never seen it so low in my life.

- Guy Thacker, Barge operator and trapper, Fort Smith[49]

You're paddling through one of the world's major weather machines. These huge river basins drive the whole weather systems of the planet. You mess up the Slave valley, you're messing up the weather.

- Patrick Simon, Fort Resolution, Deninu Ku'e Nation [50]

Lower water levels during fall and winter could affect fisheries and reduce the probability of spring flooding in wetlands and deltas.

- Stewart Cohen, *Climate change [and] the future of the Mackenzie Basin* [51]

Something is happening here that is not right. Water is becoming a central environmental issue for everyone - not just in [Fort Smith], but nationally and internationally. If we destroy that we'll be destroying ourselves, ultimately.

- Francois Paulette, Fort Fitzgerald[52]

Environmental indicators used for generations to predict weather and aid hunting and travel over sea ice no longer work reliably. With temperature and precipitation increasingly unpredictable and the look and feel of the land becoming unfamiliar, it is increasingly difficult for Inuvialuit to read the land and follow the seasons.

- Sheila Watt Cloutier et al., *Responding to Global Climate Change*[56]

It is baffling, this change that has occurred over the last few years. It is starting to make hunting chaotic. The weather is harder to forecast and has led to a lot of unfortunate situations where Inuit have lost their lives.

- Norman Attungalak, *Elders Conference on Climate Change*[57]

We can't read the weather like we used to. It's changing our way of life. We've always had extreme weather conditions. What is more extreme now is that there's no predictability.

- Rosemarie Kuptana, Sachs Harbour[58]

Climate change cuts at the heart of land-based cultures

Hunters in Lutsel K'e cut short their spring hunting season due to rapid thawing of ice on the East Arm of Great Slave Lake. Long-time fishermen in Hay River are no longer able to read the weather with any certainty and must depend entirely on radio or TV forecasts. In the traditional community of Trout River, east of Fort Liard, elders complain that they can't finish scraping and drying their moose hides because of too much rain. Trappers from Fort Simpson can't harvest fur-bearers during their peak fall condition due to slower, unpredictable freeze-ups. They worry that warmer weather may ultimately decrease the global demand for furs. Families spending part of their summers at fish camps in the Mackenzie Delta discover that higher temperatures are causing fish meat to peel off the skin before it can be properly dried and preserved. Beluga hunters along the Beaufort Sea coast abandon traditional meat caches carved into the permafrost because, as the ground thaws, these caches are no longer reliable. Shrinking ice in the Beaufort Sea threatens the viability of traditional polar bear hunts. Snow conditions in the high Arctic have become so inconsistent that hunters can no longer count on building igloos for shelter during trips on the land.

From one end of the NWT to the other, climate change is making traditional land-based activities more difficult. The impacts vary from community to community, depending on what activities people want to pursue and to what extent they rely on a wage-based economy. For example, in a 1994 case study from Aklavik, the community developed a clear vision of both traditional and wage-based "futures", concluding that traditional lifestyles would be most vulnerable to climate change.[53]

Climate change joins a long list of factors that impact the ability of northerners like Robert Hardisty of Willow Lake River to follow traditional lifestyles. (Jamie Bastedo)

Climate change joins a long list of factors which affect the lifestyle options of northerners. With or without climate change, traditional livelihoods are already very much in flux, and any impacts must be weighed in that context. In a survey of climate change impacts across the Mackenzie basin, University of BC researcher Stewart Cohen suggests that the pace of climate change could outstrip some communities' ability to adapt. "There is a real concern that if future changes were fast, dramatic, and surprising, Native communities would be left in a very vulnerable position. Traditional lifestyles would be at risk of disappearing."[54] Franklyn Griffiths, an Arctic affairs expert from the University of Toronto agrees. "There's a real worry that the physical basis for the culture will be wiped out. There's a cultural genocide implied."[55]

Yellowknife battles thawing permafrost on main street

From shifting buildings to broken sewer pipes, Yellowknife is already experiencing some of the negative impacts of a warmer northern climate - and paying the price to protect its infrastructure.

There's a big hill on Yellowknife's main street, Franklin Avenue, that used to be well known for its crazy potholes, dips and dives. Its roller-coaster pavement required nearly constant maintenance and was covered with countless patches and fill. The problem was melting permafrost underfoot.

As Franklin heads north down to Old Town, the underlying sediments change from well-drained sands in the downtown core to ice-rich silts and clays near the base of the hill. To make matters worse, the permafrost in this area is very "warm", hovering just below zero, making it especially sensitive to warmer temperatures.

In 1990, the City decided to tackle the growing problem of melting permafrost by trying to remove all the ice-rich soil under the road and replace it with gravel. But the deeper they went, the more ice they found. It was like emptying a river with a teacup. In went tons and tons of gravel, topped with a conventional layer of heat-absorbing pavement.

Within less than a decade, water and sewer systems beneath the new pavement began failing as sidewalks dipped precariously towards a sinking road. Franklin was a roller-coaster once more. By 2004, it was time to rip up the road and try again.

Expecting warmer days ahead, the City decided to invest in a cutting edge pavement liner called "Cematrix." This light but amazingly strong material is full of air cells which help stabilize frozen ground by keeping the cold in and heat out. It's much more expensive than foam or rigid insulation - which had been used on some Yellowknife streets with little success - but the City hopes that, over the long term, it will slash repair and maintenance costs, and prolong the lifespan of the underlying ice - and Yellowknife's busiest road.[59]

Franklin Avenue snakes down towards Yellowknife's Old Town. An insulating layer of cellular concrete protects underlying permafrost from melting. But for how long? (Trevor MacInnis)

Thawing shoreline prompts water warning in Yellowknife

Bottled and filtered water was flying off store shelves in Yellowknife for most of June, 2004, after the City issued a boil-water advisory due to unusually cloudy tap water. Local health officials with the Stanton Medical Health Authority warned of the potential of bacterial contamination due to the increase in suspended solids. The turbid water had became somewhat of a mystery after City staff assumed it would clear up in a few days once the year's usual spring run-off had run its course. But with the boil-water advisory into its second week, it became clear that something else was at play.

Tim Bastedo conducts bird survey during break-up on the Yellowknife River. (Jamie Bastedo)

The cause of the higher than normal turbidity was eventually traced to a shoreline collapse along the Yellowknife River six kilometres upstream from Yellowknife's water intake. During a helicopter tour of the river, public works and health workers spotted a large plume of silt and sand released into a narrow stretch of shallow water just above Cinnamon Island. The adjacent riverbank had fallen into the river due to melting permafrost, releasing massive amounts of sediment into the water. The current then picked up the silt and carried it downstream - directly into the mouth of the City's main pumphouse.

Repeated tests throughout Yellowknife's water advisory, which lasted over two weeks, revealed no bacterial concerns. Once the water cleared and the advisory was lifted, the City had to open fire hydrants across town and release water in an effort to flush out service lines and fill them with fresh, clean water.

Did that riverbank collapse because of climate change, creating a prolonged water crisis in the NWT capital? No one can say for sure. What is certain is that similar disruptions to water services should be anticipated - and prepared for - as the northern climate warms.

While building in the North has always been challenging, melting permafrost will add a huge additional challenge.

- Ecology North, *Towards a Dehcho Regional Climate Change Plan*[60]

The permafrost [below Franklin Avenue] was very warm, being only about -0.3 oC at a depth of 7 m. Thaw settlement and frost heaving were considered serious problems in several places.

- Stephen Wolfe, *Living with Frozen Ground*[61]

Nature is always challenging. The cellular concrete solution was the best balance of cost and performance for the hill. Over the years we'll be able to evaluate it.

- Greg Kehoe, City of Yellowknife[62]

There's the potential to have contamination with bacteria.

- Dr. Kami Kandola, Territorial Health Authority[65]

Climatic events that have occurred in the recent past, which caused disruptions to water services, are due to both temperature and precipitation. These are not necessarily due to climate change, but there is a direct link from climate to water services in these events...Thaw slumping is definitely a phenomenon that will increase with climate change.

-Krystal Thompson, *Impacts of Climate Change on Municipal Water Services*[63]

Ice road meltdowns cost time and money

Imagine a huge, energy-intensive mine where all supplies and fuel can be delivered by road for only 8 to 12 weeks each year. Now cut that window in half. In 2006, that's exactly what happened to BHP Billiton which operates the NWT's Ekati diamond mine, normally accessible by ice road during a small operating window in the winter. That year, unseasonably high temperatures forced the ice road to close several weeks early before site machinery, building materials, and fuel oil could be trucked to the mine. The early closure meant that almost 200 truckloads had to be flown by Hercules aircraft to the remote mine, some 300 kilometres northeast of Yellowknife. To make up the backlog of supplies, the number of cargo flights per week was almost tripled from 7 to 20. This schedule continued for several weeks, adding millions of dollars to the mine's transportation costs.

The Tibbit-Contwoyto ice road - the main winter artery serving several tundra mines - operated for just 42 days in 2006 compared to 76 in 2005. Even before the early closure, many trucks operated at half-capacity due to unstable ice conditions. Ice roads connecting communities were also impacted by the unusually high temperatures. For instance, in 2006 ice on the Mackenzie River crossing near Fort Providence was the thinnest on record.

Did the winter of 2006 represent an isolated bout of warm spring weather? Long-term trends for the Mackenzie River ice crossing suggest not. Over the last 40 years, it lost about 30 days of operation time. During that same period, the region's temperatures rose by about 6 degrees. Averaged across the NWT, the season for safe operation of winter roads is now 40 per cent shorter than it was in 1985. Today's trends for both temperature and ice conditions clearly point to shortened ice road seasons. It seems that climate change will continue to nibble away at these temporary transportation corridors so vital to northern commerce and communities.

Aber Diamond Corp. [reported] that the early closure of a winter ice road serving the Diavik diamond mine could add $18 million US to the company's costs.

- CBC News[66]

Shorter and less dependable winter road seasons have increased costs and reduced the reliability of getting goods and materials into remote locations where there is no other form of surface transportation.

- NWT Greenhouse Gas Strategy[67]

We can't fight the weather or predict it. In the face of that, the [Tibbit-Contwoyto] ice road isn't healthy. That area is not safe from an environmental or human perspective.

- Tom Hoefer,
Winter Road Joint Venture[68]

Tandem trailer fuel truck heads south over a frozen lake after dumping its load at a remote tundra mine.
The season for such cargo hauls is getting shorter. (Diavik Mines)

The world is a mine and the North is a canary. The land is literally melting beneath our feet.

- Former NWT Premier Joe Handley[2]

Arrival of white-tailed deer raises concern for moose and caribou

Cougars and coyotes, black-billed magpies and American crows - the list of "new" species that have rapidly expanded their range north of Great Slave Lake in just the last decade or two seems to be growing fast. And now, apparently, white-tailed deer. This species captured much media attention across the NWT when Dettah hunter James Sangris shot a mature doe on October 17th, 2007 near Wool Bay just south of Yellowknife. "I was surprised," said Sangris, 50, who has hunted most of his life.

A handful of rare sightings of white-tailed deer in the North Great Slave region go back about 30 years. But over half were spotted after 1998 suggesting a trend towards range expansion. A few weeks before Sangris bagged his deer near Yellowknife, Henry Chorney from Fort Good Hope shot a three-year old white-tailed buck at Little Chicago - the first ever recorded north of the Arctic Circle. Commenting on the northern rise in harvested deer, University of Alberta biologist Stan Boutin said[69], "Now that people are able to actually shoot them suggests that numbers are getting reasonably high."

Dettah hunter James Sangris beside a female white-tailed deer, one of several new species spreading north into the Yellowknife region. (GNWT)

The reasons for the northward spread of white-tailed deer aren't entirely clear but climate change is likely a major factor. Like other recent arrivals to this region, this is a highly adaptable and biologically productive species, well suited to take advantage of new habitat opportunities offered by the North's warmer, shorter winters. The arrival of deer to this region may represent a bonus to biodiversity and hunting options. On the other hand, this species may bring a host of ecological concerns.

Abundant deer populations tend to draw more predators like wolves and bears which, in turn, can spell trouble for woodland caribou and moose. A brain worm carried by deer, but causing them few problems, can be fatal to moose. In New Brunswick and Nova Scotia, a dramatic decline in moose numbers has been directly linked to the expansion of white-tailed deer onto their range. Another parasite, the deer liver fluke, can also cross over to moose causing serious internal infections and weakness.

The northward spread of white-tailed deer shows that, as new species adapt to our changing climate, northern ecosystems must, in turn, adapt to them.

No white-tailed deer had ever been reported north of the Arctic Circle before. That one just floored me. Who knows where the next one will show up? Inuvik?

– Alasdair Veitch, GNWT biologist[70]

When you increase any alternate prey [because of] more deer, that really upsets the apple cart and the caribou take it on the chin. We're in a real mess in Alberta with our caribou. One has got to be very aggressive in trying to prevent further expansion of species or you'll face the problems we're facing in the South.

– Stan Boutin, University of Alberta biologist[71]

It is widely acknowledged that [brain worms] carried by white-tailed deer, but fatal to moose and other cervids, have caused widespread population declines where deer have invaded [their] ranges.

– Oswald Schmitz et al., *Parasite-Mediated Competition in Deer and Moose*[72]

We can't read the weather like we used to. It's changing our way of life... I believe the Arctic is a very important ecosystem to the health of the rest of the planet. I guess what we can do is just try and educate people and say: "Hey, watch out, this is what's happening to us."

- Rosemarie Kuptana, Sachs Harbour[1]

Climate change alters flow of Canada's largest river

People living on the Mackenzie River can expect to see big changes in its streamflow throughout the year according to a study on the potential impacts of climate change on Canada's largest river. This study, conducted by University of Victoria hydrologist Vivek Arora, predicts that water levels in the Mackenzie will be lower in spring and summer than they are today, but will rise during the fall and winter.[73] The main reason for this is that snow-melt, a major source of river water in northern Canada, will likely come a lot earlier in a warmer climate. Arora's study shows that an early snow-melt, predicted by most climate models, could shift the river's peak flow - usually arriving in May or June - by 21 days to arrive as early as mid-April.

Arora predicts not only an earlier peak flow but also a marked lowering in the volume of spring flows - by as much as 17%. This is because, for snow-fed rivers like the Mackenzie, the spring flow volume depends a lot on the amount of snow stored up the winter before. With shorter winters, more of the year's precipitation will likely fall as rain, rather than snow. Less snow stored over the winter means less runoff in springtime when it melts. On the other hand, a longer rainy season could mean higher volumes of water flowing in the fall and winter.

Many climate change models predict that northwestern Canada will experience an increase in annual precipitation which could result in an overall boost to the Mackenzie's average *yearly* flow. But Arora's work shows that, as the climate warms, dramatic changes in the timing and amounts of river flow *from season to season* are very likely. These changes could, in turn, have wide reaching impacts on fish and wildlife movements, shipping, flood patterns, bank stability, ice roads, and ferry crossings. Just what this would mean for people using the Mackenzie - traveling its waters, crossing its ice, fishing and hunting along its shores, and building near its banks - is as yet unknown.

Canoeists wave at a passing barge train chugging up the Mackenzie River. Altered river flows brought by a warmer climate could impact activities like this. (Jamie Bastedo)

In a warmer world, the snow that used to give high flows during spring is reduced, and hence lower water levels in summer.

- John Fyfe, Environment Canada climate scientist[74]

Relatively modest changes in temperature and precipitation can have a marked effect on the volume and duration of spring runoff, as well as the intensity of flooding and drought.

- Natural Resources Canada[75]

The people of the Dehcho recognize that water is their most important resource.

- Dehcho Keepers of the Water Declaration[76]

The hydrology of the North is particularly susceptible to warming since snow and ice drive virtually all of the major hydrological processes and related aquatic ecosystems.

- Lynn Rosentrater and Aynslie Ogden, *Building Resilience in Arctic Ecosystems*[77]

Climate remains the critical determinant of the destiny of the Arctic people...Nowhere else in the world are people's food choices and an ecosystem's health tied so strongly to climate.

- Marla Cone, *Silent Snow: The Slow Poisoning of the Arctic*[3]

The changing footprint of northern forest fires

In many parts of northern Canada, climate change appears to be shrinking the gap between record-breaking forest fire seasons. This used to be measured in decades. Now, previous heights in fires fought, hectares burned, and dollars spent are often surpassed in two or three years. For example, during the summer of 1994 forest fires burned a record-breaking 3 million hectares, an area over five times the size of Prince Edward Island. That fire season, 627 fires were fought - over 3 times above average - and the fire fighting bill climbed to $30 million. The next summer was almost as bad, with 2.8 million hectares burned. That year, all of the 900 residents of Fort Norman (now Tulita) and Norman Wells were evacuated because of a 58,500-hectare fire that burned out of control for almost 2 months. The price tag for attacking that one fire was almost $3 million.

A massive forest fire licks at the outskirts of Fort Norman during the summer of 1995. Climate models predict warmer temperatures and longer burning seasons for the Mackenzie valley region. (Courtesy Jim LeFleur)

2004 was another blockbuster year for forest fires from northern Alberta to Alaska. In the NWT, the number of fires doubled, covering nearly seven times more forest than the previous summer. That same year Alaska suffered the largest total timber loss in its 56-year record.

Boreal ecologists link this upward spiral in wildfires to warmer temperatures, drier forests, parched soils and a longer burning season. Many climate models predict more unstable, stormier weather in the North. That means increased lightning, which starts most forest fires, and more wind, which spreads them around. The same models predict that the forest fire season over much of the Mackenzie basin will increase by 30 to 50 days. The blazing summers of both 1994 and 1995 were only 1.5° C above normal, coupled with below average rainfall. In contrast, climate predictions for the Mackenzie valley call for a 4 to 5 degree increase in summer temperatures.

Such changes in climate, combined with the extra carbon released from more burns, could spark a perilous upset in fire's ancient balancing act between destroying the forest and rejuvenating it. Over the next few decades, this balance may tip towards destruction, resulting in a net loss of boreal forest even as it advances northward onto the tundra[78].

The North is a barometer of climate change,
and and a harbinger of what lies in store for the planet.

- Ron Freedman, *Canada Research Horizons*[1]

It was like the hand of God went up and stopped the [1995] fire smack at the edge of town!

- Jim LeFleur, Tulita[79]

In a climate change scenario, forest fire years like 1994 and 1995 could become more common.

- Stewart Cohen, *Climate change [and] the future of the Mackenzie Basin*[80]

If we liberate that carbon [stored in the boreal forest] it has the potential to hugely increase global warming. The problem is that most of that carbon ends up in the atmosphere. The boreal forest is not so much a vacuum cleaner sucking carbon out of the air. Its most significant role is as a pool of carbon. People call it the "carbon bomb".

- Jay Malcolm, *Impact of Climate Change on Canada*[81]

Even though [lost fish species] might be replaced by warm-water assemblages, it is by no means certain that fisheries of comparable value or ecosystems of comparable diversity would be reestablished quickly.

- David Schindler, Freshwater biologist[83]

It is an indication of climate change because historically the water temperatures in the Mackenzie River have been too cold for [salmon] to successfully live and make it back out to the ocean.

- Erin Hiebert, DFO fisheries biologist[84]

I didn't know what kind of fish it was. I had to call the Department of Fisheries and Oceans up to define it...There seemed to be more, and different kinds, too. They were catching them all over the place, Arctic Red, and McPherson, and Aklavik.

- Willy Simon, Inuvik Fisherman[85]

Warmer waters bring good news and bad for northern fish

Another concern posed by climate change is the impact of warmer waters on fish, especially those species prized as traditional country foods. What's the prognosis? Good for some species, not so good for others according to a team of freshwater biologists led by David Schindler at the University of Alberta. For over 20 years, his team studied the effects of climatic warming on lakes in northern Ontario. The results of his "Experimental Lakes Project" provide a preview of how climate change may affect boreal lakes and rivers across northern Canada.

One of Schindler's most disturbing discoveries was that, as temperatures rise, several cold-adapted species including lake trout may be "locally extirpated" - they may disappear - from many smaller lakes. His team predicts that, in some northern rivers and lakes, the cold, oxygen-rich bottom layers which lake trout depend on in summer may shrink significantly or disappear altogether. Once trout and other cold water species are gone, there is no guarantee that other warm water species like northern pike or walleye will simply move in and take over the empty habitat.

On the other hand, sockeye salmon may be benefiting from warmer northern waters, particularly in the Mackenzie River. Usually found off the BC and Alaskan coasts, this species was observed in the Beaufort region a few times back in 1965 but never in the Mackenzie. Then, in 2003, people from one end of the Mackenzie Delta to the other started discovering salmon surprises in their fishnets. Their observations led the Department of Fisheries and Oceans to launch a monitoring study of the rise of saltwater fish in the Delta. "It's hard to tell if [salmon are] actually occurring more now, than in the past," says DFO biologist Sam Stephenson, "Or it's just that people know we're interested and they're reporting it more. People do know that the appearance of salmon may be an indication of climate change. [It] may be an indicator that things are changing very rapidly." [82]

Inuvik fisherman Willy Simon holds a fresh whitefish. Warmer waters may be responsible for the spread of sockeye salmon across the Mackenzie Delta. (Jamie Bastedo)

The Puzzle Takes Shape

The picture that emerges from these nine stories is one of subtle but widespread changes - big changes that effect entire ecosystems, economies and cultures. In the Northwest Territories, climate change is already shifting the water levels, flows and temperature of our largest lakes and rivers, creating as yet unknown ripples for shipping, flooding, and fish and wildlife habitat. It is nibbling away at our vital network of ice roads, boosting transportation costs for remote communities and industry. It is threatening the provision of such basic commodities as clean water, smooth roads, and healthy moose. It is altering the way in which northern forests burn and regenerate. It is eroding the lifestyle options of northerners, especially the ability to pursue traditional activities on the land.

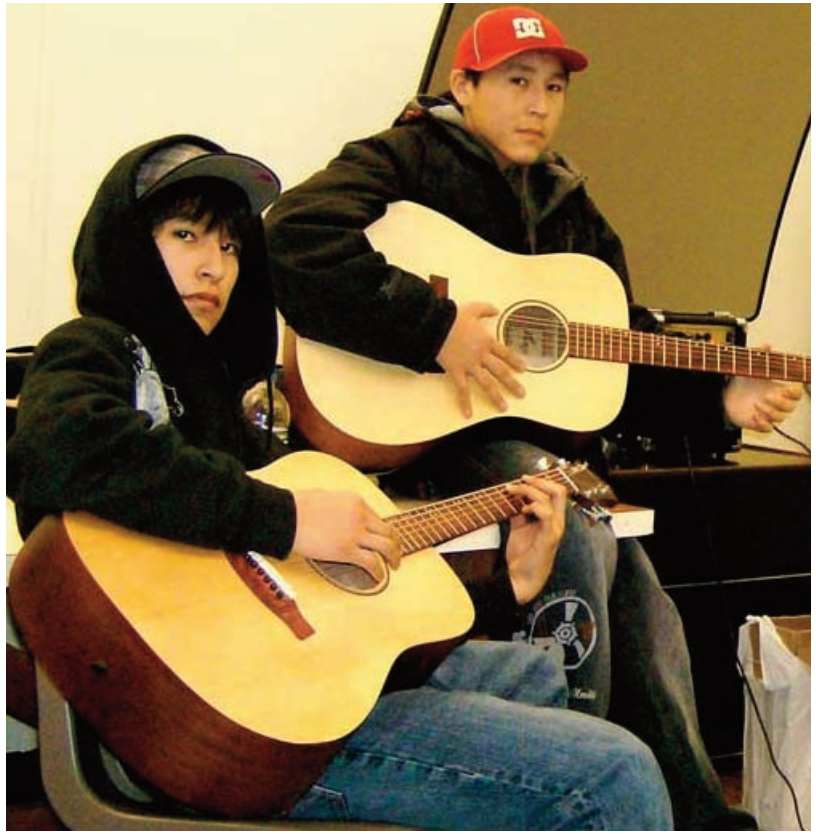
What's Happening? - Part 2

Northerners brace for heavier snow loads

While spring snow cover has declined rapidly in the Arctic over the past 40 years, disrupting the normal flow of rivers, the total amount of snowfall for many northern regions has actually increased. For Inuvik residents, this new face of climate change came dangerously close to home on May 5, 2004 as they dug out from under piles of warm, wet snow. That morning, students got a shock when they arrived at the Samuel Hearne secondary school to see that the roof of the foyer had collapsed. The cause: a record-breaking build-up of snow. Just minutes before the school doors were to open for the day, tons of cement, steel and snow crashed to the floor of the foyer, one of the most well-used gathering places in the school. Miraculously, no one was hurt in the collapse.

News of the near tragedy quickly spread across the country, tied inevitably to the spectre of climate change. Higher temperatures and heavier snowfalls often go hand in hand, a trend climate models predict for this region. The GNWT's Department of Public Works took the school cave-in as a wake-up call to climate change. The roof structures of more than 150 of its buildings were carefully inspected to make sure they could stand up to heavier snow loads. During a top to bottom inspection of the school, it was discovered that its building piles, driven into the frozen permafrost, had become unstable. Deep, drifted snow around the base of the school may have insulated the ground, enhancing the effect of warmer winters on thawing permafrost.

Of the other government buildings inspected, two were found to need structural upgrades to accommodate heavier snow loads. The inspectors felt all their work was worth it. Given the high stakes of doing nothing to prepare for climate change, it's always better to be safe than sorry.



Students settle back into normal routines at Inuvik's Samuel Hearne Secondary School after a near disastrous roof collapse caused by record snowfalls. (Samuel Hearne school)

The [school] foyer collapsed because of the snow load. It is only by the grace of God that no one was injured or killed. Here we are in October and the school has yet to reopen, because it has been declared unsafe due to problems with the pilings.

– Michael McLeod, NWT Minister of Municipal and Community Affairs[86]

The roof was carrying the heavy load from the season's higher than average snowfall.

– Al German, Inuvik Fire Department[87]

This [snow load] study provides an example of how governments and communities are adapting to potential impacts of climate change.

– Bill Wyness, GNWT Department of Public Works[88]

To Arctic Indigenous peoples, climate change is a cultural issue...Climate change is already threatening our ways of life and poses everyday, practical questions, such as when and where we go hunting, and when and where not to travel. There is very little time for Indigenous peoples and the resources on which we depend to adjust and adapt.

- Arctic Council[4]

Declining caribou herds take multiple hits from climate change

Five of the NWT's eight barren-ground caribou herds are in decline, some by as much as 85 per cent, and the remaining three herds are uncertain at best. For example, the Cape Bathurst herd, which ranges around the Mackenzie River delta, has gone from an estimated 17,500 animals in 1992 to 2,400 in 2005. The Peary caribou which inhabit Canada's northernmost caribou range are officially designated as "Threatened". Several years ago, government officials anticipating their disappearance from the wild seriously considered establishing a breeding herd in Calgary.

Exactly what is driving these declines is not clear, and the reasons may be different for different herds. Natural cycles, industrial encroachment, predation, and hunting pressures are among many interacting factors which can shrink caribou herds. Superimpose the impacts of rapid Arctic climate change and this puzzle gets even more complex. Heat stress, altered plant growth, frequent forest fires, deep ice-encrusted snow, greater insect harassment - these are all factors directly linked to climate change which together add up to increased nutritional stress, a key driver in caribou declines.

Susan Kutz, a University of Calgary biologist, is looking at climate change impacts on caribou from yet another angle: parasites.[89] Her work focuses on how a warmer and wetter climate - already occurring in much of northern Canada - may influence the transmission of intestinal nematodes which, once well established in a caribou herd, can lower their fertility rates, reduce resistance to disease, and, in their weakened state, increase their susceptibility to wolves and other predators. Her research suggests that warming in the Arctic has radically increased the survival and development rates of some parasites and so, their infection rate in caribou. Unless today's climate trends are arrested or reversed, Kutz expects parasite infestations to increase, bringing tougher times ahead for caribou herds already struggling to survive.

The decline of caribou is one of the hottest environmental issues in the north. Nutritional stress is probably the main factor, caused by heavy, ice-covered snow in winter and increased heat and insects in summer. When faced with these kinds of challenges, they're just not spending much time feeding.

- Bruno Croft, Caribou biologist[90]

We know that caribou numbers are declining and we must take reasonable conservation measures now to prevent serious or irreparable damage to this resource.

- Michael Miltenberger, NWT Minister of Environment & Natural Resources[91]

When the buffalo went from the plains, the people of the plains, the Cree, the Dakota - their culture died, their spirit died. Here, we have a chance to save it.

- Fred Sangris, Chief, Yellowknives Dene[92]

These caribou from the Bathurst herd likely carry parasites that are spreading farther and faster as the Arctic warms. (Chris O'Brien)

Inuvik can expect foundation damage from thawing permafrost in up to 75% of its existing buildings. Supporting infrastructure such as the "utilidors" (foreground) will also be impacted.
(Jerry Peek)

Inuvik to feel the pinch of thawing permafrost

The stability of building foundations in many northern communities relies on the strength of the underlying permafrost. If the ground thaws, usually more than foundations need repairing. Whole buildings may tilt at odd angles creating structural damage from top to bottom - cracked windows, damaged drywall, stuck doors, broken plumbing, cold air leaks, or bent chimney systems causing smoke or fire hazards. Such problems can erode the quality of daily life for people living or working in damaged buildings and repairs can add up to a serious financial burden. In extreme cases of permafrost decay, damaged buildings have been abandoned and destroyed.

To help understand the scale of this growing problem, Natural Resources Canada did a case study of five communities across the NWT to assess the potential impacts and costs of thawing permafrost on building foundations. Out of all northern Canadian jurisdictions, the NWT was chosen for this study because of its strategic importance for northern resource development - such as major pipelines and mines - and, with that, the high demand for supporting infrastructure.

The results of this first-of-its-kind study shed a glaring light on the real costs of potential climate change impacts in northern Canada. Of the communities studied, Inuvik, long considered "a hot spot" in terms of permafrost hazards, stands to lose the most as temperatures warm, with foundation damages likely in up to 75% of its existing buildings, compared to 25% in Norman Wells for instance. In a fast warming climate scenario, the cost of doing nothing to prepare for permafrost decay in Inuvik could reach $120 million - and that's just for foundations alone.

In all communities assessed, this study concluded that proactive adaptation strategies - such as reinforcing foundations before major thawing begins - *could reduce costs by about two-thirds*. The take-home message seems clear. In adapting to the impacts of thawing permafrost, whether on building foundations, roads, or industrial infrastructure, northerners can pay less now to do it right, or pay more later - much more - by taking a "wait and see" approach and doing nothing to get ready for a warmer climate.

In the Arctic, even a slight shift in temperature, pushing averages to above freezing, can bring about rapid and dramatic changes in an ecosystem that is defined by being frozen.

- Lynn Rosentrater, *Understanding Dangerous Climate Change!*[15]

Our land is changing, some of the lakes are draining into the ocean and the permafrost is melting. Those communities located on soft or sandy soils are in for a lot of trouble should that happen. House foundations such as pilings are moving up and down, either due to the permafrost melting or the land moving.

- Tommy Pigalak, *Elders Conference on Climate Change*[93]

As the permafrost degrades, people's houses are starting to split apart. The roads need to be repaired more often; sometimes they just cave in.

- Elizabeth Colbert, *A Planetary Problem*[94]

In all case communities where climate change will likely cause foundation damage, it was found that 'informed adaptation' (i.e. [cost-effective] remedial measures) would reduce the impacts to about two-thirds of the costs with no action taken.

- Fuqun Zhou et al., *Potential climate change-induced permafrost degradation and building foundations*

Thawing permafrost sheds new light on old drill wastes in the Mackenzie Delta

In the quest for northern oil and gas, hundreds of exploratory drill holes have pierced the hydrocarbon-rich floor of the Mackenzie Delta. While rich gas resources have been discovered, luring pipeline builders north, the wastes created by all this drilling are a potential source of pollution which must be contained for decades to come. For over 40 years, drill wastes, composed of drilling fluids, rock cuttings, and cleaning agents, have been disposed in sumps - shallow pits dug into the permafrost, which are then backfilled to form a soil cap. The idea was - and still is - to permanently lock these toxic wastes into frozen ground to avoid leakage into surrounding waters, soil, or vegetation. How well have they worked?

An assessment of sump performance indicated that approximately 50% of sumps constructed in the Mackenzie Delta region during the 1970's have collapsed or are actively collapsing. Degradation of the sump cap indicated that drilling wastes were no longer immobilized in frozen ground... Climate change is changing the way we think about doing business on the land.

- Steve Kokelj, Permafrost scientist, Indian and Northern Affairs Canada[96]

Factors such as cap revegetation and climate warming may impact long-term sump-cap integrity indicating that a long-term management approach to drilling-mud sumps constructed in permafrost is necessary.

- Robert Jenkins, et al., Permafrost scientist, Indian and Northern Affairs Canada[97]

Drill site near the Beaufort Sea coast with waste sump in background. Permafrost is not so permanent these days, prompting new ideas for safely storing drill wastes. (NRCAN)

Since 1965, over 150 drill waste sumps have been constructed in the Mackenzie Delta region. Widespread collapse and ponding of the sump caps suggests that permafrost, the primary "glue" meant to stabilize these wastes, has decayed due to warming temperatures. When caps cave in, the surface water that collects can lead to further warming of the ground below, triggering yet more collapse and potential destabilization of drill wastes. In short, when permafrost starts melting, sumps can leak toxic wastes into the environment.

A recent joint study undertaken by Indian and Northern Affairs Canada and Ottawa's Carleton University discovered substantial ponding in about 40 per cent of the drilling sumps built before 1980.[95] Does this trend simply mean that construction of drill sumps in the Mackenzie Delta has much improved since 1980? Or does it actually reflect the gradual but inevitable decay of sumps over time? The study's authors could not say.

Lessons learned from the collapse of aging drill sumps and current temperature trends in the Delta's permafrost are being carefully weighed in light of a proposed pipeline and renewed interest in hydrocarbon exploration. Though drill waste disposal practices have indeed improved over the years, other climate change indicators in the region - from sea ice declines to the breaching of lakes - suggest that the days of relying on permafrost to safely contain toxic wastes may be numbered.

The Arctic has been referred to as a "battleground" for climate change research because of possible amplification of a global change signal in the region.

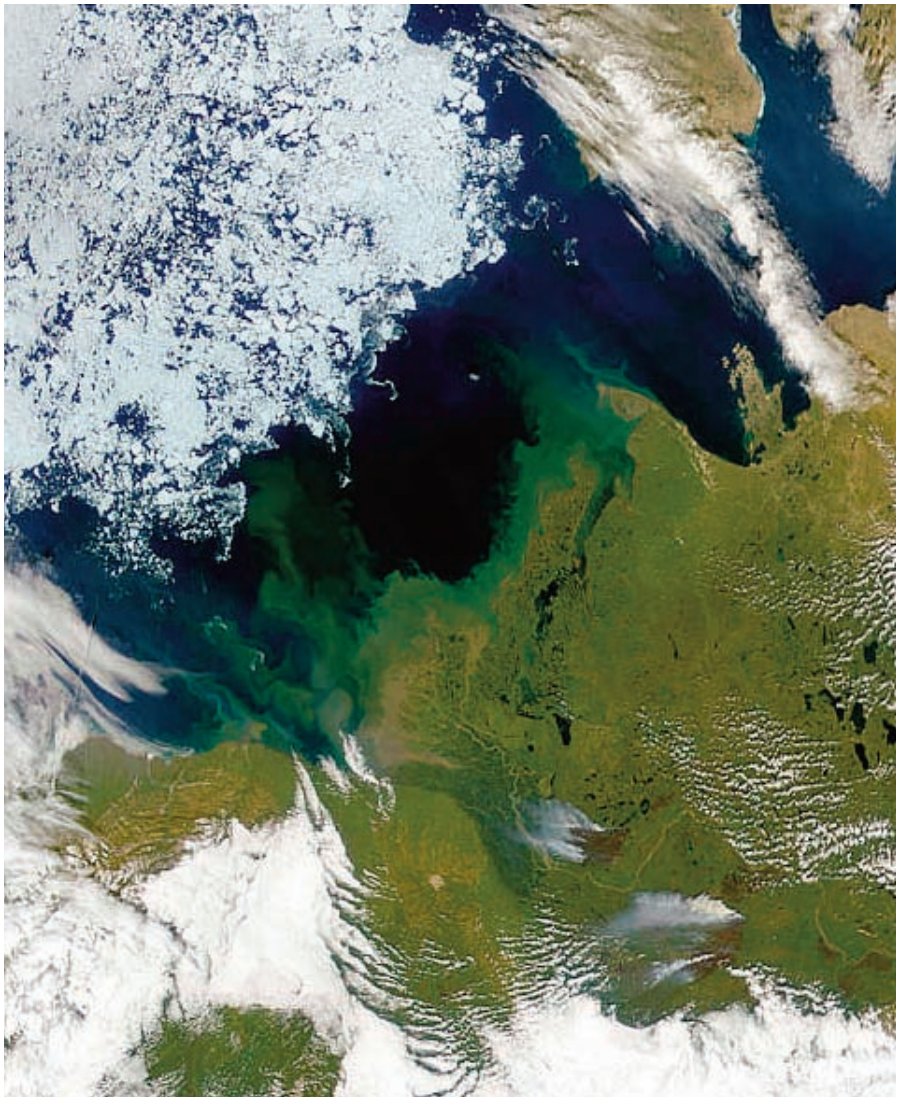
- Josefino Comiso, *Impacts of a 2°C Global Warming on Arctic Sea Ice Cover*[6]

Melting glaciers and beluga whales - what's the connection?

Between 2000 and 2005, the total yearly flow of water from both the Yukon and Mackenzie Rivers was much higher than normal. What's going on? Many climate models predict increased rain for northwestern Canada, a long-term trend which may already be a factor contributing to river flow changes. The same models predict that melting glaciers may increase the overall output of northern rivers, a trend which is well underway in other parts of the circumpolar world - particularly in Russian and Greenlandic rivers - and likely the Mackenzie.[98]

Runoff from glaciers into northern rivers and, ultimately, the Arctic Ocean has steadily increased over the past 20 years as a result of climate change. This could affect many aspects of northern ecosystems, especially marine organisms which are sensitive to changes in water temperature, salinity, oxygen levels, and clarity. The Mackenzie sends a warm, muddy plume of freshwater far into the Beaufort Sea, creating a unique transitional ecosystem in which beluga whales thrive. Changes in the Mackenzie's flow, in part fed by melting glaciers, could change the size and characteristics of that plume, visible from outer space.

In other parts of the Arctic, food chain components such as algae, zooplankton and fish populations that support whales and other large marine mammals, have been impacted by changes in water conditions near the mouth of major rivers. For instance, subtle changes in temperature and salinity were linked to a decline in some plankton and fish species and a rise in others. The ranges of some species expanded while others contracted.



A satellite view of the Mackenzie Delta and southern Beaufort Sea. Upstream changes such as melting glaciers could affect marine ecosystems near the mouth of the Mackenzie River. Note the forest fires south of the Delta. (NASA)

Beluga whales are prized by the Inuvialuit as a source of both nutritional and spiritual wealth. It may seem like quite a stretch to link melting glaciers in the Mackenzie Mountains to the health of beluga whales in the Beaufort Sea. But high-latitude oceans are particularly sensitive to shifts in the kind and amount of water flowing into them. The impacts of climate change can be complex and far-reaching, potentially sending ripples all the way down the Mackenzie River to offshore ecosystems and the beluga whales - and cultural traditions - they support.

The contribution of glaciers to the freshwater inflow to the Arctic and world oceans has been increasing as a result of climate warming and will affect many aspects of the Arctic climate system.

- J. Richter-Menge et al., *State of the Arctic*[99]

Based on substantial new evidence, observed changes in marine and freshwater biological systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation. These include shifts in [species] ranges and changes in algal, plankton and fish abundance in high-latitude oceans.

- International Panel on Climate Change[100]

I've been on every whale hunt over the last 30 years. This is what kept the Inuvialuit alive. As long as the whales came, we were okay. I work all year to come out here for a month. I wouldn't give this up for anything.

- Richard Binder, Whitefish Station[101]

It's going to need a lot of dollars to do all the work we need to do, and we don't have that kind of money. We're getting concerned enough that we'll have to get something done by next season. But at the present time, it all boils down to money.

– Ernest Pokiak
Former mayor of Tuktoyaktuk[102]

It's only a Band-Aid measure. A plan has to be developed to get an alternate lake. They're just going to have more problems in the future with further breaches, and right now the lake isn't holding a lot of water.

– Pete Cott
Fisheries biologist[103]

Breached lake creates water woes in Tuk

Climate change has cast a shadow over the security of basic water services for the people of Tuktoyaktuk, a community of about 900 located east of the Mackenzie Delta on the Arctic coast. In 1998, widespread thawing of permafrost caused by warming temperatures triggered a series of breaches threatening the integrity of the Kudlak Lake reservoir, Tuktoyaktuk's primary source of drinking water. It began with the rupture of a natural berm around Freshwater Lake, the upstream waterbody that feeds the Kudluk Lake reservoir. The reservoir's water rose quickly, spilling over its banks and carving two additional breaches. In turn, these breaches caused a dramatic drawdown of Kudlak Lake. Water levels fell so far and so fast that, after hastily plugging the breaches with rock weirs, residents worried there wouldn't be enough water to fill the reservoir again. A creek formed between the reservoir and Tuk Harbour, and water has been draining out to sea ever since.

Thanks to costly reinforcements, the water supply from the reservoir has continued unbroken since 1998. However, the looming threat of further uncontrolled drops in water levels, caused by permafrost decay, has forced the community to explore alternate water supply strategies, including moving the main water intake, building a new pumping station, and/or finding a more secure reservoir option at a different lake.

Here is a case where climate change had a direct impact on a northern community's ability to meet a very basic need: the supply of freshwater. In trying to adapt to further impacts like this, the hamlet of Tuktoyaktuk has tried to get the Territorial government to foot the bill for safeguarding its water supply system. To date, no additional funds have been made available.

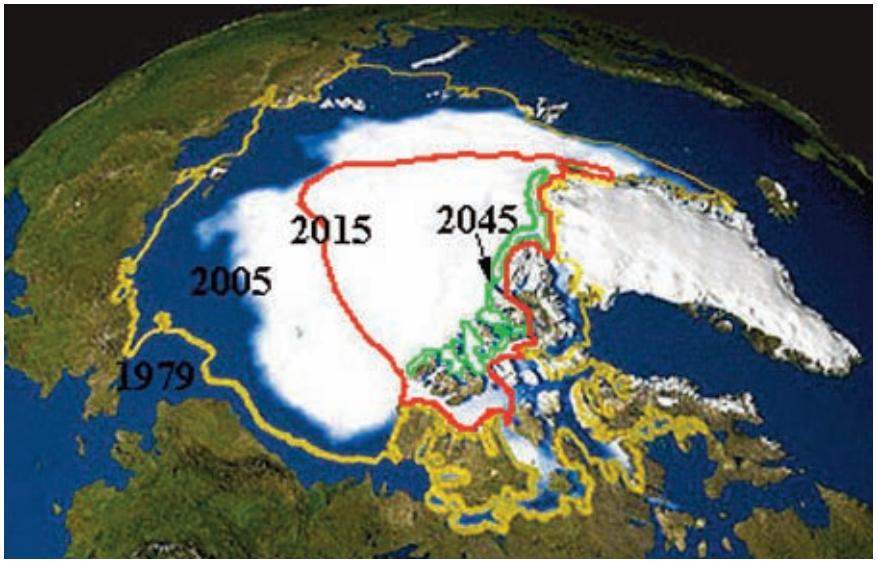
Melting permafrost threatens the freshwater supply of all Tuktoyaktuk residents including hanah Lucas and her dogs Deh Cho and Bambi. (Jamie Bastedo)

Arctic climate change is a major issue for our children and grandchildren. What we do now through mitigation will be of greatest benefit to them. In the meantime we must also adapt to make our lives a little easier.

– Henry Hengeveld, Environment Canada climate scientist[6]

Arctic sea ice decline sends ripples across the North - and the rest of the planet

It's no news: the Arctic sea ice is shrinking. It may even disappear this century. From 1979 through 2001, the rate of sea ice loss was just over 6.5 percent per decade. Beginning in 2002, this rate rose to 7.3 percent. Since then it has jumped to almost 9 percent per decade. Year after year, records are broken for the rate and area of ice loss. "Having four years in a row with such low ice extents has never been seen before in the satellite record," says Walter Meier of the National Snow and Ice Data Center. "It clearly indicates a downward trend, not just a short-term anomaly."[104]



September Arctic sea ice extent observed in 1979 (yellow line), and 2005 (white area). The predicted coverage of sea ice is shown for 2015 (red line) and 2040 (green line). By 2040 summer sea ice could occur only in narrow bands along the high Arctic coast. (M. Holland et. al.[109])

The loss of Arctic sea ice is one of the strongest proofs that our planet's climate is changing - and fast. But more than a symbol of global warming, shrinking sea ice contributes directly to rising temperatures worldwide. Just as light clothes reflect the sun's heat on a hot day, bright sea ice reflects much of its energy back into space. As sea ice melts, less energy is reflected as more is absorbed by the darker ocean waters. This creates a feedback loop in which melting sea ice causes yet more ice to melt - and higher temperatures across the planet.

Besides shrinking in area, the thickness of so-called "permanent" sea ice is also falling dramatically. Other signs of change include reduced surface albedo - a measure of how much solar energy ice reflects - and reduced age, indicating that older pack ice has broken up and been flushed out of the Arctic. The Beaufort Sea is an Arctic "hot spot" where all of these indicators show a marked drop.

Sea ice has been called the "ecological linchpin" of the Arctic since it is so intimately connected to northern ecosystems, both marine and terrestrial. Over 80% of Arctic tundra is within 100km of seasonally frozen seawater which cools the land enough for tundra to exist. A 2006 *State of the Arctic* report concludes that changes in sea ice boundaries could impact plant growth, wildlife, permafrost, soils, river flows, snow conditions, and of course, the people who call the Arctic home. [105]

The point is that ***we humans are speeding up [climate] change and making it worse.*** *Nature will cause any environment to change on its own. But the environmental damage we are doing all over the planet is making the change more profound and* ***this is nowhere more evident than in the Arctic.***

- Marianne Douglas, Director, Canadian Circumpolar Institute[9]

Even after warm summers, Arctic sea ice has typically recovered in wintertime, but this has changed in recent years. Besides showing dramatic retreat in the summer, Arctic sea ice has begun to decline in the wintertime as well. Some scientists have begun to wonder whether Arctic sea ice has crossed a critical threshold from which it can't recover.

- NASA, Record low for June arctic sea ice[106]

Feedbacks in the [sea ice] system are starting to take hold. There doesn't appear to be a way to turn this around, or even slow it down.

- Ted Scambos, National Snow and Ice Data Center[107]

Even in summertime, the bears stayed on the ice. Never came to land. But now you never see the ice during the summer. Lucky if you see ice now from a distance in summertime. It used to come close to the settlement. That was a good time. Lots of seals.

- John Keogak, Sachs Harbour[108]

Beaufort Sea polar bears among the most threatened by ice loss

Polar bears have become the "poster child" of global climate change, featured prominently in major media and environmental appeals. Often pictured on a pan of melting ice, such stirring images portray the threat of climate change to a species which depends on sea ice as a platform for hunting seals, seasonal movements, finding mates, and breeding. As the decline of Arctic ice accelerates, predictions of possible extinction of polar bears in the foreseeable future are grabbing headlines around the world. However, even as potential impacts of climate warming on polar bears become clearer, the popular press still seems divided on the reality of this threat.

Most [polar bear] populations have not been monitored long enough to assess a trend in numbers, let alone possible effects of climate change... However, if the climate continues to warm and negatively affect the duration, extent, and thickness of arctic sea ice as predicted, it will ultimately have a negative effect on all populations.

- Ian Stirling et. al., *Melting Under Pressure*[112]

The effects of climate change are becoming clearer. Climate change is the main threat to polar bears and is clearly implicated in the western Hudson Bay sub-population. It is likely also a key factor in the Southern Beaufort Sea. Climate stabilisation is the key conservation action now for polar bears.

- Andrew Derocher, Chair, IUCN Polar Bear Specialist Group[113]

Polar bear caught in a spotlight on melting Beaufort Sea ice. This population has declined by 17 per cent over the past 20 years. (Limewire)

For example, in December 2006, several Canadian newspapers declared that, "of the 13 [polar bear populations] in Canada, 11 are either stable or increasing in size." In fact, in 2005, polar bear specialists from all Arctic nations unanimously endorsed a status report stating that, of the 13 populations within Canada, or shared with Greenland, two were severely depleted, five were declining, another five were stable, and one may be increasing. Of these, the Southern Beaufort Sea population - whose habitat includes the NWT coast - is among the worse off, having declined by 17 per cent over the past two decades.

Another rumor spread by the media is that, as sea ice declines, polar bears will simply switch to land-based foods, relying heavily on berries just like other bears. In a recent article on "the real scoop on climate warming and polar bears," leading polar bear scientists Ian Stirling and Andrew Derocher state that, "polar bears are large animals, and they got that way by eating seals, not berries. Their survival [depends] on large and accessible seal populations and vast areas of ice from which to hunt."[110]

Stirling and Derocher stress that, though the timing of impacts of climate warming on polar bears will vary in different regions, *all* populations will eventually suffer with a continued decline in sea ice. Over the long term, they see only one way to avert the loss of this "iconic" species and the local culture and economy it supports. "If the population of this planet is truly concerned about [polar bears], we need to collectively reduce greenhouse gas production significantly and quickly."[111]

Observations by the Inuvialuit of Sachs Harbour support what has long been predicted – that climate change would be felt first in the Polar Regions. This community's way of life is at risk, an urgent warning of the negative impacts of climate change predicted to occur elsewhere in the world.

International Institute for Sustainable Development[7]

Ancient ponds dry up and disappear in High Arctic

Warmer temperatures are destroying Arctic ponds that have existed for thousands of years. This is bad news for the local wildlife they support and an ominous warning for the rest of the globe, say John Smol and Marianne Douglas, the scientists who made this discovery on Ellesmere Island. Smol likens these ponds to canaries once kept in coal mines to warn of dangerous air. "The canary is coughing and choking," he says. "What happens in the Arctic is an early warning of what's going to be happening in other places soon."

Their study, dating back to 1983, shows that many small, Arctic ponds are drying up and could begin to release greenhouse gases that make the problem worse. They suggest that a key "tipping point" has now been passed: Arctic ponds that were permanent water bodies for millennia have shrunk to a fraction of their former size, some lasting only for a few weeks each summer - if at all. "The final ecological threshold for an aquatic ecosystem is loss of water," says Smol. "These sites have now crossed that threshold."

Climate researcher John Smol examines cracked floor of a dried-up tundra pond on Ellesmere Island. "I remember getting off the helicopter and looking out and wondering: What the hell is going on here?" (Marianne Douglas)

In the relatively dry Arctic, these small ponds are an important part of Arctic ecosystems. They provide habitat for waterfowl, drinking water for animals, and homes for algae, tiny invertebrates, and insects – major foundations for the Arctic's fragile ecosystem. "We don't really know how this cascades through the whole system," says Smol, "But if you're an eider duck, you're not so happy."

The scientists also observed wetlands drying up. Areas that once required hip waders to study could be set on fire with a lighter. Wetlands that formerly stored carbon in plants and peat now may release carbon as they dry and decompose, adding further to climate warming.

In the past, researchers like us have sometimes been accused of being alarmist when we discussed climate warming. We now think we have been overly optimistic. The speed and magnitude of environmental changes are worse than even we imagined... What happens in the Arctic will affect us all, and not in good ways.

- John Smol, Queen's University Climate Scientist[114,115]

Not a lot of people believed it... I think we are at a tipping point. We never expected to see these ponds dry up so soon.

- Marianne Douglas, Director Canadian Circumpolar Institute[116]

Climate change is like a stone being thrown into pond with ripples in all directions. The ripples caused by climate change will touch almost every aspect of the land and the lives of the people of the Dehcho. While we are sure that there will be ripples, we're not sure of their impact.

- Ecology North, *Towards a Dehcho Regional Climate Change Plan*[8]

Climate is a complex agent of change. If global warming occurs as projected, its effects will depend not only on the direct impacts on land and water resources, but also on how technology, economies, and societies change over time. This complexity represents a significant research challenge.

- Stewart Cohen, *Climate change [and] the future of the Mackenzie Basin* [117]

How can we prepare ourselves for such unpredictability? What will happen to us if we can no longer rely on our instincts and traditional wisdom?

- Rosemarie Kuptana, Sachs Harbour[118]

The good news is that humans are gifted by the potential for self-awareness and intelligent choice, and knowing our circumstances is an invitation to change.

- William Rees, *Our Ecological Footprint*[119]

Canada can no longer ignore the threat of climate change. We can no longer deny the economic benefits of fighting it. We can no longer risk the future of our natural environment.

- Stéphane Dion, Federal Liberal Leader[120]

Putting the Pieces Together

More stories, more big changes. Rapid climate change is likely a major factor contributing to steep declines in northern caribou herds. It is creating huge financial burdens for communities that must harden building foundations and other infrastructure against the impacts of thawing permafrost. It is forcing non-renewable resource industries to rethink the way they do business in permafrost terrain. It is impacting the ability of some communities to meet needs as basic as supplying freshwater. It is rapidly shrinking sea ice, and with it, a vital Arctic ecosystem which supports countless marine species - including the beleaguered polar bear - and helps stabilize the wider global climate.

Conclusion

Northern climate change: What's the upshot?

Added together, these eighteen stories about northern climate change point to several stark conclusions:

- **It's real and it's now**
  Though climate change impacts in the high Arctic may be capturing most media attention - such as shrinking sea ice and threatened polar bears - other less dramatic but equally insidious impacts are now occurring throughout the Northwest Territories.

- **It's going to cost big bucks**
  Replacing water reservoirs threatened by melting permafrost, chartering high-priced Hercules aircraft to deliver fuel and supplies to remote mines when ice roads close early, planning for massive reinforcements to building foundations and other community infrastructure parked on frozen soil - these are but a few of the major costs that communities, governments and industry now face thanks to climate change.

- **It has global implications**
  The North truly is a "canary" on the stage of global climate change. The drying up of ancient ponds or the shrinking of sea ice are more than peculiar scientific discoveries from the faraway Arctic. They provide early warning signals of profound global change. More than this, many local changes have direct, wide-ranging impacts on the global climate, such as the absorption of heat by ice-free waters or the carbon-belching effect of increased forest fires and a warming tundra. The issue of sovereignty over Arctic waters and resources heats up as sea ice shrinks.

- **It's hitting people close to home**
  Securing clean drinking water straight from the tap, relying on permafrost for solid building foundations, travelling safely over the ice on hunting or trapping trips, relying on time-tested cues to predict the weather, following traditional routes on rivers and lakes, counting on caribou in the freezer every winter - these are among the hallmarks of a northern lifestyle which, due to climate change, many people can no longer take for granted.

- **It's complex**
  Like any force in nature, northern climate change does not act alone and its impacts are often difficult to isolate. For example, climate change joins a long list of economic and social factors already restricting traditional lifestyles on the land. As well, climate change is just one of many factors at play in contributing to the alarming decline of northern caribou.

- **It's confusing**
  Regional variations in climate change, a relatively limited understanding of northern ecosystems, and controversial media coverage combine to throw a smokescreen over the true impacts of the North's fast-changing climate. On top of this, some changes, like sea ice and caribou declines, are outpacing the ability of both science and local knowledge to keep up, let alone understand.

- **It's calling us to action**
  Lack of clarity or certainty about climate change impacts is no excuse for inaction. The federal government's study of northern building foundations clearly shows that the longer we wait to respond to known impacts, the more it will cost. Together, these stories demonstrate that there is much we *do* know and that the time to act is *now.*

Call to Action

Tackling climate change calls for two kinds of actions, *mitigation* and *adaptation*. Putting the brakes on global climate change begins with mitigation - reducing greenhouse gas emissions from using fossil fuels. For instance, we can drive a smaller vehicle, increase the energy-efficiency of our homes, or adopt a more sustainable lifestyle based on local renewable resources. Individual efforts like these may seem trivial in the face of such a daunting global problem. But Canadians contribute a relatively large per capita share of greenhouse gases compared to many other nations. By reducing these emissions, individuals can save money, honour future generations, and set a worthy example for the rest of the world.

Mitigation

Anything we do to fight the *causes* of climate change, mainly by reducing our greenhouse gas output from the use of fossil fuels.

Adaptation

Anything we do to reduce the negative *impacts* of climate change. Planning to make the best of its positive effects is a part of adaptation.

All levels of government - from hamlet councils to federal Parliament - can support individual efforts to reduce greenhouse gas emissions using such tools as education campaigns, incentive programs, public transportation improvements, carbon tax and rebate programs, research programs, smart growth planning, energy efficiency standards, and renewable energy development. The best way for governments to show "green" leadership is through their own buildings, transportation practices, purchasing, waste management, and energy use. This raises the bar for what individuals and the private sector can do while helping to build the market for less fuel-intensive goods and services. For example, a government commitment to purchase carbon offsets for all air travel tells the public that mitigation is a high priority and that practical action can be taken.

Carbon offset - striking a balance

Carbon offsetting is the act of reducing or avoiding greenhouse gas emissions in one place in order to "offset" emissions occurring elsewhere. For instance the carbon dioxide emitted by a particular plane flight is offset by supporting the planting or protection of trees which absorb the equivalent amount of the same gas. Because greenhouse gases mix well in the atmosphere, the idea is that it doesn't matter where that mitigation occurs. (eg. Gold Standard Carbon Credits: www.cdmgoldstandard.org)

Rosemarie Kuptana wallpapers a room with climate change issues at a workshop in Sachs Harbour. Compared to most Canadians, northerners are feeling the impacts of climate change "first and worst". (Graham Ashford)

Northerners need to start thinking of ways to adapt to the inevitable changes warming will bring. The magnitude and rate of change 50 years from now are still in our control. But what happens between now and then, in many respects, is already in the works. So we better learn to anticipate those changes and prepare for them.

- Henry Hengeveld, Environment Canada climate scientist[121]

Changes in the world's climate, now clearly underway, are being felt very deeply. These changes will require major human adaptation and mitigation, and they will affect virtually every human enterprise in northern Canada.

- Frances Abele, *Canada Research Horizons*[122]

Solving the climate problem requires a shift away from fossil fuels in our energy system, efficient energy solutions, and the widespread adoption of renewable energy sources such as wind, biomass, geothermal, and solar electricity. The technologies and polices for putting these in place are achievable at low cost and carry additional benefits for human health and food and energy security. What is needed now is the political leadership to ensure that dangerous climate change is kept to a minimum. Rapid change in the Arctic tells us there is no time to lose.

- Lynn Rosentrater, *Two Degrees is Too Much!*[123]

I don't think any country can say that climate change is a crisis in the life of our planet - in the life of our species - and not do anything about it.

- Stephen Harper, Prime Minister of Canada[125]

No matter how successful we are at tackling the causes of climate change, we will continue to feel its effects on the land, water and air for generations to come. So, we also need to prepare for the impacts of climate change. We need to adapt. Adaptation means planning for the inevitable impacts of climate change - avoiding them completely or at least softening their blows. The City of Yellowknife chose to pay a premium price for state-of-the-art road insulation to protect its main street and underlying sewers from the expected impacts of thawing permafrost. Stirred by a nearly tragic school cave-in, the GNWT tested and reinforced all of their buildings to prepare for increased snow loads. These are examples of adaptation in action - enhancing resilience to climate change impacts. Other northern examples include:

- Revise dates and design standards for safe operation of ice roads.
- Reinforce or relocate infrastructure threatened by new climate risks.
- Develop regional climate change models to better predict and avoid local impacts.
- Strive as far as possible for local self-sufficiency to meet energy and food needs.
- Reinforce shorelines threatened by increased flooding or storms.
- Develop industrial waste disposal technologies that do not rely on permafrost.
- Adjust land-based activities and schedules to changing climatic conditions.
- Establish a well equipped search and rescue capacity for all communities.

Anything we do to reduce the bad effects of climate change is adaptation. *Planned Adaptation* means things we do to prepare for a climate event and reduce its potential impacts. Plan for change - that's the best way to go. *Reactive Adaptation* means things we do after climate change impacts happen. This route is generally more expensive and risky.

Well thought-out adaptation measures allow a community to plan for and respond to the challenges of climate change. In most cases, the aim of adaptation is to increase a community's ability to face these challenges. Sometimes climate change brings positive effects like longer summers and lower heating costs. Planning to make the best of new opportunities is another part of adaptation.

Carrying out the best laid plans, whether for mitigation or adaptation, will depend on close collaboration among communities, scientists, aboriginal governments, the GNWT, and the federal government. Several northern communities and regions are developing their own adaptation plans with the help of Ecology North. The GNWT has developed a comprehensive Greenhouse Gas Strategy and is currently preparing a complementary Adaptation Plan. The northern scientific community has made climate change a top research priority during the 2007-2008 International Polar Year.

A recent grassroots "Climate Change Summit" organized by Ecology North identified five key areas for confronting this issue:

1. Improve Coordination;
2. Enhance Public Awareness;
3. Share Technical Expertise;
4. Support Community Research; and
5. Integrate Traditional Knowledge.

The federal government has substantial resources, authority, and research capacity to provide support in all of these areas. A multi-stakeholder strategy for collaborating on northern climate change, combined with vigorous deployment of federal resources could go a long way in helping northerners face the challenges of living on the frontlines of climate change.

In taking action to fight climate change - at whatever level - half the battle, to paraphrase the famous "Serenity Prayer", is seeing the things we cannot change, having the courage to change the things we can, and finding the wisdom to know the difference.

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