Fictional Example Community

Adapting to a changing climate

For consideration in preparing a community-based

Climate change adaptation plan

Draft: April 30, 2019

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UP NORTH ON CLIMATE
Climate Change Impact and Adaptation
Study for the North of Ontario

About this report

This report is for “Fictional Example” First Nation. It belongs to the First Nation and will not be distributed in anyway without permission. The knowledge of Elders and community members was given anonymously in interviews with community member “A. Person”, and remains their intellectual property. Discussions with professionals in the community and community leaders supplemented the interviews. They are often the only ones identified by name.

The purpose of the report is and will always be to assist community leaders and members of the community in preparing for the growing impacts of a changing climate. The observations of Elders and those with memories that go back more than 40 years have been the foundation for the story of the climate in the past. Science, integrated with that knowledge, enables projections of the climate and its impacts in the future, during the lifetimes of our children and grandchildren. Describing the range of ways to adapt and reduce the risks from those impacts, is the main goal of this report.

Being part of a larger “Climate Change Impact Study for the north” called for by Grand Chief Isadore Day in December 2015, means that some of the evidence of change found in this *Fictional Example Community* may be included in a report summarizing what has happened and is likely to happen over the entire north of Ontario. At the time of creation of this report, many First Nations in the north are participating in the project, most, through their Tribal Council or through NAN.

The information in this report was assembled thanks to the work of many individuals out of Laurentian University’s School of the Environment, including Dr. David Pearson, Chantal Sarrazin-Delay, Emily Smenderovac, Andrea Hanson, Kat Middleton, Kim Fram, Brittany Rantala-Sykes, Emily Hulley and Adam Kirkwood.

Thanks to all who participated in interviews with “A. Person”. Without your observations and memories, this work would not have been possible. Thanks for the many conversations with our team and to the young people in school classes we have visited, for their energy and interest and for their friendly smiles and greetings while walking through the community. Thanks for making us feel so welcome.

Above all, thanks to *“A. Person”*. for your initiative in learning about the land and in conducting interviews with Elders and community members which is the foundation for the climate change story on which preparing for the future must be based.

More info on our website www.upnorthonclimate.ca

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Summary: *Fictional Example Community* in a changing climate

The past was different… changes people have seen

Situated on the boreal shield, the traditional territory of *Fictional Example Community* has a long and storied history. Less than 15,000 years ago, the region was covered by a sheet of ice. As the ice slowly and naturally melted over thousands of years, the familiar landscape of rock, forest, rivers and lakes was shaped. Indigenous peoples were the region's first inhabitants.

Living on the land in *Fictional Example Community* territory meant harvesting animals through hunting, fishing, and trapping. Plants and berries were gathered for both food and medicine. People travelled from place to place either by canoe or on foot. In winter, dog sleds and snowshoe travel were common over frozen lakes and snowy land.

Today

The traditional lands of *Fictional Example Community* have seen many changes. Human-caused climate change, mainly due to the release of greenhouse gases into the atmosphere, is altering temperature, precipitation, and weather patterns all over the world. Northern Ontario is already warming at twice the global average and there are no reasons to expect that pattern will change.

Today, many of those interviewed said the animals they harvest are less plentiful, including geese and ducks, and the plants and berries they gather are harder to find. New birds, like pelicans and turkey vultures, have been spotted in the area, while once common songbirds are said to be disappearing. Changes in winter are making travel over ice more dangerous and limiting time available for activities like ice fishing.

The Future

Projections of future climate for northern Ontario say that the area will continue to warm as we approach the year 2050 and beyond. Winters in *Fictional Example Community*, for example, are predicted to warm between 2°C and 4.5°C. Changes in the amounts of rain and snow can also be expected, as can changes in the frequency of extreme weather events such as droughts, heatwaves and heavy rainstorms.

The climate is changing, and people should prepare. This could include recognizing where vulnerabilities lie, assessing their risk, and discussing possible adaptation strategies. For *Fictional Example Community*, perhaps ice thickness monitoring and community alert system (e.g. Facebook page) should be considered to reduce the risk associated with unpredictable ice conditions. Lighter vehicles may also be required for travelling over ice and safety gear, such as floater suits, could be made available. Species of interest could be monitored through community-based programs. Song meters, for example, could be used to help determine the presence of songbirds in the area. Potential benefits of climate change for an area, such as a longer growing season, allow better vegetable gardening.

Overview

Background

Background

A landscape with an icy past and an uncertain future

All of us who live in the north live on a landscape shaped by extreme climate change. Less than 15,000 years ago there were no lakes or rivers, no forests, no Great lakes, no Hudson Bay. The land we know was covered by a sheet of ice. Slowly it melted away. Today we live on the landscape and under the warmer climate that Nature created in its place. Now, climate and landscape are changing again, but this time Nature is being pushed.

The changes in climate Elders have seen

Indigenous peoples have lived on the land and successfully adapted to changes for thousands of years. Todays Elders, who have lived with a lifetime of changes, speak with regret and concern about a future of ever more disruption of the traditional relationship of indigenous people with the land. Although much of the disruption is social and cultural, changing climate is adding another layer to the issues in Ontario, especially in remote northern communities. From changes in the migration patterns of wild food animals and the dangers of winter travel on thinner ice, to the impact of severe storms on homes and community infrastructure and the threat of wildfire, changing climate is bringing increasing disruption and risks to indigenous peoples in the north.

Records from the weather station in Kitchenuhmaykoosib Inninuwug, KI (Big Trout Lake) in the far north west of Ontario, show in numbers what Elders throughout the north have seen happening during their lifetimes since the 1950s.

One possibility for the future is that the speed and size of the changes in the seasons that Elders have seen will continue to grow at the same pace. On the other hand, they could slow down if international efforts to reduce the release of global warming gas pollution into the atmosphere are successful. If those efforts are not successful, changes will speed up and the consequences will become more severe.

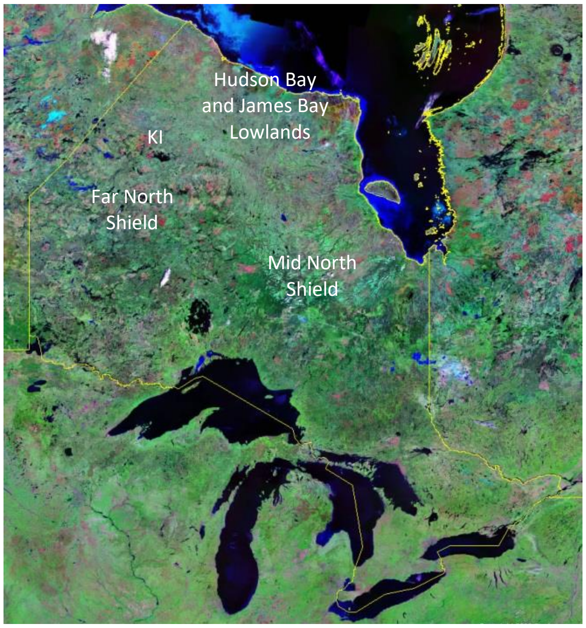

Figure 1 Ontario with the Kitchenuhmaykoosib Inninuwug (KI) weather station in the north west on the rocky landscape of the Far North Shield.

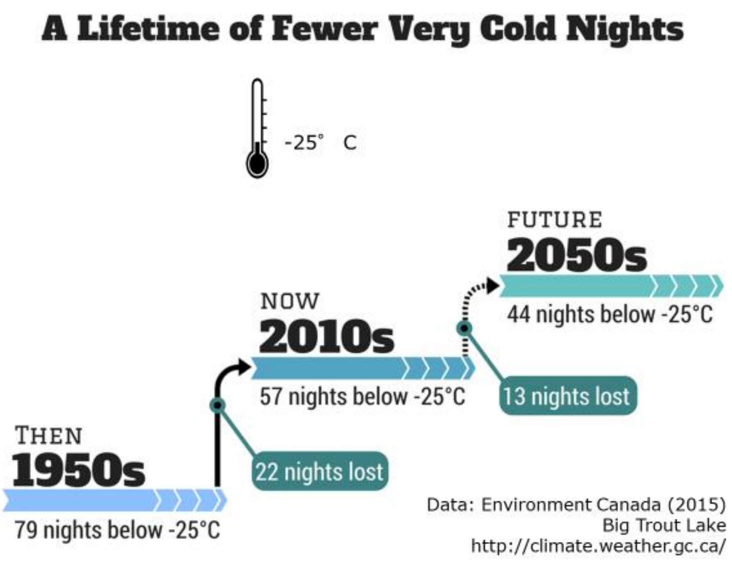

Figure 2: Change in the number of very cold nights, below minus 25°C, in the past, today, and in the future, if climate change continues. Numbers from the EC Kitchenuhmaykoosib Inninuwug (KI) weather station.

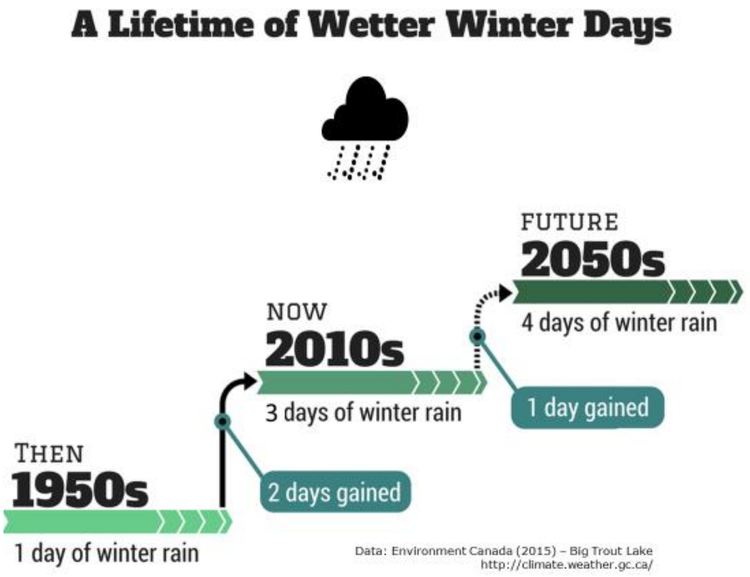

Figure 3: Change in the number of winter days when it rains instead of snowing, in the past and today, as well as in the future, if climate change continues. Numbers from the Kitchenuhmaykoosib Inninuwug (KI) weather station.

Elders frequently speak of there being fewer very cold winter nights, especially in December (Figure 2). This means that ice on lakes takes longer to become thick enough for safe snowmobile travel. Warmer winter nights have also made it more difficult to begin winter road construction. Winter road builders say that as many as ten very cold nights in a row are needed for the ice on lakes to freeze thick enough to allow flooding and thickening of the ice. Only then can roads on lakes be made safe for cars, trucks and especially transport trailers carrying fuel, supplies and building materials.

Rain in winter is becoming more common (Figure 3). When the ground is still frozen, rain runs off and floods low areas that might include the crawl spaces of homes. Culverts that are critical for good drainage in communities might be blocked by ice and frozen leaves and garbage, making the problem of flooding in communities worse.

Rain can quickly turn the surface of winter roads into slush for several days. When the weather turns cold again the slush freezes into deep ruts making ice road travel very slow and dangerous or even impossible until the road has been freshly graded with a heavy grader.

Freezing rain can coat surfaces like tree branches, power lines, and cars. It only happens when a wedge of warm air pushes into cold air so that falling snow melts to rain as it falls through the warm wedge (Figure 4). The raindrops then cool to freezing point just before they hit the ground or a tree or a structure like a hydropole, where they instantly turn to ice. Sometimes the weight of ice can break branches or bring down a hydropole not designed to take the extra load.

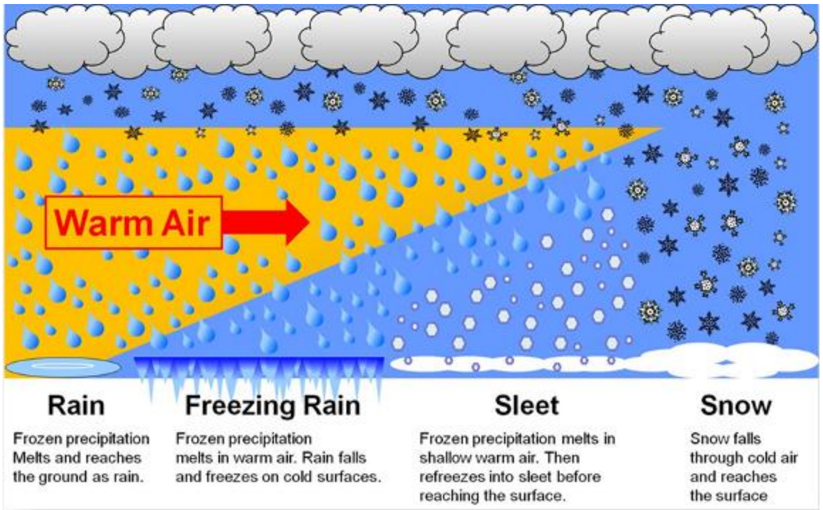

FIGURE 4: TYPES OF PRECIPITATION (IMAGE TAKEN FROM HTTPS://EN.WIKIPEDIA.ORG/WIKI/PRECIPITATION_TYPES)

Freezing rain is more common in valleys like the Ottawa valley than in the north, but freezing rain warnings have been issued all the way to the Hudson Bay coast. Important risks in the north are dangerous walking and driving conditions, as well as damage to infrastructure, homes and community buildings.

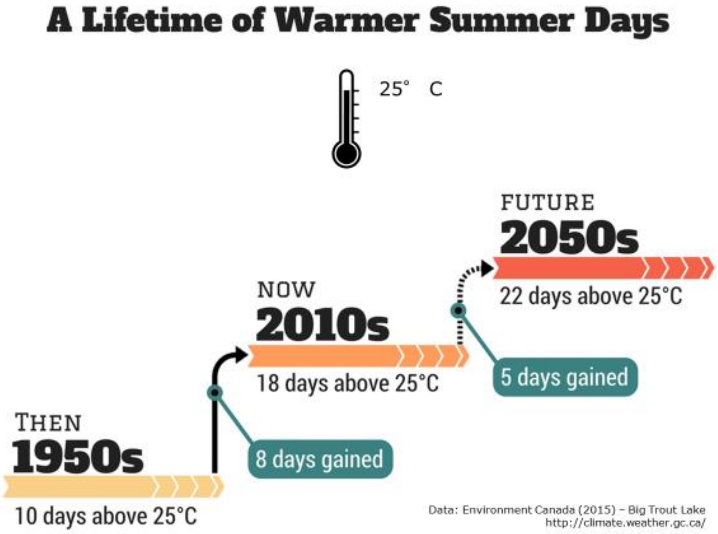

FIGURE 5: CHANGE IN THE NUMBER SUMMER DAYS ABOVE 25°C IN THE PAST, TODAY, AND IN THE FUTURE IF CLIMATE CHANGE CONTINUES. NUMBERS FROM THE KITCHENUHMAYKOOSIB INNINUWUG (KI) WEATHER STATION.

Elders have noticed that summer is becoming warmer in the north (Figure 5). Heat waves of more than three very hot days along with nights when the temperature stays above 20˚C can be very stressful for Elders and very young children, to the point of being fatal if there is no cool place available. Heat waves also increase evaporation from lakes and rivers and can cause drought that can lead to increase in forest fires.

Shaped by ice: The landscape as science sees it

Earth has often been warmer or cooler than it is today, especially tens and hundreds of millions of years ago when very slowly sliding continents were nearer to the poles or the equator. In the much more recent past, while humans have been on Earth, we know that just 18,000 years ago a sheet of ice as much as 2 or even 3 kilometres thick covered almost all of Canada (Figure 6). This massive sheet of ice was formed by thousands of years of snow falling in winter and lasting through to the next winter where once it would have melted. Cooler summers south of the Arctic allowed the snow to survive and reflect more of the Sun's energy back into space, cooling the summer even more. As the snow accumulated it became ice under its own weight. Interestingly, small bubbles of air were trapped in the snow and then in the ice. We can tell what the atmosphere was like thousands of years ago by carefully sampling that ancient air in long cores of ice from Greenland as well as from Antarctica.

The ice over Ontario began to slowly melt away about 12,500 years ago and was completely melted from the north about 8,400 years ago. The edge of the sheet has been melting north ever since. Its remains still cover Greenland and the Arctic islands.

Figure 6: The approximate extent of the ice sheet (white) covering Canada about 20,870 years ago, before melting began. The outline of the future Great Lakes and the Hudson Bay helps show how far the ice extended.

The ice of a glacier or an ice sheet slowly slides downhill like thick, cold syrup. It grinds across the underlying rock at a few centimetres or even a metre or two a day, pulling fragments from the cracked surface. Those rock fragments scratch and polish the rock bed like grains in icy sandpaper, wearing it down and producing very fine rock flour. The rock in the north was polished by the sliding ice sheet for about 100,000 years before the ice began to melt. As the front of the ice sheet melted back by about 200 or 300 metres every year, occasionally slowing and even re-advancing during cold periods, it might have looked like the Canada Glacier in Antarctica looks today (Figure 7).

Meltwater draining from the ice collected in lakes at the edge of the sheet. They were small at first, like Lake Jökulsárlón in Iceland is today (Figure 8), but by 11,000 years ago meltwater had filled the Great Lakes that we know today. It is easy to imagine that some of the water deep in Lake Superior is still old glacial meltwater.

Southern Ontario might have looked like this 11,000 years ago as the ice sheet was melting.

FIGURE 7: THE FRONT OF THE CANADA GLACIER IN ANTARCTICA. PHOTO BY TERRY HEALY, UNIVERSITY OF WAIKATO, NEW ZEALAND. COURTESY OF GRAEME SPIERS, LAURENTIAN UNIVERSITY.

FIGURE 8 : JÖKULSÁRLÓN GLACIAL LAKE IN ICELAND WITH ICEBERGS BREAKING AWAY FROM THE GLACIER. PHOTO BY MARTIN PEEKS. APRIL 2007. HTTPS://COMMONS.WIKIMEDIA.ORG/W/INDEX.PHP?CURID =1888356

The greatest lakes of them all, Lake Agassiz and Lake Ojibway

Although the Great Lakes are very large and hold 21% of all the fresh water on the surface of the Earth, they are small compared to the huge lakes of meltwater created as the ice sheet melted back toward Hudson Bay. The reason that they were so big is that the weight of the ice sheet had pressed down the rocky surface of the Earth by as much as 280 metres into the hot, soft rock far below creating a very large depression[1].

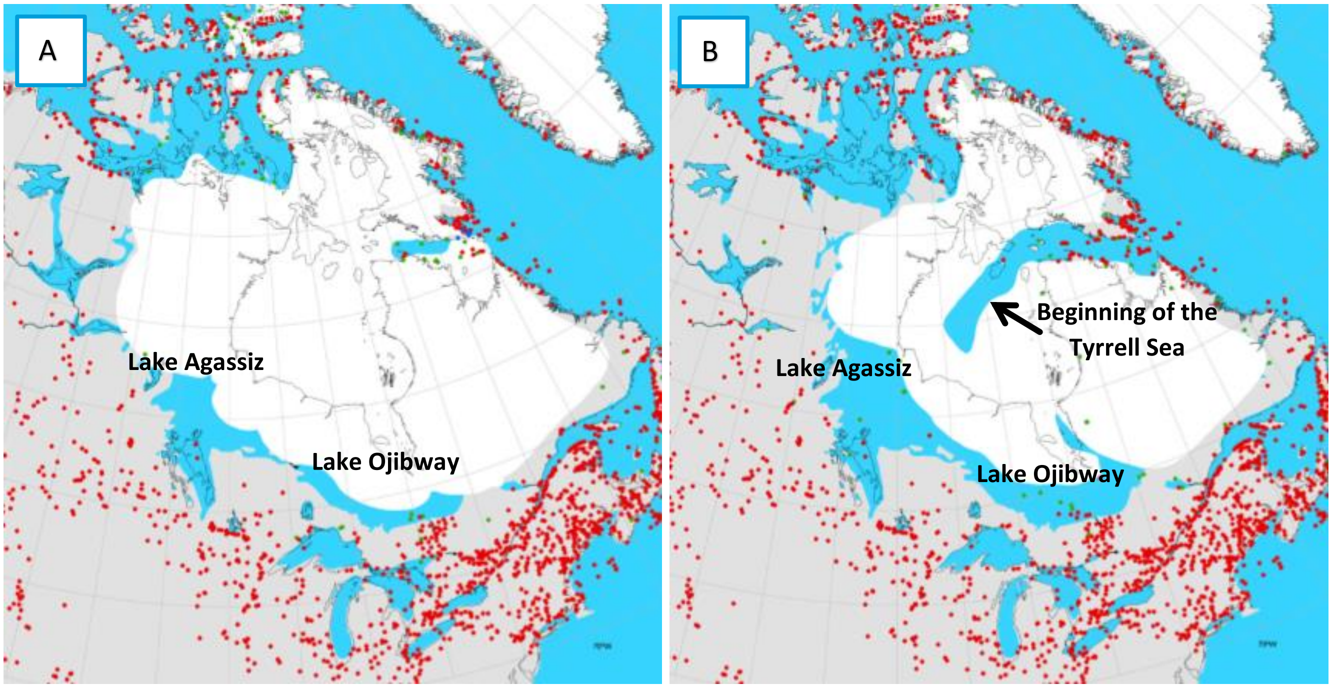

FIGURE 9: A. 9,100 YEARS AGO WHEN LAKE AGASSIZ EXTENDED FROM SASKATCHEWAN TO WESTERN ONTARIO WHERE IT CONNECTED WITH LAKE OJIBWAY WHICH EXTENDED ACROSS EASTERN ONTARIO INTO QUEBEC, TOGETHER COLLECTING MELTWATER IN FRONT OF THE ICE SHEET. B. 8,670 YEARS AGO. SALTY OCEAN WATER WORKED ITS WAY INTO THE CENTRE OF THE ICE SHEET MIXING WITH FRESH MELTWATER, CREATING AN ICEBERG-FILLED CHANNEL AND SLOWLY DIVIDING THE ICE INTO TWO PATCHES.
RED DOTS ARE LOCATIONS WHERE IT HAS BEEN POSSIBLE TO DATE WHEN THE ICE SHEET MELTED AND LEFT THE LAND SURFACE EXPOSED. FROM DYKE, 2004.

As the edge of the ice sheet melted, it left a vast depression that collected water in two very large lakes, Lake Agassiz in the west from Saskatchewan through Manitoba into western Ontario, and Lake Ojibway in the east, from northeastern Ontario into Quebec (Figure 9A)[2]. By 9,100 years ago, the two lakes had grown enough to connect into a huge lake in front of about 4,000 km of the melting sheet.

At the same time as Lake Agassiz ran along the south edge of the shrinking sheet, ocean water was pushing into the north creating the Tyrrell Sea that was to become Hudson Bay (Figure 9B)[2].

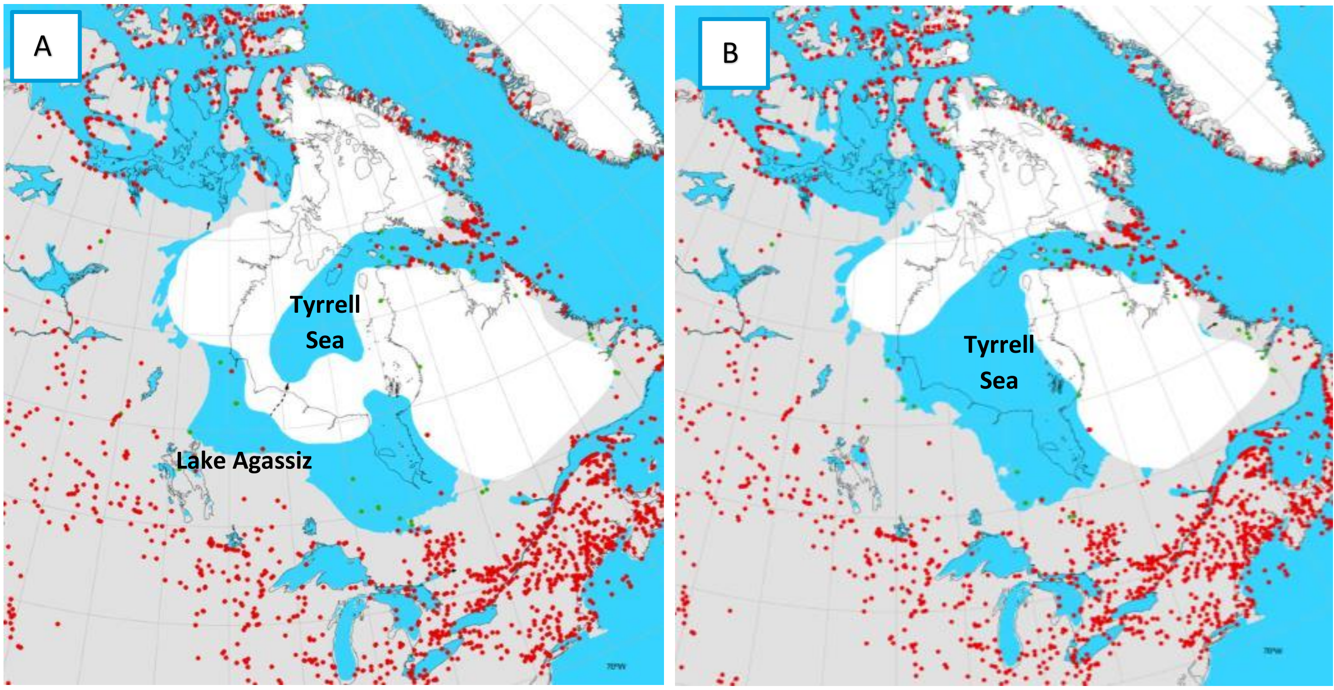

Figure 10: A. 8,520 years ago when melting allowed water from the North Atlantic to work its way south at the same time as an ice dam still held back Lake Agassiz from flowing north. :B. 8,470 years ago. Salty water from the Atlantic Ocean flooded into lake Agassiz from the north creating the Tyrrell Sea.
Red dots are locations where it has been possible to date when the ice sheet melted and left the land surface exposed. From Dyke, 2004.

By 8,520 years ago only a narrow barrier of ice separated the fresh water lakes from the salty bay referred to as the Tyrrell Sea (figure 10 A)[2]. Eventually the ice dam broke and was washed away about 8,470 years ago (figure 10 B)[2]. It must have been a spectacular event with ice bergs carried by a deluge of water over a waterfall into the Tyrrell Sea. Tracks cut into the mud on the floor of the Tyrrell Sea have been found on the bottom of Hudson Bay that show what the deluge might have been like. The sea flooded today's Hudson and James Bay Lowlands, covering almost all bedrock with sand and clay. Remembering that Lake Agassiz was still being fed by melting ice, it may have taken hundreds of years for the huge lake to completely drain into the Tyrrell Sea.

So much ice-cold freshwater from Lake Agassiz poured into the Tyrrell Sea and then into the Atlantic Ocean that it disrupted ocean currents in the Atlantic and was very possibly responsible for a cooling of the climate for a thousand years.

Figure 11: North east of Sandy Lake. 53° 30' N 92° 28' W. Three lines of sand and gravel, now covered with trees, marking 8,650 to 8,550 year old shorelines of Lake Agassiz. Waves washed the shore of this island of sand and gravel building shoreline bluffs.

Lakes in the far north west today, like Big Trout Lake, are the remains of Lake Agassiz while silty clay soils in the Clay Belt of Cochrane, Constance Lake and Kapuskasing are sediments from the bed of Lake Ojibway in the east. In some places, near the community of Sandy Lake for example, the shorelines of these ancient lakes are still evident on the landscape (Figure 11).

As melting progressed, the land, now free of the weight of the ice sheet, began to rise like a boat does when its cargo is unloaded. Even after several thousand years, this process, known as “rebound”, is still not quite over (Figure 12). From Fort Severn to Peawanuck near the Hudson Bay coast, the land is rising by over a metre (3 feet) in 100 years.

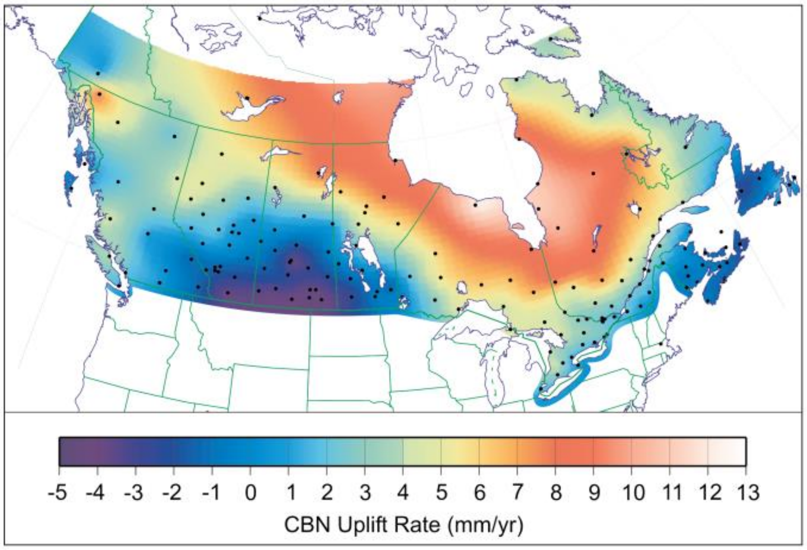

Figure 12: Pattern of present day post-glacial uplift from the Canadian base network (CBN) of GPS pillars (black dots) https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/geomagnica.pdf

The area flooded by the Tyrrell Sea has since become known as Hudson Bay and James Bay. Evidence of glacial rebound can be seen when flying over the far north. As the shore has risen, more than a hundred old sandy beaches have been left high and dry running across the landscape, parallel to the coast for more than 200 km inland (Figure 13). The sand was brought by rivers like the Severn and Winisk and washed into place as beaches near the sea during storms [3].

Figure 13: Shrub covered ridges of beach sand running parallel to the shore of Hudson Bay near Fort Severn. The valley of the Severn River is visible in the foreground underneath the plane. March 21, 2012.

The grinding and polishing of the rock by the ice sheet produced grey clay made of rock flour which often lies under the sand. It was once mud on the bottom of the salty Tyrrell Sea. Sea shells in the clay are witnesses to that early sea. The sand and silt near the surface of the land comes from far inland where it was washed in to the sea by rivers, then pushed by waves onto the land near the mouth of the river. As the land rose these areas became costal flats. The layers are clearly seen in the banks of the Severn River and other rivers that cross the Lowlands (Figure 14).

Figure 14: The bank of the Severn River about 7 km upstream from Fort Severn showing a typical succession of grey silty clay, once on the floor of the Tyrrell Sea (now Hudson Bay), covered by sand and silt washed in by rivers near the old river mouth August 18, 2018.

Warming up from an icy past

Are the changes seen by Elders just another step in the end of the Ice Age ?

A good question to ask is - are the changes seen by Elders and the warming of the climate everyone is experiencing around the planet now, just a continuation of the warming that melted the old ice sheet or are we facing something new ? The answer lies in comparing how slowly the ice sheet melted with how fast the Earth is warming today.

Why do Ice Ages come and go ?

We know from many years of carefully measuring the position of stars in the night sky and the angle of the Sun above the horizon during the day, that the Earth's orbit, or path around the Sun, as well as its tilt toward the Sun are always changing, but very, very slowly.

The Earth's journey around the Sun, its orbit, is not a perfect circle. Instead it is an oval, like a stretched elastic band, so that the Earth is closer to the Sun at one end of its orbit than at the other (Figure 15-Eccentricity). That means that right now we are closer to the Sun in January (147 million km) than we are in June (152 million km). Remembering that January is our winter in the north, it might seem wrong that we are closer to the Sun in winter, but it isn't.

It's not the shifting distance to the Sun that changes our northern weather between the seasons. The reason lies in the tilt of the axis of the Earth around which we slowly spin like a spinning top. In Ontario, we are warmer in June because in that part of our orbit the axis of the Earth is pointing toward the Sun. We see the Sun more face on and we enjoy longer days. In the winter, on the other end of the Earth's orbit, the axis is pointed away from the Sun, the north pole is dark all day, we have shorter days and face the Sun at a low angle. That's why January is cooler than July and why our seasons are different.

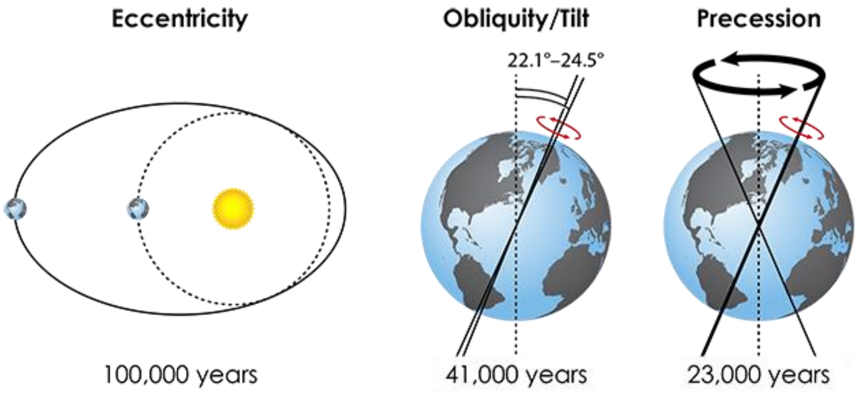

FIGURE 15: THE WAYS IN WHICH THE ECCENTRICITY OR STRETCH OF THE EARTH'S ORBIT; THE TILT OR WOBBLE OF ITS AXIS, AND ITS SPIN OR PRECESSION, SLOWLY CHANGE OVER TENS OF THOUSANDS OF YEARS. THE NUMBER OF YEARS NOTED UNDER EACH MEASURE IN THE DIAGRAM IS HOW LONG IT TAKES FOR THE ORBIT TO CHANGE FROM EXTREMELY OVAL TO ALMOST CIRCULAR (ECCENTRICITY); AND FOR EACH OF THE TILT AND PRECESSION TO COMPLETE A CHANGE FROM MAXIMUM TO MINIMUM AND BACK TO MAXIMUM.

The angle of the tilt of the Earth towards the Sun changes by an extremely tiny amount every year, taking about 41,000 years to increase from just over 22 degrees to 24 ½ degrees and then back again (Figure 15-Tilt). To make things more complicated, the axis of the Earth slowly spins like a top (Figure 15-Precession). So, the Earth can be tilted more directly or less directly toward the Sun when it's either close to or far from the Sun. Each of these changes takes thousands of years and there are many possible combinations.

Careful calculations of how those very slow changes affect the warmth of the Sun received in the north have shown that sometimes spring and summer weather could become cool enough to very slowly, over hundreds of years, allow winter snow and ice to last all year round. When it builds up for thousands of years, it can become an Ice Age ice sheet and eventually grow to as much as 2 or even 3 km thick and last 100,000 years. Careful study of long cores of ice from Greenland show that there have probably been eleven very large ice sheets over Canada in the last three million years (Figure 16).

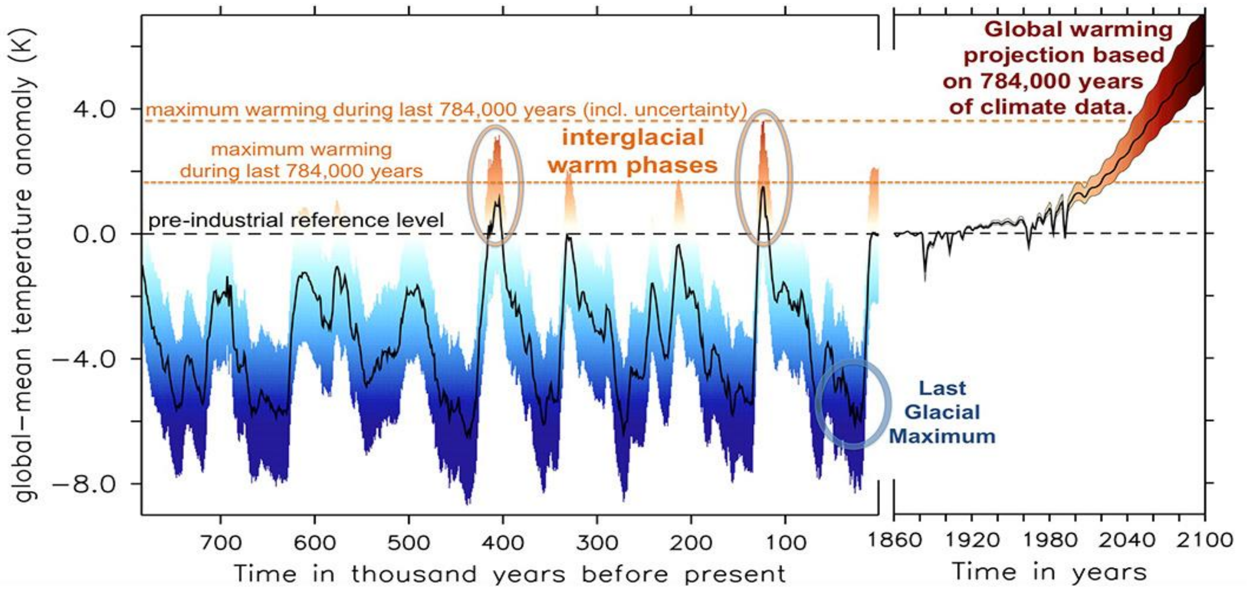

Figure 16: Global mean temperature anomaly with respect to preindustrial reference level.
Left panel: Reconstruction of last 784,000 yrs. Right panel: Global warming projection to 2100 based on newly calculated paleoclimate sensitivity. Adapted from Friedrich, et al (2016).
https://phys.org/news/2016-11-climate-sensitive-atmospheric-co2.html

We have evidence that when ice last covered Canada, the average temperature of the Earth was about 5 – 7°C colder than it is today. Eventually, as the tilt of the Earth and its path around the Sun changed, summers in the north became warmer and the ice sheet began to melt. That is what has been happening for the last 12,000 years. When we remember that the ice on the Arctic islands and Greenland is part of that Ice Age ice sheet, we see that it is still going on. But the memories of Elders, the work of scientists, and records from weather stations tell us that what is happening now is different from the past. Earth is warming much faster today.

Why has warming speeded up ?

It took over 10,000 years for the Earth's temperature to rise by 5 - 7°C after the last Ice Age. That's about 1°C every 1,500 years. Since 1901, the Earth's average surface temperature has risen by almost 1° C and the rate of warming has nearly doubled since 1975 according to the international *State of the Climate in 2017* report[4]. That's nearly 30 times faster than the increase at the end of the Ice Age. The ten warmest years since we began to record temperature have all been since 1998, and the four warmest have been since 2014[5].

The acceleration in warming cannot be explained by what we know about slow changes in the Earth's orbit or in the tilt of its axis. Today's combination of "stretch, wobble and roll" of the Earth does not show a reason for the faster warming we are experiencing in the north and over the whole of the Earth. Today's warming is not just the next step in Nature's way of melting of the ice sheet.

Capturing the Sun's energy in the atmosphere

Earth's natural "greenhouse effect"

Earth's temperature begins with the Sun. Roughly a third of sunlight that arrives on Earth is reflected back into space by bright surfaces like clouds and ice. Of the remaining two thirds, most is absorbed by the land and ocean, and the rest is absorbed by gases and dust in the atmosphere.

As rock and soil, lakes and oceans are warmed by the Sun, they radiate "heat" energy back toward the sky and into space. From the surface, this energy travels into the atmosphere where most of it is absorbed by so called "greenhouse gases" such as carbon dioxide and methane, and also by water vapour. Greenhouse gases get that name because they keep the Earth warm in a way that seems similar to the way that glass traps heat in a greenhouse and warms the air inside.

When tiny molecules of greenhouse gases and water vapour absorb the energy radiating from Earth's surface, they turn into tiny heaters. Like the rocks around a fire pit, they radiate heat even after the fire goes out. They radiate in all directions. The energy that radiates back toward Earth heats both the atmosphere and the surface, adding to the heating we get from direct sunlight. We call this the "Greenhouse Effect" (Figure 17).

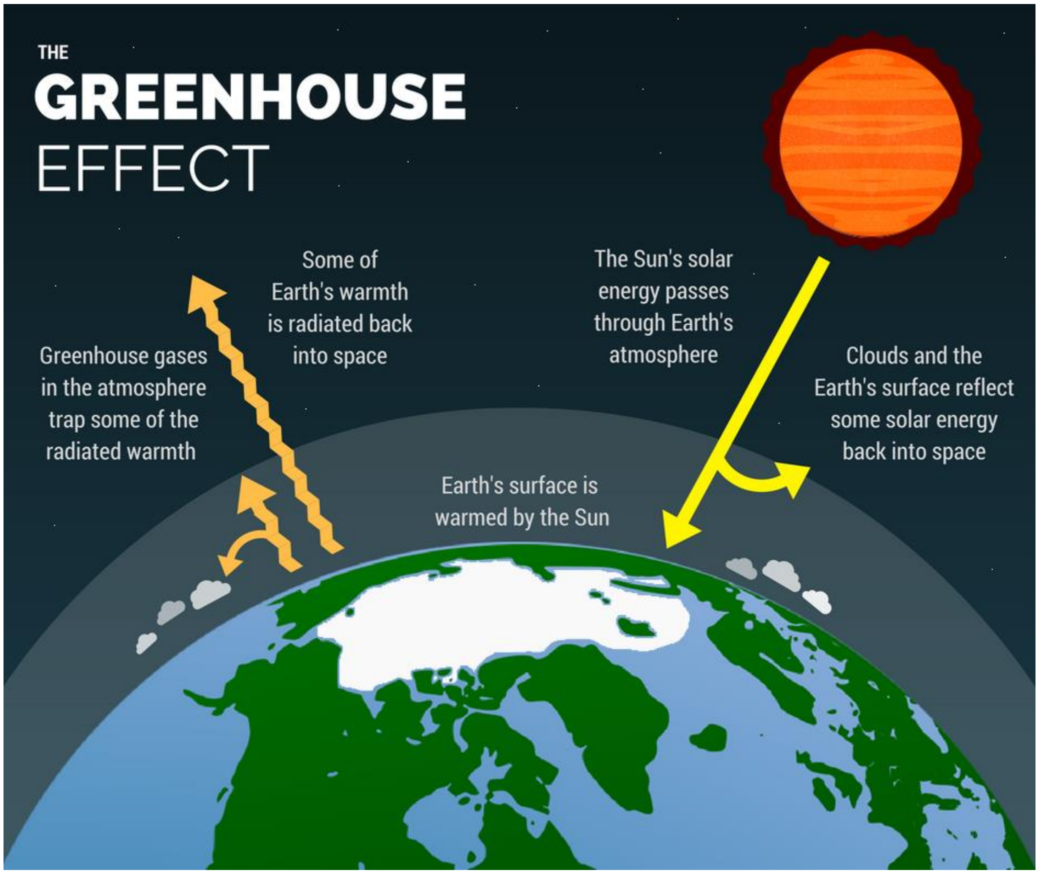

FIGURE 17: ENERGY FROM THE SUN WARMS THE LAND AND THE OCEANS OF EARTH. MOST OF THE ENERGY RADIATED FROM THE WARM EARTH BACK INTO SPACE IS TRAPPED BY "GREENHOUSE GASES" IN THE ATMOSPHERE.

This absorption and radiation of heat by the atmosphere—the natural greenhouse effect—is very important for life on Earth. Without the greenhouse effect, the Earth's average surface temperature would be much colder, about -18°C instead of the comfortable +15°C that it is today. However, the more greenhouse gas there is in the atmosphere, the hotter the Earth becomes.

Global Warming

Over the past 260 years, humans have been increasing the volume of greenhouse gas in the atmosphere at an ever-rising rate, mostly through carbon dioxide in pollution released into the air from industries burning oil, natural gas, and coal, and from vehicles. Cutting down forests has also contributed because living trees take carbon dioxide out of the atmosphere to build into wood. Since 1750, carbon dioxide in the atmosphere has increased by 45%. Methane, another important greenhouse gas, has increased by 150%.

Climate change or "global warming" is used to describe this unusually rapid increase in Earth's average surface temperature. It has risen by just a little less than 1°C since 1901 and the rate at which temperature is increasing has nearly doubled since 1975 (Figure 18).

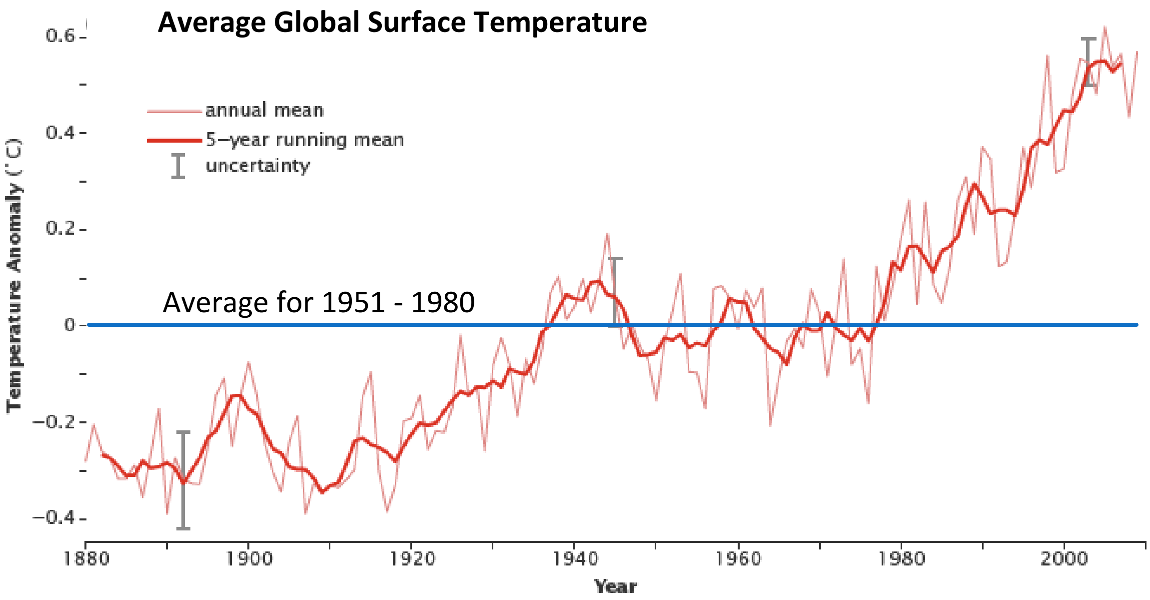

FIGURE 18: DESPITE UPS AND DOWNS FROM YEAR TO YEAR, THE AVERAGE TEMPERATURE AT THE SURFACE OF THE EARTH IS RISING. BY 2001 EARTH'S TEMPERATURE WAS ROUGHLY 0.5 DEGREES CELSIUS ABOVE THE AVERAGE FOR 1951–1980. (NASA FIGURE ADAPTED FROM GODDARD INSTITUTE FOR SPACE STUDIES SURFACE TEMPERATURE ANALYSIS)

How do we know what to expect in the future ?

During the last twenty years it has become possible to use very powerful computers and extremely complex computer programs to predict (scientists prefer to say "project") the climate of the future. Scientists first create realistic working models of the Earth with its oceans, continents and circulating atmosphere, and then add the growing pollution from warming greenhouse gases such as carbon dioxide. Complex computer programs then estimate how warm the Earth will become in the future and how the rest of the climate, such as rainfall, will change. One way of checking projections of the future is to ask the computer to calculate the climate of the last thirty years and compare the result with what actually happened. Those checks show that models are becoming more accurate, as long as there are no surprises such as changes in the circulation of the atmosphere or the oceans.

What might weather in the north be like in the 2050s ?

The computer projections we have used for this report have been developed by Environment Canada and can easily be found on line at http://climate-scenarios.canada.ca/?page=main .

Environment Canada's projections show that the temperature in Ontario will increase by 1 to 5°C depending on the season and the location (Figure 19). The highest increase in temperature is projected for winter which can affect the safety of travel on lakes and rivers and on winter roads. More snow in winter is projected for the north, however, due to warmer temperatures from fall to spring, winter snow depth overall could be lower by as much as 15%. As many community members have observed, this may impact winter travel and wildlife. Detailed projections suggest the north will be in a region where there may be a great deal of variation in snowfall from year to year. Some winters might include some very heavy snow days.

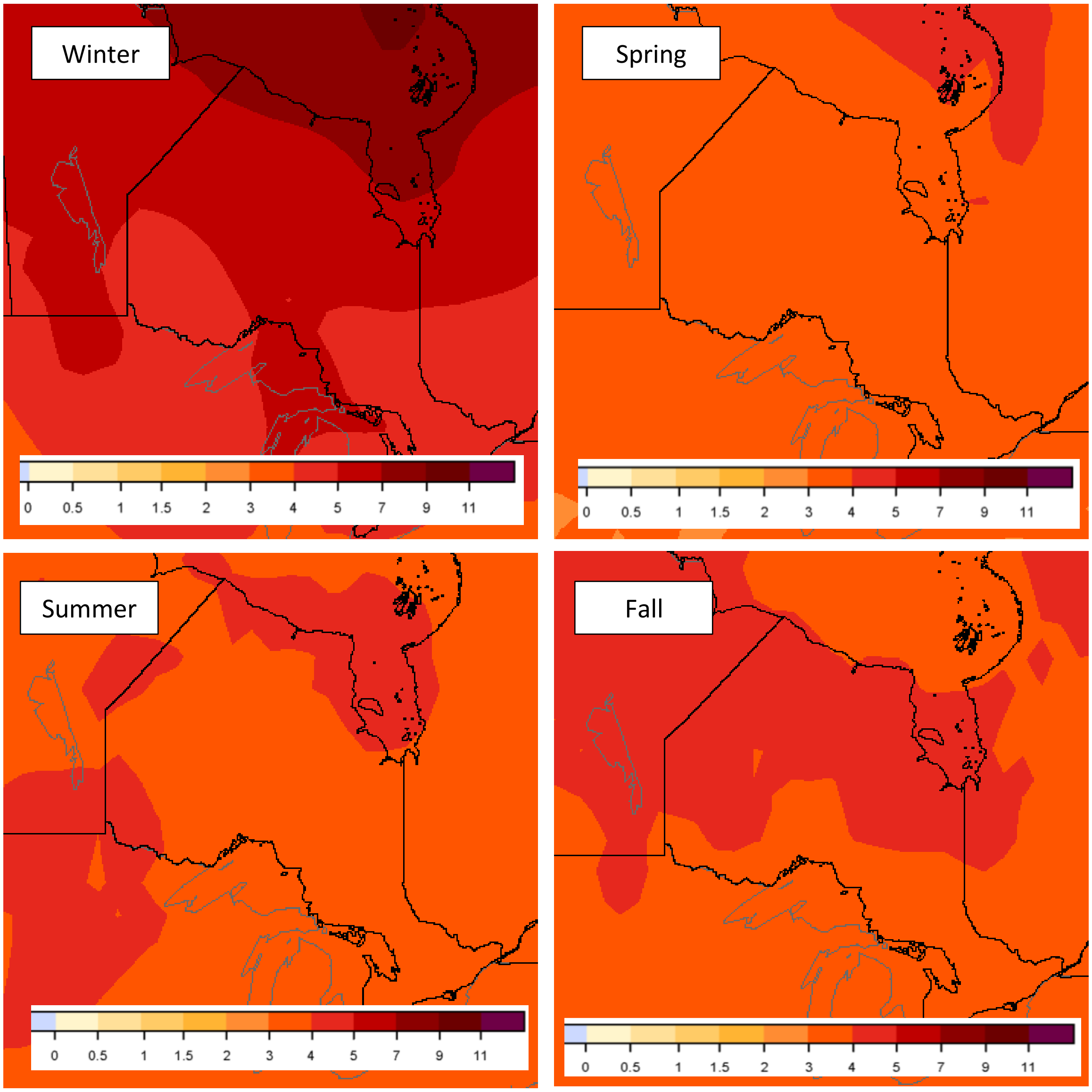

FIGURE 19: THE PREDICTED INCREASES IN TEMPERATURE IN ONTARIO FOR EACH SEASON BY THE 2050S. PLOTS FROM HTTP://CLIMATE-SCENARIOS.CANADA.CA/?PAGE=MAIN. FOR MORE DETAILED INFORMATION ABOUT PREDICTED CHANGES FOR YOUR COMMUNITY, SEE THE *WHAT TO EXPECT IN THE 2050S* SECTION OF THIS REPORT.

An increase in rain instead of snow in the winter should be expected because of warmer temperatures especially near the end of winter. While the ground is still frozen, rapid run-off can quickly raise the risk of flooding on low lying property, as well as flooding of ditches, especially those with culverts that are damaged or blocked by frozen debris. A serious consequence of late winter or early spring rain, accompanied by a rapid snow melt, is the potential for rivers and lakes to flood communities.

Higher temperatures cause more evaporation from lakes and rivers during ice free periods and from the surface of the land, lowering water levels. Warmer summer temperatures will also dry leaf litter and the ground in the bush. This will raise the risk of wildfires spreading more easily.

Warmer air can hold more water but, within just a few days, it can condense into clouds and fall as rain. Rainfall in the north is projected to increase 5 to 20% in spring, 0 to 10% in summer, and 5 to 15% in the fall, by the 2050's compared to today. However, it is difficult to predict, at a community level, how these changes in precipitation will be felt.

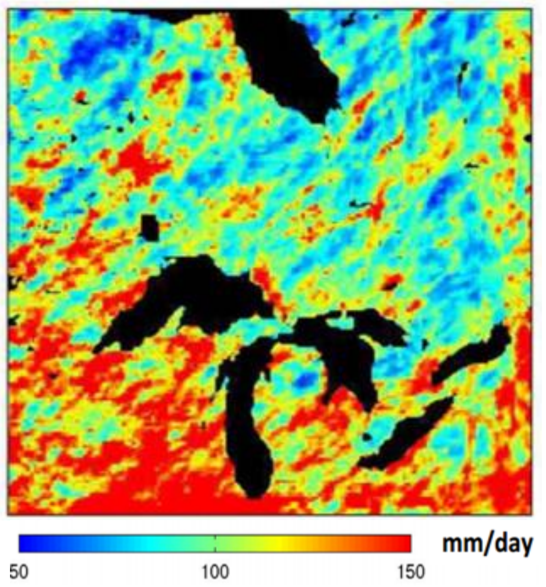

Figure 20: Projected future changes in extreme rainfall in 2045-2060. D'Orgeville and Peltier, JGR – Atoms. 2014 University of Toronto

A more damaging change projected change between now and the 2050s is an increase in heavy and severe rainfall, with longer dry periods between those events. More research is needed but one set of detailed projections predicts an increase of 14-29% in extreme rainfall events. The University of Toronto models predict a pattern of scattered storms delivering between 50 to 150 mm in a day (Figure 20). What that might mean is that a severe rainstorm that would have been experienced in a community once in fifty years might, in the future, occur once in twenty-five or even once every fifteen years.

For more detailed information of the projected changes in temperature and precipitation for your community, refer to the *What to Expect in the 2050s* section of this report.

And after 2050 ? How bad might it get ? Should we prepare for the worst ?

The amount of change our children and grandchildren will experience after 2050 will depend on our generation reducing the volume of global-warming greenhouse gases we release into the atmosphere, especially carbon dioxide and methane. We must change our habits to slow down our demand for energy and resources; we must replace the coal and oil burning technology used to generate energy and power our industries and replace it with renewable sources; and we have to limit how much forested land we clear for farming. We know what needs to be done. The question is, do we have the resolve and the vision to do it?

If we can collaborate internationally and implement immediate and extensive reduction of greenhouse gases, then the Intergovernmental Panel on Climate Change (IPCC) projects that future average global temperature might only increase by 1°C in the last half of this century compared with today (Figure 21 - RCP 2.6). On the other hand, if we carry on as if there is no problem, little international collaboration and hardly even a slowdown in the release of greenhouse gases in the next 20 years, then the scientists of the IPCC project an increase in the global average temperature of between 3 and 5.5°C by the end of the century compared with today (Figure 21 - RCP 8.5). That might be a hundred times faster than the warming when the ice sheet of the Ice Age was melting.

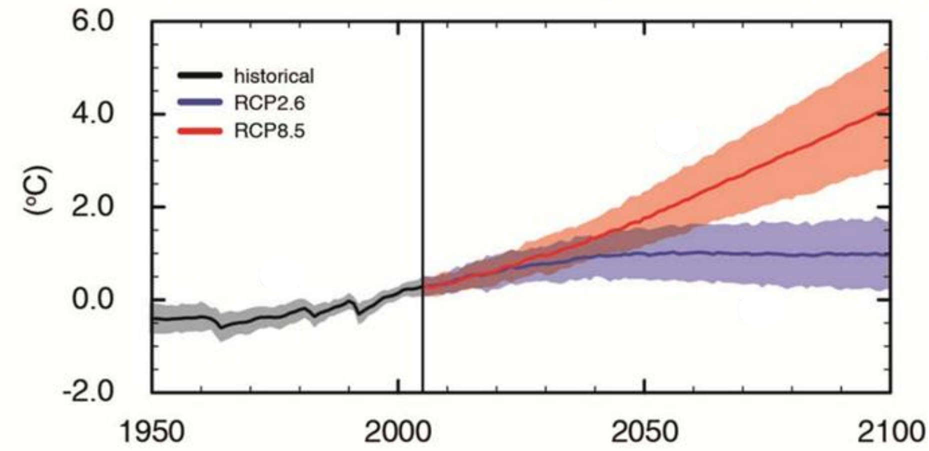

Figure 21: Earth's future average temperature increase for the rest of this century if we reduce our greenhouse gas emissions (RCP 2.6) with the future average global temperature only increasing by 1°C and if we continue on the same path of increasing our greenhouse gas emissions (RCP 8.5) which will result in between 3 and 5.5°C increase in the global average temperature. RCP: Representative Concentration Pathway)

Northern Ontario is already warming at twice the global average and there are no reasons to expect that pattern will change. Although we can hope that large industrial nations will greatly reduce the amount of greenhouse gases they release, we believe it will be better for everyone, including First Nations, to prepare for the worst. The temperature and precipitation projections for the 2050s prepared by Environment Canada and used in this report are based pathway RCP 8.5, in other words they assume little reduction in the release of warming greenhouse gases in the next 20 years. Until there are clear signs that we are moving to a better path, we have to begin considering the impacts of temperatures along the path of RCP 8.5.

Reference Materials

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2. Dyke, A. S. An outline of North American deglaciation with emphasis on central and northern Canada. *Dev. Quat. Sci.* **2,** 373–424 (2004).
3. Riley, J. L. *Flora of the Hudson Bay Lowland and its postglacial origins.* (NRC Press, 2003).
4. Blunden, J., Arndt, D. S. & Hartfield, G. State of the Climate in 2017. *Bull. Am. Meteorol. Soc.* **99,** S1–S279 (2018) https://www.ametsoc.net/sotc2017/StateoftheClimate2017_lowres.pdf.
5. NOAA National Centers for Environmental Information. *State of the Climate: Global Climate Report for Annual 2017*. (2018) https://www.ncdc.noaa.gov/sotc/global/201713.

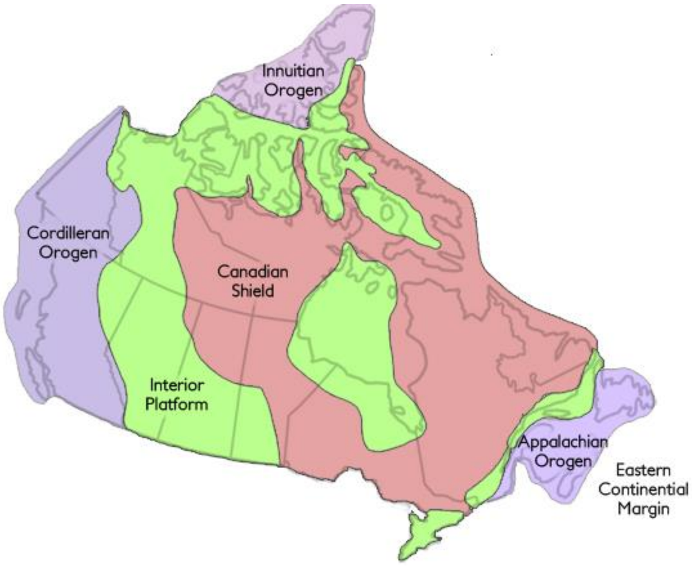
The Climate Story

The Community

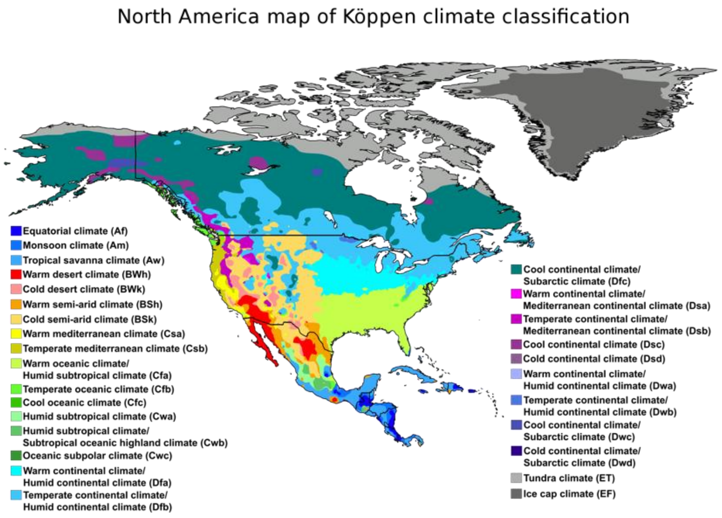
Fictional Example Community is a small Ojibway First Nation community in northern Ontario. Located to the east of Highway 642, the community is accessible year-round by road. The population is approximately 550 people.

The boreal forest of the traditional lands of *Fictional Example Community* are a mix of coniferous (black and white spruce, jack pine, balsam fir, tamarack and eastern white cedar) and deciduous (poplar and white birch) trees. Boreal forests are heavily influenced by natural fire disturbances. Boreal tree species have adapted regular fires. Many tree species need the high heat of fire to help release their seeds from cones and start the next generation. This patchiness with old and new forests allows the boreal forest to sustain hundreds of species of plants (e.g. ferns, mosses, fungi, shrubs and herbs) and animals (e.g. black bears, wolves and lynx, moose, caribou, songbirds, marten, hare, fox, porcupine.

Fictional Example Community is located on the Canadian Shield, a massive U-shaped, formation of mainly exposed Precambrian rock ranging in age from 570 million to more than 3 billion years old. The igneous (formed from volcanoes) and metamorphic (changed over time) rocks mean that there are many metallic mineral deposits that can be mined. There is very little soil on the Shield creating a unique mix of trees and plants adapted to such harsh conditions, the boreal forest.



Being on the edge of two climate types, the humid continental climate and the subarctic, Fictional Example Community experiences large seasonal temperature differences, with warm to hot (and often humid) summers and cold (sometimes severely cold) winters. The coldest month is typically January, when the temperatures averages -16°C and a record low of-46°C was experienced in 1935. In summer, the average temperature in July is 17°C with the record high being 36°C in 2004.


North America map of Köppen climate classification

Fictional Example Community Climate Story

Traditional Ecological Knowledge (TEK) is knowledge that has been collected in the minds of individuals through their personal observations of the environment and by storytelling from generation to generation. TEK is extremely valuable for learning about changes that happen in the environment over a lifetime, especially because of slowly changing weather. Climate is changing around the world, but the impacts are different for each community. TEK is local knowledge that shows those differences.

In remote northern regions, measurements of changes in weather over the years do not date back as far as the memories of people living in communities. Weather stations are often spaced out hundreds of kilometers across the landscape and do not capture the local details. Simply put, the people that use and travel the land every day are the first to observe changes. Their observations show the reality on the land not recorded by weather stations. They can also lead to investigation of environmental questions important to their community. The most powerful stories about how weather is changing and the risks this might bring to communities over generations in the future, come from combining local knowledge with knowledge from science. Summarizing the community impacts, outlining the potential risks, and discussing adaptation options is the purpose of this project.

Community: *Fictional Example Community*

Interviewer: *A. Person*

Date interviews were taken: April 2019 **Number of participants:** 9

Changes in the "bush" …. trees and plants

1. **Any changes in the plants or the trees in the bush – such as areas of dead or dying trees or bushes…. Any kinds that have disappeared or any new ones?**

Several respondents talk of seeing dying trees. Four people say they've seen dying birch specifically. Two people spoke of seeing new plants in the area, one of which might be thistle.

2. **Have any of the changes made a difference to harvesting activities by members of your community, such as finding healing plants or harvesting in the community, such as berries?**

Many respondents say there are fewer berries and/or that they must go further now to collected them. Berries mentioned include: blueberries, wild strawberries, Saskatoon berries, raspberries, choke cherries, and hazelnut. Two people say the berries are smaller and one says the blueberries have changed in taste.

3. **Have any of the changes on the land been good or bad for people in your community?**

Many of those interviewed said the changes have been bad. Some expressed concern about the health of trees and some say it is harder to practice their traditional harvesting of berries and other wild edibles. Another said trapping has been negatively affected because there are fewer animals in the area.

Other observations

One respondent talked about the traditional uses of birch trees.

Changes in lakes and rivers

4. **Any changes in lakes, rivers and creeks, such as unusual water levels or colour, or how warm the water is, or when it freezes and thaws?**

Several respondents say that water levels in lakes have been dropping and the rivers can have low water, especially mid-summer.

All agreed that lakes and rivers freeze later than they used to, with several participants saying that the timing of freeze-up has changed from mid-November to mid-December.

One participant expressed concerns about water pollution.

5. **Any changes in the water plants in lakes and creeks? Have you seen new ones? Have any disappeared? Are there more or less of any of them?**

Most say they have noticed no change in water plants. One person said there are fewer lily pads in ponds.

6. **Have you noticed unusual growth of green scum (algae) on any lakes or creeks?**

Mixed observations about algae, with some saying there is more and some saying it has not changed.

7. **Do you think any of the changes in lakes and rivers have been good for people in the community?**

Of those who responded, all said the changes have been bad. Concerns were expressed about water pollution and the safety of drinking water.

Other observations

One participant said a creek they used to play by when they were younger is now dried up.

Changes in swamps and wet areas

8. **Any changes in swamps and wet areas, changing in size or looking different in any way?**

Participants tend to agree that swamps and ponds are becoming smaller and/or are drying up. Several participants pointed out that this is particularly the case in early spring and/or mid-summer. One participant believes it is the lack of snowfall in winter leading to dry swamps in spring.

Changes in fish

9. **Has fishing changed? Have you noticed any change in the kinds of fish or their size or their health?**

Several respondents believe fish health is declining, saying fish they have caught have had sores, worms, etc. Many also say that the meat is softer than it used to be. Some lakes are said to have healthier fish than others.

Three people say there are more bass in the area now than there used to be.

10. **Have you noticed any changes in the places and times when fish spawn?**

Mixed opinion about the timing of fish spawning, with some saying it has not changed, some saying it has, and some saying they have not noticed.

Two people said spawning locations have changed, with one person pointing out an area where fish had spawned when they were younger but noting that fish do not spawn there anymore. They believe it has to do with changes in water levels.

11. **Do people in your family eat as much fish as they used to? More? Less?**

Some respondents said they still eat as much fish as they used to, some respondents said they eat less.

Changes in birds, animals and insects

12. **Any changes in the migration of birds and the movement of animals on the land?**

Many people have noticed changes in the migration of geese and ducks. Some say there are fewer than there used to be, some say the geese now come from a different direction than they used to. One respondent said that the ducks no longer taste the same.

13. **Any different birds, insects or animals that you haven't seen before?**

Pelicans and turkey vultures are both mentioned as being relatively new to the area. Some say that deer are new to the area, while others say deer aren't new but are increasing in numbers.

One participant mentioned seeing a new insect but did not know what it was.

14. Greater numbers of some birds, insects or animals?

Some respondents said there seem to be more mosquitoes and blackflies. Two respondents said there have been more eagles.

Several respondents said they see and hear fewer songbirds than they used to. One respondent said there are now fewer frogs.

15. Have you or others in your community altered your activities because of changes in birds, animals or insects?

Three people say that goose hunting has changed due to the changes in migration. They now have to hunt at different times and often get fewer geese than they used to.

Warmer falls were also said to be affecting the timing of moose hunting, with people now waiting for cooler weather.

16. Would you say that some of the changes you have seen in birds, insects and animals have been bad or good for you and people in your community?

The lack of songbirds and the decrease in the goose harvest are both given as examples of negative changes.

The increase in eagles was mentioned as a positive change.

Changes in winter

17. Has there been a change in the amount of rain during the winter?

All respondents agreed that there is more rain in winter now than there used to be. Several respondents mentioned a thunderstorm that occurred last winter in January.

One respondent pointed out that winter rain creates slippery conditions in the community.

18. Have you noticed any changes in the snowpack? Have they caused problems for people or land?

Three participants said there used to be more snow when they were younger. Two participants said this past winter had lots of snow.

One participant noted that winter rain can create an ice crust over the snow.

19. Animals?

One participant said that an ice crust on the snow can impact the animals, making it harder for some to find food.

20. Have there been any changes in how warm or cold it is in winter?

Most participants say that winters are warmer now, with two participants pointing out the lack of days at -40°C. Many also say winter starts later than it used to.

Two participants say they find winter weather more variable, with periods of warm temperatures followed by periods of cold temperatures.

21. Has the date of the first and last snowfall changed? From when to when?

Some respondents said snow fall comes later than it used to, with one respondent pointing out that there used to be snow at Halloween. Some respondents said snowfall times vary from year to year.

Two respondents said that snow will fall several times and then melt before a snowfall actually stays on the ground.

Changes during the rest of the year

22. Have you noticed changes in temperatures in summers during the day and during the night?

Some participants said they find the summers hotter now, with two participants pointing out that temperatures remain hot even during the night.

Some participants said they find temperatures in the summer quite variable with spells of cooler weather.

Two participants said hot temperatures have prevented them from going outdoors.

23. In the spring? In the fall?

Thoughts on spring were mixed, with some saying the find spring comes late and some saying they find spring comes early. Two people said that warmer temperatures in spring lead to faster spring melt.

Many people felt that fall is now warmer than it used to be, with some saying they also find that it lasts longer.

24. Have there been changes in droughts and periods of dry weather and have they affected you and other people in your community?

Some participants said that the land can get dry, especially when it gets hot. One participant pointed out that this can lead to forest fires.

Wind and rainstorms

25. Have you noticed any changes in the number of rainstorms and how severe they are? Any changes in windstorms?

Observation on rainstorms were mixed, with some saying there are more storms than there used to be, some saying there are less, and some saying the number of rainstorms has not changed.

Three respondents said they find winds and/or windstorms more severe.

Changes in air and clouds

26. Have you noticed any changes in the air at any times of the year?

Most participants say they have not noticed any changes, however, one says they find there is more pollution and another says that air quality is affected by smoke from forest fires.

27. Have cloud shapes and patterns changed at some times of the year?

Most have not noticed a difference.

One respondent said their grandfather could predict weather from the clouds.

Travel outside the community

28. How has your community been affected by changes in the winter roads?

This community does not have a winter road.

29. Have changes in winter weather and ice or lakes and river affected land animals in your traditional territory?

One participant said that the state of the snowpack affects how animals can move over the land.

30. Have there been changes in the ice on lakes and rivers that have affected people in your community?

All participants agreed that freeze-up happens later than it used to and many participants said that ice conditions early and late in the season are unpredictable and unsafe. Many participants mentioned a snowmobile that went through the ice several years ago.

Most participants also feel that the ice isn't as thick as it used to be. Three participants said that there is less blue ice (the strongest ice).

31. Have traditional routes changed because of unsafe ice in winter or low water in summer?

Three participants said they must wait longer to cross the ice for fishing or trapping.

32. How have people been affected?

Many participants again noted the incident of the snowmobile that fell through the ice.

Some participants said there is less time for ice fishing.

Effects of changing weather on buildings, roads and services (especially water)

33. Have changes in weather damaged buildings in your community? What have people done to deal with the damage?

Several participants spoke of flooded crawl spaces in either their home or the homes of others in the community. Some relate it to rapid spring melt or melts that occur in winter due to warm spells.

Two participants also noted an area of the community (near the community centre) where spring flooding seems to occur often.

34. Have the roads in your community been affected by weather? How has the community dealt with the effects on roads?

Three participants said localized flooding has affected the roads in the community by either damaging them or making them temporarily impassable.

35. Have changes in weather affected service such as electricity, sewage treatment and drinking water? And has the community been able to cope with them?

Power outages in the community were mentioned by several respondents and many linked the power outages to storms in the area.

One respondent recalled a power outage during winter that had them worried about heating their home. They believed that outage was the result of heavy snow.

Flooding

36. Have you noticed changes in how often and bad flooding is in your community?

Flooding in crawlspaces as a result of spring melt or melt during the winter was mentioned by respondents. Some said it has always been a problem, others say it has gotten worse in recent years.

Wildfires

37. Have there been any change in wildfire in your traditional territory, such as how often they happen, their size, the time of year when they happen and how close they come to the community?

All respondents recalled being evacuated from their community due to smoke from a threatening wildfire.

Some say that conditions in the bush/forest have been drier in recent years, creating concerns that the potential for wildfire is higher.

Mixed observations about whether wildfires are more frequent now than in the past. Some say wildfire has always been a concern, some say that they are now bigger and/or happen more often.

Heatwaves and droughts

38. Are periods of very hot weather a problem for some people? Is that new?

Some say that hot weather can be a problem, especially for elders, children, and those with health issues. Two respondents go on to say that hot weather can be problematic for activities such as berry picking.

One respondent said that they find the risk of sunburn higher now, saying it was never an issue when they were younger, but that now they require sunscreen, or they must stay in the shade.

39. Are long periods with very little rain causing problems in the bush? Is that new?

Some participants said the bush has been drier in recent years, leading to concerns about wildfire.

The Community

40. Any emergencies caused by the weather?

All recalled a 2001 community evacuation due to smoke from a nearby wildfire.

One participant recalled a winter storm that left some people stranded.

41. What difference has changing weather made to your life?

Respondents said they have a harder time harvesting from the land. Some said there are fewer plants/berries on the land now and/or that the quality of wild edibles has declined. Two respondents said that hotter weather makes it harder to pick berries.

One respondent said drier conditions on the land means you have to be more careful with campfires. Another respondent said they stay indoors because there are more mosquitoes.

42. Has changing weather resulted in any benefits to your community?

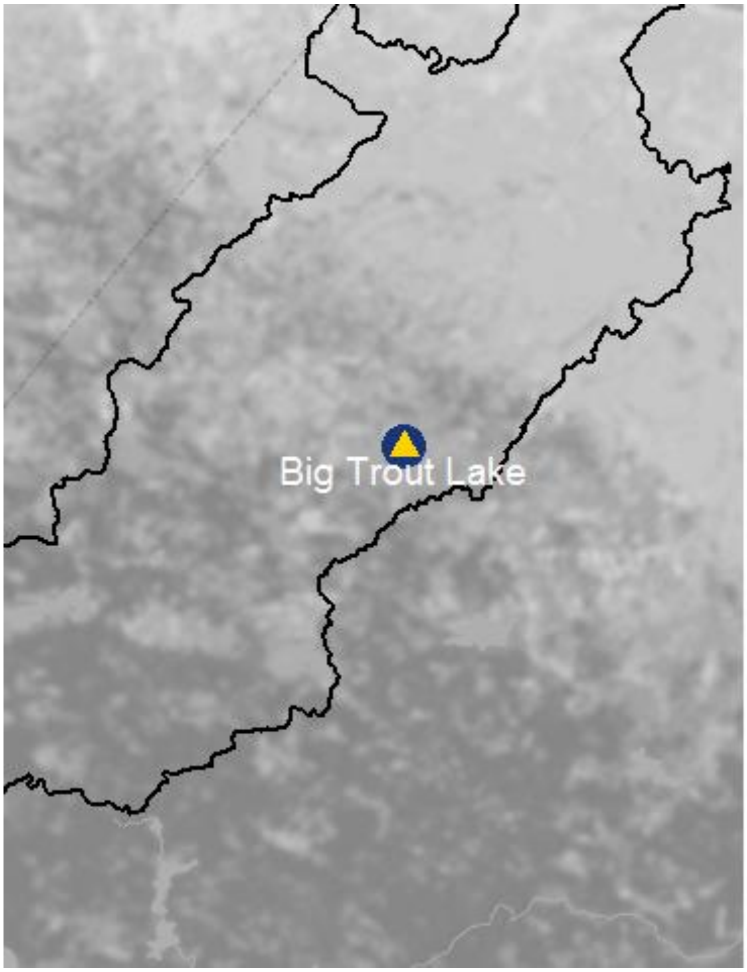
Few respondents felt there were benefits. One mentioned that, with warmer winters, people can pay less to heat their houses.

43. Are there ways you think the community might be harmed or might benefit in the future if the weather keeps changing?

Most participants felt that the community would be harmed.

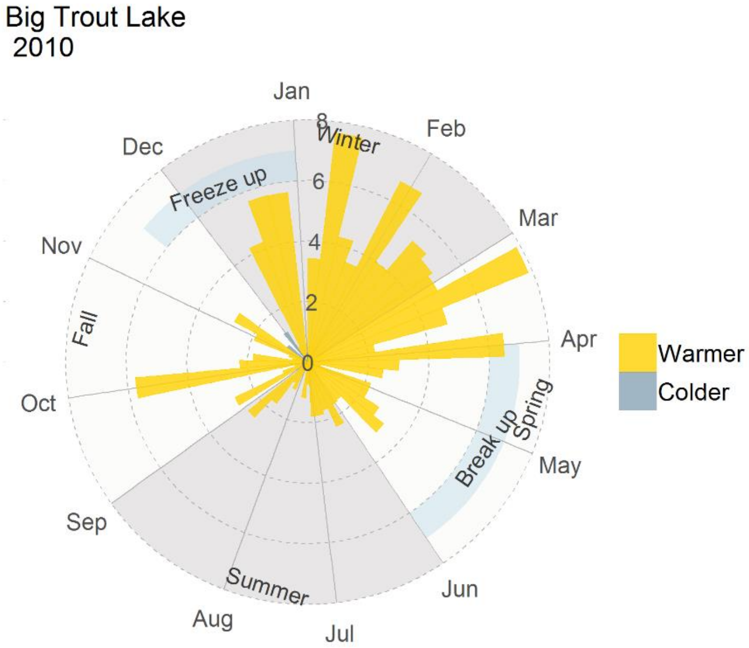
The Science of the Climate Story

Historical weather data is not available for *Fictional Example Community* because in the past, there wasn't an Environment Canada weather station in the community. Data from the nearest weather station should be similar and will be used here as an approximation of the weather in *Fictional Example Community*. Temperature data, precipitation data, and snow accumulation data were taken from the Big Trout Lake weather station. The data used in this section can be found at: *ftp://ccrp.tor.ec.gc.ca/pub/EC_data/AHCCD_daily/.*



This map shows the location of the Big Trout Lake weather station. Blue circles indicate stations with precipitation (rain and snowfall) data and yellow triangles indicate stations with temperature data. A station with both precipitation and temperature data will appear as a blue circle point with a yellow triangle on top. The black line shows the boundary of the watershed.

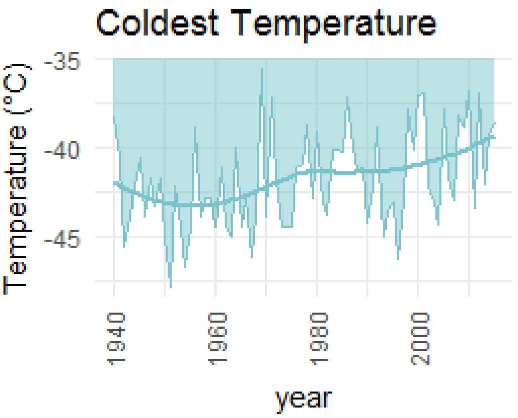
Temperature changes



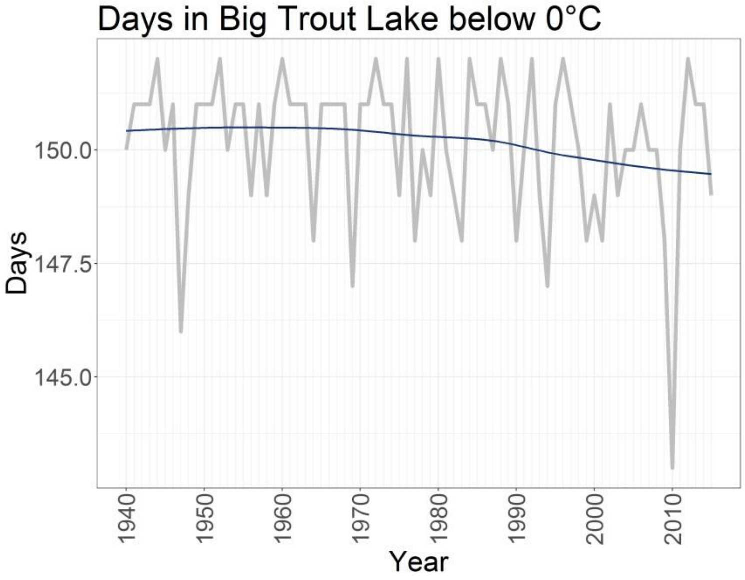
In this figure, each month is a piece of a pie that represents a whole year with January at the top. Each bar is a week of the year. The length of the bar is the change in average (°C) temperature for the years of 2001 - 2010 compared to the weekly average temperatures of 1951-1979. For that week the change can be warmer (yellow) or colder (blue).

Looking at the plot, we see that most weeks in December, January, February and March are now, on average, much warmer than they were before. In some cases, weeks are as much as 8°C warmer in 2001-2010 than they were in 1951-1979.

Changes in cold weather



This figure shows the coldest temperature measured each year in Big Trout Lake. The coldest temperature ever recorded was -48°C in 1951. The darker blue line shows the trend of the coldest temperatures over time. The average coldest temperature changed from -41°C in the 1980s to -39°C in 2015, a warming of 2°C.



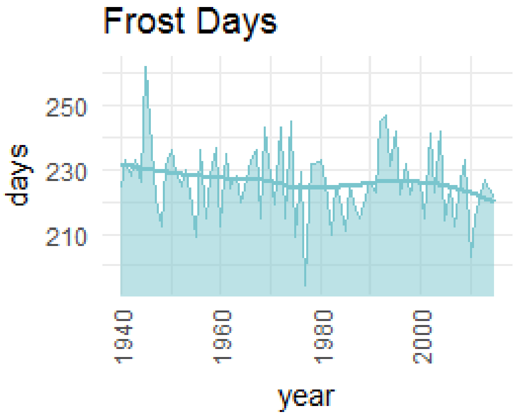
The grey line in this figure shows the number of days per year with an average temperature below 0°C. The blue line shows the trend in the number of days below 0°C, over time. From 1980-2015, days where the average temperature was below 0°C has decreased by 1 day per year.

Please note there is missing data in 2010 but this should not affect the overall trend presented in this section.

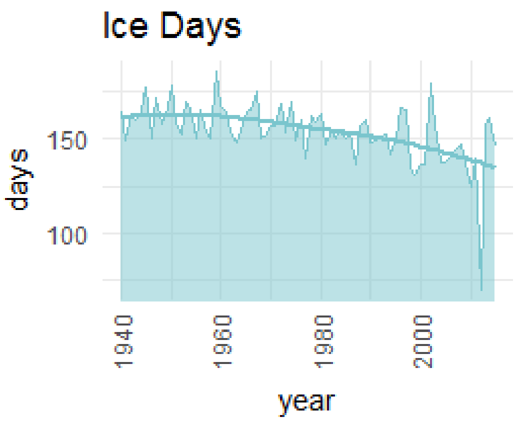
Winter Weather

The weather data tells us that days of **extreme cold** (-40°C or below) have decreased by 2 days.

Between 1980-2015 there were 5 fewer **cold spell days** (6 consecutive days with a minimum temperature of -20°C or lower).



When temperatures become colder, frost can occur. Here we are calling a frost day when the temperature in a day goes below 0°C. In the plot on the left, the light blue line is the number of days where the temperature went below 0°C. The dark blue line is the trend over time. In Big Trout Lake, there has been a decrease in **frost days** by 2 days from 1980-2015.

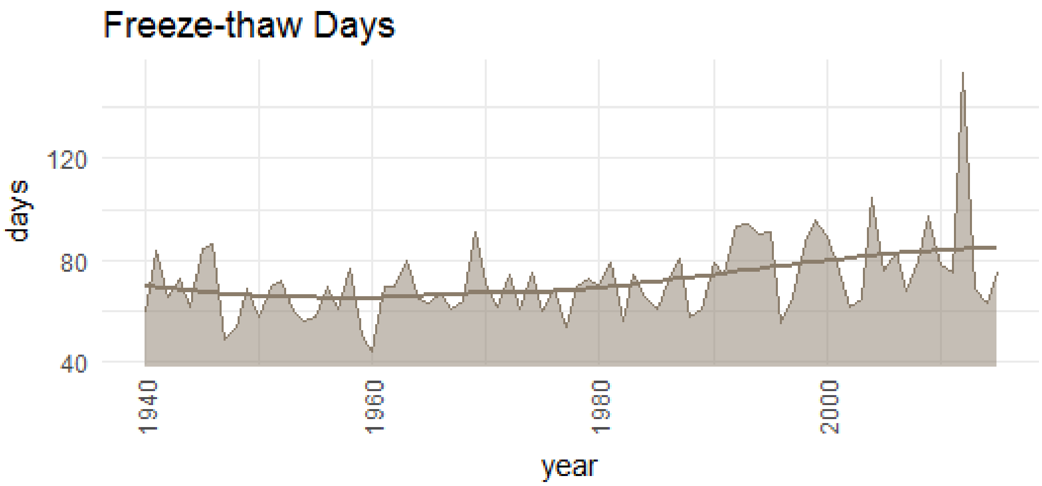


In the winter when the temperature doesn’t warm to above 0°C, we call that an ice day. In the plot, the light blue line is the number of days where the warmest temperature was below 0°C. The dark line is the trend over time. Big Trout Lake had a decrease in **ice days** (days with daily maximum temperature less than or equal to 0°C) by 20 days from 1980-2015.

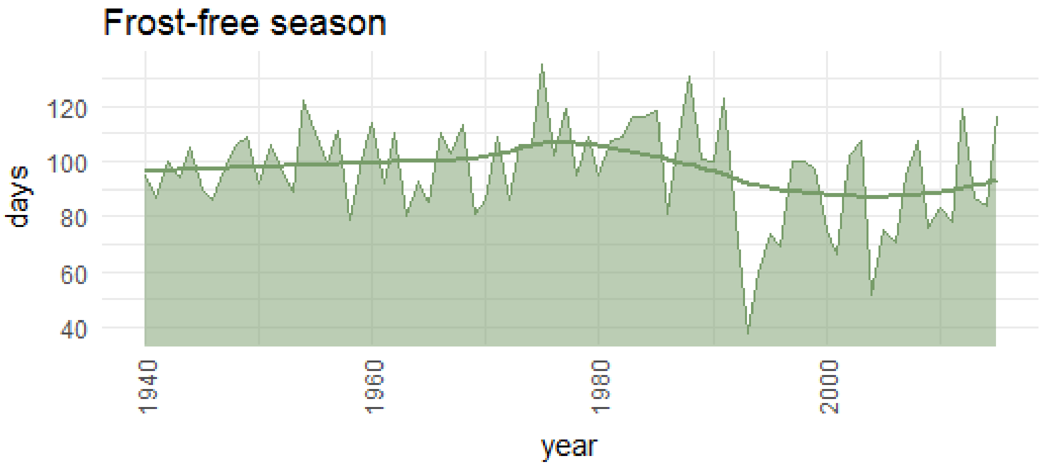
Please note there is missing data in 2010 but this should not affect the overall trend presented in this section.

Changes in spring and fall

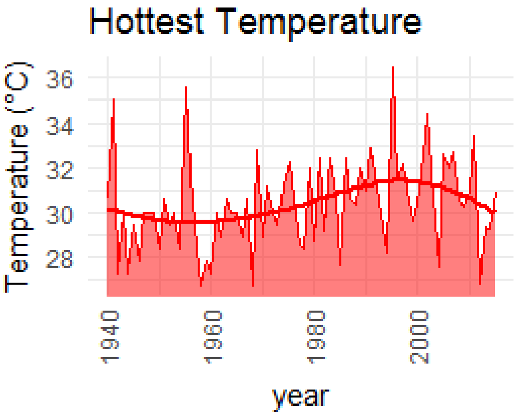
During spring and fall, there are days when the average temperature is near 0°C. When in one day the temperature goes above zero during the day and below zero during the night, we call that a “freeze-thaw day”. The brown peaks and valleys in this figure show the number of freeze-thaw days for each year. The brown line shows the trend in freeze-thaw days over time. Freeze thaw periods increased by 18 days through 1980-2015. **Please note there is missing data in 2010 but this should not affect the overall trend presented in this section.**



When we try to understand the requirements of plant growth like trees and berry plants, we talk about frost-free days. This is the number of days between the last frost of spring and the first killing frost of fall or winter. The green peaks and valleys in this figure show the number of frost-free days for each year. The green line shows the trend in frost free season over time. The frost-free season in Big Trout Lake has reduced by 6 days, starting 6 days later between 1980-2015. The frost-free season ends at the same time now as in the past.



Changes in warm weather

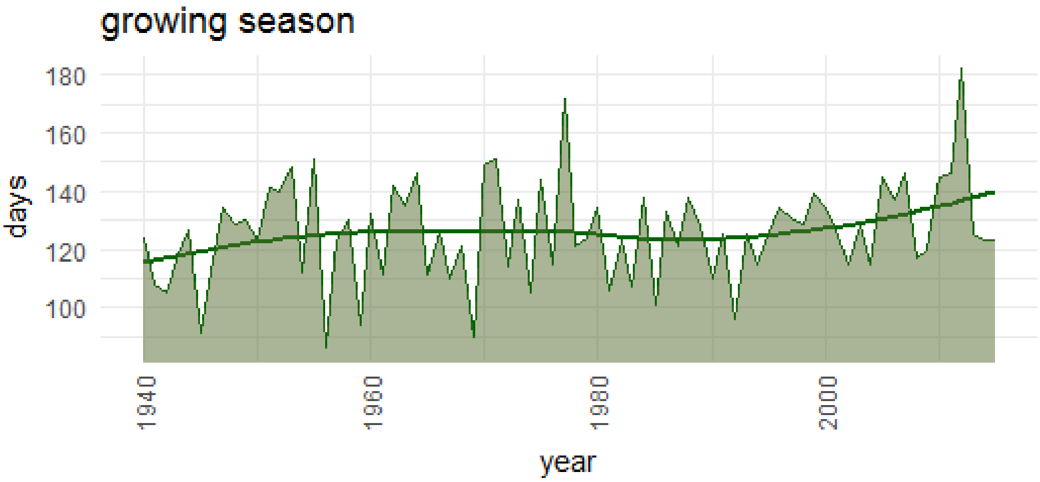


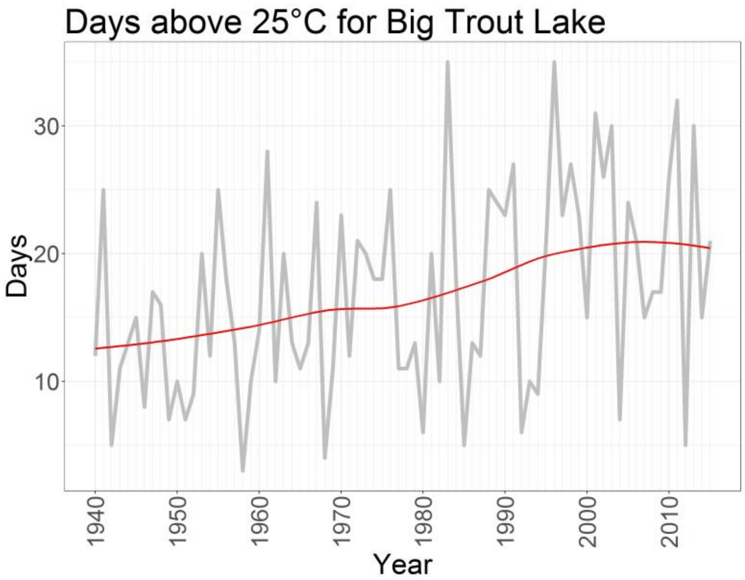
This figure shows the hottest temperature measured each year in Big Trout Lake. The hottest temperature ever recorded in Big Trout Lake was 36°C in 1995, however it is probable that this value contains some error. The darker red line shows the trend for the hottest temperature over time. The average hottest temperature has not changed from 30°C.

Growing Season

The **growing season** is important for growing vegetables but also for the trees and cultural and food plants and berries. The growing season is the time from spring to fall when the average temperature in one day is warmer than 5°C for 6 days in a row. The green peaks and valleys of the graph below show the length of the growing season, in days, for Big Trout Lake. The thicker green line shows the trend in growing season length.

The growing season in Big Trout Lake was once 125 but it has increased by 13 days between 1940-2015, making the growing season now 138 days. The start of the season is 5 days earlier and the end of the season is 8 days later.

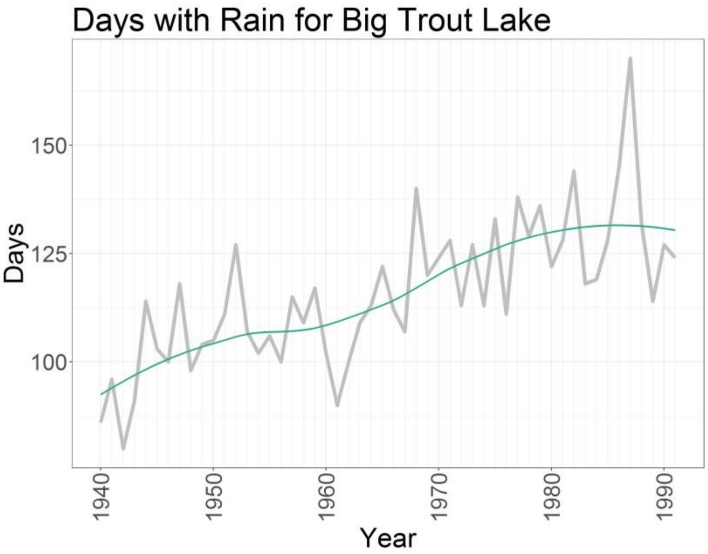




The grey line in this figure shows the number of days per year with an average temperature above 25°C. The red line shows the trend in the number of days above 25°C, over time. Through 1940-2015 there have been 4 more days per year where the average temperature was above 25°C.

Changes in precipitation

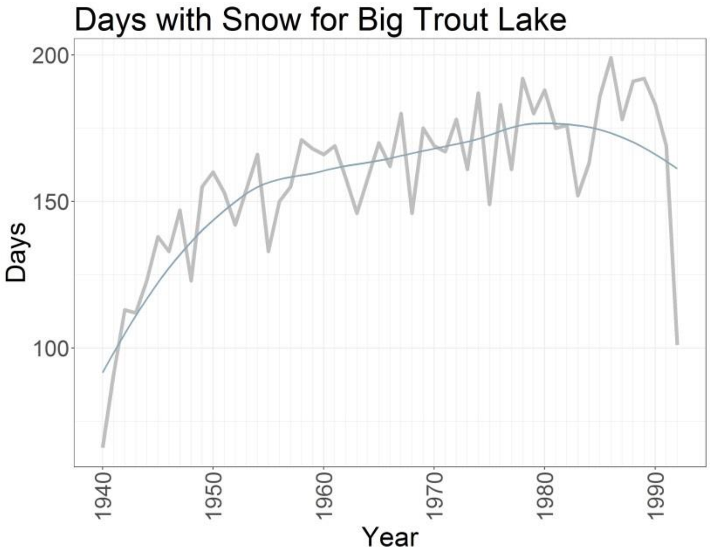
Rainfall



The plot on the left shows the number of days with a rainfall of greater than 2mm for the Big Trout Lake weather station.

On average, there has been an increase in rain events (greater than 2mm of water) per year since the weather station began recording data. However, between 1980 and 2015, the average number of days per year with a rain event has remained stable.

Snowfall



In the figure, the grey line with peaks and valleys shows the number of days with snowfall, per year, for the recorded history of Big Trout Lake. The smooth blue line shows the trend in the snowfall amount in one year.

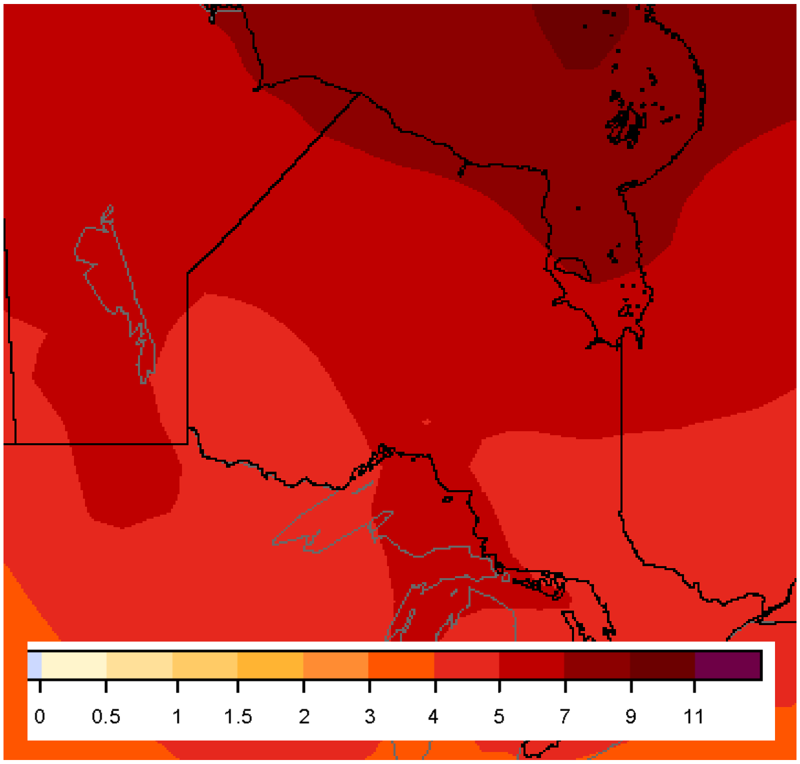
There has been, on average, a decrease of 15 days of snow per year for the Big Trout Lake weather station between 1980-2015.

What to expect in your community in the 2050s

Projections of future changes in weather patterns in Canada and Ontario, developed with sophisticated computer modelling, extend the changes seen in the last 60 years of the weather records.

Environment Canada (EC) projections as well as others developed by the Ontario Ministry of Natural Resources and Forestry, and for the Ontario Ministry of Environment and Climate Change, all agree on the severity of the upcoming changes by 2050s, with some differences in the details. The EC projections used in this report are calculated under a scenario where there is little reduction to current emissions (RCP8.5, Figure 21). Northern Ontario is already warming at twice the global average and that trend is expected to continue. Predicted changes in temperature and precipitation as snow and rain in your community are presented as maps on the next pages.

Winter Changes (December-January-February)



THE PROJECTED CHANGE IN WINTER TEMPERATURE (°C) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005, ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

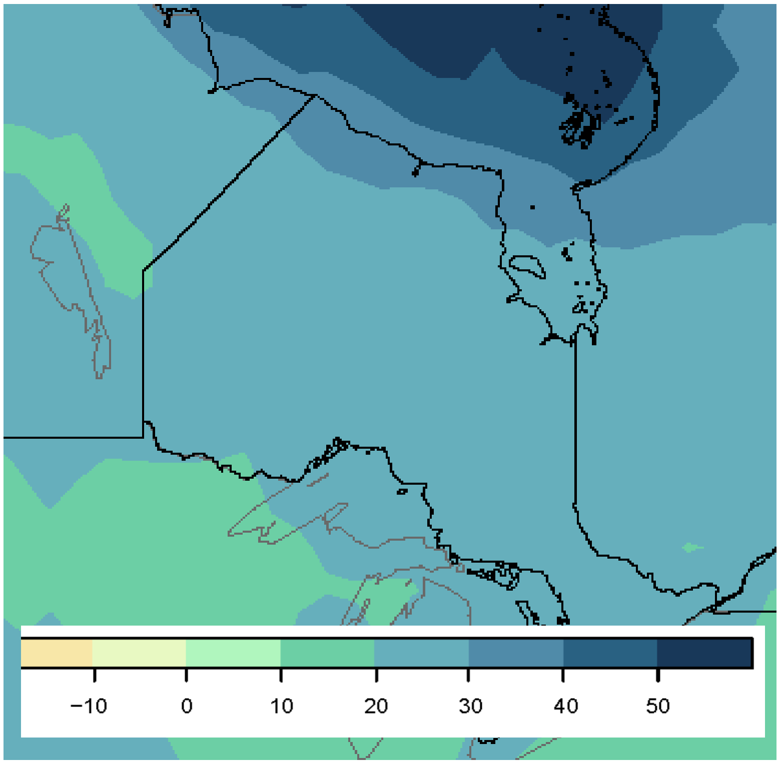
Projections for the 2050's show considerable winter warming in Ontario of 4 to 9°C, compared to the average temperature for 1986-2005. We have already experienced about a third of this warming. In the next 35 years, we can still expect a 3 to 6°C increase in temperature.

In *Fictional Example Community*, we can expect a warming of 4 to 5°C, with 2.5 to 4.5°C still to come by 2050.

The winter season is projected to have the greatest temperature increase, and warmer winters are already being felt and seen in communities. In particular, delays in ice freeze-up time have impacted some people's ability to travel or hunt. Changes in ice thickness can be a hazard to people's safety, and incidents of break-through could become more frequent. It is also likely that warmer temperatures will lead to a shorter winter road season interrupted by warm periods, which may result in increased costs of goods and services that are transported and accessed through the winter road.

Increases in winter temperatures may lead to more frequent mid-winter rain events [2]. Rain in the winter is often in the form of freezing rain and stresses infrastructure, including transmission lines and roofs. In addition, mid-winter rains can cause flooding when water, which cannot drain into frozen ground, runs off and pools at low points, often leading to basement or crawlspace flooding if proper drainage designs are not in place.

The warmer winters may also lead to the invasion of certain pests that couldn't previously survive the harsh winters. For instance, black-legged ticks carrying Lyme's disease are now found in northern Ontario and are expected to increase their range northward with climate change [3]. There is also fear that the mountain pine beetle may enter Ontario's boreal forest by the end of the century and could have major economic impacts in the logging sector [4].



The average winter precipitation (most falling as snow) is projected to increase in Ontario by as much as 10 to 40% by the 2050's compared to the average for 1986-2005. This means the amount of precipitation could still increase 7 to 27% by the 2050s, compared to today.

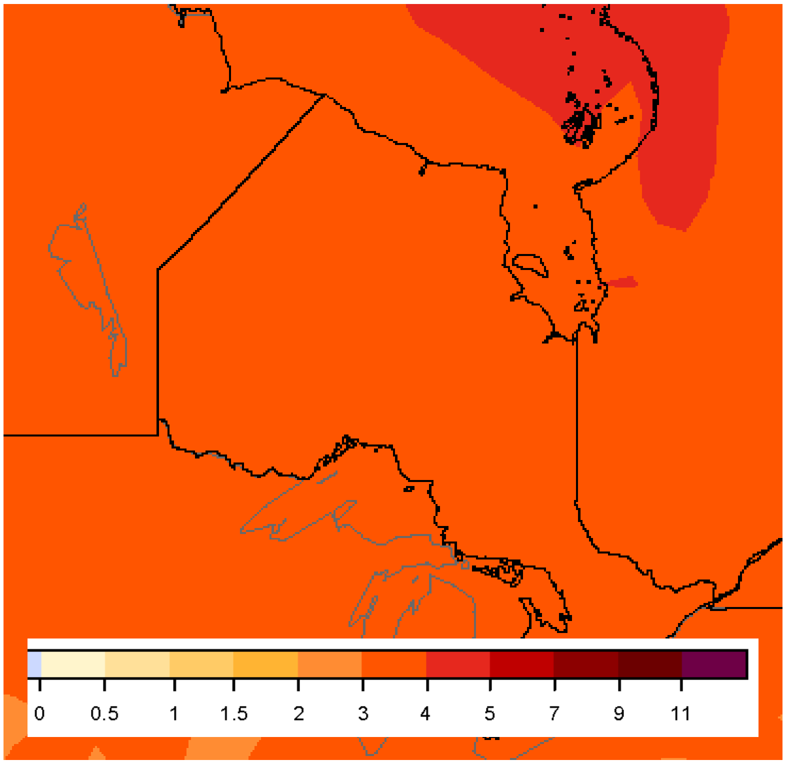
In *Fictional Example community*, we can expect an increase of 20 to 30%, with 13 to 20% still to come by 2050.

THE PROJECTED CHANGE IN WINTER PRECIPITATION (%) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005, ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

However due to warmer temperatures from fall to spring and perhaps mid-winter rain events, winter snow depth overall is expected to decrease by up to approximately 15%. Changes to the amount and quality of snow in the winter will impact certain key wildlife species that are sensitive to snow depths both because it can be more difficult to walk in deep soft snow as is the case for moose and because it restricts access to food as is the case for the snowshoe hare. Furthermore, winter rain can hinder thermoregulation in many species, such as moose[5] causing them to lose energy when it is difficult to eat enough to maintain life.

Conversely, more snow could be an advantage for winter road building, if it falls after the frost has penetrated the ground[6].

Spring Changes (March, April, May)



By the 2050s, the average spring temperature in Ontario is projected to be 3 to 4°C warmer than the average temperature for 1986 – 2005. This means an increase of about 2 to 3°C in the next 35 years.

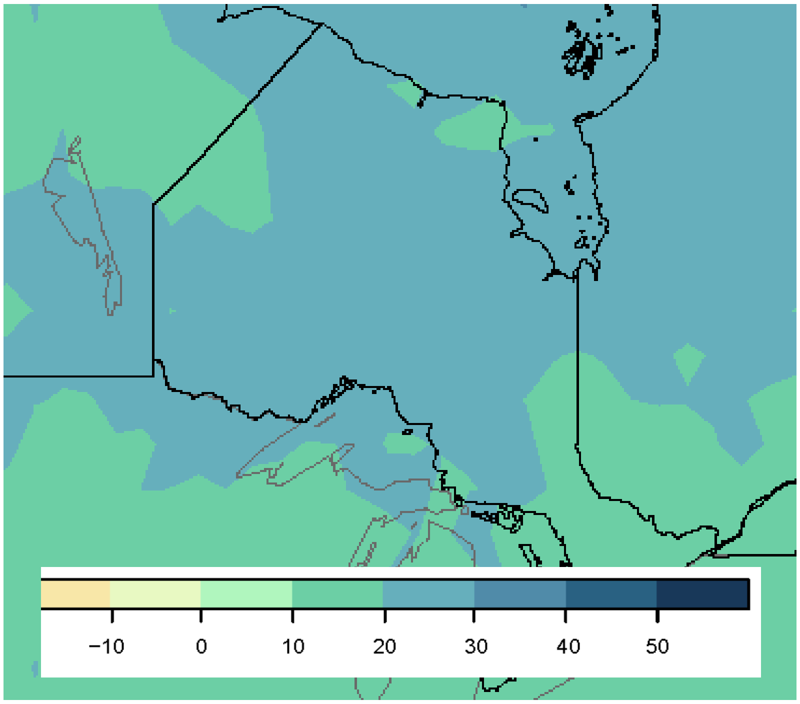
In *Fictional Example Community*, we can expect a warming of 3 to 4°C. With 2 to 3°C still to come by 2050.

THE PROJECTED CHANGE IN SPRING TEMPERATURE (°C) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005, ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

A warming spring has contributed to rapid melt of ice and snow, creating unsafe ice conditions earlier than when they may have occurred in the past.

Some people have noticed a change in geese migration timing and fish spawning times, which could be related to a warmer spring and the time that certain vegetation/food becomes available[7]. This shift could impact the timing and duration of goose harvests.

In contrast, a warmer spring could have the benefit of extending the growing season and be beneficial for the production of food in vegetable gardens.



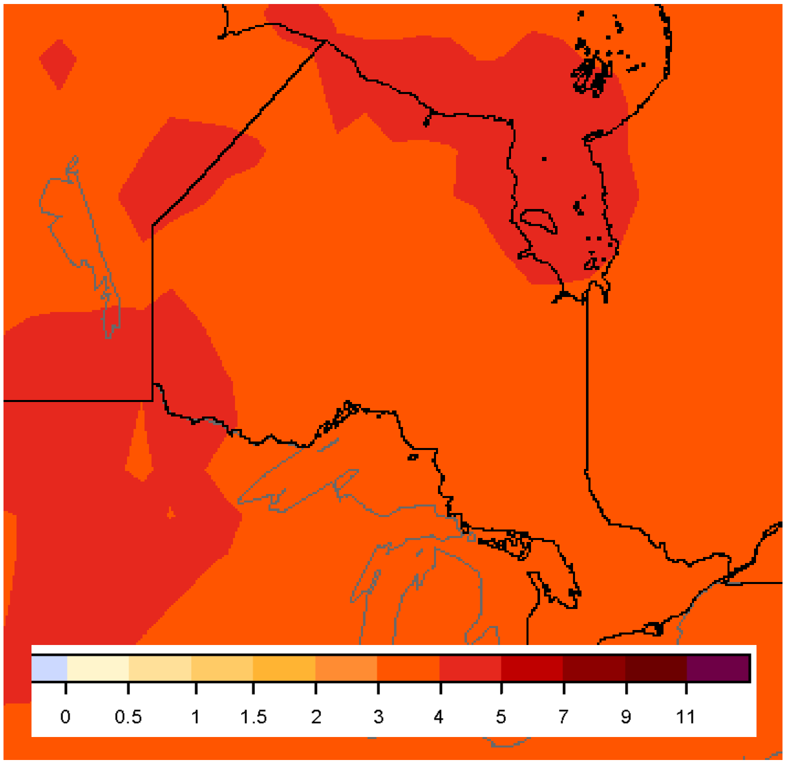
THE PROJECTED CHANGE IN SPRING PRECIPITATION (%) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005, ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

A warmer spring and the projected increase in precipitation could lead to localized flooding within communities as water runs off the frozen ground and pools in low lying areas. Precipitation in the spring in Ontario is projected to increase 10 to 30% by the 2050s, compared to the average for 1986-2005. This means in the next 35 years we will continue to see approximately 7 to 20% more precipitation.

In *Fictional Example Community*, we can expect an increase of 20 to 30%, with 13 to 20% still to come by 2050.

Increased run-off and rapid melt of increased snowfall, could lead to flooding of nearby waterbodies, including lakes and rivers. Spring climate also affects the timing and severity of river break-up. Water levels, water flow rates, and run off should be monitored closely by community members vulnerable to flooding from the river. River ice-jamming may be influenced by spring climate conditions, such as run off rates and solar effects from the sun that contribute to ice decay.

Summary Changes (June, July, August)

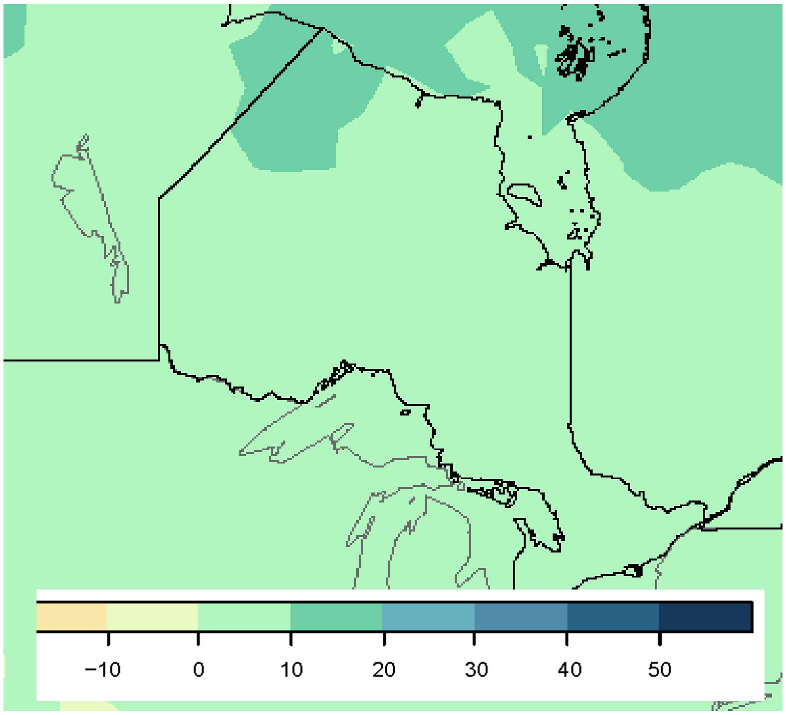


THE PROJECTED CHANGE IN SUMMER TEMPERATURE (°C) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005.ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

Summer temperatures are projected to increase 3 to 5°C by the 2050s in Ontario, compared to the average for 1986-2005. This means we can still expect approximately 2 to 3.5°C of increase in the next 35 years.

In *Fictional Example Community*, we can expect a warming of 3 to 4°C, with 1 to 3°C still to come by 2050.

Warmer summers may mean that heatwaves will become more common. Increased summer temperatures, coupled with only minimal increases in precipitation, may lead to drought. It is likely the effects of drought will be felt more strongly in western and southern Ontario and could contribute to the frequency and severity of fires in those communities. People with breathing difficulties such as asthma, the elderly, and young children may be at risk if smoke from fires enters the community. Plants may be impacted, in particular important edible berry plants.



By the 2050's, precipitation in the summer is expected to increase up to 20% in Ontario, compared to the average for 1986-2005. This means the amount of precipitation could still increase up to 13% by the 2050s, compared to today.

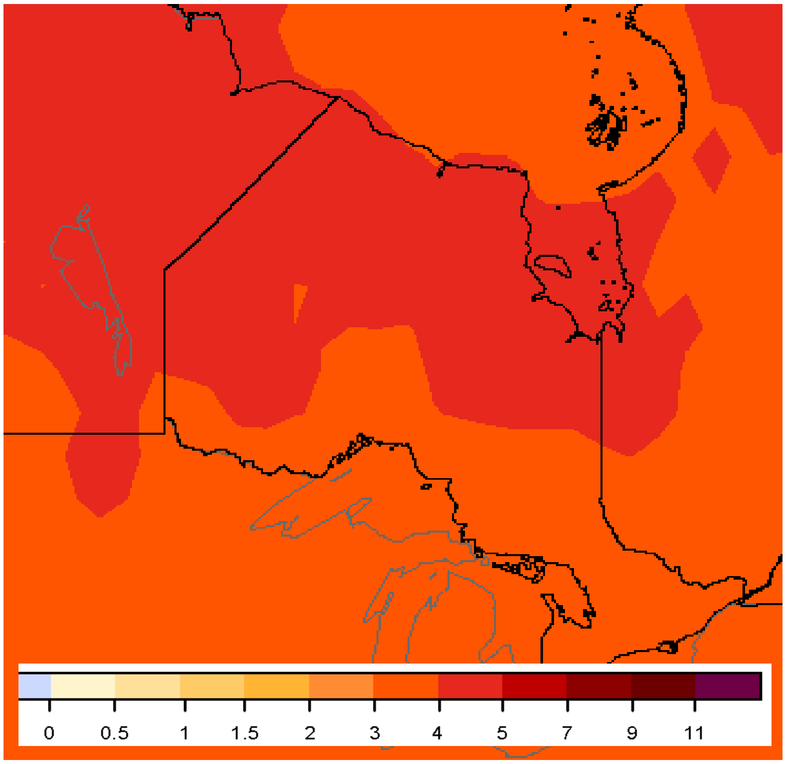
In *Fictional Example Community*, we can expect an increase of up to 10%, with up to 7% still to come by 2050.

THE PROJECTED CHANGE IN SUMMER PRECIPITATION (%) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005. THIS PROJECTION WAS DETERMINED USING A HIGH CARBON EMISSION SCENARIO (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

People have been observing shallower waters in swamps and wetlands, but shallow water in rivers is most pronounced because traditional routes are being altered. The rising on the land as a result of glacial rebound is also contributing to shallower rivers and swamps.

Under extreme events, such as prolonged heatwaves and drought, fish die offs have occurred and may occur more frequently, due to climate change[8]. Warmer summer temperatures may have ecosystem impacts. As waters slowly warm, we are seeing a northward movement of warm water fish, such as small mouth bass, into systems that previously only hosted cool and cold-water species. This invasion of warmer water species could impact native fish populations that also have a climate range shifting northward. We are also likely to experience a change in plant distributions. In other words, the plants that we find growing in forests today, may not be able to tolerate the climate in 50 years. Scientists are not sure exactly how forests will adapt with climate change, but several tree and plant species will likely be affected.

Fall Changes (September, October, November)



Fall temperatures are projected to increase 3 to 5°C by the 2050s in Ontario, compared to the average for 1986-2005. This means temperatures will continue to rise 2 to 3°C in the next 35 years.

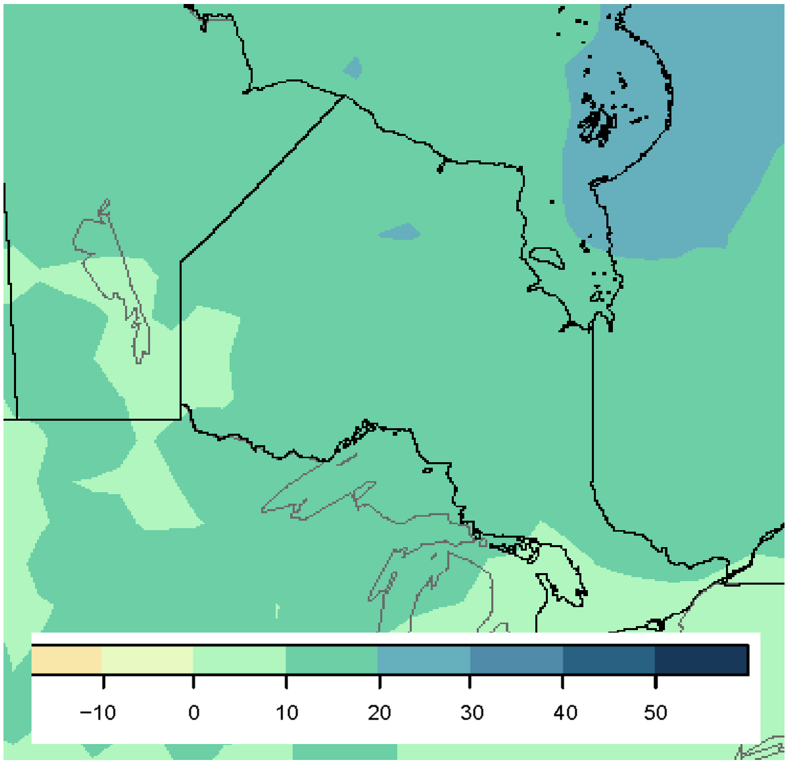
In *Fictional Example Community*, we can expect a warming of 3 to 4°C, with 1 to 3°C still to come by 2050.

THE PROJECTED CHANGE IN FALL TEMPERATURE (°C) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005. ASSUMING A SMALL REDUCTION IN CARBON EMISSIONS (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

Warmer falls are contributing to delayed ice-freeze up and people have said this is altering the timing and the ways they hunt and fish. Many people have said they must now delay hunting until later in the season because there is a risk of food spoilage if it is unexpectedly warm. A warmer fall is also increasing the length of the potential fire season in the north.

Warmer fall temperatures also lead to the winter road season opening dates being delayed more frequently.

However, warmer falls could have the potential benefit of increasing growing season length allowing for vegetable gardening.



By the 2050's, there will be up to 20% more precipitation in the fall in Ontario compared to the 1986-2005 average. This means the amount of precipitation could still increase up to 13% by the 2050s, compared to today.

In *Fictional Example Community*, we can expect an increase of 10 to 20%, with an increase of 7 to 13% still to come.

THE PROJECTED CHANGE IN FALL PRECIPITATION (%) BY THE 2050S, COMPARED TO THE AVERAGE FOR 1986-2005. THIS PROJECTION WAS DETERMINED USING A HIGH CARBON EMISSION SCENARIO (RCP8.5; 75TH PERCENTILE). ACCESSED: JANUARY, 2018 FROM: HTTP://CLIMATE-SCENARIOS.CANADA.CA/INDEX.PHP?PAGE=DOWNLOAD-CMIP5

More fall rains can lead to high water levels when the ice forms which can contribute to the severity of river ice jams and subsequent spring flooding. Early snowfall in the fall can delay winter road construction and access to winter travel routes over water because snow insulates the ice from the cold air slowing its production.

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Preparing for the Future

Preparing for change

First Nation peoples have always had to adapt to change, in particular changing weather. This means adaptive capacity is built into their culture and day to day lives. In the north, adverse weather is not unfamiliar. However, as climate changes people and the environment may become vulnerable in ways that they don't anticipate.

People and communities can equip themselves to become better prepared for the changes to come. Warmer weather in all seasons, more extreme weather, and changes in the plants and animals have already been noted and will become even more pronounced over the next 40-100 years. Now is the time to plan and prepare for these changes.

On the next page is the adaptation planning matrix that combines observed changes and vulnerabilities with projected changes in climate, risk assessment before adaptation, risk after adaptation, and some of the adaptation options. It is then left to the community to set their adaptation priorities. By taking this approach, the adaptation planning is relevant to your community. In addition, by examining all these vulnerabilities as a whole, there is the opportunity to look for 'win-win' scenarios with respect to adaptation strategies. For instance, having a longer growing season allows communities to grow more food in their community via gardens or greenhouses. In turn, this reduces the reliance on food being transported by air or on the winter road, thereby reducing the impact of climate change within these sectors. Adaptation planning within a community can benefit from taking this holistic approach.

Following the adaptation matrix are sections that outline areas where vulnerability and change may be experienced due to a changing climate. They include: Ecosystems, Health, Infrastructure, Transportation and Travel, Food Security and Traditional Harvests, Fire and Flooding.

Community-based climate change adaptation matrix

The community-based adaptation matrix provides a framework for community knowledge, information, projections of future change, and adaptation options to be addressed in each community. It is made up of four main sections. From left to right, those sections are:

Vulnerability Indicators (**green header**)
Climate trends and projections to 2050 (**blue header**)
Risks and Adaptations (**red header**)
Priorities (**yellow header**)

Vulnerability Indicators

This section lists and describes the ways changing weather patterns are already affecting the land and, because of that, the well-being and way of life of First Nations in the north. This is the first step in deciding how to adapt to those changes both personally and collectively as a community.

TEK and Community Observations

The statements in these boxes are drawn from the answers given by community members in the TEK collection interviews. This way, the issues addressed in the matrix are specific to each community.

Community Weather Incidents

Incidents include weather-related events like windstorms, floods or fires in the traditional territory of a First Nation but could also include events like people breaking through ice while travelling. These incidents will provide an example in support of the observation.

Technical Information / follow-up

Observations from interviews can sometimes be supported if they are followed up by checking in documents or with someone who has special knowledge.

Climate projections for the 2050s

This section addresses what science predicts the climate in the 2050s will be. Individuals can personally relate to 2050 because it is within the lifetime of today's families. There is also more certainty about the possible climate in 2050 than at the end of the century

Temperature and Precipitation; seasonal weather patterns

Projections provided here about climate conditions in the 2050s are based on work done by Environment Canada (http://climate-scenarios.canada.ca/?page=main).

Extreme events

Predicted changes in the future frequency of certain extreme weather events such as very heavy rainfall, snowfall, heat-waves and droughts are presented here.

Risks and Adaptations

Risks are ranked as Low, Medium and High. Tentative initial risk assessments have been included for the purpose of encouraging discussion but, ultimately, risk and priority assessment must come from the community.

Before Adaptation Risk

Risks to health, safety, and infrastructure implied by observations noted in interviews, combined with projections of future climate, are the basis for these assessments of risk. Risk assessment should combine the consequence of given event and the likelihood that it will occur (Risk = Likelihood x Consequence).

Adaptation Options

Options for adapting to a particular risk are presented in this column. Often, more adaption options are possible than just the list presented here. These options can act as a starting point for adaptation discussion.

After Adaptation Risk

Adaptation actions can sometimes reduce the risk or impact of a particular event.
If change can be adapted to in some way, the risk can be reassessed (Risk = Likelihood x Consequence / Capacity to Adapt).

Community Priorities

Decisions about which risks most require action depend on a community`s assessment of their importance. In some cases, a more technical look at the adaptation options and the capacity of individuals and/or the community to implement them will be needed. While some adaptions may be possible from an engineering standpoint, there may be financial or equipment limitations to consider. Other obvious options might be chosen for action right away.

Community-based Climate Change Impact, Risk, and Adaptation Planning Matrix

Community: ……*Fictional Example Community*……………………………………. (D.P. Nov 2017)

Vulnerability Indicators – land, life, infrastructure, health			Climate trends and projections to 2050		Risks and Adaptations			Priorities
TEK and Community Observations	Weather Incidents Examples - flood; heavy snow; winter rain; freezing rain; heatwave; drought; fire	Technical information and follow up re observations and incidents	Examples - temp; rain; snow; freeze up; break up; seasonal weather patterns	Extreme Events Examples - rain, snow, heatwave, drought, wind	Before Adaptation Risk = Likelihood x Consequence High - Med - Low	Adaptation Options (for community discussion)	After Adaptation Risk = Likelihood x Consequence / Capacity to Adapt High - Med - Low	Community Priorities Selected for action High - Med - Low
Dying trees, birch trees mentioned specifically.		Some people blame tree death on the logging in the area. Birch sensitive to changes in moisture (drought and flooding).	Summer temperatures are expected to increase 1-3°C by the 2050s. Evaporation rates from warm summer temperatures may exceed precipitation leading to drier forests.	Periods of drought may be more frequent.	**Uncertain** Potential loss of habitat. Dead trees may act as fuel for wildfires.	-Monitor, identify cause. -Consider a FireSmart program to mitigate risk of wildfire (www.firesmartcanada.ca).	-If cause can be found, mitigation actions may be possible. -Wildfire planning, like Firesmart, can decrease risk from wildfires.	
Fewer of many types of berries, including (but not limited to) blueberry, wild strawberry, Saskatoon berries and raspberries.		Changes in temperatures, precipitation, local weather and pollinators can impact wild edibles.	Temperatures expected to increase across all seasons. Changes in precipitation expected.	Periods of drought may be more frequent.	**Low – Med** Loss of important traditional food source/cultural practice.	-Monitor species: identify berry patches. -Further travel or greater collection effort may be required. -Protect areas of berry growth. -Consider cultivation options.	**Low** risk as a food source: -If berries are no longer found where they used to grow, maybe new areas can be found. -If people must travel further, consider ride-sharing to reduce costs and improve access for all. **Low-Med** risk of loss of a traditional practice.	
Appearance of new plant species, including (possibly) northern thistle.		Climate change is expanding the range of some plant species northward.			**Low** If species is considered invasive, control measures may be necessary.	-Monitor for new species, identify if possible. -Create actions plans for invasive species of concern.		

Vulnerability Indicators – land, life, infrastructure, health			Climate trends and projections to 2050		Risks and Adaptations			Priorities
TEK and Community Observations	Weather Incidents Examples - flood; heavy snow; winter rain; freezing rain; heatwave; drought; fire	Technical information and follow up re observations and incidents	Examples - temp; rain; snow; freeze up; break up; seasonal weather patterns	Extreme Events Examples - rain, snow, heatwave, drought, wind	Before Adaptation Risk = Likelihood x Consequence High - Med - Low	Adaptation Options (for community discussion)	After Adaptation Risk = Likelihood x Consequence / Capacity to Adapt High - Med - Low	Community Priorities Selected for action High - Med - Low
Low water in swamps and ponds (especially in early spring or midsummer) and rivers and creeks (especially in summer).		Decreased amounts of snow in winter may lead to low water levels in early spring. Low summer levels may be a result of longer periods without rain and/or warmer temperatures causing more evaporation.	Winter snow depth is projected to decrease 5-15% by the 2050s. Summer precipitation expected to increase 0-10% by the 2050s. However, projected increases in summer temperatures (1-3°C) will also increase evaporation rates and may outweigh precipitation gains.	Periods of drought may be more frequent.	**Low** Impedes travel over water. Potential to impact fish habitat and migration.	-Monitor water levels. -Alter/modify travel equipment/methods -Protect important aquatic habitat. -Protect fish migration routes. -Identify important wetlands.	**Low** -Alternate equipment/travel methods may mean travel over water is still possible. -Fish will be less impacted if migration routes and important habitat are still available.	
Change in the migration of geese and ducks.		Changes in migration patterns have been observed by many first nations. Research suggests boreal populations of Canada geese are stable and mallard ducks are increasing[1].			**Low-Med** Loss of traditional food. Loss of cultural practice.	-Monitor local populations. - Alter hunting time/locations if necessary. -Share harvest within the community.	**Low** -If harvesting can still occur, risk is lower. -Perhaps new hunting locations can be determined. -If further travel is required, consider ride-sharing to reduce costs and improve access. -Sharing harvested animals can help improve food security in the community.	
More bass than before.		Bass invading lakes, moving northward. Warmer annual temperatures: (winter and summer) reduces fish kill in the winter and warmer waters allow fish to move northward.	Summer temperatures expected to increase 1-3°C by the 2050s. Winter temperatures expected to rise 2.5-4.5°C by the 2050s.		**Low-Med** Impacts other native fish species. However, bass can be consumed.	-Monitor. -Alter catch regimes, ex. begin catching bass. -Encourage practices that limit the spread of invasive species (proper disposal of bait fish for ex.).	**Low** -Potential for bass to become a food source. -Human caused spread of species can be mitigated.	

Vulnerability Indicators – land, life, infrastructure, health			Climate trends and projections to 2050		Risks and Adaptations			Priorities
TEK and Community Observations	Weather Incidents Examples - flood; heavy snow; winter rain; freezing rain; heatwave; drought; fire	Technical information and follow up re observations and incidents	Examples - temp; rain; snow; freeze up; break up; seasonal weather patterns	Extreme Events Examples - rain, snow, heatwave, drought, wind	Before Adaptation Risk = Likelihood x Consequence High - Med - Low	Adaptation Options (for community discussion)	After Adaptation Risk = Likelihood x Consequence / Capacity to Adapt High - Med - Low	Community Priorities Selected for action High - Med - Low
Concerns about fish health (sores, parasites, softer flesh)		Fish health: changes in climate can stress fish species and alter parasite/ disease frequency/ distribution[2].			**Med** Loss of traditional foods/cultural practice	-Monitor fish health. -Protect aquatic system health. -Consult with experts in fish disease/ parasites.	**Low-Med?** -A healthy aquatic system can help protect fish health.	
Winter temperatures warmer, less consistent.		Most weeks in Dec., Jan., and Feb. are, on average, warmer now than they were in the past. (Environment Canada weather station data).	Temperature of winter expected to rise 2.5-4.5°C by the 2050s.		Warmer winters could reduce heating costs (**benefit**). Warmer winters can lead to unsafe ice conditions (**High**).	For adaptations for ice conditions, see below.		
Later freeze up of lakes and rivers, earlier thaw, thinner ice.	Snowmobile went through the ice in 2015 (CBC News).		Winter temperatures projected to increase 2.5-4.5°C by the 2050s. Temperature increases in spring and fall may also lead to shortened ice-on seasons.		**High** Potential loss of life. Sorter season for ice fishing, delayed access to trap lines. Loss of some traditional routes	-Monitor ice conditions each season, especially at freeze up and break up. Share information with the community. -Assess safety of common/traditional travel routes, propose alternatives if necessary. -Lighter vehicles may be required for crossing ice.	**Med-High** -If ice conditions are known, people can make informed choices about their activities. -Alternatives to over-ice travel may be the safer option.	
More winter rain.	Winter thunderstorm occurred last January (TEK).	Winter rain may become more common with increasing winter temperatures.	Winter expected to warm 2.5-4.5°C by 2050s.	Increased frequency of freezing rain [3].	**Low-Med** Flooding risk (water runs off frozen ground and can damage infrastructure). Freezing rain can stress infrastructure.	-Infrastructure vulnerability assessment for flood and freezing rain risk. -Retrofitting may be necessary of some buildings or hydro infrastructure.	**Low** -A vulnerability assessment can point out vulnerable areas so mitigation can occur. -Retrofitting can protect infrastructure.	

Vulnerability Indicators – land, life, infrastructure, health			Climate trends and projections to 2050		Risks and Adaptations			Priorities
TEK and Community Observations	Weather Incidents Examples - flood; heavy snow; winter rain; freezing rain; heatwave; drought; fire	Technical information and follow up re observations and incidents	Examples - temp; rain; snow; freeze up; break up; seasonal weather patterns	Extreme Events Examples - rain, snow, heatwave, drought, wind	Before Adaptation Risk = Likelihood x Consequence High - Med - Low	Adaptation Options (for community discussion)	After Adaptation Risk = Likelihood x Consequence / Capacity to Adapt High - Med - Low	Community Priorities Selected for action High - Med - Low
Warmer/longer fall season.		Some weeks in the fall season are having higher average temperatures (Environment Canada weather station data).	Fall temperatures projected to rise 1-3°C by the 2050s.		**Low-Med** Potential to affect fall harvesting activities (moose, fish) and food storage.	-Alter harvest times if necessary. -More effort may be required to keep harvested meat cool -Consider community coolers	**Low** -If fall harvesting can still occur and food spoilage avoided, risk is low.	
Localized flooding. Winter melt or rapid spring melt results in flooding in crawl spaces and localized areas in town.	Flooding near the community centre the past two springs (TEK).	Water runs off frozen ground, can't drain. Rapid spring melt can occur with higher spring temperatures and less overall snow.	Winter expected to warm 2.5-4.5°C by 2050s. Spring temperatures expected to rise 1-3°C. Winter precipitation expected to increase 5-20% by 2050s, but some may be in the form of winter rain. Winter snow depth is projected to decrease 5-15%		**Med** Potential for flooding and damage to community buildings and infrastructure.	-Maintain and improve drainage infrastructure around roads and homes and buildings. -Slope ground away from foundations, manage snow, pile away from low lying areas. -Consider flood retention ponds for melt water management.	**Low** Steps can be taken to mitigate flood risk from rapid melt.	
Increasing concern of sunburn, heatstroke, especially during activities such as berry picking/collecting traditional plants.		CO2 and other greenhouse gases play a role in determining stratospheric ozone and cloud cover. Modelling suggests that surface UV-B radiation could decrease by 2050[4]	Summer temperatures expected to increase 1-3°C by the 2050s.		**Med** Certain members of the community (elders, children, those who work outdoors, etc.) especially at risk.	-Increase awareness of heat illnesses and their prevention. -Increase awareness of sunburn and how to prevent it. -Consider community cooling stations.	**Low** -Awareness of heat illness and steps to prevent it can help lower risk. -Community cooling centers can help those without access to a cool space.	
Power outages as a result of severe weather (storms, wind, snow).		Strong winds, severe storms, winter ice storms, etc. can threaten power infrastructure.	Spring and fall wind speeds projected to increase 0-10% by the 2050s. Summer wind speeds projected to decrease 0-10%	Freezing rain projected to increase[3]. Frequency of extreme storms could also increase[5].	**Low-Med** Risk could be more substantial if outages occur in winter when heating is required.	-Be prepared for potential power outages with supplies, generators, alternate heat sources, etc. -Create a community plan for prolonged power outages.	Low -Preparing for potential power outages can lower risk.	

Vulnerability Indicators – land, life, infrastructure, health			Climate trends and projections to 2050		Risks and Adaptations			Priorities
TEK and Community Observations	Weather Incidents Examples - flood; heavy snow; winter rain; freezing rain; heatwave; drought; fire	Technical information and follow up re observations and incidents	Examples - temp; rain; snow; freeze up; break up; seasonal weather patterns	Extreme Events Examples - rain, snow, heatwave, drought, wind	Before Adaptation Risk = Likelihood x Consequence High - Med - Low	Adaptation Options (for community discussion)	After Adaptation Risk = Likelihood x Consequence / Capacity to Adapt High - Med - Low	Community Priorities Selected for action High - Med - Low
Drier conditions on the land could mean a higher risk for wildfire.	Community evacuation in 2001 due to smoke from nearby wildfire (TEK, CBC News).	Wildfire activity predicted to increase with climate change[6],[7].	Temperatures expected to increase across all seasons by the 2050s.	Periods of drought may be more frequent.	**Med-High** Potential damage to community and surrounding area, need for evacuations.	-Monitor bush conditions -Encourage safe fire practices (campfires, etc.). -Create a community fire plan (www.firesmartcanada.ca) -Ensure community evacuation plan in place.	**Med** -risk of human caused fires can be lowered -Firesafe plan can help reduce risk to community. -Evacuation plan can protect citizens.	
New species: pelicans, turkey vultures, and deer.		Climate change is expanding the climate range of some animals, including birds and deer. The decreased use of DDT and other chemicals has also allowed some bird populations to recover from earlier declines.	Temperatures expected in increase across all seasons by the 2050s.		**Low** Deer may introduce parasites increasing moose vulnerability. However, the benefit is deer can be a new food source in the future.	-Monitor for new species. -Consider harvesting deer.		
Fewer frogs and songbirds		Frog populations can be threatened by climate change, habitat degradation, infections, etc[8].			**Low** Potential loss of native species	-Monitor frog and bird populations (the use of song meters can be useful). -Consider established programs like Frog Watch Ontario. -Protect/enhance frog and bird habitat.		

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Climate Change adaptation ideas

First Nation peoples have always had to adapt. Whether it be changing weather, changes in animals, or changes on the land. Adaptive capacity is built into First Nation culture and day to day lives. In the north, adverse weather is not unfamiliar. However, there are many ways people, communities and the environment may become vulnerable with the changing climate that they don't anticipate.

People can equip themselves to become better prepared for the changes to come. Warmer weather in all seasons, more extreme weather and changes in the plants and animals have already been noted and will become even more pronounced over the next 40-100 years. Now is the time to plan and prepare for these changes.

The following sections outline some of our vulnerabilities to climate change. They include: Drought, Ecosystem Changes, Health, Infrastructure, Transportation, Food Security, Fire and Flooding. At the beginning of this section was the adaptation planning matrix. This matrix is based on observations from your community members and combines the observed vulnerabilities with information about projected changes in climate to create a risk assessment before adaptation, a risk assessment after adaptation, community priorities, and some of the adaptation options.

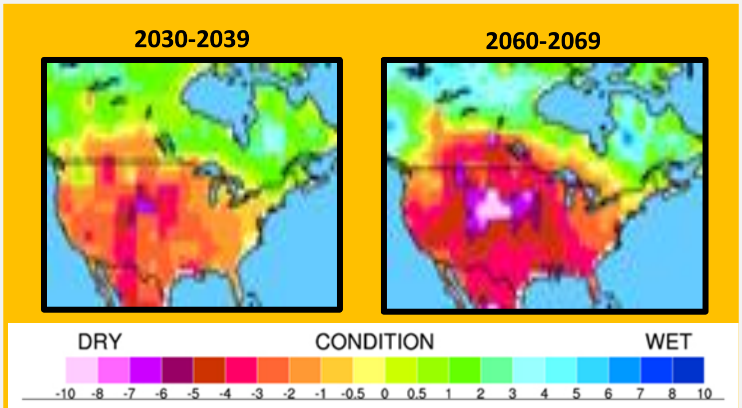
By examining all these vulnerabilities, there is the opportunity to look for 'win-win' scenarios with respect to adaptation strategies. For instance, an obvious example may be that having a longer growing season allows communities to grow more food via gardens or greenhouses. In turn, this reduces the reliance on food being transported by air or on the winter road, therefore reducing the negative impact of climate change within these sectors. Adaptation planning within a community can benefit from taking this holistic approach.

Drought

Dry river bed in Winisk, photo by Isabell Souliere

Both humans and ecosystems need water and periods of drought can lead to social, environmental, and economic impacts.

Drought is a temporary dry period with less than average precipitation relative to the local normal conditions [1]. However, a broader definition of drought might be thought of as "ecological drought" which is when a system experiences a shortage of water that pushes it beyond the limit where it can adapt and natural and/or human systems[2] become impacted.



Potential future drought in the 2030s and the 2060s from Dai, 2011 [1].

DROUGHT-INDUCED DAMAGE TO TREES.

Climate change is expected to increase the risk of drought events globally due to increases in temperature and evaporation rates [1,3,4]. Climate change is also expected to change the amount of precipitation received, and the frequency and severity of rain events[5]. However, predicting the details of future drought events, like frequency, duration, and specific region, is difficult[3]. It is thought that North America is one area likely to experience an increase in intensity and duration of droughts by the end of this century[4].

Impacts of Drought

Social

- Health problems from dust, poor driking water quality, as well as water and foodborne illnesses
- Water shortages
- Threat to public safety from increased number, frequency and range of forest fires
- Food shortages
- Loss of human life
- Conflict between water users
- Reduced incomes and quality of life
- Impact to cultural practices
- Anxiety, depression or other mental illness from drought impacts
- Low water affecting use of traditional routes

Environmental

- Decreased fitness in wildlife/plants
- Loss of fish and wildlife habitat
- Death of vegetation/trees
- Ecosystem shifts (forest to grassland for example)
- Migration of wildlife out of drought area
- Migration of invasive species into drought area
- Lower water levels in lakes, rivers, ponds, etc.
- Loss of wetlands
- More intense wildfires
- Poor soil quality
- Wind and water erosion of soil
- Soil and sediments in lakes and rivers
- Increased amounts of dust covering plants

Economic

- Increased time, effort and travel costs to fish and hunt for food
- Loss of income from reduced wildlife availability
- Loss of income from outdoor tourism
- Increased cost for outside food and water supplies
- Loss of crops from community gardens

Adaptation and Mitigation

Vulnerability Assessment and Action Planning

The impact of drought on a community will depend on a region's exposure to drought and its ability to react and recover. Communities may, therefore, wish to perform a drought impact assessment for their region to identify vulnerabilities to drought, and create an action plan to address these issues.

Knutson *et al.* (1998)[6] produced a report outlining a 6-step process communities can use to assess and potentially reduce their risk to drought events. A brief outline of the steps it recommends can be found in the box to the right. The full report can be found via Google books.

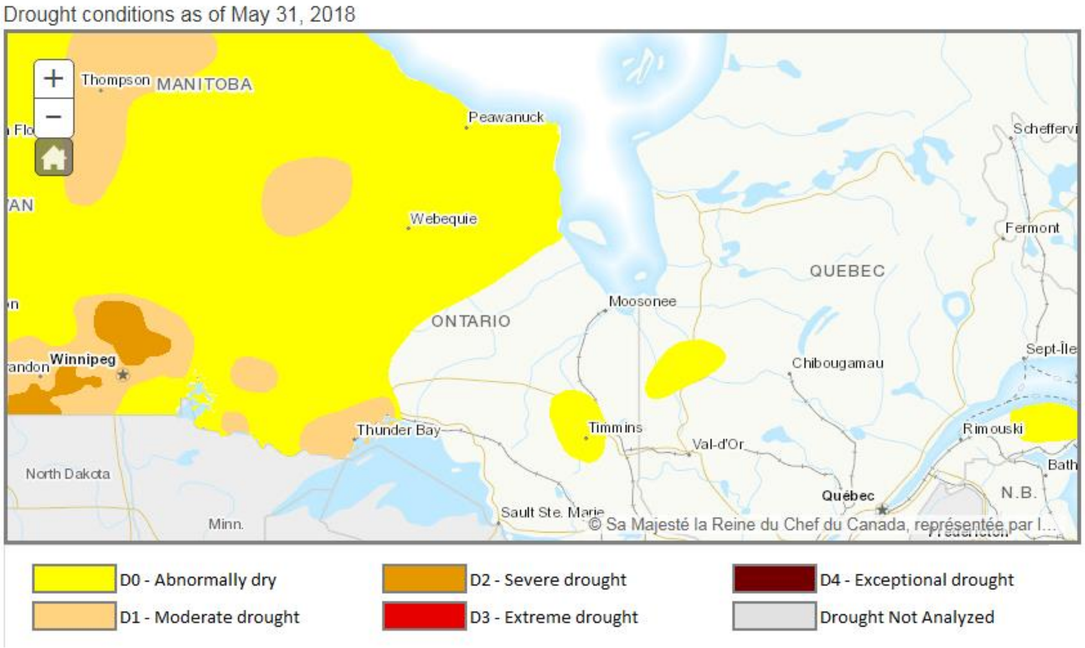
A similar approach was taken by the Drought Ready Communities Project which presents a 5-step plan for preparedness. It can be found online at http://drought.unl.edu/archive/Documents/NDMC/Planning/DRC_Guide.pdf

'How to Reduce Drought Risk'
from : Knutson *et al.* (1998)

Step 1 – *Assemble a group of people (community leaders, community members, and researchers/ consultants if necessary) to conduct the drought impact assessment and gather information.*
Step 2- *Identify the consequences of drought relevant to your community (ex. loss of clean drinking water, damage or loss of fish habitat, impacts on plants and forests, etc.).* Knutson *et al. provides a sample checklist.*
Step 3- *Rank consequences by level of priority.* Knutson *et al. provides guidance on how to rank each impact.*
Step 4- *Consider the underlying causes for the impacts and determine if it is possible to mitigate those causes.*
Step 5 and 6 - *Identify and prioritize realistic and cost-effective actions that can be taken to address the issues.*

Monitoring

Communities may wish to monitor for potential drought events. Agriculture and Agri-Food Canada shares data on drought conditions, soil moisture, and other parameters, on a monthly basis. This data is available online (www.agr.gc.ca/eng/programs-and-services/drought-watch/canadian-drought-monitor/?id=1463575104513). A sample drought conditions map is pictured below.



It may also be valuable to measure soil moisture and water levels and keep records of death of large areas of trees. Seeing changes in these measurements could give communities an early warning of coming drought. Knowing how drought conditions have been observed in the past can give direction on what areas to monitor[7]. Incorporating traditional knowledge of landscape and weather can also be useful.

Low water makes navigating this tributary of Eabamet Lake challenging

Drought is a complex issue that depends on the interaction of many factors. There are many indicators used for predicting drought and gauging drought severity, but they can be challenging to calculate. More information on these indicators and indices can be found in this publication from the Integrated Drought Management Program: www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

Community Education & Awareness

Communities may wish to provide information to community members about the potential of drought occurring and the impact it can have. This might include drought awareness education, water conservation strategies, forest fire risk awareness and mitigation, or involving the community in drought-action planning.

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Preparing for drought

Vulnerability Assessment and Action Planning

- Assess community risk and impacts of drought and have an action plan in place.

Monitoring

- Canada-wide information on drought conditions is available through Agriculture and Agri-Foods Canada (www.agr.gc.ca/eng/programs-and-services/drought-watch/canadian-drought-monitor/?id=1463575104513).
- Local observations and measurements can also be recorded.

Community Awareness

- Share information on water conservation, forest fire risk and mitigation, etc.

Ecosystems

SEVERN RIVER, PHOTO BY SINCLAIR CHILDFOREVERALONE

Forests

from www.ontario.ca

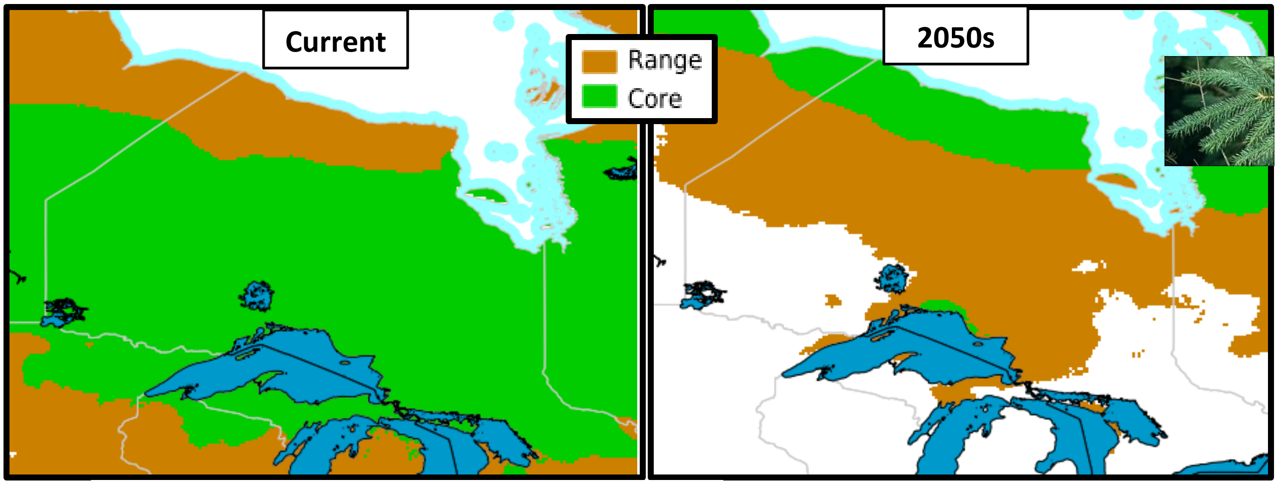
Forests are a big part of Ontario's landscape. These diverse ecosystems are home to an abundance of plant, animal and insect species, and provide resources to support region's economy. The effects of climate change are already being seen in Ontario's forest [1]. With further climate change being predicted, forest will continue to be impacted, including drier forests, shifts in animal and plant ranges, changes in timing of temperature driven events, changes in tree disease and tree insect interactions as well as the economic impacts that will follow.

Drier forests

Much of Ontario is predicted to become drier under projected climate change scenarios. Drier conditions not only increase the risk of forest fire, but drought stress negatively affects many tree and plant species, making them more susceptible to disease and insect attack. The loss of plants affects the grazers which can affect the predators.

Range shifts

Plants and animals are adapted to suit their environment. As climate continues to change, plant and animal species may find themselves less adapted to the climate where they live. Habitat ranges will shift, contract, or expand with changing environmental conditions. Many species, like the white spruce, will shift north (pictured below, www.planthardiness.gc.ca).



Current range of white spruce (1970-2000)

Projected climate envelope for white spruce with continued greenhouse gas outputs.

There is also the potential for deciduous hardwoods such as oaks, ash, maples, and walnuts to tolerate the climate of northern Ontario and the Hudson Bay Lowlands under future conditions. But trees may have a hard time keeping up with the change because they are long-lived species. Species with heavy seeds or poor dispersal, such as oaks, may be particularly affected. Scientists expect that in the next 50 years, the range for most plants will shrink [2].

Already, people in the north have reported seeing plant species such as birch, willow and thistle more often than before. Canada thistle as well as many different species of willow are predicted to continue their northward expansion with continued climate change.

Animals may also see their ranges alter as climate changes but not all will be affected equally. Species that can shift to stay within their preferred climate envelope will fair best under changing conditions[3].

Species	**Range change Prediction**	**Mechanism of Change**
Moose	Contraction	Southern areas will become too warm.
Eastern Bluebird	Expansion	Grassland habitat is predicted to increase with increased forest disturbances. Warmer temperatures will lead to a longer breeding season increasing bluebird abundance.
Red Squirrel	Expansion	Suitable habitat may expand north of current range. However, if spruce trees become less abundant, a diet switch to pine cones may be required.
Black-capped Chickadee	Contraction	Northward expansion of the Carolina Chickadee may lead to hybridization of the 2 species. Hybrids could replace the Black-capped Chickadee at the south of its habitat range.

Change in timing of temperature-driven events

Many biological processes in both plants and animals are driven by environmental cues. These cues, like temperature, amount of daylight, and precipitation, can determine the timing of events like bud burst and leaf out, flowering, migration, breaking hibernation, and breeding. But a changing climate may alter some of these cues, like temperature and precipitation. There is the potential for certain events to become decoupled. Species might not emerge at the same time as their food sources, or breeding may not occur at the optimal time. Changes such as these have the potential to impact species survival.

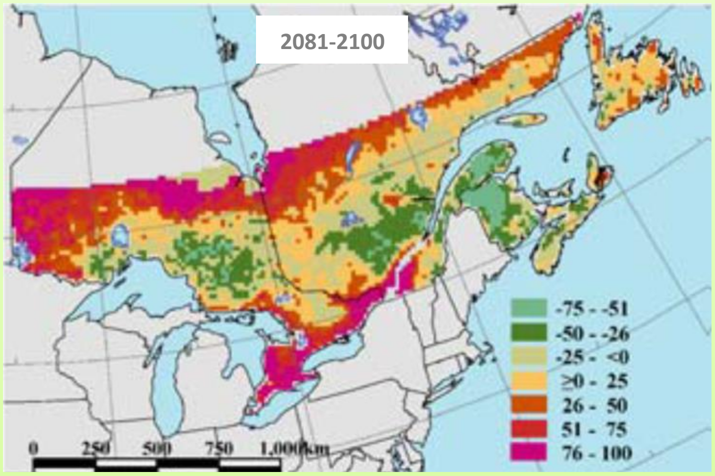
PLANT FLOWERS AND POLLINATOR HAVE AN IMPORTANT PARTNERSHIP WHERE TIMING IS EVERYTHING, PHOTO FORT HOPE.

Changes in tree disease and tree insect interactions

The relationship between tree species and the diseases and insects that prey on them is complex. Changing climate will very likely have an impact on these interactions, but the specifics are hard to predict. Most important tree diseases in Ontario are predicted to increase with climate change[4]. Warmer winter temperatures may allow the survival of diseases that are usually killed by the cold. Warmer winters may also make areas more hospitable to new forest pests. An example of shifting insect/tree dynamics is presented below[5].

Case Study: Spruce Budworm
Changing tree-insect interactions

The Eastern Spruce Budworm is a species of moth naturally found in Ontario. The larval (caterpillar) form of the moth feeds on the needles of balsam fir and white spruce and, during a major outbreak, tens of millions of hectares of trees can be defoliated (loss of needles). Although this insect is native to Ontario, changing climate may increase the length and severity of spruce budworm outbreaks, especially at northern latitudes. Major outbreaks of spruce budworm can cause significant losses of timber and non-timber resources, which can negatively affect communities that depend on the forest industry.



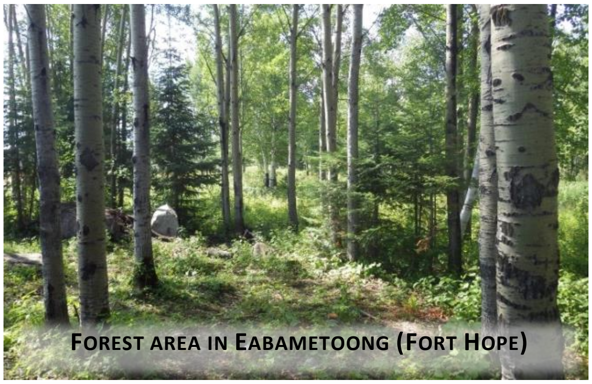
Predicted change in spruce budworm outbreaks (shown as % defoliation) under future climate conditions. The highest rate of defoliation (76-100%) is shown in pink. Map from Gray, 2008[5].

Economic Impacts

Shifting habitat ranges may mean a decrease in commercially valuable tree species in regions where they are currently harvested. This could lead to economic losses for areas that currently rely on forestry operations. On the other hand, an increase in the warm weather period could mean a longer season for outdoor recreation and actually provide a boost for the tourism industry in some areas.

Adaptation and Mitigation

Identify Important Species/Areas


Forest area in Eabametoong (Fort Hope)

Species that are especially at risk from climate change or areas of forest that are particularly important (breeding grounds, refuges, habitat for species at risk, economically important areas, etc.) may be good places to direct resources. Create or increase existing habitat protection measures. If forest fire is a concern, make sure a FireSmart plan is in place (www.firesmartcanada.ca. *Also refer to the section on fire adaptation*).

Increase habitat suitability


Bat boxes assembled by youth at Camp Chikepak to be installed in their community

Healthy forests help support all species, including plants and animals that live there. Encourage good stewardship of forest areas and provide suitable homes for important animal species. Installing bird houses and bat boxes, planting milkweed for monarch butterflies are common examples of enhancing habitat.

Decrease forest fragmentation

A changing climate will make it necessary for some species to shift their ranges to areas that offer suitable habitat. A fragmented landscape (where patches of forest are disconnected from each other) makes it difficult for species to move into new locations. Many forest plant species show little to no ability to colonize new areas in places where the landscape is highly fragmented[3]. Maintaining untouched forest corridors between forest landscapes and ensuring land use planning decreases forest fragmentation can help combat this problem. This can be accomplished at the community level but may also require policy change at the government level.

Assisted migration

Assisted migration is the process of purposefully moving species to new and more favourable locations with the aim of helping them survive a changing climate[6]. This definition can encompass:

- moving a population of a species (with a distinct genetic makeup) to an area within that species' existing range (e.g. moving lowbush blueberry plants from the southern part of its range to the northern part of its range)
- moving a species to an area just outside of its current range (mimicking how it would migrate naturally) (e.g. moving lowbush blueberry plants from the northern part of its range to just outside the northern part of its range)
- moving a species to an area far outside of its current range (e.g. moving highbush blueberry plants outside its range, into the range of lowbush blueberry)

Given that trees can be slow to migrate, assisted migration is sometimes proposed. The movement of any species into a new location is not without risks, however, such as the species failing to thrive in the new area, or the species becoming invasive in its new environment. All risks should be weighed carefully before any assisted migration plan is implemented.

Monitoring

Monitoring allows us to gather information about the environment and the changes that are occurring. Monitoring activities can take many forms and can be directed at any aspect of the environment. It can be conducted by environmental stewards, researchers, and community members. When community members help gather data, it is sometimes termed "citizen science". Citizen science is a growing field thanks in part to the availability of apps and websites that make it easy to collect and share data. Citizen science is also a good way to engage people in environmental issues and encourage good stewardship.

Examples of what to monitor:

- species at risk
- leaf out/flowering times
- species abundance
- frog/bird songs
- tree diseases and insect outbreaks
- new/invasive species

Prevent Invasive Species

The changing climate is allowing new forest pests to inhabit areas they couldn't inhabit before. The first line of defense when it comes to invasive species is always prevention; for example, don't move firewood and don't plant horticultural plants because insects and plants can become invaders. Monitor for potential invaders in your area and have a control plan in place in case they arrive. More information on invasive species can be found in Species Invasions below.

Forest Harvesting Adaptations

Changes to forest harvesting regimes may also be necessary in the face of climate change. This may include altering harvesting rates, altering harvesting strategy, changes in replanted species.

FIREWOOD HARVEST NEAR GULL BAY

Aquatic Systems

Lakes, rivers, streams and wetlands are an important part of Ontario's landscape. Not only are they a valuable source of freshwater, they also house a vast array of species, including plant life, invertebrates, and fish. Changes in climate are already making a mark on these ecosystems, with more change predicted.

Climate change has the potential to alter:

Lakes

- water level
- water temperature
- water transparency
- turbidity
- wind patterns
- ice regimes
- chemical characterisitics (pH, O, C, P, N, Hg)

Streams/Rivers

- water level
- water temperature
- turbidity
- ice regimes
- chemical characteristics (O, C, P)

Wetlands

- water levels (including the drying of wetlands)
- temperature dependant processes
-soil ice conditions
- chemcial characteristics (O, C)

Biological Implications for Aquatic Systems

Changes in habitat

Decoupling of ecological cues

Increased stress on animal and plant life

Changes in species occurrence

Decoupling of species relationships

Climate change can cause alterations in water levels through changes in rain and snow fall volumes and frequency and by increases in evaporation with higher temperatures. Water levels impact many facets of aquatic systems, including water temperature, light penetration, contaminant levels, and access to aquatic habitats.

The bank of the Severn River naturally marked by changing water levels

Higher seasonal temperatures will also lead to increases in water temperature. In aquatic systems, water temperature is a major determinant of habitat suitability and ecological processes. Fish, for example, are cold-blooded meaning that their body is the same temperature as their environment which means that they will seek out the right environmental temperature; for e.g. trout will be in the cold bottoms of lakes.

Changes in water transparency can change the amount of light penetration in aquatic systems and lead to changes in plant productivity. Increased turbidity in lakes and especially streams as a result of extreme storms, run-off and erosion can lead to decreased plant productivity which affects the entire food chain. Increases in water transparency can lead to increased UV penetration in aquatic systems and can damage aquatic organisms.

On lakes, rivers and streams, decreased periods of ice and longer periods of open water mean an increase in evaporation and less shoreline protection. However, it could also lead to an increase in system productivity, increased levels of oxygen and increased over-winter survival for some species. In wetlands in the far north of Ontario, decreased soil ice can dramatically alter ecosystem function, composition and structure.

Ice formation in Kashechewan

Wind is another important factor in lake ecosystems. Increases in wind have the potential to increase evaporation, speed ice-out, deepen thermocline (the hot layer of water at the top of lakes in summer), and increase sediment deposition. Decreases in wind have the opposite effect.

Oxygen (O), carbon (C), phosphorus (P), nitrogen (N) and mercury (Hg) all play important roles in aquatic ecosystems and have the potential to be altered either directly or indirectly by changes in climate. The level of water acidity (pH) may also shift.

More detailed information on the impacts of climate change on aquatic systems in Ontario can be found in the report: Summary of the Effects of Climate Change on Ontario's Aquatic Ecosystems[7]. http://files.ontario.ca/environment-and-energy/aquatics-climate/stdprod_088243.pdf

Adaptation and Mitigation

Identify Important Areas


Lake Trout spawning, photo by Cooperative Freshwater Ecology Unit

Areas that are ecologically important or especially vulnerable to change are a good place to aim your resources. These might include:

- wetlands
- spawning grounds
- cold water refuges
- migration routes
- habitat for vulnerable species

Plans of action for these areas might include restoration, enhancement, protection measures, or increased monitoring.

Improve System Health

A system that is already stressed or degraded may be more vulnerable to the impacts of climate change. Maintain good water quality or improve existing water quality. Improve or rehabilitate habitats that have been damaged. Remove threats and decrease non-climate stressors on aquatic systems. Examples of these threats and stressors include:

- pollution
- deforestation
- water extractions
- over harvesting
- wetland destruction


Deforested area

Establish or increase buffer and riparian zones

Riparian zones are the ecosystems that occur along the banks of lakes, rivers, creeks, or any other waterbody, and are important components for the health of the water system. Riparian areas help aquatic systems by:

- protecting against erosion
- cooling water by providing shade
- providing organic inputs (leaf litter, woody debris) which is the base of the food chain especially in rivers
- decreasing the impact of land uses (like urban development, forestry, and agriculture)

Photo from http://cowsandfish.org/riparian/riparian.

BUFFER ZONE IN IOWA FARMING AREA

Riparian vegetation is often an important component in providing cold water refuges used by fish. While riparian habitat is important everywhere, it has been suggested that small streams (tributaries), rather than large channels, are an effective place to put improvement resources[8]. The impact of riparian shading on a wide river is minimal when compared to narrower tributaries. Sufficient shading will help tributaries stay cooler. That water then flows into the main channel, providing cold water refuges in the larger river.

A buffer zone is a riparian/habitat area that helps protect a waterway from nearby land uses. They can help clean the surface run off water before it reaches the waterbody by intercepting things like sediments, nutrients, and other pollutants. They can also serve as wildlife corridors where habitat has been fragmented by land use.

Monitoring

Monitoring allows us to gather information about the environment and the changes that are occurring. In aquatic systems, monitoring could include:

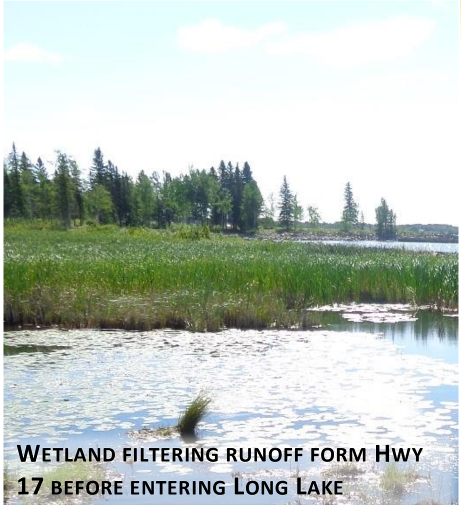
- vulnerable habitats
- water quality parameters
- systems trends
- biomonitoring
    - benthic invertebrates
    - fish
    - species at risk
    - invasive species

Monitoring activities can take many forms and be driven by community needs (community-based monitoring) with the work being done by various groups of people including environmental stewards, community members, citizen scientists and researchers.

Protect wetlands

Community and land-use planning can also help protect aquatic systems. Avoid wetland destruction when building or creating infrastructure. Consider the impact on aquatic systems in community planning and ensure aquatic systems are protected from nearby land uses.

Proper storm water drainage can help improve the quality of water entering aquatic systems. Adequately sized culverts, drainage ditches, and natural buffers help limit pollutants, nutrients, and sediments entering aquatic systems from surface water runoff [8].



WETLAND FILTERING RUNOFF FORM HWY 17 BEFORE ENTERING LONG LAKE

Education and Outreach

Engage the community on water related issues. Inform them of the challenges facing aquatic systems and encourage good stewardship. This is especially important for youth.

HIGH-SCHOOL STUDENTS LEARN ABOUT AQUATIC SYSTEMS AND MONITORING IN ATTAWAPISKAT

COMMUNITY CLIMATE CHANGE COMMUNITY MEETING IN KITCHENUHMAYKOOSIB INNINUWUG

GETTING YOUTH INVOLVED IN AQUATIC SCIENCE AT A FORT SEVERN SUMMER CAMP.

Peatlands and Permafrost

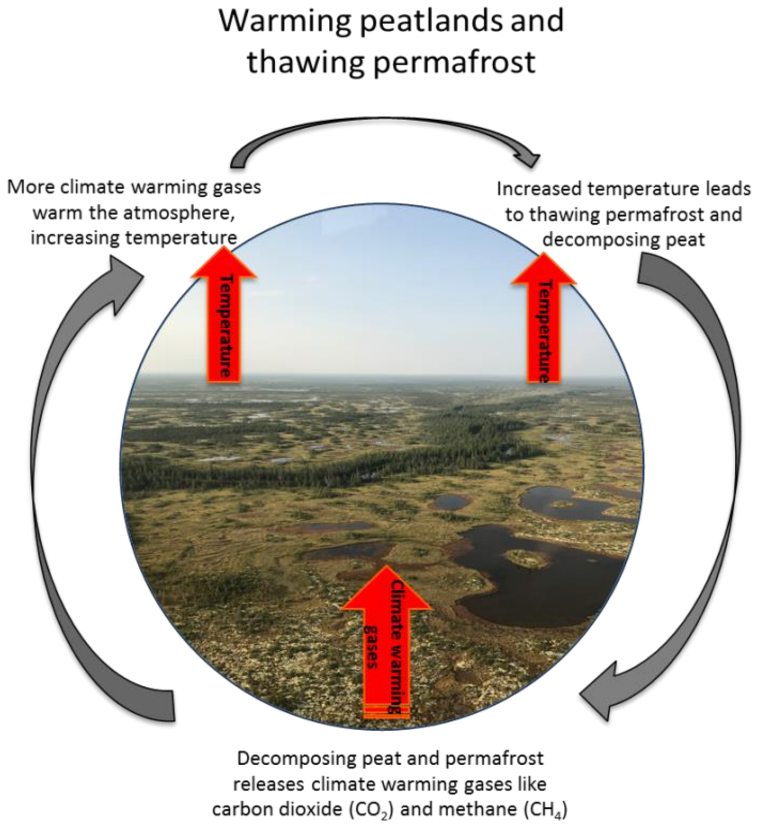
Peatlands are very important ecosystems in Ontario, and account for 33% of total peatlands in Canada. Peatlands are created when there is slow accumulation of old and decaying vegetation in wetlands and are very common in northern areas including the far north of Ontario. The Hudson Bay Lowlands is the largest peatland in North America. It, and other peatlands in Ontario, play important environmental roles including:

- Water regulation and filtration: Peatlands reduce pollution in nearby aquatic systems by cycling nutrients, trapping pollutants, and storing materials. Peatlands also play an important role in regulating water flow as they are able to retain water and are able to help moderate potential flooding from extreme rainfall.

- Carbon storage: Often, peatlands are very old, and have stored tons of decomposing plant material, which stores carbon keeping it out of the atmosphere where carbon dioxide, a greenhouse gas, warms the Earth.

- Biodiversity: Peatlands are home to a variety of species of plants and animals that are not commonly found in other areas. In the Hudson Bay Lowlands, features found in the peatland are also important nesting areas for many bird species.

Climate change in northern Ontario can have negative consequences on peatlands, which could lead to furthering the effects of climate change. Climate change can cause the decomposition of peatlands, which release climate warming (greenhouse) gases like methane and carbon dioxide. Warming temperatures may also cause drying in peatlands, which may limit their ability to filter nutrients and pollutants before they enter aquatic systems.



Permafrost thawing beneath roads or buildings can lead to the ground sinking, damaging infrastructure.

Permafrost in Ontario extends further south than anywhere in Canada because of the cooling effect of the Hudson Bay. In a warming climate, thawing permafrost can create issues for infrastructure. Building on permafrost can cause the ground to thaw, which may cause a decrease in ground volume, leading to subsidence, or sinking of the land. The damage to buildings and roads can be significant. The loss of permafrost can lead to loss of riverbank integrity and slumping of the banks into the river which can be a dangerous situation for a community built along rivers. In the Hudson Bay Lowlands, permafrost has stored carbon for thousands of years in the peatlands and is sensitive to environmental change. Warming temperatures in the Hudson Bay Lowlands will lead the permafrost to thaw, which will allow greenhouse gases (carbon and methane) to be released to the atmosphere, contributing to climate change.

Adaptation and Mitigation

Monitoring and identification of important areas

Hudson Bay Lowlands as seen from the air

The identification of peatlands that are most likely sensitive to change, or peatlands that are known to be well connected to aquatic systems should be identified. Through identification, more care can be taken to ensure that these peatlands are provided with extra protection. Variables such as height of water table, dryness, invertebrates and other animals present, vegetation present, etc., can be used to monitor the health of peatlands. Increasing public awareness of peatlands is also an important step and can lead to increased monitoring and protection of peatlands in Ontario.

Habitat/biodiversity protection

Protecting peatlands requires proper identification of important peatlands. The identification of wildlife or plants that live in the peatlands is also important, as they may be rare and require that their habitats remain undisturbed. Monitoring habitats and biodiversity also allows the health of peatland ecosystems to be determined. Peatlands can be disturbed through the introduction of industrial activities such as mining, road development, or any other processes that may impact that land. Proper communication between industry, government, and communities can ensure sustainable development of infrastructure on or around peatlands in Ontario.

SPHAGNUM MOSSES ARE COMMON IN NORTHERN PEATLANDS. THE PRESENCE OF THESE MOSSES INDICATES A HEALTHY PEATLAND.

Fire prevention

Taking extra precautions to prevent burning of peatlands is an important mitigation effort. Peatlands are very sensitive ecosystems, and many plants found in peatlands cannot survive fires. Burning decreases the cover of mosses and affects the ability of the peatland to recover from fires. Fires may also thaw permafrost beneath the peat, leading to ground subsidence (sinking). Wildfires can be prevented through taking extra caution to control campfires, or any other ignition sources such as matches and lighters.

Contaminant prevention

Many species found in peatlands are sensitive to contamination and pollutants. Since peatlands are important filters for water in ecosystems, ensuring their cleanliness increases quality of water downstream. Contaminants can be prevented from entering peatland ecosystem through the prevention of dumping garbage or other wastes in or around peatlands.

Proper engineering

Living and building on permafrost can be challenging, but with proper engineering, infrastructure can be successfully developed and sustained. Properly engineering buildings and roads can prevent the thaw of permafrost, and therefore prevent damage to the infrastructure. (https://nsidc.org/cryosphere/frozenground/people.html)

Resources and Information

http://www.peatsociety.org/peatlands-and-peat/peatlands-and-climate-change

http://peatmoss.com/what-is-peat-moss/the-role-of-peatlands/

https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2011EO120001

Invasive species

Changes in climate are causing shifts in the habitat range of many plant and animal species, allowing them to live in places they didn't live before. As temperatures rise, plants and animals can move farther north; they may even be pushed out of more southern parts of their ranges as temperatures there become too hot. Warmer winters mean that species who could not survive winters in the north before may be able to survive them now and establish populations. And fewer frost days in spring and fall are increasing the growing season and allowing plants to thrive in new areas.

Plant and animal range can slowly shift as conditions change with seeds dispersing and animals moving across the landscape. In other instances, a species range can change quickly as people who, knowingly or unknowingly, move species from one place to another. Boats and motors that aren't cleaned as they move from one waterbody to another and fishermen who release their bait are examples of how this can happen in aquatic systems. Transporting wood can bring forest pests into new areas. And gardeners planting non-native species can bring plants into new locations.

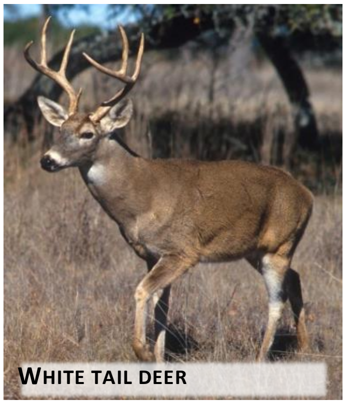
Invasives in Ontario

Shifting ecosystems have the potential to impact native and non-native species alike. There are many species classified as invasive in Ontario. Some examples include:

- spiny water flea
- rusty crayfish
- zebra mussels
- Eurasian milfoil
- purple loosestrife
- giant hog weed
- emerald ash borer

The introduction of new species can affect both the ecosystem and the people who live there. Many species have already or have the potential to move and impact new environments as the climate of the north changes.

Deer

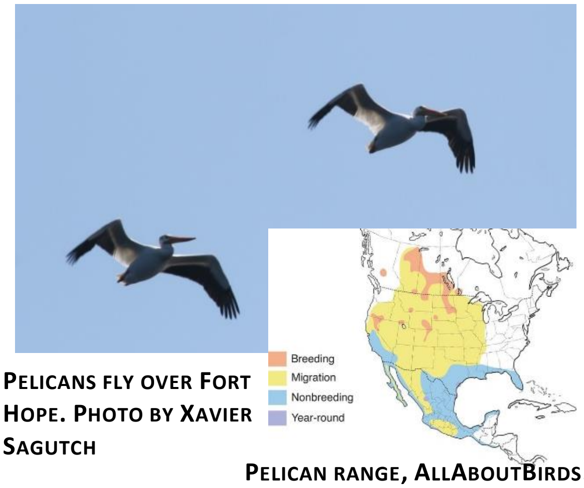


WHITE TAIL DEER

A number of factors are likely involved in the northward migration of white-tailed deer. Historically, deer may have been limited from northern mixed forests by the high frequency of cold, deep-snow winters[9]. Deer are less adapted to these conditions than moose, for example, who can tolerate deeper snow and colder temperatures much more easily than deer. But with winters becoming warmer and snow depths projected to decrease, deer are becoming more abundant in northern areas. While, on one hand, the introduction of deer into an area can provide an additional food source for hunters, white-tailed deer can also carry diseases and parasites affecting other cervids like moose and caribou (e.g. chronic wasting disease (not yet present in Ontario) and meningeal worms[9]) and humans (e.g. blacklegged ticks which can be vectors for Lyme disease).

Pelicans

People have reported seeing American White Pelican as far north as Fort Hope and Fort Severn. Historical records tell us that these birds spend winters as far south as Mexico and migrate north in the summer but never as far north as recent sightings. As temperatures become warmer and warmer, winter and summer ranges are being pushed further and further north[10]. Pelicans are fish eaters and some worry that their presence will deplete fish stocks in the area, however this is not necessarily the case[11].



Pelicans fly over Fort Hope. Photo by Xavier Sagutch

Pelican range, AllAboutBirds.com

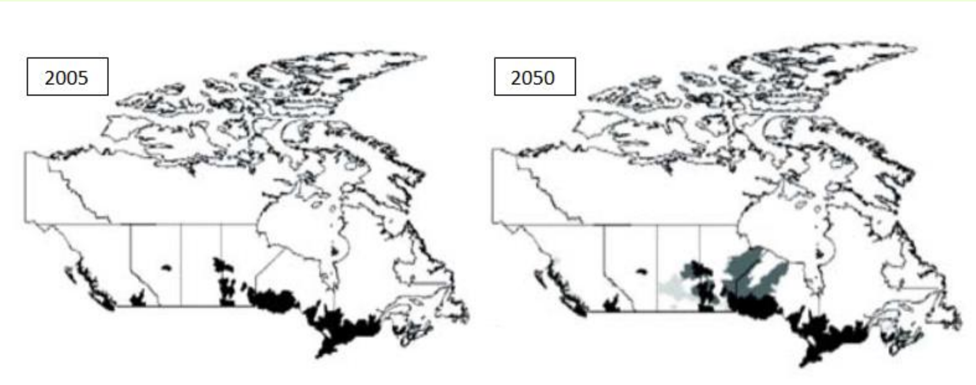
Turkey Vultures

Once only seen in southern areas, the past decades have seen the range of the turkey vulture expanding north. While a number of factors are likely at play in this shift, including the decrease use of pesticides like DDT, changing climate may also be a factor[12].

Fish

Warming waters as a result of climate change are allowing the certain fish species to move further north. Smallmouth bass, for example, is a warm water species who's range, while currently limited to south and near north Ontario, could be found in almost all of the province by the 2050s[13]. Cool water fish like yellow perch and northern pike are also expected to expand their range northward as climate change progresses[14,15]. The opposite will be true of cold-water species such as trout that are expected to be lost to most of Ontario by 2050[7].

The habitat of Smallmouth Bass – past and future

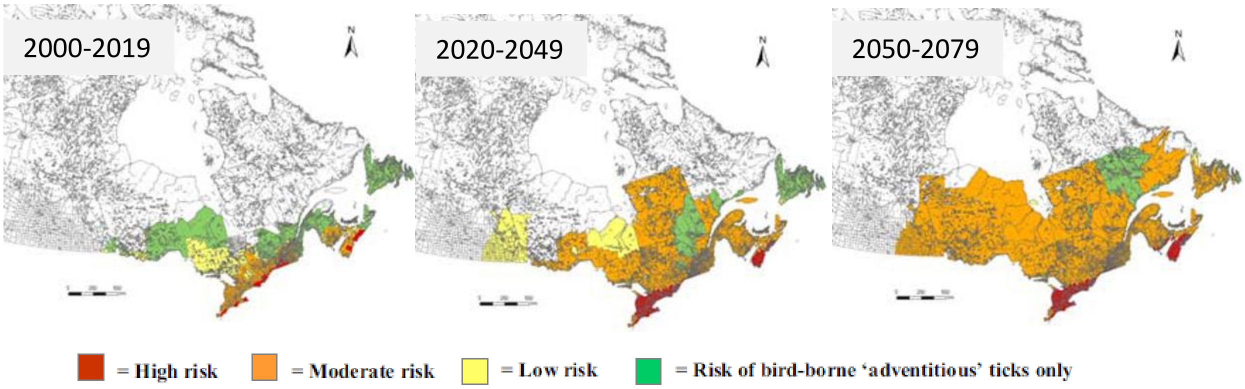


These maps compare the range of small-mouth bass as it was in 2005 to how it is projected by the 2050s. Black patches are where the species was found in 2005. Dark grey means there is a high chance of small-mouth bass occurring; light grey means a lower chance. Maps from Dove-Thompson et al., 2011[7] .

The introduction of new fish species in an area can sometimes be attributed to human factors, like anglers releasing bait fish. Educating the public on the potential consequence of these actions will hopefully reduce its occurrence.

Blacklegged ticks

Blacklegged ticks (also known as deer ticks) are moving further north not only in Ontario but across Canada. Warmer winters are allowing the ticks to establish populations in places where they wouldn't have been able to before[16]. The northward spread of deer, who act as a host species for these blood feeding parasites, may also be aiding in the spread of blacklegged ticks (although other animals, like rodents and birds, are also suitable hosts). A predicted expansion of the habitat range of blacklegged ticks is presented below[17].



Predicted expansion of the range of blacklegged ticks. This model assumes ticks will have a high level of establishment in areas that become climatically suitable. Colours refer to the level of risk of black-legged ticks establishing populations. Taken from Ogden et al., 2008[17].

Blacklegged ticks warrant special attention because of their ability to transmit Lyme disease to humans when feeding. As such, it's important for people in areas where the ticks may become established to be aware of the risk of Lyme disease and how to mitigate it. *Information on Lyme disease and reducing risk can be found in Health section of this report.*

Mountain Pine Beetle

Mountain Pine Beetle is a bark beetle native to western North America. Historically, its range in Canada was almost entirely confined to British Columbia, where low and endemic populations posed little risk to healthy trees. However, as beetle populations increase, they can overwhelm the natural defences of a tree and large-scale outbreaks can result in a massive loss of trees.

Mountain Pine Beetle. Photo from http://www.dailyheraldtribune.com/2012/08/06/annual-mountain-pine-beetle-ab-survey-numbers-patchy

In the past, the habitat range of mountain pine beetle in British Columbia has been limited by cold winter temperatures (lows of -40°C) and cooler summers. But increasing temperatures in both seasons is removing this limitation and populations of mountain pine beetle have expanded. Although the mountain pine beetle has not yet reached Ontario, the changes in climate are allowing for the potential spread of the mountain pine beetle to this province, where populations of jack pine may be at risk[18].

Gypsy Moth

Native to Europe and Asia, gypsy moths were first found in Ontario in 1969. Gypsy moth caterpillars eat the leaves of many deciduous tree species, like oak, poplar, willow, maple and birch and have caused widespread defoliations. Climate conditions are thought to play a role in limiting the current range of gypsy moths in Ontario. But predicted climate warming will serve to expand the area of suitable habitat north for these invasive pests.

WWW.ONTARIO.CA/PAGE/GYPSY-MOTH

Adaptation and Mitigation

Prevention is the key

In cases where humans play a role in species transportation, public education campaigns can help raise awareness of how our actions can contribute to the spread of invasive species and what can be done to prevent it. Actions that can prevent the introduction of invasive species into new environments include:

- proper disposal of bait fish
- cleaning of boats and gear
- not transporting wood from one area to another
- planting non-invasive plants in gardens

Public education can take the form of signage at boat launches and other vulnerable locations, posters and brochures in public areas, education in schools, radio and television campaigns, etc.

Monitor

Know what is new to your area and what has the potential to come into your area. This is especially important when the invading species can be highly disruptive to the existing ecosystem, as is the case with forest pests.

Monitoring is a group effort. Some species are monitored by provincial, federal, or community programs. But within these programs and outside of them, citizen science (when area residents record or report environmental information) is an important component.

There are also several apps that allow users to organize and share their own data such as:

- EDDMapS - help track of invasive species in Ontario and beyond
- iNaturalist - track your observations, create a project or join one, connect with others
- Nature Watch - participate in projects such as Ice Watch, Frog Watch, and Plant Watch

Report Invasive Species

Community members can report invasive species of interest in their area via:

The Invading Species Hotline
1-800-563-7711

The Early Detection and Distribution Mapping System for Ontario (EDDMaps)
http://www.eddmaps.org/ontario/
or available as a smartphone app

EDD MapS Ontario
Early Detection & Distribution Mapping System

Control measures

When a new species causes or has the potential to cause major damage or disruption to the ecosystem, control measures may be required. This may include eradication or population management measures. Barriers are also sometimes put into place to keep a species from moving further.

Sea Lampreys in the Great Lakes basin are an example of an invasive species that has an extensive control program. The control protocols include lampricides, barriers, traps and pheromone cues. Control measures can also be as simple as pulling and properly disposing of invasive plants found growing on your property. Response protocols for invasive species can be discussed and created before a species enters the area. That way, if a destructive invasive species does enter the region, response can be quick and, hopefully, effective.

Resources and Information

Ontario's Invading Species Awareness Program - www.invadingspecies.com
Invasive Species Centre - www.invasivespeciescentre.ca
Ontario Invasive Plant council - www.ontarioinvasiveplants.ca
Ontario Ministry of Natural Resources and Forestry - www.ontario.ca/invasionON
Grow Me Instead (a guide to native planting) - www.ontarioinvasiveplants.ca/resources/grow-me-instead/

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Preparing for Shifting Ecosystems

Forests

- Identify important species/areas – consider directing your resources to these areas.
- Increase habitat suitability – bird and bat boxes, healthy forests.
- Decrease forest fragmentation.
- Assisted migration but there are risks of creating an invasive species problem.
- Monitor - various aspects of forests are suitable for monitoring.
- Control invasive species.
- Adapting forest harvesting practices

Aquatic Systems

- Identify important species/areas – consider directing your resources to these areas.
- Improve system health.
- Establish or improve buffer and riparian zones.
- Monitor – various aspects of aquatic systems are suitable for monitoring.
- Maintain/improve wetlands and infrastructure for water run-off (ditches, culverts, etc.), consider aquatic systems in community planning.
- Education and outreach can promote good stewardship of aquatic systems.

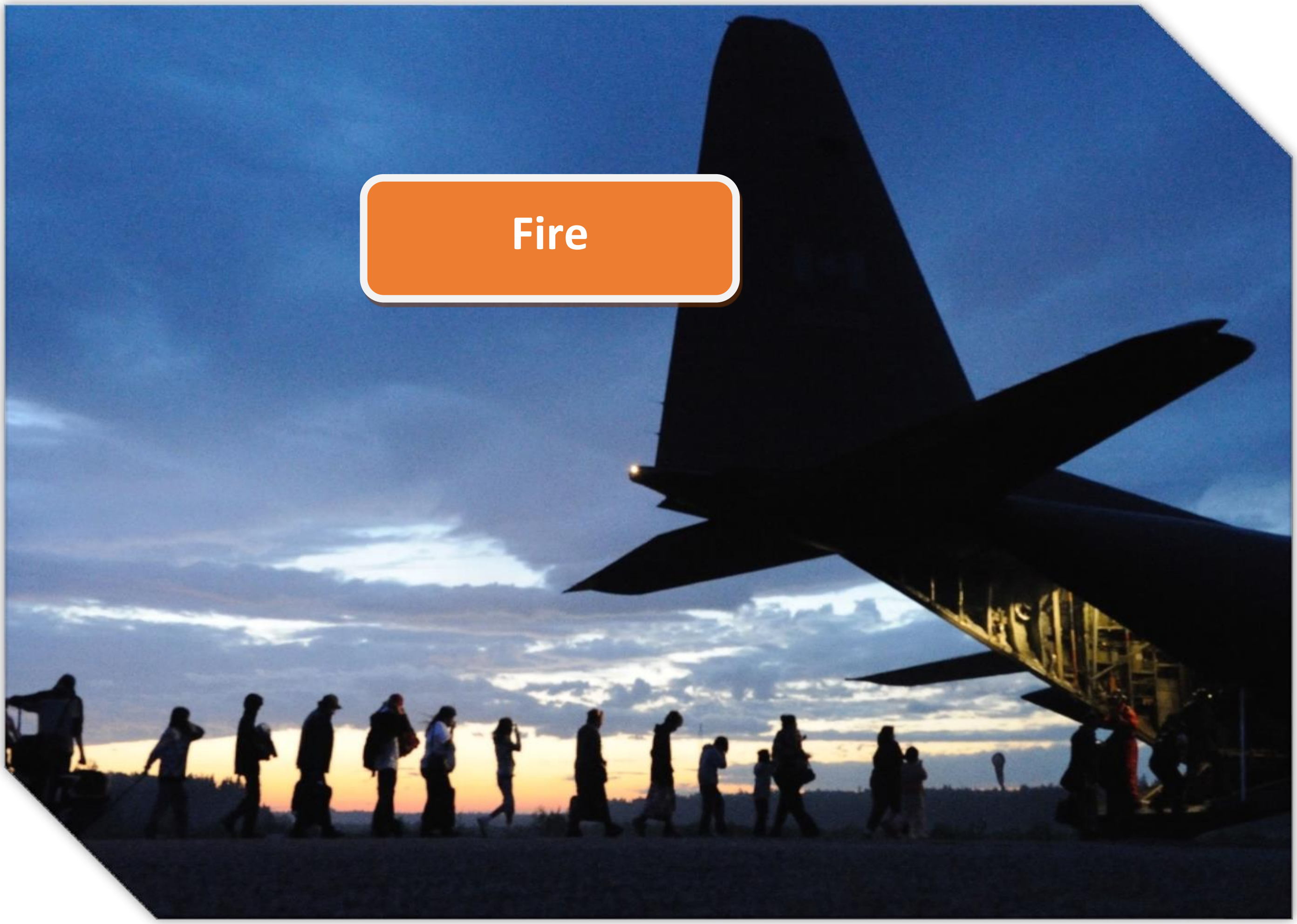
Peatlands and Permafrost

- Identify and monitor important areas.
- Protect habitat/biodiversity.
- Implement fire prevention measures.
- Prevent contamination of peatlands.
- Ensure proper engineering for building on permafrost.

Species Invasions

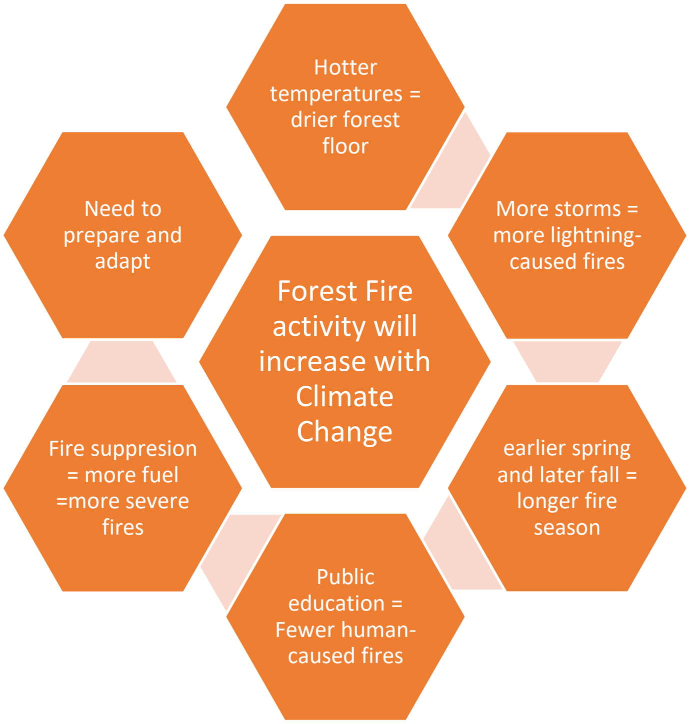
- Promote prevention measures to decrease the human role in invasive species distribution.
- Monitor for new/invading species.
- Control measures may be necessary if an invasive species is found in the area.

Fire



Fire evacuation, Deer Lake First Nation, 2011

Climate change is predicted to increase forest fire activity. With more storms likely to produce lightning comes more chances of starting a fire. Hotter, drier and longer summers will extend the fire season. Communities need to be prepared for more fire and smoke.



Adaptation and Mitigation

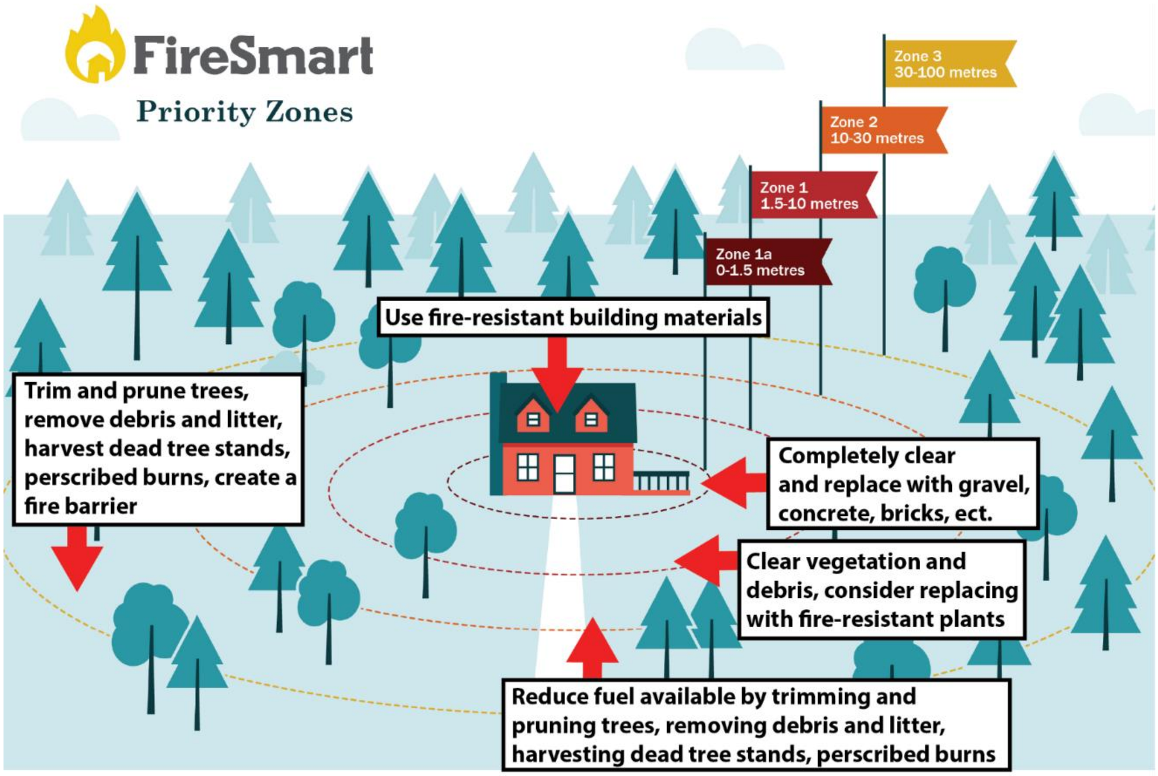
Generally, fire mitigation and adaptation options help to prevent fires from starting or reaching the community or help communities cope with fires and reduce harm and damage. Many communities in northern Ontario are remote and have limited forest fire management resources making fire suppression more challenging. Currently, many forest fires in northern Ontario are allowed to burn if they don't threaten a community. More fires, over longer fire seasons will create a larger demand for fire management and could put communities at risk. Communities across northern Ontario may benefit from enrolling in the Canadian FireSmart program that offers education to communities to help understand the potential for forest fires that could affect their communities.

SMOKE FROM FOREST FIRE NEAR EABAMATOONG FN

Fire prevention

Community awareness and education in schools can help to prevent fire starts due to human activities. Education empowers individuals with the knowledge to take preventative actions, for instance camp fire safety and maintaining a buffer zone around their home. Communities themselves can create fireguards. Fireguards act as barriers to potential fires, they can be made by digging a trench down to the mineral soil around the perimeter of the community and clearing fuel sources, like trees, on either side of the trench. Replacing existing conifer species, especially white and black spruce, with less flammable deciduous trees like birch, poplar, or maples, can reduce the risk of fire spreading toward the community. Vegetation under power lines in and around the community should be kept clear. Thinning the forest stands at the community-forest interface can also reduce the spread of fire into a community. This preventative work can employ local people and provide firewood for community members.

Community fireguard. www.livefiresmart.ca/community/



FireSmart priority zones and risk reduction actions for each zone. Figure modified from FireSmart Canada's original image wildfire.alberta.ca/firesmart/documents/FireSmart-PriorityZonePoster-May15-2017.pdf

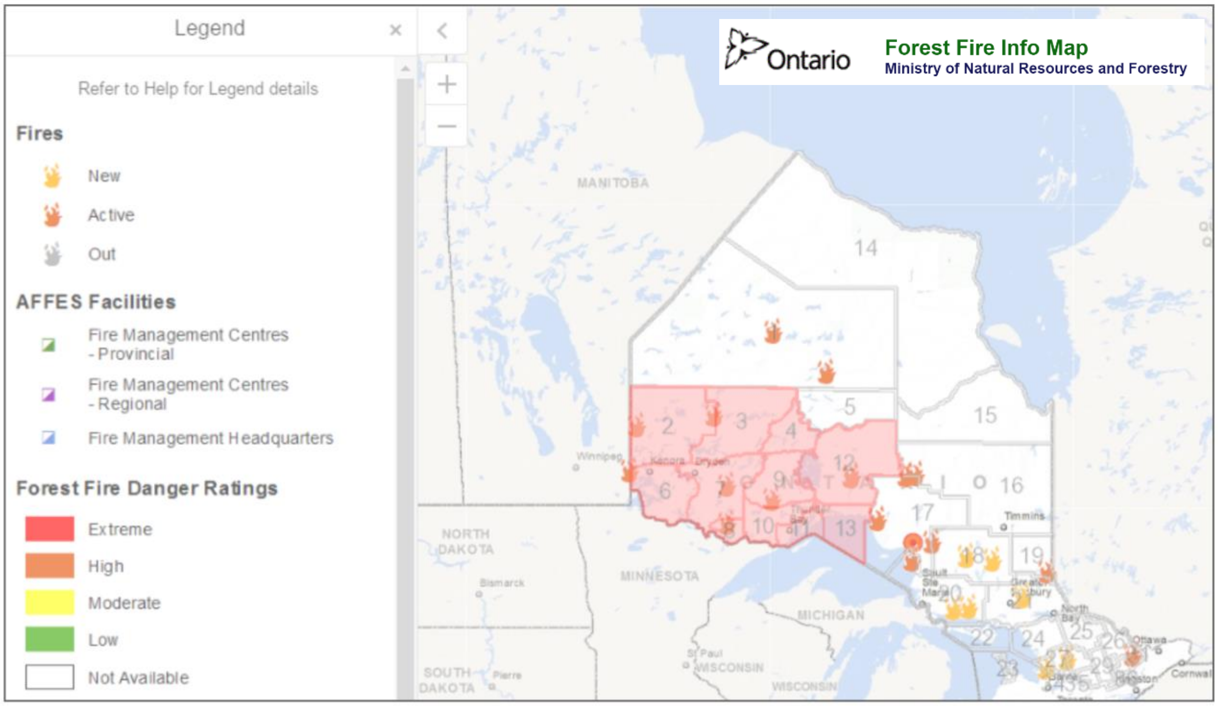
Emergency Preparedness and Response

In the remote parts of Ontario, OMNRF will allow wildfires to burn. The land in the north has evolved with fire. It is a necessary part of renewing the forest. Without fire, forest material like branches accumulate making travel difficult and providing fuel for more severe fires. OMNRF responds to forest fires in the north only if it threatens a community. Many communities also actively participate in fire suppression when a fire is a threat.

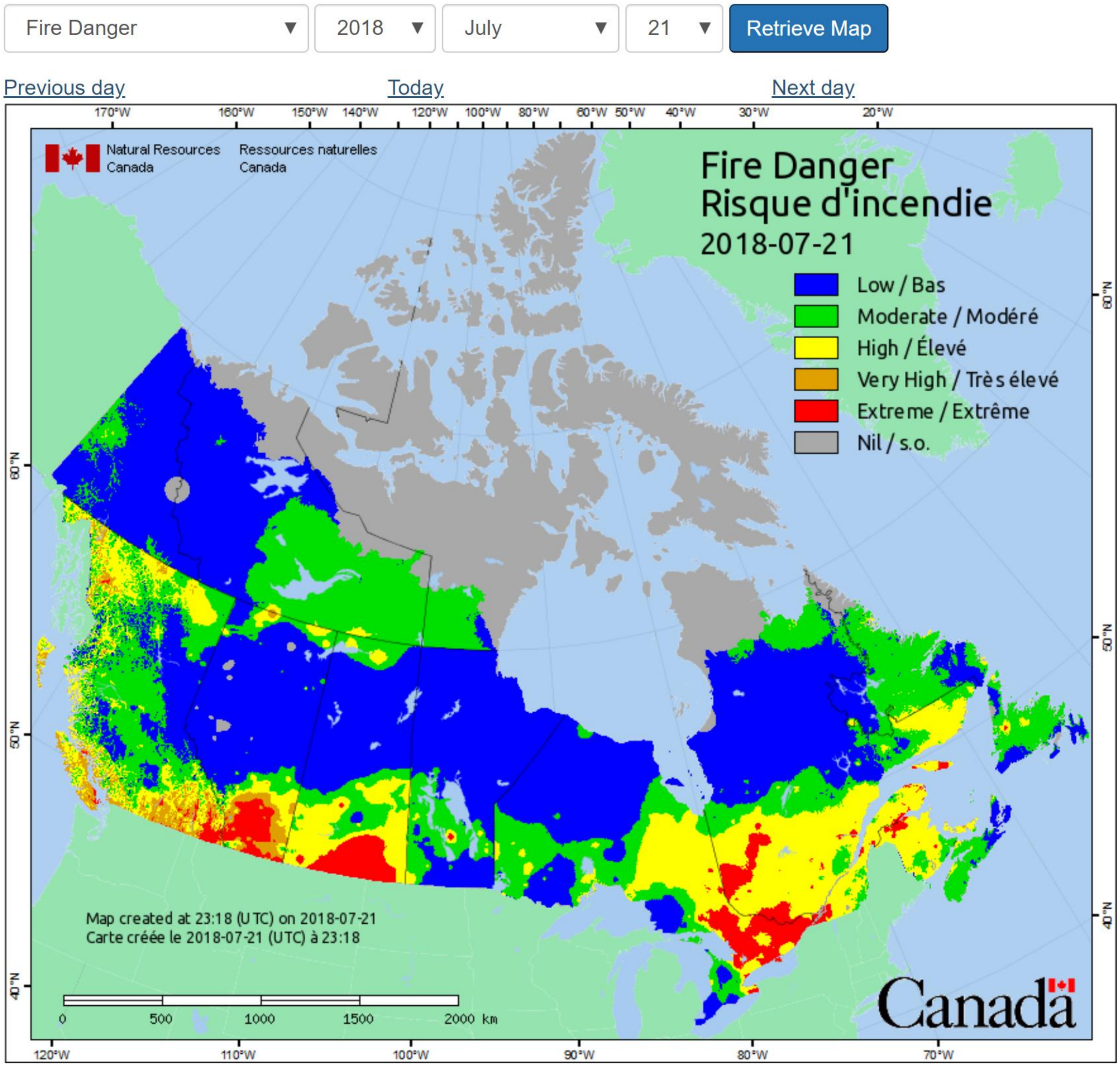
ROCKY BAY FIRST NATION FIRE HALL

There are steps that individuals and communities can take to be better prepared. The community may wish to take charge of community awareness for emergency planning, by hosting community information meetings, posting information on their website or social media, and including this information in community newsletters. Communities can educate themselves by reviewing the FireSmart guide: www.firesmartcanada.ca[1]

Communities can track the current fire hazard by using tools like the provincial government's Forest Fire Info Map. https://www.ontario.ca/page/forest-fires.



Communities may also begin a smoke monitoring system or monitor changes in daily fire weather indices to develop earlier warnings that a fire is approaching. Online tools from the Canadian Wildland Fire Information System (cwfis.cfs.nrcan.gc.ca/home) may be helpful. Communities may also wish to develop a warning alarm and/or community alerting system to inform residents when emergency measures are necessary.



Fire Danger is a relative index of how easy it is to ignite vegetation, how difficult a fire may be to control, and how much damage a fire may do.

In case of an emergency evacuation, individuals should have emergency bags packed with essential items, a list of emergency contacts, and be aware of escape routes and emergency meeting places [2]. The community should maintain a list of individuals who are sensitive to smoke, to help prioritize who is evacuated first in an emergency. The community emergency plan should outline who is responsible for a given task, for instance to ensure hazardous materials such as fuel tanks are protected. The plan should also outline who can act as a back-up if those individuals are unavailable. Communities should inventory their fire suppression equipment and ensure supplies are up to date. The OMNRF developed an online tool "Northern Community Tool" to assist 63 First Nation communities during forest fire emergencies. The tool includes information on the location of sprinklers, power pumps, hose lines, tees, and gated wyes within each community to protect valuables. It also includes contacts within the community, and hazard zones that exist around the community. Communities can contact their local OMNRF office for more information.

Infrastructure improvements

Home and building improvements are outlined in detail in the FireSmart guide, Chapter 3. Roofs are the most vulnerable part of the building; therefore, the type of roofing material is important to create fire resistant homes. The best material is asphalt, metal, or slate. For siding materials, stucco, metal siding, brick, and concrete are the preferred material. These infrastructure improvements can be used during new construction or when retrofitting buildings.

Policy and forest management

Some changes to policy and forest management can help to reduce the incidence and severity of fires in some cases. Fires should be restricted during periods of high fire activity [3]. In many regions, controlled burns take place to reduce the amount of fuel available that would otherwise contribute to more severe fires. This activity should be only be performed by trained individuals. Clearing sections of the forest through controlled and prescribed burns were performed at nine First Nation communities across Ontario in 2017. Fire suppression does not occur if a fire is burning in an area that doesn't pose a risk to communities. This practice can help to reduce available fuel and, therefore, reduces the severity of future forest fires in the same area and is a part of the natural forest cycle [3,4]. Forest fire management may need to explore more indirect attack options, such as burning areas in advance of a fire to prevent its progression, or fragmenting landscapes prone to high fire activity such as the boreal forest [5].

A SMALL FIRE STARTED BY HUMAN ACTIVITY, WAS ONLY A FEW KILOMETERS FROM TOWN, COULD HAVE HAD MUCH BIGGER CONSEQUENCES IF WEATHER CONDITIONS WERE SUITABLE FOR THE FIRE TO SPREAD.

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Preparing for Fire

Emergency Preparedness

- Increase community awareness of emergency preparedness, including what to do on an individual/household level.
- Make a community emergency plan (evacuation priority, task assignment, etc.)
- Inventory community fire suppression equipment and supplies.
- Create a community alerting system.
- Monitoring programs for smoke conditions, fire indices, etc.
- Use resources like FireSmart (www.firesmartcanada.ca).

Fire Prevention

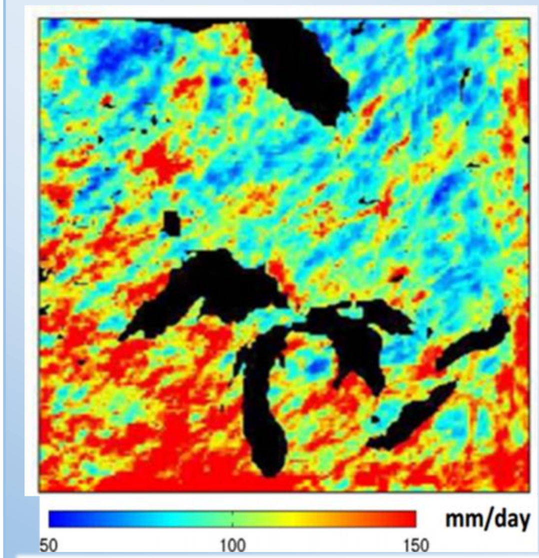
- Promote safe fire practices to decrease the potential of human-caused fires.
- Buffer zones and fire guards can be created to protect homes/communities in the event of wildfire.
- Manage vegetation of reduce wildfire risk.
- Use resources like FireSmart (www.firesmartcanada.ca).

Other

- When choosing materials for building/retrofitting, keep fire in mind.
- Consider changes/updates to fire and forest management policies.

March 21, 2012, Fort Severn, Temperature 9°C

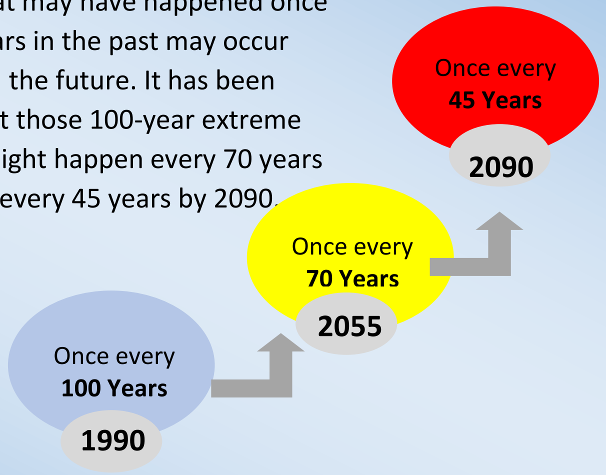
In Ontario, changes in precipitation amounts and extreme weather events are likely to lead to an increase in flooding events. Rapid temperature fluctuations and more rain in the spring and winter causes run off on frozen ground to low lying areas. In some years, melt is occurring more rapidly than it did in the past and frequent mid-winter thaws are causing flood issues that were rare in the past. Annual precipitation amounts may still increase as much as 15% from now until 2050, with the largest increase in the spring and winter. Extreme precipitation events will be among the biggest contributors to localized flooding and can rapidly increase water levels in lakes and promote severe river break-ups.



Projected future changes in extreme rainfall in 2045-2060. D'Orgeville and Peltier [1], JGR – Atoms. 2014 University of Toronto

Extreme Rain Events and Flooding

With climate change, extreme rain events of 50-150mm of rain in a day[1] are expected to happen more often. A heavy rain event that may have happened once every 100 years in the past may occur more often in the future. It has been predicted that those 100-year extreme rain events might happen every 70 years by 2055, and every 45 years by 2090.



Localized Flooding

Localized flooding refers to flooding in a particular area as a result of rapid snow melt or an extreme rain event. It can also be a result of rain on frozen ground in winter and early spring. Any low-lying area in a community is at risk of significant damage because of localized flooding.

Local flooding in spring, Fort Hope

The capacity of a community's infrastructure to drain water away from structures and roads may quickly be surpassed during these extreme events, resulting in flooding of homes or basements, road washouts and wastewater lagoon overflow. In some cases, sewage backups into homes may occur when sewer lines become saturated from heavy rainfall. Flooding in homes and basements leads to costly repairs and, if such flooding happens often or is not repaired properly and immediately, will lead to growth of mould, a human health hazard. Roads flooded by water may lead to washouts, limiting road usage and creating additional risks in emergency situations, especially if there is only one road in and out of a community. Freeze-thaw cycles and precipitation can also contribute to costly road repairs due to the formation of potholes. Overflows of wastewater lagoons can pose serious risks to ecosystem health and human health because of groundwater and drinking water contamination.

Adaptation and Mitigation

From roads, to buildings, to water and wastewater systems, infrastructure is vulnerable to localized flooding and so communities should consider repair and maintenance of such systems a high priority. When planning for future development, it is critical to use the latest technologies, materials and methods in new construction.

Ground sloped away from house to ensure water drains away and into ditch, Attawapiskat.

Drain water away from buildings. To protect homes and community buildings, drainage systems should include weeping tile in well drained backfill gravel, a sump pump, eavestrough and drain pipes all to promote drainage away from the house. To reduce sewage back-ups during heavy rain events, backflow prevention valves should be installed on the sewage lines. The Northern Infrastructure Standardization Initiative can provide a good resource www.scc.ca/en/nisi. The ground around a foundation should be built up and sloped so water will run away from the building. Snow should be piled away from the building to manage melt water. If the ground around the home is level, consider trenching or grading the property to manage melt water and rain so it runs away from the building.

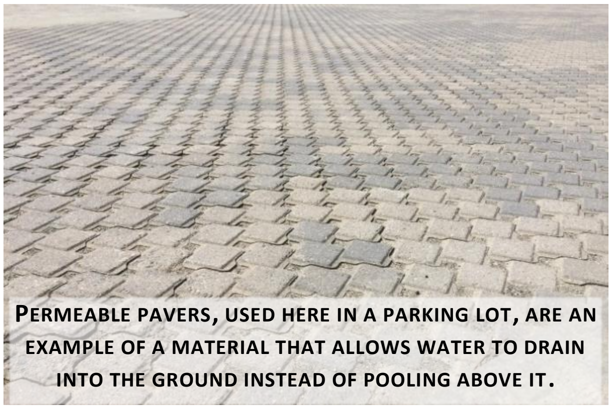
Drain water away from the community. Drainage in the community must be well designed and maintained. Water should quickly drain away from the community. Ensure that culverts are clear and not crushed at the ends, and that ditches are established and maintained. To reduce the likelihood of flooding, manage snow piles and remove snow from roadside ditches before the spring melt to promote drainage and reduce flooding. If an area of the road is vulnerable to flooding, perhaps because it is low-lying or runs over a stream or creek, consider improvements that can be made to this section of the road, such as: controlling erosion at the base or sides of the road or building up the road with a material that drains well. If this road is the only road access to a community nursing station or other important structure, consider creating an alternate route or an emergency plan to quickly repair the road and remove the water.

CULVERTS MUST BE CLEAR TO ALLOW PROPER DRAINAGE. CRUSHED CULVERTS NEED TO BE REPLACED.

IN THE LATE WINTER TO EARLY SPRING, COMMUNITY EXCAVATORS CLEAR DITCHES OF SNOW AND PILE IT AWAY FROM VULNERABLE SECTIONS OF THE ROAD. THIS PROMOTES DRAINAGE FOR MELT WATERS AND PREVENTS WATER FROM FLOODING THE ROAD.

For wastewater treatment systems, such as sewage lagoons, the storage capacity must be designed to accommodate increased precipitation and extreme precipitation events to avoid overflow into the environment.

Limit surfaces that don’t allow water to pass through. The pavement and concrete that make up sidewalks, roads, and parking lots, don’t allow water to absorb. Instead, water that hits these surfaces becomes runoff and pools on the surface. Consider alternate materials, like gravel or permeable pavers that allow water to pass through into the ground. Increasing green spaces, which also absorb water, can also help lower flooding risk.



PERMEABLE PAVERS, USED HERE IN A PARKING LOT, ARE AN EXAMPLE OF A MATERIAL THAT ALLOWS WATER TO DRAIN INTO THE GROUND INSTEAD OF POOLING ABOVE IT.

Protect or restore wetlands. Wetlands can provide natural flood mitigation by storing water from rain events. They act as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and flood waters. This has the potential to reduce the amount of runoff over land and running through community drainage systems[2].

WETLANDS ACTS AS NATURAL SPONGES THAT TRAP AND SLOWLY RELEASE WATER HELPING PREVENT FLOODING.’

Major flooding: Rivers or lakes

Major flooding from waterbodies occurs when water inflow is greater than the outflow. High inputs can be from precipitation, runoff from snow and ice melt, or a blockage (ex. ice jam or dam). In coastal communities, storm surges can cause floods in extremely windy conditions. Whatever the cause, the result is a rise in water levels that may exceed the banks of a lake or river, causing flooding.

Appropriate land use planning and traditional knowledge of highwater marks and past floods are key to prevent community flooding. Active monitoring and forecasting of weather and watershed parameters can improve times for evacuations, reducing human safety risk and potentially reducing infrastructure damage.

Ice Jams and Flooding

Ice jams are caused when river ice builds up or thickens enough to slow the flow of water [3]. As a result, water levels upstream of this blockage increase. These events, which can occur during freeze up, breakup, or mid-winter thaws, can lead to major flooding, either through the rise of water upstream of the jam, or from the surge of water when the jam lets go. Ice jams are naturally broken or degraded as the ice begins to weaken, by melting, and as the pressure of the water behind the jam builds until the ice can no longer withstand the force.

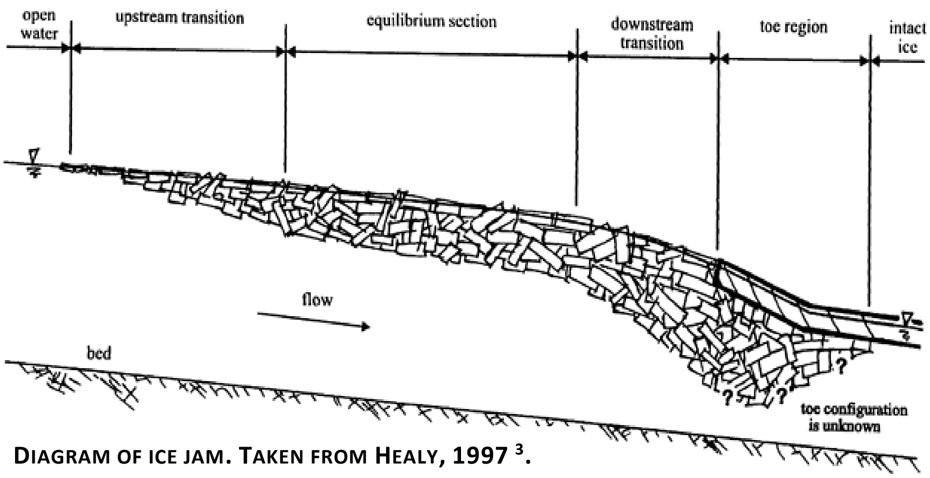


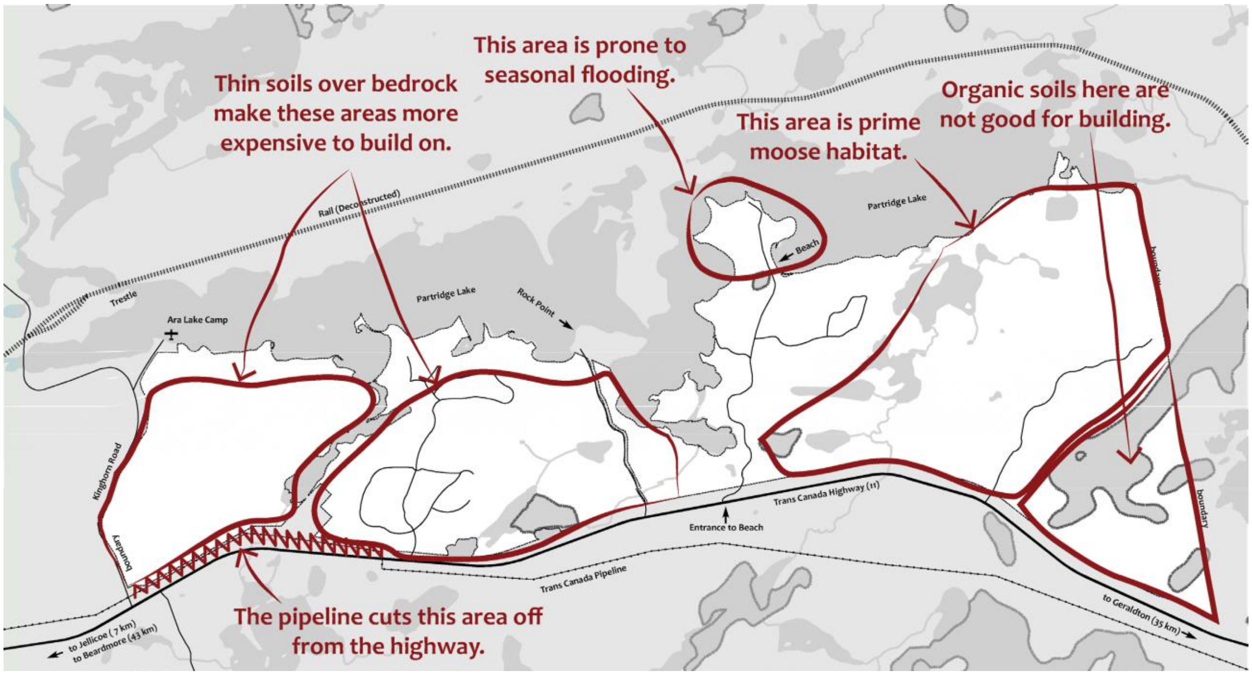
Diagram of ice jam. Taken from Healy, 1997 [3].

Scientists are uncertain how climate will impact the frequency or severity of ice jams [4]. On one hand, thinner ice can form a weaker and less cohesive ice jam, meaning the jam may not hold for as long and water level change may not be as great. On the other hand, rapid spring melt, coupled with more precipitation in late winter and spring, could lead to an abrupt break up that has the potential of forming severe ice jams. Changing climate is also increasing the occurrence of mid-winter thaws in some regions. These thaws can create minor breakups that form thickened ice bridges, which pose an increased risk of ice jams occurring, especially for the spring.

Adaptation and mitigation

Land use planning: Land use planning for new development, including housing and roads, should consider the flood zone and highwater marks from the previous 50 or more years. Since many remote communities do not have water level records, traditional knowledge about high water levels and past floods are invaluable to planning.

Most communities are already established and are located near water because waterways are transportation corridors, provide food and water, and are used for recreation. However, building homes close to a waterbody or within a flood zone increases a community's risk of flooding. Established communities should use land use planning for future development, as well as planning for infrastructure or drainage pathways, similar to the diagram below. Areas of greater risk of flooding should be identified and avoided. Wetlands should be protected, or consider creating retention ponds for flood control, both within the community and in the surrounding area.

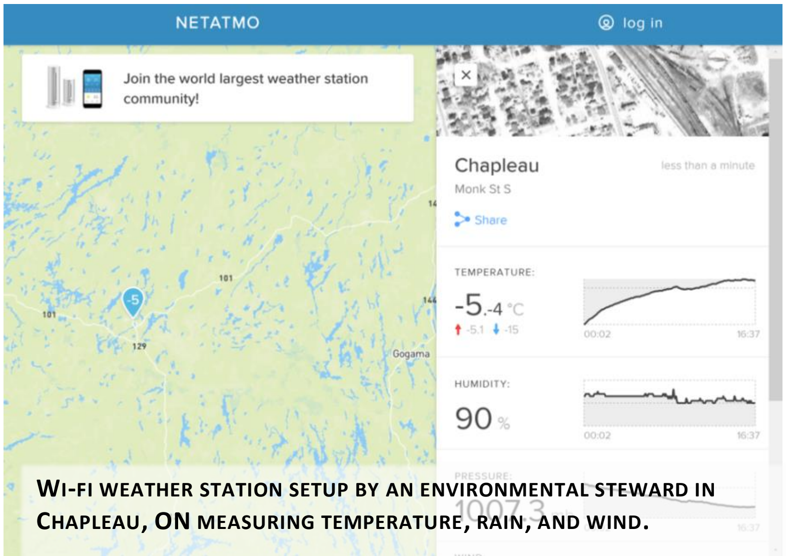


SAMPLE FLOOD MAPPING USED IN LAND-USE PLANNING HTTPS://WWW.CIP-ICU.CA/PDF/2013-26-GIIWEDAA-PARTRIDGE-LAKE-LAND-USE-PLAN.PDF

Monitoring and forecasting: Being prepared means knowing what has happened in the past. Traditional knowledge and measurements of past climate can be combined to build a better understanding of flooding trends. Environment Canada has weather stations in very few far north communities. Communities can take ownership of keeping their own records. They can take local measurements with systems like the NetAtmo to help provide an early warning that flooding from lakes or rivers may occur.

Consider measuring:

- temperature
- precipitation as rain or snow
- water levels
- water flow rates.
- ice thickness
- snow depth

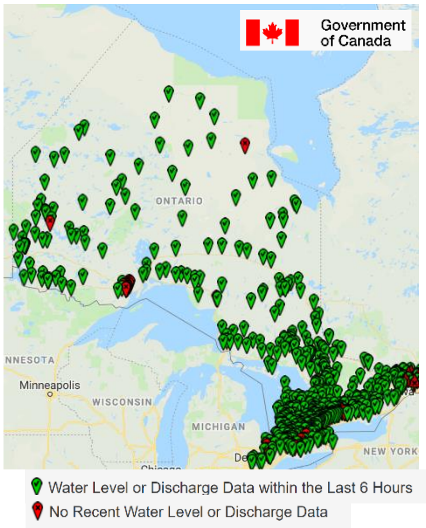


WI-FI WEATHER STATION SETUP BY AN ENVIRONMENTAL STEWARD IN CHAPLEAU, ON MEASURING TEMPERATURE, RAIN, AND WIND.

Local measurements of weather and water levels and flow can be used to develop a flood forecasting model like the one created for Kashechewan described in the next box [5].Communities that frequently experience flooding from nearby waterbodies will benefit from regular monitoring. This data can shed light on the conditions and peak values that result in flooding and can lead to more accurate risk assessments and flood forecasting. Consultation with professionals may be required to develop a suitable monitoring program and flood forecasting model for communities.

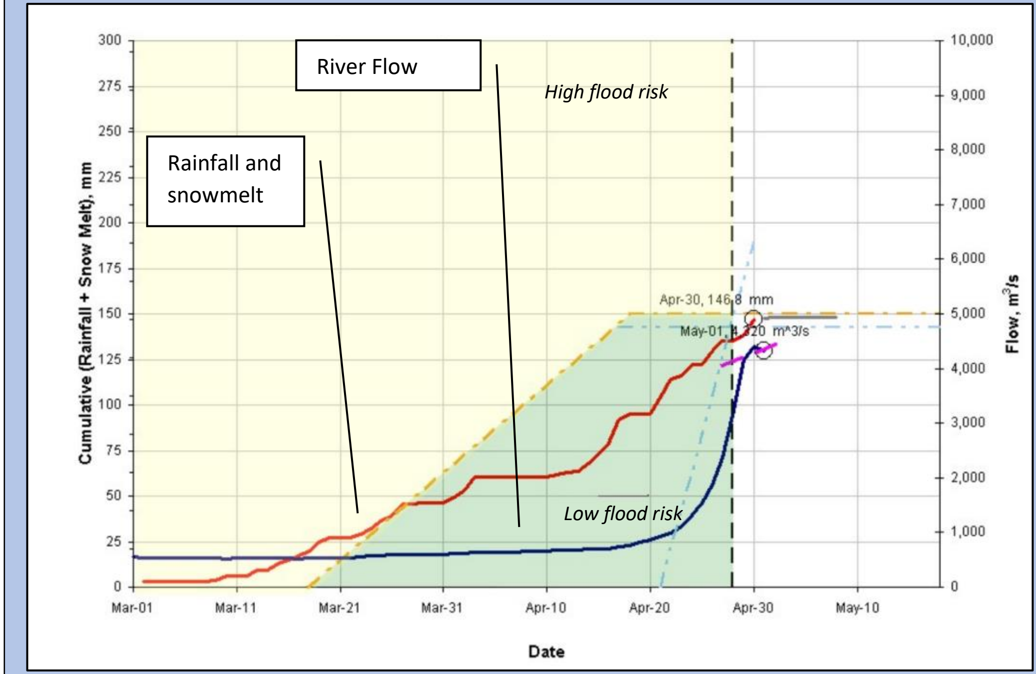
The Ontario government provides flood forecasting mapped and updated regularly here: www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program

The Federal government monitors water levels and flows. Current and historical data can be found here: https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time&search_type=province&province=ON

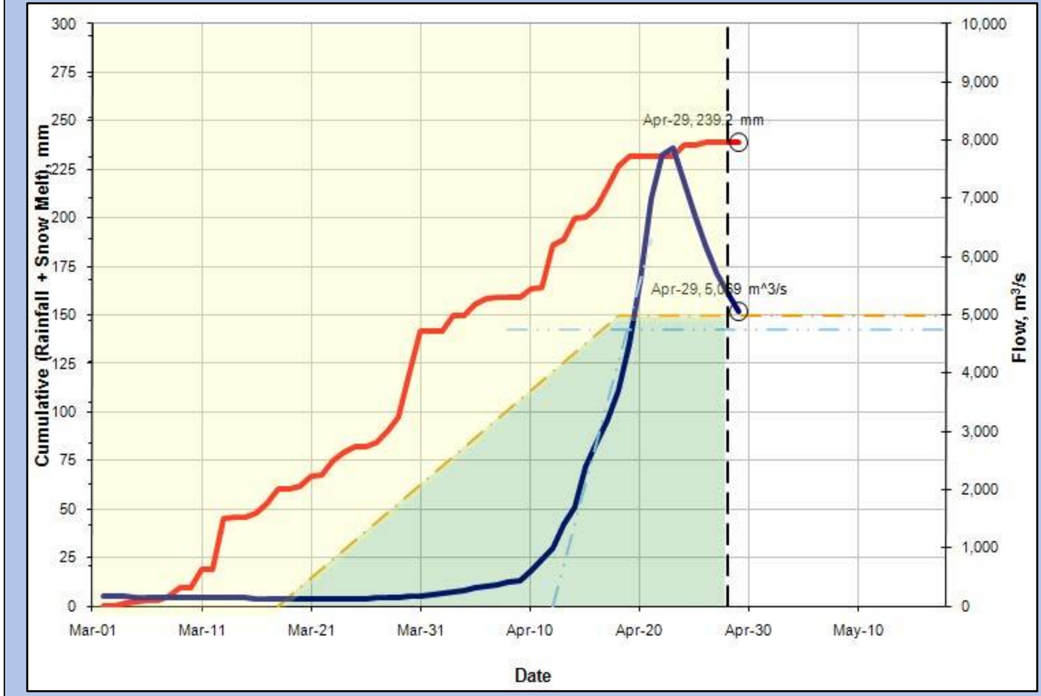


Case study: forecasting model for Kashechewan

A Flood Forecast Tool was developed specifically for Kashechewan First Nation on the North Albany River. It provides a 10-day advance notice of the degree of risk of an impending ice break-up event being severe enough to cause flooding of the community allowing time to evacuate[5]. It tracks rainfall and snowmelt (blue line) as well as flow rates of the Albany at Rat Island (red line). When flow rates and accumulated rain and snowfall are low, staying within the green zone (Below 150mm and 4750m^3/s) flood risk is low, as was the case in 2010. When flow and accumulated rain and snowfall are high, and these values fall within the yellow area of the graph, flood risk is high, as in 2006. From Shaw et al. 2013 [5]



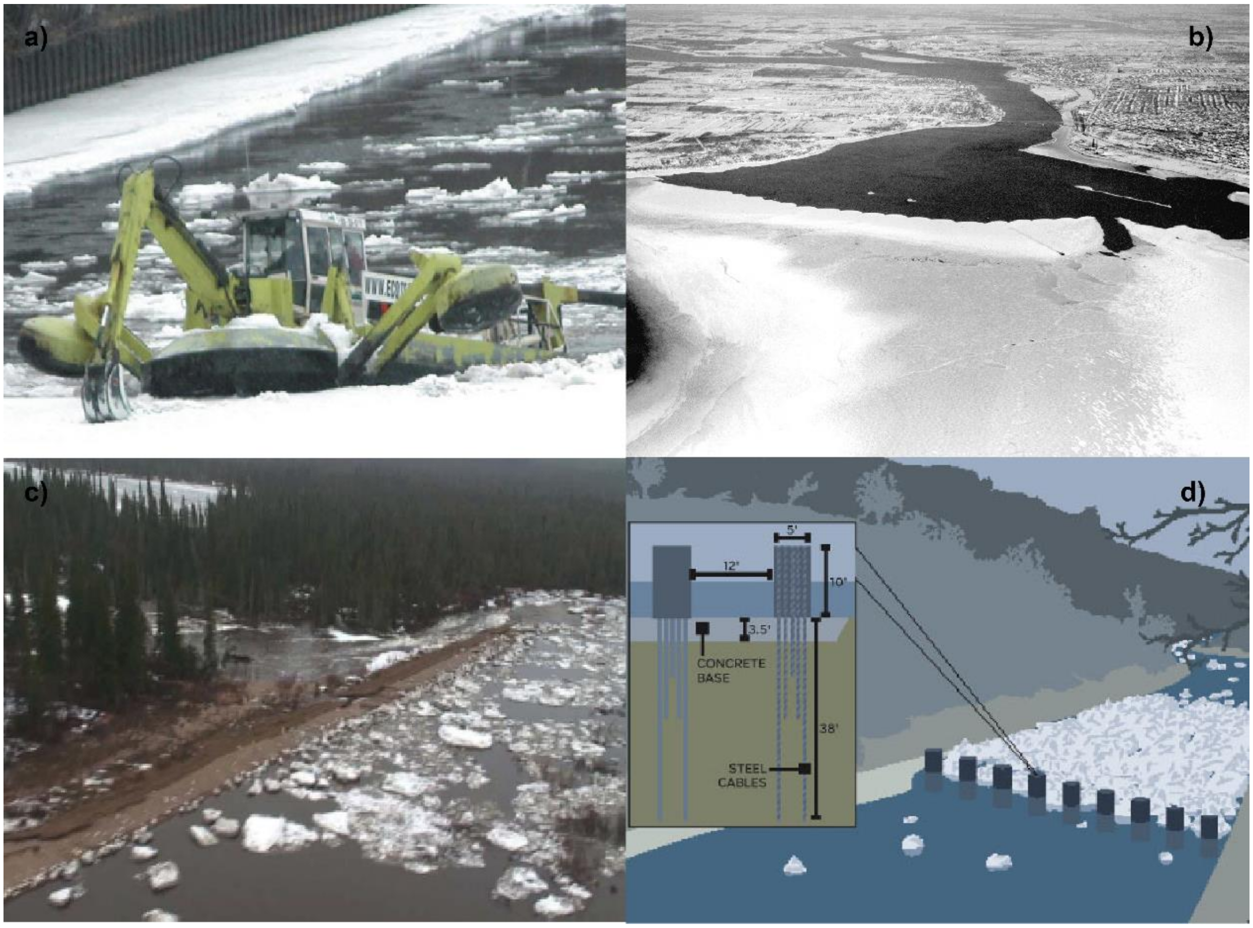
2010 -NO FLOOD



2006 -FLOOD (most severe on record)

Emergency Planning: An emergency plan should be drafted in the event of community flooding. This may include evacuation plans, a list of vulnerable residents and homes, packing lists for residents, stockpiling emergency materials such as sandbags to reduce flooding severity, and refuge center if full evacuation is not possible. The government of Canada and Ontario cover how individual households can be better prepared in emergencies and what to pack in an emergency kit, see: www.getprepared.gc.ca/index-en.aspx and www.emergencymanagementontario.ca/english/beprepared/beprepared.html.

Structures for water level regulation: Structural and non-structural efforts have been undertaken in various regions to prevent ice jam flooding, as shown below. Structural modifications tend to be more effective but are also more expensive and are not always feasible for remote areas or some river systems. Structural modifications could include: dams, ice booms, ice- retention structures, dykes, levees, or modifying the river channel[6].



A) An amphibex unit breaking up ice on the Kaministiquia River near Thunder Bay [7].
B) Ice booms set up across the Niagara River (https://niagaraatlarge.com/2010/04/15/join-neighbours-on-both-sides-of-niagara-river-in-celebrating-our-shared-waters-on-%E2%80%98boom-days%E2%80%99/).
C) Dyke along the Albany River in the South Channel [8].
D) Ice-retention piers or structures (www.vigilantfire.com/News/News_Detail.asp?id=60).

Promoting ice decay: In areas where ice jams are common, in particular the toe of the jam, reducing the quality of the ice can reduce the ice jam severity or prevent the ice jam from forming. An example of this can be found in winter road construction. Previously, winter road crossings over water encouraged ice jam formation as the road was essentially an ice bridge with thickened, strong ice. Now when an ice road is decommissioned, holes are drilled in the ice road crossing to reduce its strength and promote ice melt.

Non-structural modifications need to be implemented annually, or as permitted based on the weather conditions and water flow rates. This could include the suppression of ice formation and/or mechanical destruction of the ice cover through cutting or weakening of the ice. The following examples are cited in Ice-Jam Effects on Red River Flooding and Possible Mitigation Methods [6].

- Ice cutting: Involves equipment that mechanically cuts slots into large sections of ice to reduce its strength and encourage early break off. This is done several weeks ahead of break up to reduce the hazards to crews, but once the runoff has begun.
- Hole drilling: Drilling holes at equal intervals into the ice can increase the rate of melting within that hole and reduce the strength and integrity of the ice, thereby promoting earlier break up. This is performed approximately one month before break-up. This method is currently practiced on ice bridges.
- Ice dusting: Ice dusting is accomplished by spreading dark material across the ice in problem areas. The dark colour absorbs more sunlight, making the area hotter and promoting ice melt before break-up. Dust material could include wood ash or leaves, and the composition of this material should be considered so it does not cause any environmental damage when it enters the water after melt. The effectiveness of dusting varies from year to year, depending on weather conditions, especially snowfall, amount of sun, and air temperatures [9].

AN EXAMPLE OF HOW ICE DUSTING CAN PROMOTE MELTING. THE REGION IS COVERED WITH DARK COLOUR WOODY DEBRIS AND HAS MELTED APPROXIMATELY 30CM BELOW THE SURROUNDING SNOW.

Reference Materials

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Preparing for increased flooding

Localized Flooding (flooding from rain or melt events)

- Infrastructure updates for the community – ensure wastewater capacity is designed for increased precipitation and extreme precipitation events.
- Infrastructure updates for homes – weeping tile, sump pumps, eavestroughs, good ground drainage, backflow prevention valves, etc.
- Manage melt and rain water – piling snow away from structures, keeping culverts and ditches clear and in repair, etc.
- Protect/restore wetlands and increase green space.
- Limit non-permeable surfaces (surfaces that don't allow water to drain through).

Major Flooding (flooding from lakes/rivers/storm surges)

- Avoid building within flood zone, consider the 50-year high water mark.
- Monitor conditions that can lead to flooding – temperature, water level, precipitation, etc.
- Have a community emergency plan.
- Consider structures for water level regulation – dams, levees, booms, etc.
- Promote ice decay to decrease the chance of ice jam flooding.

Food security

Cisco

There is still uncertainty as to what climate change will mean for some animals and plants and their capacity to adapt. We are likely to see the northward movement of many plants and animals. This is already being observed as hunters are sighting deer where they have never seen them before, and fisherman are catching warm water species such as smallmouth bass in northern lakes. Gardeners are testing their limits and finding out they can grow more crops than was possible 20 years prior. Although many of these sound like opportunities for a diversified diet, the invasion of warmer climate species leaves uncertain consequences for local animals and plants. Along with a general northward movement of species, researchers expect that suitable habitat and the range of many species will shrink. Some species are quicker and more able to adapt than others. What will this mean for the people that rely on these animals and plants for food and traditional practices? Hunters, trappers, and gatherers must also adapt.

Many First Nations have noted changes in how, when, and where they must hunt. Changes in fall, winter, and spring temperatures are creating unpredictable hunting times, posing risks of food spoilage, and creating unsafe travel routes over ice in areas that were safe in the past. Others have noticed changes in the migration timing and behaviour of some species, which may be a result of changes in the timing and availability of food sources.

Climate change is a probable contributor to many issues impacting traditional harvesting. With more changes in climate predicted to come, changes and challenges to traditional lifestyle are likely to continue.

Observed changes to food security and traditional harvests

- fewer animals, fish, berries, plants, or birds
- changes to the timing of hunting/ fishing
- changes in migration patterns and timing
- changes (loss, growth, or shifts) in vegetation in nesting, staging, or other habitats
- northward movement of many species
- permafrost melt affecting caribou travel
- winter travel risks to animal and human safety
- warmer water and reduced fish quality
- concern about the health of harvested animals
- changes to the taste of certain meat
- risk of food spoilage (difficulties keeping meat cool)
- changes in water levels affecting travel routes and animal habitat
- invasive species (risk to existing species or the potential to hunt/harvest new species)
- longer growing season.

Mammals: Moose, caribou, deer, and other fur-bearers

The hunting and trapping of mammals provides important resources for First Nation communities. Large mammals, like caribou and moose, are hunted for food. Smaller mammals, like rabbit and marten, are trapped for meat and/or fur. But changing climate conditions will have an impact on these animals and, consequently, the people who rely on them. Already, people in First Nations communities have said that later snowfall, unsafe ice on lakes and rivers, and low water levels are negatively affecting their access to hunting grounds, fishing areas, and trap lines. Warmer winters mean lower quality furs and decreased fitness in animals adapted to colder conditions. Moose, for example, an important traditional food, are a cold weather species and suffer heat stress when temperatures get too high[1]. As such, moose and other cold adapted species are likely to shift their ranges further north in response to changing climate and habitat conditions. Similarly, mammals associated with more southern areas will begin to be seen in northern Ontario. Deer, for example, have been able to establish themselves further north due to warmer winters and decreased snow depths[2]. Areas of northern Ontario may also see an increase abundance of temperate fur bearing species like raccoon, skunks, fishers, bobcats and even opossums[3].

PHOTOS BY XAVIER SAGUTCH

Birds: Geese, waterfowl, and grouse

Several geese species can be found soaring over Ontario in the spring, using northern Ontario and the Hudson Bay wetlands for staging and breeding grounds. Some stay, and others continue their journey to the arctic. The Canada goose is among the most hunted goose across Ontario and the lesser snow goose is common in communities along the Hudson Bay and James Bay coast [4]. They consume vegetation along the coast, primarily grasses, sedges and horsetails[4]. Several communities have noticed changes in vegetation in these areas including a disappearance of certain grasses and increased growth of willows that may be impacting important feeding and nesting habitat for the geese. People have also noticed a change in geese migration patterns and behaviour. These observations require further investigation to understand the cause and impacts to geese as well to create adaptation plans. It is likely that there are multiple contributing factors that are forcing geese to other areas or changing their migration pattern and behaviour.

Commonly harvested birds
(not limited to this list)

- Canada goose
- lesser snow goose
- small Canada goose
- spruce grouse
- ruffed grouse
- mallard duck
- black duck

Ducks and grouse are also commonly hunted. Ruffed grouse (partridge), spruce grouse, and mallard ducks are probably the most popular, but certainly not the only birds that are important to food security or have traditional value. The mallard duck and the ruffed grouse can be found across Canada and Ontario, but climate change may impact these birds differently. The ruffed grouse will likely lose some of their summer and winter range by the 2080s, but the mallard duck may actually gain some winter range by the 2080s.To see the current and projected range of these and other birds, visit the Audubon Climate Report website http://climate.audubon.org/ (or http://climate.audubon.org/birds/mallar/mallard for the mallard duck & http://climate.audubon.org/birds/rufgro/ruffed-grouse for the ruffed grouse).

Fish

Fish are a staple in the traditional diet of most First Nations in Ontario. But a changing climate has already begun to impact this important group of animals. Warming temperatures will change the distribution of warm water, cool water, and cold water fish in Ontario (see Box)[5]. A changing climate may bring the introduction of new fish diseases or parasites or change the dynamics of ones already present. Processes that are dependent on temperature cues, like spawning, may be altered. Changes in water level may lead to loss of important fish habitat and present problems for fish migration.

The ability to harvest fish is also being affected by climate change. Lower water levels can cut off traditional routes and limit access to fishing areas. And a delayed ice-on season and questions of ice integrity are shortening the season for ice fishing. In some cases, these hurdles to harvesting are leading to less fish consumption by First Nation community members.

Commonly harvested fish

(not limited to this list)

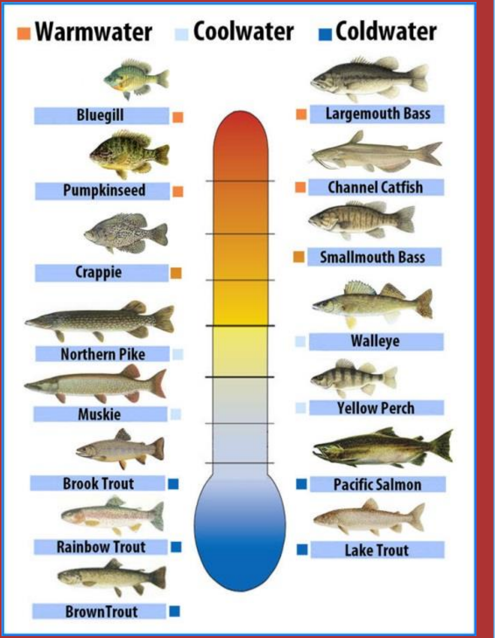
- walleye
- brook trout
- lake sturgeon
- lake whitefish
- lake trout
- cisco
- white sucker
- northern pike
- yellow perch
- rainbow smelt

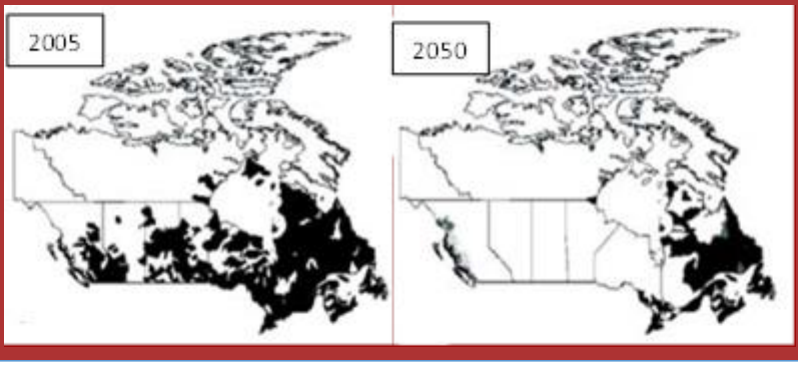
The Importance of Water Temperature

Water temperature is a very important factor for fish. As cold-blooded animals, their internal temperature depends on the temperature of the water surrounding them. Temperature is also a driver of many of their biological processes including spawning, growth, and metabolism.

The preferred temperature range varies from species to species, but fish in this region are generally categorized as either warm-water, cool-water, or cold-water species.

With warmer temperature projected across all seasons due to climate change, cold water fish, like brook trout, are likely to see their habitat ranges shrink and move farther north. While warm water fish, like small mouth bass, will be able to live in a larger area of the province.





These maps show how brook trout range (black area) is predicted to shrink by 2050. This once wide spread species could be almost excluded from Ontario under future climate conditions.
Map from Dove-Thompson et al., 2011[5].

Berries and Plants

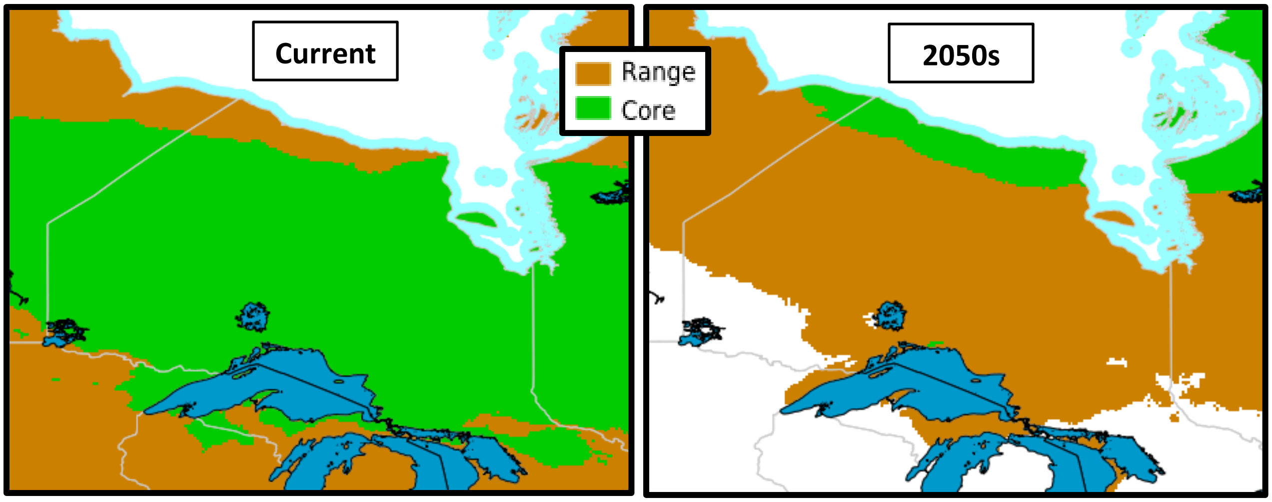
Plants and their berries or seeds are harvested for food and for traditional or medicinal purposes. Climate change is likely to impact the distribution of several important plant species. For some water plants such as wild rice [6], or wetland plants such as cedar, cranberries, cloudberries and Labrador tea, changing water levels may have major impacts, especially during extreme events of drought and severe rain. In the subarctic, permafrost decay is disrupting muskeg plant communities. The severity of these impacts may depend on the species ability to adapt but can also depend on additional mitigation and adaptation strategies from communities. In some ways, climate change may benefit key berry producing plants or expand the types of berries and plants that can be cultivated in northern regions.

Commonly harvested plants
(not limited to this list)

- blueberries
- cranberries
- raspberries
- cherries
- Saskatoon berries
- cloudberries
- wild rice
- cedar
- sweet flag
- Labrador tea
- sage
- birch (bark)

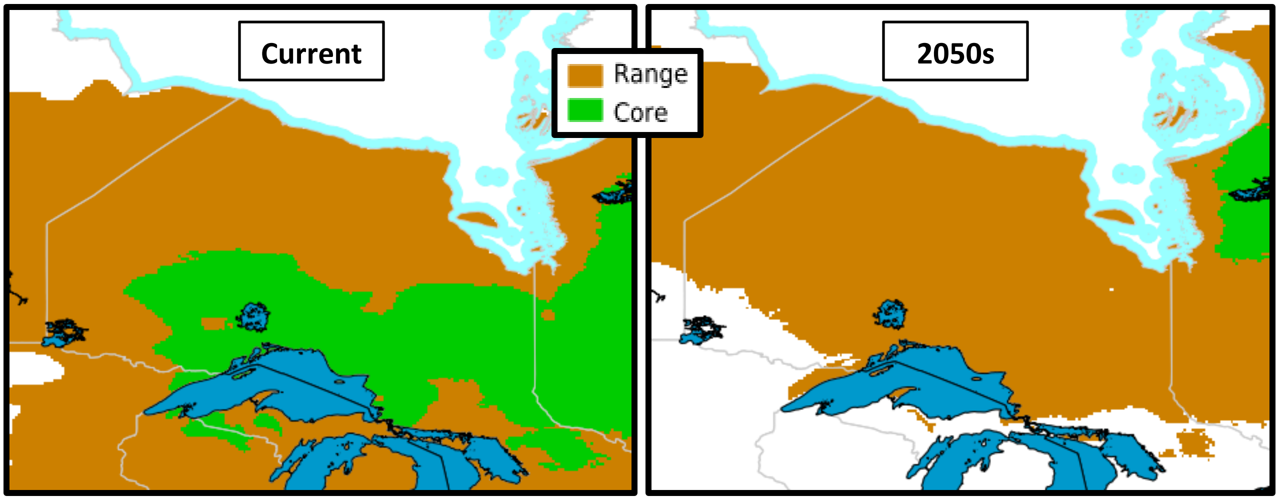
This could be a benefit or opportunity for some gardeners and certain wild species that are able to adapt to the changing climate.

To find out how the climate envelope (specific temperature ranges and rainfall conditions) may change for a specific plant, visit: http://www.planthardiness.gc.ca/?m=2b.



CURRENT RANGE OF LABRADOR TEA (1970-2000)

PROJECTED CLIMATE ENVELOPE FOR LABRADOR TEA IN 2040-2070, WITH CONTINUED GREENHOUSE GAS OUTPUTS.



CURRENT RANGE OF LOWBUSH BLUEBERRY (1970-2000)

PROJECTED CLIMATE ENVELOPE FOR LOWBUSH BLUEBERRY IN 2040-2070, WITH CONTINUED GREENHOUSE GAS OUTPUTS.

Adaptation and Mitigation

Monitoring

Understanding the status of species of interest and their potential threats will provide the first step to developing adaptation or mitigation strategies. Monitoring activities can range greatly in cost and man-hours. Targets and goals can be established by the community, from decisions about what needs to be monitored and how to monitor [7]. A community-based monitoring approach can involve hunters, trappers, gatherers, and other land users in data collection. Data can be collected while people are out on the land engaging in their regular activities. Some points of monitoring could include:

- Population counts
- Fish spawning times and locations
- Animal health and diseases
- Migration times and patterns
- New species
- Changes to harvested plants (location, abundance, health, etc.)

Web-based tools and applications

iNaturalist – create specialized projects, track your observations, connect with others. www.inaturalist.org

Fish ON-Line - Information on fish species present. Allows users to add information on species found. www.ontario.ca/page/how-use-fish-line

SIKU- A living wiki-archive of Inuit knowledge and social mapping platform for northern communities – Coming Soon arcticeider.com/vote-siku

EDDMapS - help track of invasive species in Ontario and beyond www.eddmaps.org/ontario/

In some areas, hunters are being trained and paid to collect data while they are already out on the land[7]. There are also an increasing number of websites and apps that collect data for monitoring programs that could be used by communities (see the box above for examples). These tools can help to reduce costs of monitoring programs, increase efficiency and help overcome hurdles, such as capacity within communities.

Monitoring guided by traditional knowledge can create regional and community baseline data, so that changes over time and the cause of those changes can be identified. Collaboration with universities, governments, or suitable authorities may help to merge traditional knowledge approaches with scientific study.


Picking raspberries


Seine netting to sample fish, Attawapiskat River

Monitoring wild food health

With the increasing temperatures predicted because of climate change, incidence of animal diseases may increase. The health of harvested animals can be a concern for those who consume them. Some organizations / government agencies offer support in tracking and identifying disease.

Ontario Ministry of Natural Resources and Forestry (OMNRF)

- Report a fish die-off (1-800-667-1940)
- Can be a first point of contact for health concerns in large game animals

Andrée Gendron is an Environment Canada scientist familiar with fish parasites.

- Contact at Andree.gendron@canada.ca or 514-496-7094

The Canadian Cooperative Wildlife Health Centre (CCWHC)

- Sick or dead wildlife (birds, bats, small mammals) can be reported at www.cwhc-rcsf.ca/ or 1-866-673-4781
- CCWHC will also accept carcass submissions (provided guidelines are followed) for cause of death investigation and disease and parasite testing.

Habitat restoration and protected areas

Protecting or restoring habitat that is important for harvested species is one way to help protect food security. For animals, important habitat might include spawning grounds, calving grounds, nesting areas, and migration corridors. Plants might also prefer specific conditions to grow, such as water depth, amount of light, and soil requirements. As climate changes, plants and animals may shift their ranges to follow their preferred climate envelope. This may make it necessary to change the geographic boundaries of protected areas over time. As different plant and animal species have different needs, which actions you take and where you aim your resources will be dependent on the species of interest. Below we outline some considerations and examples for some commonly harvested species.

Caribou

Caribou species are migratory and require an unfragmented territory. Further pressures from climate change, including permafrost melt, a changing landscape, the northward movement of moose and deer, and potential increases in wolf populations, add extra pressures to caribou [8,9]. Considering these threats, habitat protection should be considered as a protected areas strategy. This could include a moratorium on development through important migration routes.

Geese

Nesting and staging areas are important habitats for geese. Identifying where these areas are can allow them to be protected, restored if necessary, and monitored for change. Many communities have also noticed a decline in food sources for geese, particularly grasses declining or being outcompeted by increased woody plant growth such as willows. Restoring important grassy plants may help to re-establish goose feeding grounds.


CANADA GEESE

Fish

Identify and protect key spawning areas, migration corridors, and cold-water refuges. With temperatures rising across all seasons, cold water refuges will become even more important to cold water species. Enhancing shoreline vegetation, maintaining water levels, and protecting tributaries can all help regulate water temperature. Also remember that a healthy aquatic system is a benefit to all fish species who live there. For more information on aquatic systems, see the *Ecosystems Shifts section* of this report.

Assisted Migration

Assisted migration helps to establish plants that may grow and survive well in warmer future climates. These plants may be growing naturally just south of the community. For instance, if lowbush blueberries are under threat from climate change in your community, the same species of blueberries that grows in a more southern climate can be seeded. A more extreme version of assisted migration would be seeding a new blueberry species that grows in a more southern range, such as highbush blueberries, that may now survive further north. These species may replace or even add to the existing plants in the region by the end of the century.

BLUEBERRIES

The movement of any plant species into a new location is not without risks, however, such as the species failing to thrive in the new area, or the species becoming invasive in its new environment. All risks should be weighed carefully before any assisted migration plan is implemented.

More information on the types of assisted migration can be found at: http://www.nrcan.gc.ca/node/13121.

Case Study: Wild Rice

Wild rice restoration has been undertaken in several communities in Ontario, Manitoba and the United States and there are several protocols for re-establishing or enhancing the growth of wild rice stands. Resources are listed below.

http://blog.emergencyoutdoors.com/edible-wild-plants-northern-wild-rice-zizania-palustris-l/

The Native Wild Rice Coalition
www.nativewildricecoalition.com/wild-rice-restoration.html
Wild Rice Restoration Plan for the St. Louis River Estuary
www.1854treatyauthority.org/images/WildRiceImplementationPlan_2014_Final.pdf
Restoring manomin (wild rice): a case study with Wabaseemoong Independent Nations, Ontario
mspace.lib.umanitoba.ca/handle/1993/31160
Wetland Restoration Handbook. Chapter 12. Wild Rice Community Restoration
dnr.wi.gov/topic/Wetlands/documents/esScience/WRH12.pdf
Keweenaw Bay Indian Community, Natural Resources Dept.
nrd.kbic-nsn.gov/wild-rice-management-and-restoration

Adjusting harvesting practices

Many hunters and fisherman are already saying they have had to adjust their harvest time and methods due to unsafe ice conditions, warmer waters, and a risk of food spoilage. In particular, during the fall or early winter season, when many people are setting out fish nets, hunting moose and partridge, or collecting furs, temperatures are warmer than the past.

Weather forecasting can help overcome some of these challenges and harvesters need to be especially aware and prepared for adverse weather or ice conditions. Fisherman may need to collect their nets more frequently and earlier in the morning, before temperatures increase with the day. Ice fishing or crossing over frozen lakes and rivers may have to be delayed until ice conditions are safe. Ice conditions can be monitored, and the information shared with the community.


FORT SEVERN

People are also using different types of equipment for harvesting activities. Many in First Nations communities have said they now have to travel further to hunt or gather traditional foods. This many require more costly means of transportation, such as a vehicle, ATV or snowmobile. Helicopters are now commonly used for geese hunting and can transport hundreds of geese. Thinner, lower quality ice over lakes and rivers has made it necessary for some to replace their heavier snowmobiles with lighter ones. Later snowfall has made it necessary to use ATVs instead of snowmobiles later into the winter season.


SMALLMOUTH BASS

With some traditionally harvested species under threat or moving locations due to changing climate, it may be practical to shift to new species. For instance, fishing for smallmouth bass as they become more common can help to both, control their populations and reduce harvesting pressure on more threatened cold-water species like brook trout. Trapping can include temperate fur bearers that may enter the region, such as fishers and bobcats. Deer can also be hunted as they move further north.

Community initiatives


Community cooler in Chapleau Cree FN. Photos from Dakota Souliere

Community coolers can help reduce the risk of food spoilage due to warming temperatures. Community coolers and freezers have already been adopted by communities in Nunavut[10], Ontario, and Newfoundland and Labrador. In some cases, the freezers and coolers are powered either wholly or in part by alternative energy. In McDowell Lake First Nation, for example, a community fridge and freezer are powered entirely by solar power[11]. In Chapleau Cree First Nation, their community cooler provides a space for members to hang and store their meat before butchering. This helps to alleviate the risk of foodborne illnesses from warmer fall temperatures.

Sharing harvested resources within the community can help ensure food security for those without the resources to harvest game or those no longer able to harvest themselves.

In some areas, First Nations are contacting nearby farmers that are interested in having geese controlled on their land. These partnerships can benefit both parties. To facilitate this adaptation strategy, communities might consider acting as a point of contact for farmers to reach out or using social media such as Facebook.

Community gardens can help decrease reliance on outside food sources, which can be especially beneficial for remote communities where the cost of shipping food makes prices higher than average. A longer growing season as a result of climate change could actually be a benefit for many communities in the north. Greenhouses can allow growing seasons to be extended even further. For a guide on starting a garden, see here:

https://www.upnorthonclimate.ca/links/

Gardens in Fort Albany FN. A personal garden (above) and a community garden (below)

A greenhouse in Fort Severn FN

Alternative growing methods, like aquaponics, can be used to grow produce indoors year-round. Aquaponics uses an aquarium with fish to grow plants without soil and can be made on a small or large scale.

Examples of aquaponics systems.

Small scale system (left), larger scale system (above)

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Preparing for changes in food security

Monitoring

- Can be aimed at many aspects of the environment including animal and plant species and important habitat.
- Can allow changes over time to be tracked

Restore and protect important habitats

- Spawning areas, nesting areas, migration corridors, wetlands, etc.

Assisted migration of plant species

- For example, seeding blueberry

Adjust harvesting practices

- Could include timing of harvesting, the equipment needed, or species targeted

Community Initiatives

- Community coolers, food sharing, community gardens, community partnerships

Preparing for the Future

Health

Fort Hope, Ontario

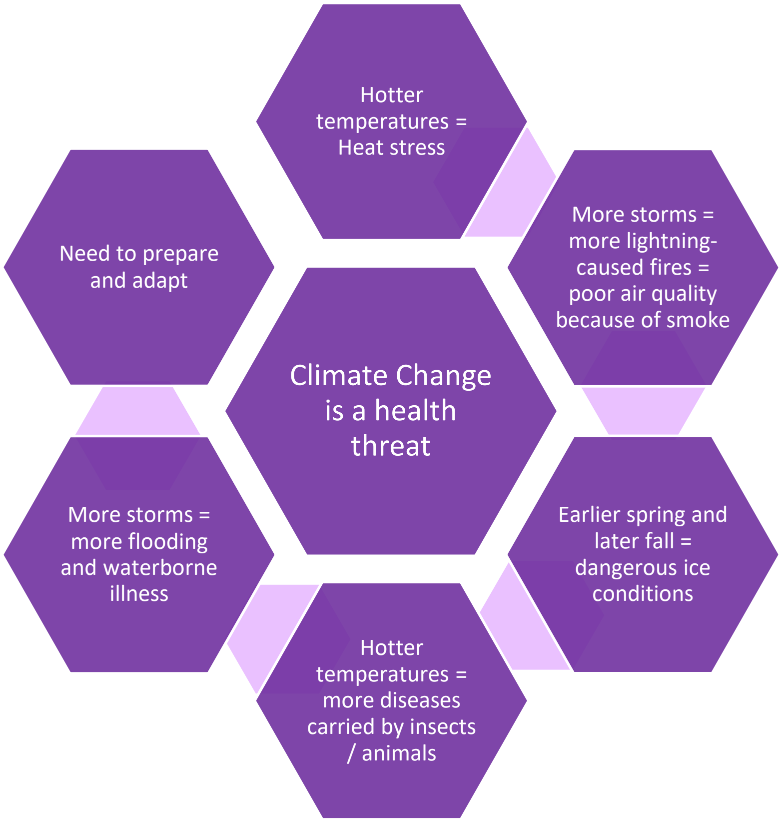
Climate Change is the largest health threat of the 21st century. Those are the frightening words used by the World Health Organization. Climate change can directly and indirectly impact human health through changing temperature and precipitation and altering the severity and frequency of extreme events such as floods, wildfires, droughts, heat-waves and storms.

Changing climate will impact food and water, vector-borne illnesses, and the occurrence of some health conditions. Indigenous peoples in Canada have an increased susceptibility to these impacts due to several factors including the remoteness of communities, higher rates of poverty, and close connections to the land. Implementing community-based adaptations for climate change-related health impacts may help communities mitigate some of the potential risks.

Direct and Indirect Health Effects

Direct Effect: Warmer summers can increase the risk of heat stress in vulnerable individuals

Indirect Effect: Unstable ice conditions from warmer winters may prevent travel, impacting mental wellness, food security, and likelihood of accidental injury or death



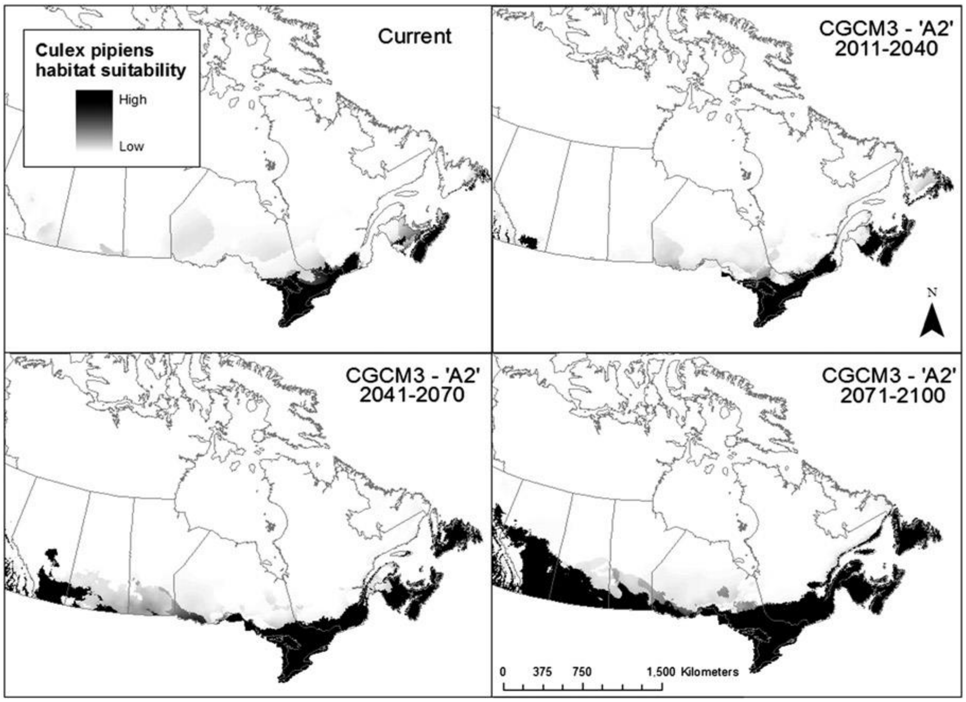
Diseases carried by insects and animals

The occurrence of diseases transmitted by animals (called zoonotic diseases) is predicted to change with changing climate. Common examples of zoonotic diseases are those transferred to humans by bites from mosquitoes, ticks or other insects. In these cases, the insects act as vectors of disease transmission and these get termed “vector-borne diseases”.

Climate change has the potential to expand the areas where the animals and insects that carry disease can live[1]. Warmer temperatures, especially in winter, are allowing more southern species to exist further north. And warmer temperatures in spring and fall are increasing the length of time some carriers and vectors can remain active[1].West Nile virus and Lyme disease are two examples of vector-borne disease that have the potential to spread north in Ontario with changing climate.

West Nile virus (WNV) was introduced into Canada in 2001 and is transmitted by infected *Culex* mosquitos [2]. Very few people have severe illness from being infected by WNV. In 80% of people, WNV causes no symptoms at all. Of those who do show symptoms (fever, headache, fatigue, skin rash), most experience only mild illness. Less than 1% of people with WNV have severe illness that involves the brain and nerves[3].The number of WNV cases per year in Canada is highly variable [2] but it is still relatively rare, with only 335 reported cases to date in 2018. However, with climate change, it is expected that range of the *Culex* mosquito, carrier of WNV, will expand northward. People in more northern areas need to be aware of WNV and the steps that can be taken to avoid infection.

PHOTO FROM WWW.PUBLICHEALTHONTARIO.CA



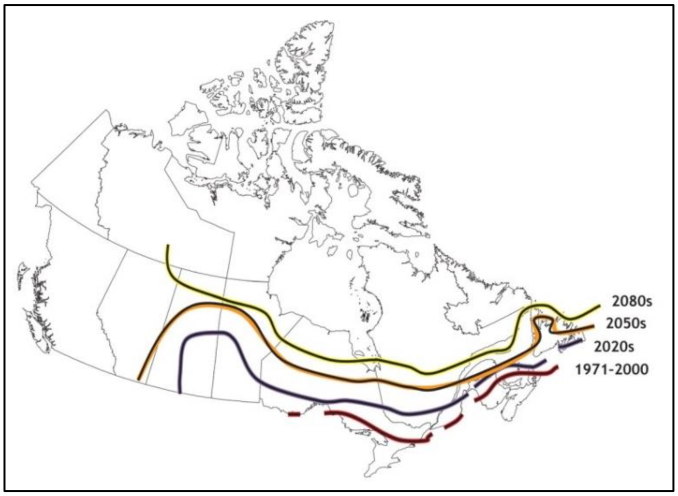
POTENTIAL HABITAT SHIFT OF THE CULEX PIPIENS MOSQUITO WITH PREDICTED CHANGES IN CLIMATE. THE DARKER THE COLOUR, THE MORE FAVOURABLE THE CONDITIONS FOR CULEX PIPIENS ESTABLISHMENT.

TAKEN FROM HONGOH ET AL., 2012[4]

HTTPS://EXTENSION.UMAINE.EDU

In the case of **Lyme disease**, the vector responsible for infection is the blacklegged tick (also called the deer tick), which can carry the bacteria *Borrelia burgdorferi*, the cause of Lyme disease. Like the *Culex* mosquito, the range of the blacklegged tick has the potential to move north with a warmer climate. The number of Lyme disease cases in Canada has increased significantly from 144 cases in 2009 to 992 in 2016, with Ontario having the highest incident rate of 25-30 cases per 100,000 people [5].

The map to the right shows the upper geographical limit of blacklegged tick historically (1971-2000) and projected into the future with predicted changes in climate and continued tick population growth[6]. With the range potentially pushing to the far north of Ontario, it will be necessary for everyone to be aware of the potential for Lyme disease and what can be done to mitigate the risk of exposure.



POTENTIAL RANGE EXPANSION OF THE BLACKLEGGED TICK WITH CONTINUED CLIMATE CHANGE. TAKEN FROM GREER ET AL., 2008 [6].

As ecosystems shift with changing climate, there is potential for the distribution of many insects and animals to change. This could pose challenges for the control of other zoonotic diseases as well, such as rabies[7], which in Canada is most commonly carried by bats, foxes, skunks and raccoons and is spread through contact with infected saliva.

Adaptation and Mitigation

Prevent bites

The best way to prevent infection from vector-borne diseases is to prevent insect bites. The Ontario Ministry of Health recommends the following steps for preventing insect bites:

- Wear light coloured, long-sleeved shirts and pants – you can spot ticks more easily and mosquitoes are attracted to dark colours.
- Cover exposed skin -wear a hat, closed footwear, pull socks over your pants, and tuck in your shirt.
- Use insect repellents (bug spray, lotions) with DEET or Icaridin.

For ticks specifically:

- Perform daily full-body checks for ticks on yourself and your children – pay extra attention to the scalp, armpits, ankles, navel, groin, in and around ears, and behind the knee.
- Check pets and outdoor gear as they could carry ticks into your home
- If possible, shower within two hours of being outdoors to remove ticks that haven't attached
- If you have access to a dryer, put clothing in dryer on high for 10 minutes to kill any remaining ticks – if clothes are damp, additional drying time is needed
- If you find an attached tick remove it immediately using tweezers or a tick removal tool. Removal within 24-36 hours usually prevents infection. Put the tick in a secure container and contact your local public health unit.

Tick Removal with Tweezers

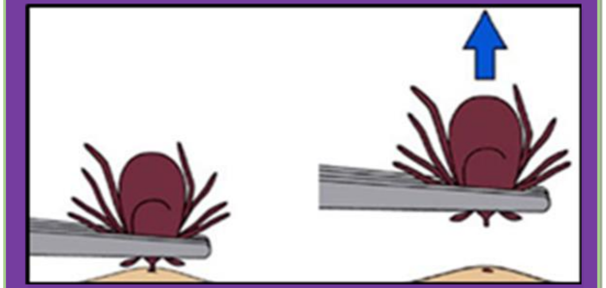


Image from
www.cdc.gov/lyme/removal/index.html

Ticks must be removed properly to minimize the chance of contracting tick-borne illnesses. To remove a tick with tweezers, grasp the head as close to the skin and possible and pull straight out. Wash the bite with soap and water or disinfect with alcohol hand sanitizer.

Remove habitat

Individuals and communities can also remove or limit habitat for ticks and mosquitos. Blacklegged ticks live in wooded areas, tall grasses, and bushes.

To make the area less appealing for ticks to live, you can:

- Keep grass mowed short and trim trees and bushes to let sunlight in (ticks avoid hot, dry places)
- Remove brush and leaf litter
- Create a border of gravel or woodchips at least 1 meter wide at the edge of wooded areas or areas with tall grasses
- Keep children's play sets away from the edges of wooded areas. Consider placing them on mulch or woodchips and in areas of sun.

To remove habitat for mosquitoes:

- Remove standing water. Mosquitoes lay their eggs in stagnant water, even small amounts.
- Keep lawn, trees and shrubs trimmed to let sunlight in and clear away brush and leaf litter. If you have a compost pile, turn it regularly. Adult mosquitoes like these cooler, darker areas.
- Put screens on windows and doors to keep mosquitoes out of your house.

MOSQUITOES LAY THEIR EGGS IN STANDING WATER

To avoid other zoonotic diseases, like rabies, avoid contact with infected wildlife. Teach children not to approach or touch animals that they do not know. Report an animal that seems dangerous to your local police or to the Ontario Provincial Police. For pets or livestock suspected of rabies, contact the Ministry of Agriculture and Food at 1-877-424-1300.

Be aware of diseases and their symptoms

Ensure community members are aware of the potential of these illnesses and are familiar with the signs and symptoms of infection. Prompt and proper treatment can help mitigate the potential health effects of illnesses like Lyme disease and rabies. Identification of these illnesses can also help provincial monitoring programs that track the spread of these and other illnesses. More information on these diseases can be found at https://www.ontario.ca/page/outdoor-health

Monitor for new species

Climate change has the potential to allow species to live in areas where they couldn't live before. The *Culex pipiens* mosquito and blacklegged tick are examples of this. Monitoring activities can help alert communities when new species have entered their area. How monitoring is conducted can differ depending on the species of interest. Ticks collection, for example, can be done with a technique called dragging. Public Heath Ontario outlines a procedure for tick dragging that can be found at https://www.publichealthontario.ca/en/eRepository/Active_tick_dragging_SOP.pdf

Dragging for ticks www.publichealthontario.ca

More information on invading species can be found in the Ecosystem Shifts section.

Photo from https://kitchener.ctvnews.ca/ticks-spreading-through-ontario-raising-fears-of-

Photo from https://www.westernsafetysign.com/products/do-not-feed-the-wildlife

Waterborne/Foodborne Illnesses & Nutrition

Extreme weather events and changes in temperature and precipitation patterns can directly impact important food sources for First Nation communities. This has been seen in many communities with the disappearance of berry bushes and fruit, changes in fish, bird and animal population sizes, migration patterns and spawning times. These have the potential to cause direct impacts on First Nations with respect to their health, nutrition and mental wellbeing [8]. *For changes in berries, fish, and wildlife please see the Food Security section.*

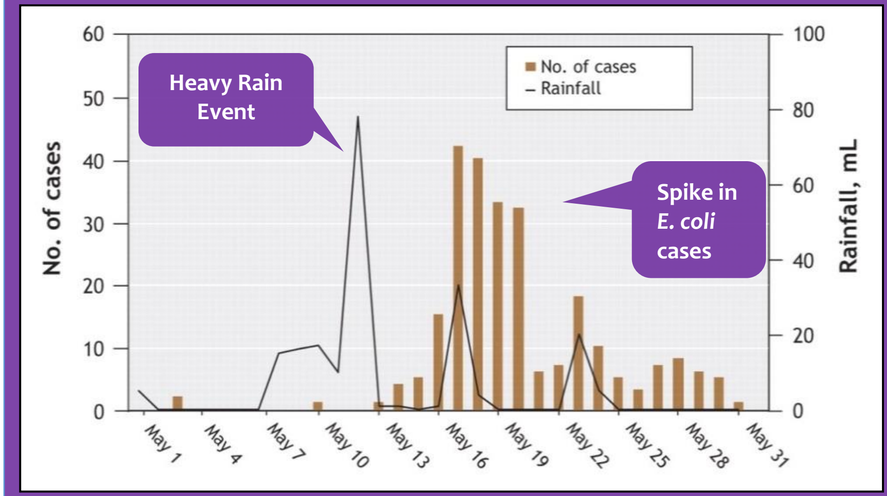
Higher temperatures can increase the rate of food spoilage and increase the risk of foodborne pathogens, like *Salmonella* bacteria[8,9]. This danger can extend to wild-harvested foods and has the potential to affect both food security and the health of people in the community.


HARVESTED MOOSE.
PHOTO BY DAKOTA SOULIERE

The occurrence of waterborne illnesses will also be influenced by climate change. These illnesses are caused by microorganisms (bacteria, viruses, etc.), bio-toxins (toxins produced by living organisms, like algae) and toxic contaminants in the water we use [9]. The majority of waterborne diseases are gastrointestinal (diarrheal diseases), however they can also impact the kidneys, the lungs, the brain and metabolic processes [9].

Lower water levels from drought can reduce water flow, which can increase pathogen concentration and pose a risk to drinking water[10,11] while heavy rain and associated flooding can quickly transport disease-causing pathogens into water supplies[6]. This may have been the case with the *E. Coli* contamination in Walkerton, Ontario in May 2000, where a large rain event (approximately 80mL of rainfall) occurred just days before massive surge in *E. Coli* cases (shown in the graph below)[6]. With heavy rain events predicted to increase with climate change, the incidence rates of waterborne diseases are predicted to increase as well.

Case Study: Heavy Rainfall and E. Coli in Walkerton, ON



THIS GRAPH DEPICTS BOTH THE RAINFALL (BLACK LINE) AND NUMBER OF E. COLI CASES (BROWN BARS) IN WALKERTON, ON, IN MAY 2000. A LARGE RAIN EVENT (ABOUT 80ML) HIT THE AREA JUST DAYS BEFORE AN OUTBREAK OF E. COLI CASES. THIS 3-4 DAY LAG TIME BETWEEN THE RAIN AND THE SPIKE OF CASES IS CONSISTENT WITH THE INCUBATION PERIOD OF E. COLI.

HEAVY RAIN AND ASSOCIATED FLOODING AND RUNOFF CAN QUICKLY TRANSPORT PATHOGENS INTO WATER SUPPLIES. GRAPH FROM GREER ET AL, 2008 [6].

Adaptation and Mitigation

Climate change has the potential to alter the availability of traditional foods and threaten food security for First Nations communities. Food security issues and related adaptation options are discussed in depth in *the Food Security section.*

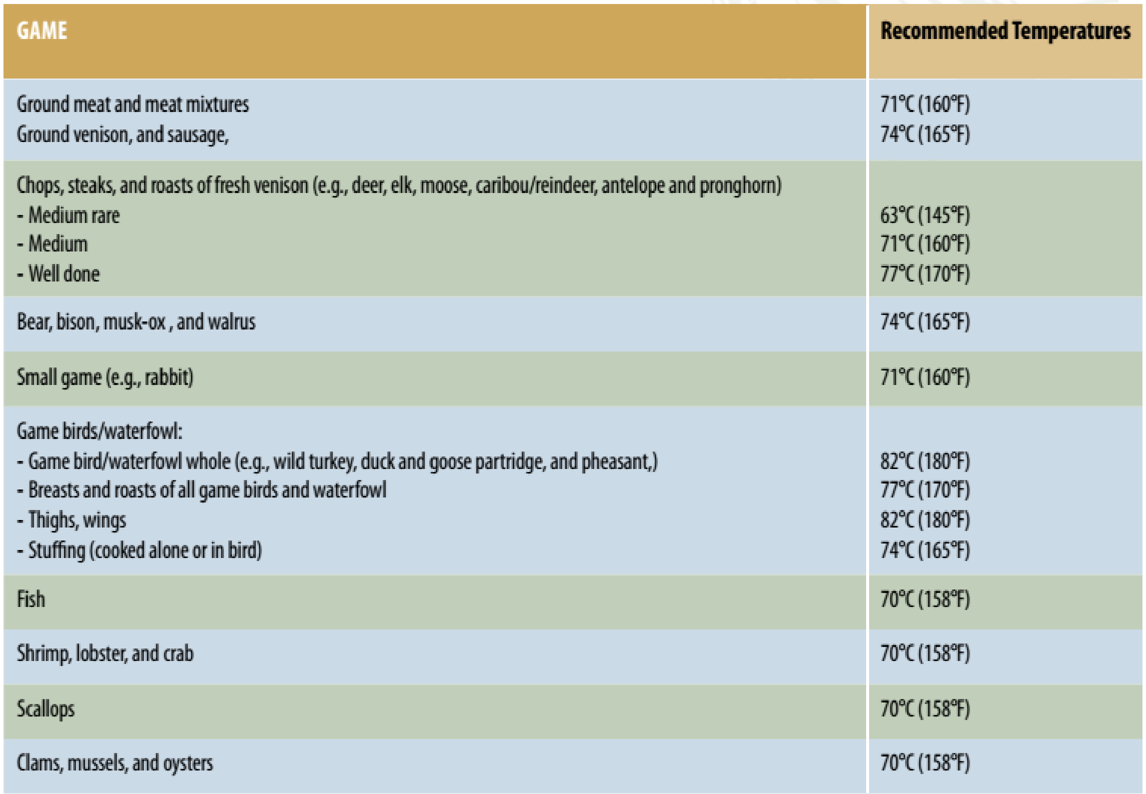
Food spoilage and foodborne illnesses

Proper thawing, chilling, and storage of food can help prevent food spoilage and dangerous bacterial growth that could lead to foodborne illnesses [12]. Hand washing and cleaning work surfaces and utensils can also help prevent bacteria from contaminating other foods and surfaces. Meat, including wild game, should be cooked to a temperature high enough to kill potential foodborne pathogens (see table below)[12]. Health Canada provides a report for First Nations on food safety outlining how foodborne illnesses arise, how they can be prevented, and other important details on food preparation and preservation (www.gov.mb.ca/inr/pdf/pubs/nhfi_food_safety_for_first_nations_people_of_canada.pdf).

Health Canada Food-Handling Recommendations:

- Keep hands and food preparation utensils clean
- Clean and sanitize all work areas
- Avoid cross-contamination of food
- Cook foods to recommended temperatures
- Ensure foods are chilled – bacteria grow rapidly at temperatures of 4 to 60°C
- Thaw foods in the refrigerator, in cold water or microwave NOT at room temperature or in hot water
- Store foods for no longer than recommended

Some communities have already found that harvested meat and fish are spoiling faster in fall. Initiatives like community coolers or community freezers can help reduce the risk of food spoilage. It may also be necessary to alter the timing of hunting or fishing due to a warmer fall season. This is discussed in more detail in *the Food Security section*.



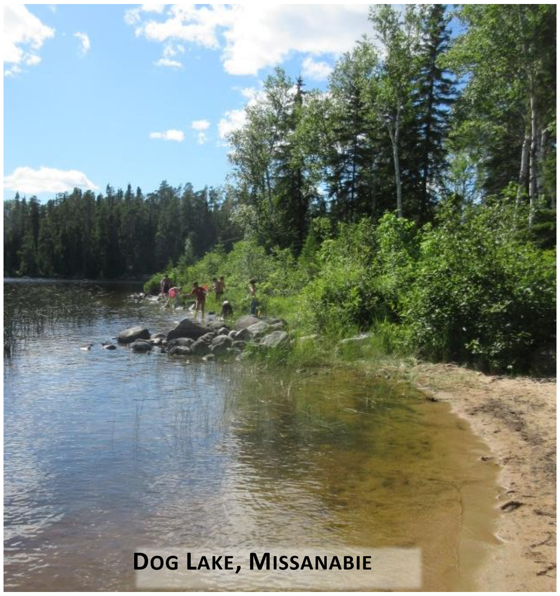
GAME	Recommended Temperatures
Ground meat and meat mixtures Ground venison, and sausage,	71°C (160°F) 74°C (165°F)
Chops, steaks, and roasts of fresh venison (e.g., deer, elk, moose, caribou/reindeer, antelope and pronghorn) - Medium rare - Medium - Well done	 63°C (145°F) 71°C (160°F) 77°C (170°F)
Bear, bison, musk-ox , and walrus	74°C (165°F)
Small game (e.g., rabbit)	71°C (160°F)
Game birds/waterfowl: - Game bird/waterfowl whole (e.g., wild turkey, duck and goose partridge, and pheasant,) - Breasts and roasts of all game birds and waterfowl - Thighs, wings - Stuffing (cooked alone or in bird)	 82°C (180°F) 77°C (170°F) 82°C (180°F) 74°C (165°F)
Fish	70°C (158°F)
Shrimp, lobster, and crab	70°C (158°F)
Scallops	70°C (158°F)
Clams, mussels, and oysters	70°C (158°F)

Recommended minimum internal cooking temperatures for game meat[12].

Waterborne illnesses

Clean, safe drinking water is already an issue for many First Nations communities. Climate change poses a further risk to drinking water supplies as the risk of waterborne diseases can increase with higher water temperatures and changes in the frequency and severity of rain [9]. Communities should continue to push for safe drinking water. In communities that do have potable tap water, ensure that monitoring programs are adequate and that local and surrounding water sources continue to be safe to drink. During times that water is not safe to drink, communities should have an alerting system to notify members and stockpile alternative water sources (bottled water, boiled water, different water sources, etc.). *Water treatment centers are covered in more detail in the Infrastructure adaptation report.*

Heat Related Illnesses


Dog Lake, Missanabie

Temperatures are expected to increase in the north of Ontario for all seasons, with summer projected to have a higher number of days over 25°C. In addition to warmer weather in general, incidents of extreme heat and heat waves will likely be more common.

There is no set temperature that defines an extreme heat event. In most jurisdictions, an extreme heat warning is called when there is the potential for an unacceptable level of health effects, including increased mortality[13]. Heat risk is also more than just temperature; it also depends on humidity (the amount of water vapour in the air), wind speed, and radiant load (heat from sunlight or other heated surfaces)[13]. The term "humidex" is an effort to combine the temperature and humidity factors into a number that describes how hot the weather feels to the average person. A "heat wave" is generally defined as 3 consecutive days of extreme heat.

When an extreme heat warning is called could differ between regions. For example, because temperatures are cooler overall in the north of Ontario, an unusually hot period might be defined as temperatures over 25°C, whereas southern Ontario might use days over 30°C.

Populations at the greatest risk for heat illnesses are[13]:

- elders
- infants and young children
- people confined to a bed
- overweight individuals
- those that have a pre-existing health condition (breathing difficulties, heart problems, hypertension, kidney problems, mental illness)
- those who work or exercise in the heat
- those with low-income
- the homeless

Adaptation and Mitigation

Increase awareness of heat illness

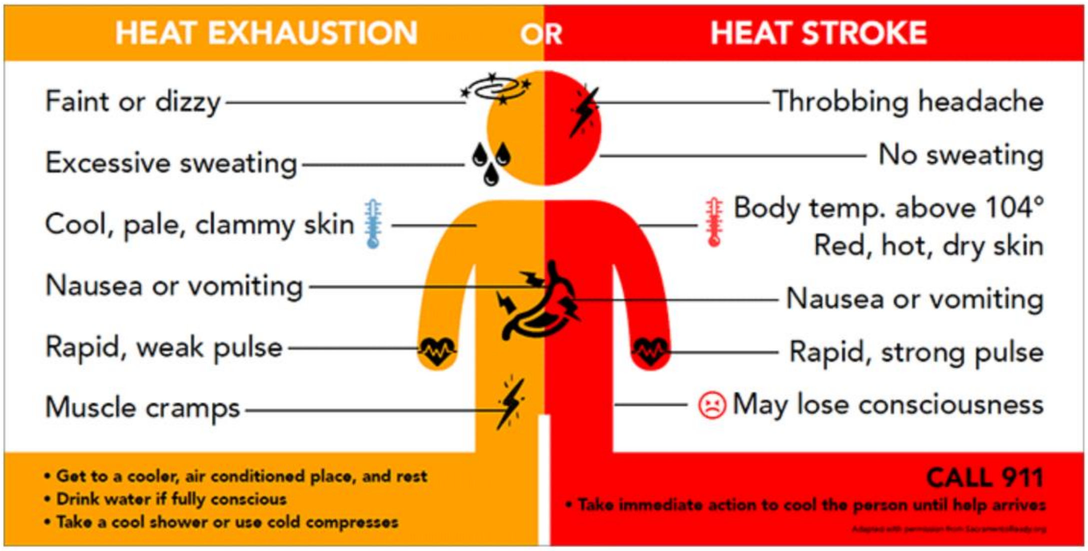
Understanding the potential for heat-related illness, and knowing what can be done to prevent it, are good ways to help reduce the risks of heat events. People should also familiarize themselves with the signs of symptoms of heat illness, so they know when they or someone else may be at risk, and what can be done to help.

Community education campaigns could be used to spread information about heat illness. They can take many forms (local television/radio, social media, community meetings, printed materials) and can be specifically targeted to the most vulnerable groups. Communication of the risks of extreme heat should begin before the summer season arrives, and continue through the summer season and during extreme heat events[13].

General information on heat illness includes:

Prevention	Signs and Symptoms	Treatment
•Avoid direct sun and use sunscreen •Wear breathable, loose fitting, light coloured clothing •Keep hydrated (drink often, avoid alcohol and caffeinated beverages) •Plan outdoor activites for the cooler parts of the day •Keep your home cool (close windows/blinds for hottest part of the day, avoid using your oven) •Use fans or air conditioning •If your home is too hot, go to a cooler place	•Muscle cramps •Headache •Dizziness and/or fainting •Weakness •Tiredness •Nausea and/or vomiting •Unusual skin colouring •Extreme thrist •Decreased urination with dark yellow colour •Rapid breathing and heart rate •Confusion •Heavy sweating •Lack of sweating	•Move individual to a cool area •Drink/sip cool water •Loosen clothing •Apply cool, wet towl to face, neck, chest, and underarms, or take a cool bath •Spray skin with water while fanning •If conditions do not improve within 15 minutes, or if they worsen, seek medical attention •If heat stroke is suspected, seek medical attention immediatley

It is important to note that heat illness is a blanket term that includes conditions such as heat rash, heat cramps, heat edema (swelling of the hand/feet/ankles), heat exhaustion and heat stroke. Heat stroke, defined when a person’s core temperature reaches 40°C, is a medical emergency.



- Get to a cooler, air conditioned place, and rest
- Drink water if fully conscious
- Take a cool shower or use cold compresses

CALL 911

- Take immediate action to cool the person until help arrives

Adapted with permission from SacramentoReady.org

More information on heat illness can be found at:

https://www.cdc.gov/disasters/extremeheat/warning.html

https://www.canada.ca/en/health-canada/services/sun-safety/extreme-heat-heat-waves.html

https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/extreme-heat-events-guidelines-technical-guide-health-care-workers.html#a2.3

A community monitoring and alerting system for extreme heat events can help warn community members of hot weather days and expected heat waves. This allows individuals to prepare the appropriate preventative measures (modifying activities, monitoring vulnerable individuals, preparing a cool rest area, etc.). Community alerting can be done through multiple avenues including online (Facebook and band websites), local media, and community bulletins.

WWW.THEWEATHERNETWORK.COM/NEWS/ARTICLES/WEATHER-WHIPLASH-SWAPS-HEATWAVE-FOR-COOL-DOWN-IN-THE-WEST/55562

Community cooling centers can offer relief for individuals that are of greater risk to heat illness, or to those who do not have access to air conditioning, electric fans or a cool area in their home. These centers could be equipped with air conditioning, provide access to cool liquids (water, sport drinks, fruit juices) and foods (fruit and vegetables with high water content, ice treats etc.). In addition, trained individuals could be available at these locations to provide any assistance or treatment to heat ill individuals.

Communities may also wish to develop an emergency action plan for extreme heat events.

Asthma, Allergies & Respiratory Diseases

Climate change is expected to have substantial effects on airborne allergens, such as pollen and mould spores, and will impact those with asthma, allergic rhinitis (hay fever) and respiratory diseases [9,14–16].

Warmer temperatures have already resulted in an earlier onset of the pollen season[14]. Warmer temperatures could also mean a longer pollen season, new plants entering the area, and an increase in plant pollen production overall[14,16].

Elevated temperatures can also negatively impact air quality with higher levels of smog and increases in ground level ozone (which irritates the eyes and lungs). A potential increase in wildfire would also impact air quality through high levels of smoke and particulate matter[1].

Increased humidity can raise moisture content indoors and in turn increase the risk of mould growth[14]. Heavy rainfall or rain in winter may lead to flooded homes, which can also increase the risk of mould growth.

Longer and more intense exposure to airborne allergens can:

- lead to more cases of allergies and/or respiratory diseases
- cause existing conditions to become more severe
- lead to higher mortality from asthma and other respiratory diseases [14–16].

Adaptation and Mitigation

Limit contact with allergens

Avoiding or limiting contact with allergens like pollen and mould can help prevent asthma attacks and allergy symptoms. Raise community awareness of the importance of allergen avoidance, especially for those with asthma or other respiratory conditions.

Pollen avoidance measures include:

- Closing windows during pollen season
- Removing shoes and leaving them at entry to buildings
- Washing clothing to remove pollen from fabric
- Avoid drying clothes outside during pollen season
- Avoid being outdoors in the morning or on windy days if possible
- Use medication before exposure
- Rinse nose with salt water many times during the day

To prevent mould growth in your home:

- Remove water or moisture immediately
- Ventilate your home (especially high moisture areas like bathrooms)
- Keep your home warm with good air circulation (cool areas increase condensation and mould growth)
- Remove items that can grow mould (wet or musty smelling items, firewood, carpet in basements, etc.)
- Minimize other indoor moisture sources (leaky roofs/windows, leaky plumbing, drying wet clothing indoors, etc.)
- Prevent water from entering your home (slope ground so rain water/snow melt runs away from homes, etc.)

The Government of Canada offers a First Nation-based report that can be used to inform your community on the on the health risks of mould, identifying mould and how to prevent and/or remove mould from the home. You can find it at https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/fniah-spnia/alt_formats/pdf/promotion/public-publique/home-maison/mould-moisissure-eng.pdf .

Community Monitoring

Communities can monitor when the pollen season begins in their area. This could be done by noting when plants and trees begin to bloom, when pollen starts to collect in lakes or on vehicles, etc. Trends of earlier and longer pollen seasons need to be communicated to community members, especially those with allergic respiratory diseases [14].

Pollen counts or pollen reports are often available alongside weather forecasts in more southern areas of the province. They provide a measurement of the number of grains of pollen per cubic meter of air and can even identify the types of pollen present. In areas where pollen counts are monitored, that information can be shared with the community. More remote communities may want to investigate the possibility of creating a pollen count program for their area.

Practice Wildfire Prevention

It is well known that wildfires negatively impact air quality. Communities may want to take actions to limit the risk of wildfire in their area. Wildfire and wildfire prevention are covered in detail in the *Fire section*.

Adequate Healthcare

Access to appropriate healthcare and medication is extremely important for managing asthma and other allergic respiratory diseases [14,15]. Accessing healthcare in remote communities can be challenging. Communities should continue to push for their healthcare needs to be met.

ATTAWAPISKAT

UV Radiation

The relationship between climate change and the amount of UV-A and UV-B radiation (the component of sunlight that damages skin causing burns) reaching the Earth's surface, is complex.

Adaptation and Mitigation

People should continue to be diligent about sun safety. A UV Index Report can be found alongside many weather reports and can help gauge the risk of sunburn. Remember that UV exposure does not happen only in summer; all seasons pose a risk of sun burn, even winter, where sunlight reflecting from snow can increase your UV exposure.

Sun Safety Guidelines

- Limit time in direct sun
- Cover exposed skin with clothing or sun screen offering broad spectrum UV protection
- Wear a wide brim, breathable hat
- Use sunglass that offer both UV-A and UV-B protection

Mental Health

Severe weather events, evacuations, and other climate related concerns can negatively impact a person's mental health. Extreme weather events, which have to potential to become more common as climate changes, have been shown to lead to mental health disorders associated with loss, social disruption, and displacement[9]. The potential for extreme weather events and uncertainty of the future can lead to emotional stress and increased anxiety[9].

EVACUATION OF FORT HOPE BECAUSE OF A NEARBY FIRE

Adaptation and Mitigation

Minimizing the severity of mental health impacts requires a support system of mental health infrastructure, resources, and services. Mental health services are already lacking in many areas. Communities should continue to push for the resources they need. It is also important to end the stigma surrounding mental health issues. People in need of mental health services may be more willing to seek out or ask for help if the attitude about metal health issues changes.

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Preparing for Health Challenges

Diseases carried by insects and animals (Zoonotic and Vector-borne diseases)

- Limit your chance of infection – prevent insect bites, remove insect habitat, etc.
- Be aware of diseases and their symptoms.
- Monitor for new species.

Waterborne and foodborne illness and nutrition

- Prevent food spoilage and foodborne illness through safe food handling, storage and cooking.
- Advocate for safe drinking water.

Heat Illness

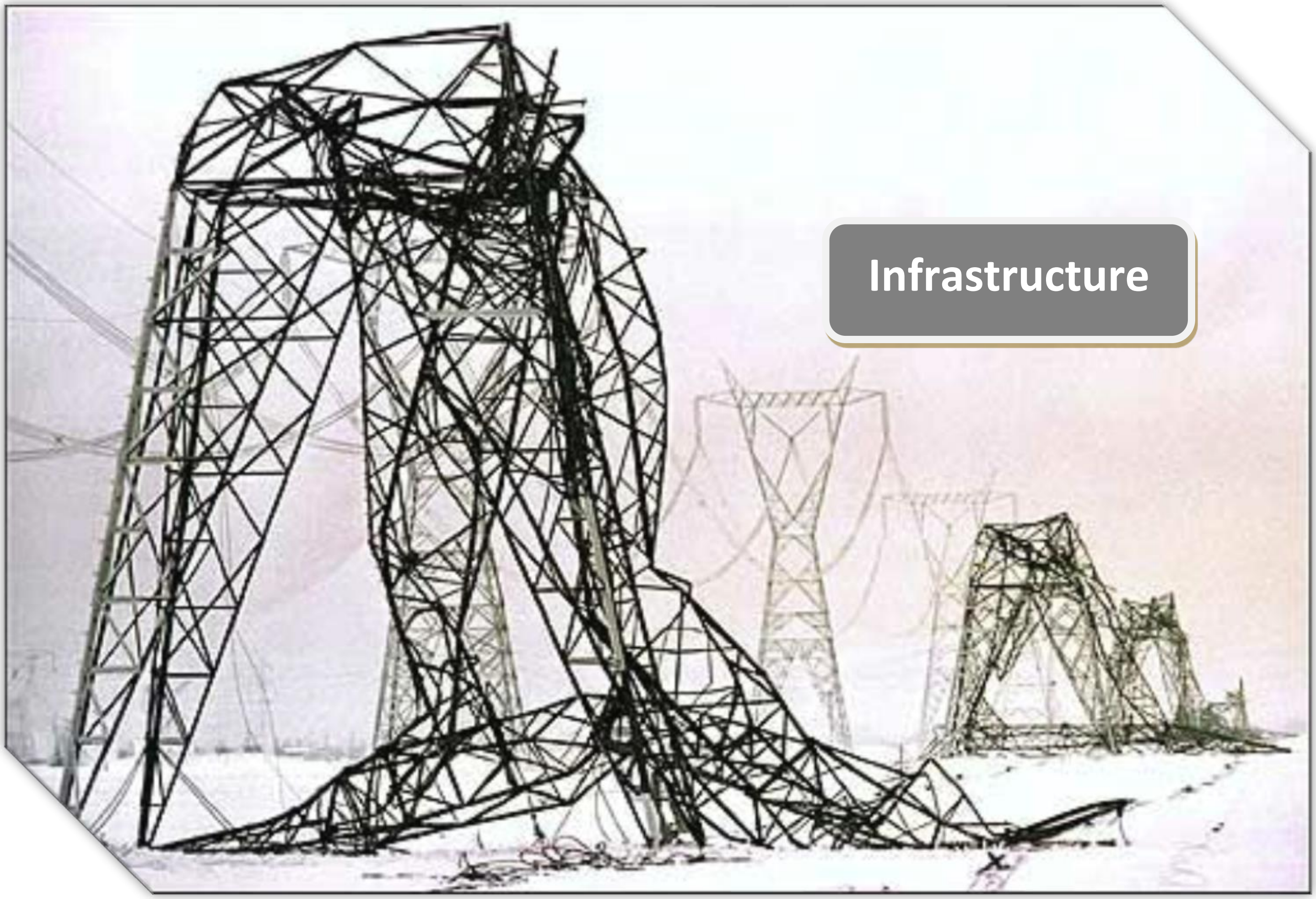
- Increase awareness of heat illnesses, ways to prevent them, and their treatment.
- Community initiatives include alerts for extreme heat events, cooling centers, and an emergency action plan.

Asthma, allergens and respiratory diseases

- Limit contact with allergens like pollen and mould.
- Community monitoring of pollen counts, air quality.
- Wildfire prevention.
- Adequate healthcare.

Other

- Protect against UV exposure.
- Advocate for required mental health services.



Infrastructure

QUEBEC ICE STORM

Extreme weather events including fire, rain, freezing rain, wind, and snow will put infrastructure to the test. Many of the adaptation options will need to be carried out through changes in policy at a government level. However, individuals and communities may need to identify the risks most applicable to their home and town. Communities may wish to undergo an infrastructure vulnerability assessment to examine the level of risk to the community which can be done through a qualified engineering consultant. Homes and buildings may require retrofitting. Roads may require more frequent maintenance and improved drainage infrastructure. The embankments of communities along rivers may be vulnerable to permafrost decay or erosion and should be assessed. In addition, water and wastewater treatment facilities may be at risk.

Homes and buildings

Homes in different areas of the country will face different challenges. Communities in Ontario facing permafrost decay or risks of wildfire, may need serious retrofitting to meet building standards. Severe snowfalls and freezing rain can overload the weight bearing capacity of a roof if the building design did not consider these extreme events and the snow is not cleared. With extreme rainfall and rapid spring melt, homes are more commonly flooded. Backwater valves are now installed on sewer lines to reduce the risk of sewage backup into homes during extreme rainfalls.

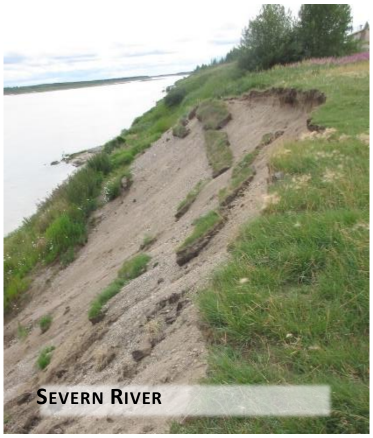
HTTPS://GLOBALNEWS.CA/NEWS/4118746/OKOTOKS-EQUESTRIAN-FACILITY-ROOF-COLLAPSE/

The Energy sector

Changes in climate may affect all energy sectors in Ontario as well as the aging or under-designed transmission infrastructure. Communities may benefit from assessing their hydro infrastructure and should plan for more frequent power disruptions due to extreme weather. This might include a community refuge center that is set up to run a generator and can house and feed people in the event of a prolonged power outage.

PHOTO FROM HTTPS://WWW.NORTHERNONTARIOBUSINESS.COM/ADVERTISING-FEATURES/TOP-5-PROJECTS-WATAY-POWER-NORTHWESTERN-ONTARIO-464610

Community roads and embankments



SEVERN RIVER

Changing precipitation and warmer winters are damaging to community roads, resulting in more potholes and washouts. Mid-winter warm spells are now more common and contribute to road damage. In areas with permafrost, roads and embankments are likely to be highly affected over the next 30 years. Embankment failure, especially where infrastructure is established, may pose a major risk to communities and human safety.

Drinking water and wastewater

ATTAWAPISKAT WATER TREATMENT PLANT

Drinking water quality will likely be impacted by climate change in a number of ways [1]. In lakes, warmer waters are resulting in less stratification and changes to oxygen solubility. Changes in precipitation, in particular severe rain events, may lead to erosion, increased sedimentation, or other inputs, like toxins and nutrients, carried by increased run-off. The combination of these changes may result in increased algal blooms and the presence of other organisms or bacteria in the water, further stressing water treatment infrastructure. Many First Nation communities are already under drinking water advisories due to inadequate infrastructure. It is, therefore, critical to consider how climate change will further impact drinking water quality in order to plan accordingly for water treatment infrastructure updates.

Adaptation and Mitigation

Many of the adaptation options for infrastructure impacts will require professional assessments and modifications to building codes and policy. Ontario is currently working to update their building codes to ensure that new homes are built to be more resilient to extreme weather and future climate conditions[2]. Communities may consider new construction standards, methods, and materials. Many online resources are also available to communities.

Preparing for the Future

Useful Resources

Northern Infrastructure Standardization Initiative: www.scc.ca/en/nisi

Ontario Center for Climate Impacts and Adaptation Resources: www.climateontario.ca/ www.climateontario.ca/APP.php

Institute for catastrophic loss reduction: www.iclr.org/citiesadaptrain.html

Building Better: Setting up the Next Ontario Long-Term Infrastructure Plan for Success: www.occ.ca/wp-content/uploads/Building-Better-Aug-23-1.pdf

Predicting frequency of severe storms with IDF (Intensity-Duration-Frequency) curves (www.idf-cc-uwo.ca/).

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Preparing for risks to infrastructure

Homes and buildings

- Many of the adaptation options will require professional assessments and modifications to building codes and policy.
- Communities may consider new construction standards, methods, and materials.
- Ontario is working to update building codes for increased resilience to extreme weather and future climate.

Energy

- Communities may benefit from assessing their hydro infrastructure.
- Plan for more frequent power disruptions. This might include a community refuge center for prolonged power outages.

Roads and Embankments

- www.scc.ca/en/nisi can provide information on vulnerability assessment and adaptation.

Drinking water and waste water

- Consider how climate change will further impact drinking water quality and plan accordingly for water treatment infrastructure updates.
- Consider how extreme precipitation events will impact wastewater lagoons and sewage treatment plants.

Transportation

Sandy Lake

Transportation for First Nation communities means more than travelling on the road or by air. First Nation traditional routes include travel over land and water in all seasons. Rivers and lakes provide transportation corridors as do traditional routes on the land. The ability to travel on the land and between communities is integral to First Nations' cultural practices. In remote communities, winter roads connect northern First Nations to each other and to urban centres, allowing goods to be transported to the community at half the cost of flying and allows people to visit with family and friends and to access special services outside their own community. These routes may become vulnerable due to climate change and in fact, some routes have already been impacted.

Traditional routes over water and land

During the summer months, increased frequency and duration of droughts may decrease water levels so much that people cannot navigate rivers or streams. On the other hand, extreme rainfall and/or wind may contribute to unanticipated and dangerous weather conditions if traveling by boat. Warmer temperatures in spring and fall are changing freeze-up and break-up dates to such an extent that historical timing may no longer be relevant, and incidents of breakthrough are a risk to human safety. It is estimated that for every 1°C increase in mean surface air temperature, the duration of ice cover on Ontario freshwater lakes decreases by approximately 11 days and the maximum ice thickness is reduced by 7cm [1]. In reality, changes in temperature are even more pronounced in some regions and can vary year to year [2].

Adaptation and Mitigation

Monitoring and community alerting systems


Ground penetrating radar system. www.shallowearthtechnologies.com

Ice thickness monitoring on traditional routes can increase the safety of community members. In some towns, a community person is delegated or hired to check ice thickness regularly on commonly used travel ways or waterbodies. Commonly, an axe or an auger is used to measure ice depth, but some places have invested in ground-penetrating radar systems, as pictured at the right. This technology can also be used for winter road building. Sharing information about ice is vital and would include information about unsafe areas, where the ice may not be as thick. Social media sharing, such as Facebook or community websites, may serve as information platforms to inform community members. For example, Lake Simcoe has a Facebook page that reports ice conditions and fish reports to interested community members.

Lake Simcoe Region Ice Conditions
March 24 at 5:37pm · East Gwillimbury ·

March 24 th 2018
Beaverton
Still finding 20 inches off 8th line
The river has opened up the lake at the mouth a little.
The shoreline looks ok for now but I suspect the warming trend may mark an end to the shoreline.
Snow patches to setup on but slippery ice where it's bare.

Equipment modifications

In some regions, people have already needed to change the snowmobiles they drive to lighter weight machines for safer ice travel. In communities along rivers or for people that rely on water navigation in the summer, some traditional routes are no longer accessible during parts of the summer season. Simple equipment modifications can involve adding a bracket that allows you to quickly pivot the motor out of the water as the driver approaches shallow waters. More costly equipment modifications could include: new motors such as a jet motor that does not use a propeller or a mud motor as pictured.


Common outboard motor is replaced by a jet motor to navigate better in shallow water and reduce damage

Infrastructure changes

Permanent roads or river crossings may be considered to improve access to traditional areas. For instance, where the river waters are shallow near a community, the construction of a permanent road can be considered to improve access. This would give residents the option of driving to their boats that are shored further downstream to avoid the shallowest waters.

Emergency planning and preparedness

Emergency planning for safe travel is always a good idea, but especially with the unpredictable and changing weather. Checking weather forecasts before a trip can help an individual to plan the best travel time and allow them to better be prepared for possible adverse weather. Telling a reliable community member where you are going and when you expect to return so that someone can come looking for you if you don't return. Safety equipment and supplies as well as food and water should always be a part of a packing list (e.g. satellite phone, extra food, pocket knife, fire starter, first aid kit, extra medication, water container and purifier, and warm clothing). Emergency planning information and a complete packing list should be available to community members either as a poster or on a community website. www.adventure16.com/info/checklists provides a useful starting point for packing and planning in different seasons.

QUADS ARE AND IDEAL WAY TO TRAVEL ON THE TUNDRA NEAR FORT SEVERN

Transport by all-weather road, air or rail

Air transportation may also be affected by the changing weather. More frequent winter rain can delay flights and create unsafe flying and runway conditions [3]. Rail transportation is vulnerable to severe heat in more central parts of Ontario as it could cause rails to buckle. For roads, severe rain events could lead to washouts and permafrost decay, as well as an increase in freeze-thaw cycles, which may lead to embankment failures.

Plane crash in freezing rain near St. Marys, Alaska, Four people were killed and several injured. www.youtube.com/watch?v=zyrzXfvQq1c

Adaptation and Mitigation

Emergency preparedness

All-weather roads, runways and railways should be considered as important means of evacuation in case of emergency. Plans should be in place for alternate routes especially where there is only one way in or out of a community.

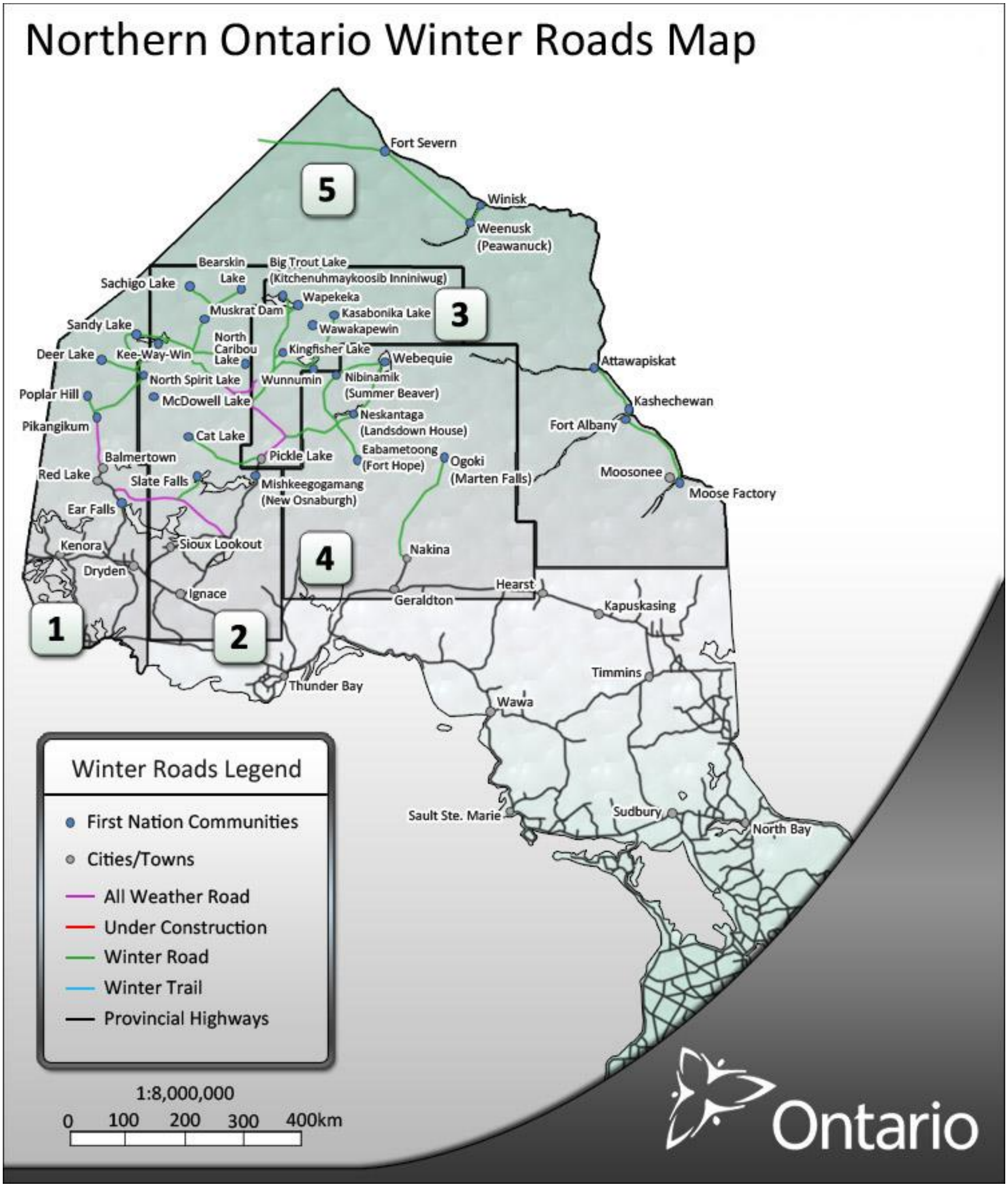
Innovative materials and maintenance

Materials that tackle or endure freezing rain and extreme heat have been developed for many sectors. For air transport, de-icing materials are more commonly used and may be made from salt, sand, or glycol solutions. De-icing materials can be applied to run-ways and aircrafts. As a result of an increase in severe rainfall events and freeze-thaw conditions, more maintenance could be required to repair runways. Stockpiling material such as gravel is a good strategy to prepare for weather damage to runways. In the railway sector, coatings that reduce solar absorption are applied to rails in sunny locations. More regular maintenance may be required of railway corridors to ensure they are not damaged and are structurally stable.

Road washout, Anderson Dyke, Fort Albany, Photo from Fort Albany Flood Watch Facebook page

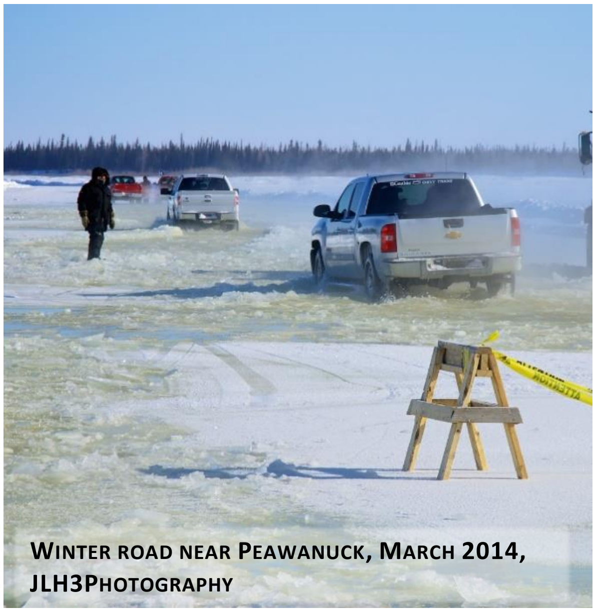
Winter roads

In the far north of Ontario, winter roads connect 31 First Nation communities to an all-season road system further south or west [4]. The winter road season in the far north typically runs about 3 months, from January to March, and makes up a total of 3,160 kilometers.



Warmer winters are likely to shorten winter road seasons and create thinner ice conditions, changing the load bearing capacity of the ice and affecting material transportation into communities. Many changes to winter roads can be expected due to the changing weather and climate.

- Weaker, thinner ice [5]
- Delays in winter road opening dates [6]
- Reduction in winter road quality [6]
- More slush [5]
- Melting of underlying permafrost [5]
- The roads sometimes have air pockets and earth patches [6]
- The muskeg no longer freezes well [6]
- The rivers freezes later or not completely, river ice melts faster and break-ups are earlier [6]



Winter road near Peawanuck, March 2014, JLH3Photography

Increased precipitation in the winter months, the timing of the snowfall, and whether it comes as rain or snow, may have unpredictable impacts on travel. For instance, a study in Alaska found winter roads opened later if large amounts of snow fell early (October) because the snow prevents the ground from freezing. [2]. In contrast, if snow only comes in November, the winter road will open earlier.

Winter road construction typically begins in December, after the first snowfall [6]. Practices differ for winter road construction over land, water, and the transition between land and water. On the land, a compact layer of snow (about 10cm) protects vegetation below the road, provides traction, and increases surface albedo to help prevent heating from the sun [2]. Over water, a compact layer of snow is also used to improve traction and reduce solar degradation of the ice[2]. After 30 to 60cm of snow has accumulated, snowmobiles are used to pack down the snow along the road corridor. This reduces the insulating effect of the snow and allows the frost to penetrate the ground. Once the ice is 15-25cm thick in the muskeg, heavier vehicles can begin to maintain the road by removing excess snow, and then bulldozers can continue compacting the road by dragging tires or heavy materials across the surface[7,8]. Often roads are flooded to form ice and strengthen the road.

Winter road connecting KI and Wapekeka

Tractor dragging a tire to compact the winter road during construction.

In the transitional zone between land and waterbodies, snow is piled in place and flooded overnight. This process is repeated until the desired shape and strength is achieved[8].

Breakthrough on Deline winter road: www.cbc.ca

Winter roads over waterbodies such as rivers or lakes are also referred to as ice roads. The consequence of inadequate construction or poor ice development over a waterbody is much more severe than poor construction over land.

Ice roads over river ways should be at least 30-60m wide and over lakes or larger waterbodies at least 60m wide [8]. Packed snow covers are often maintained over water because their high albedo (ability to reflect sunlight) reduces thermal degradation of the ice. The required thickness of the ice depends on the weight of the vehicles using the road. Gold's formula forms the basis of most guidelines on ice road construction in Canada [9,10].

Adaptation and Mitigation

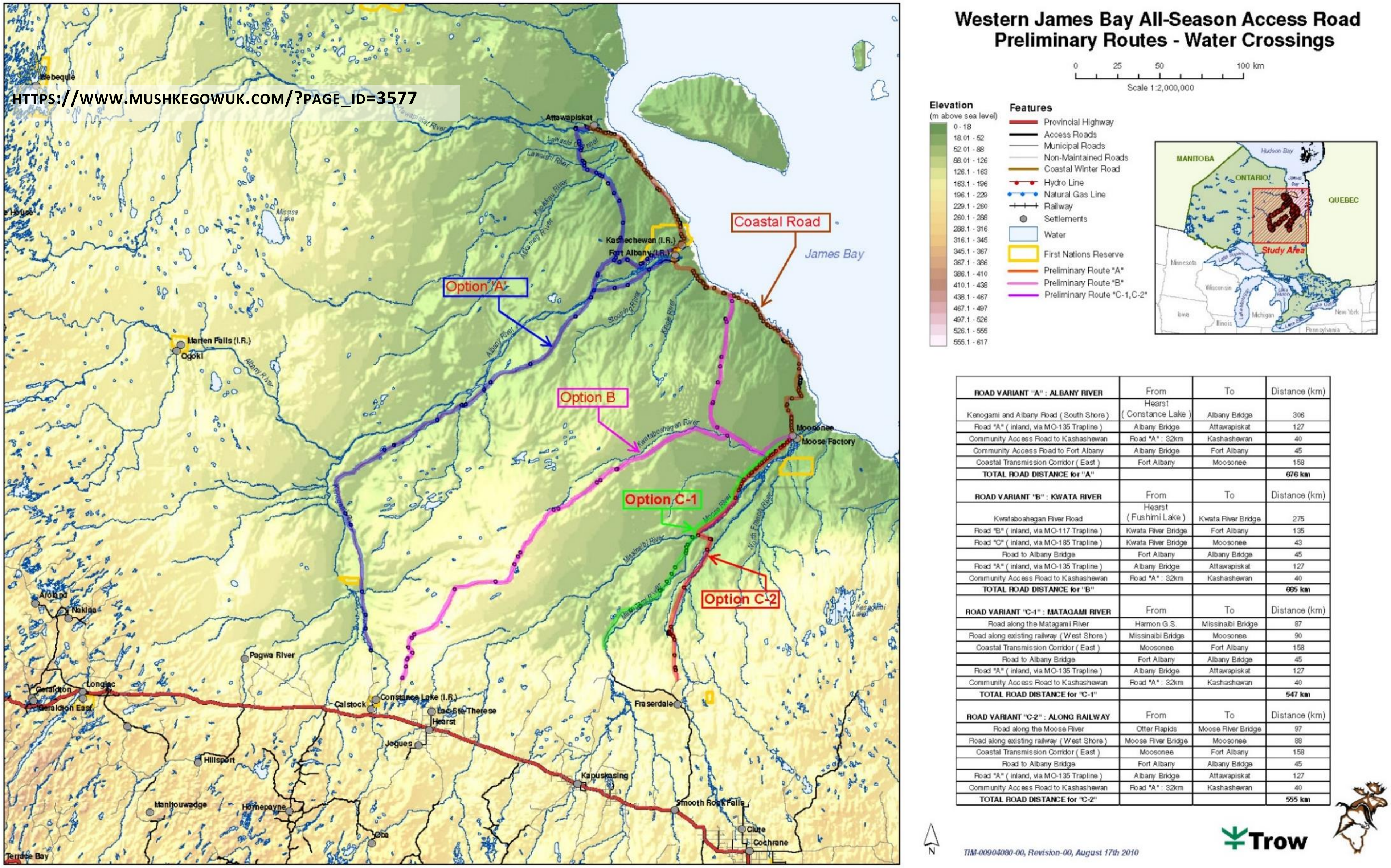
Infrastructure improvements

There are several infrastructure adaptations options to improve winter road travel. Many of the adaptation options are quite costly, ranging in price from several thousand to several million. Improving winter road construction techniques is perhaps one of the least costly options but is still highly dependent on weather conditions. Flooding roads is a common practice to increase the thickness of the ice road. However, depending on the method used to apply the water, the quality of the ice can vary [10]. For an ice road 45 to 60m wide, when the daily temperature mean is -18˚C, approximately 5cm of ice can be added overnight[2]. At -31˚C or lower, 9cm of ice can freeze overnight[2]. Stockpiling snow at crossings can also improve the timing of winter road opening dates.

Rerouting or realigning winter road corridors is another option. For example, Matawa communities underwent consultation to determine possible realignment options for their winter roads [11]. This work requires extensive consultation and assessments of landscape cover, topography, important habitats, land claims, etc. Generally, this option would involve moving existing routes away from major water crossings to uplands such as eskers or beach ridges and reducing the number or size of water crossings.

Finally, all-season road construction is being considered by some northern Ontario communities. This option can begin with permanent crossings over waterbodies, which tend to be the most vulnerable areas of winter roads, especially in a rapidly changing climate. The cost of this infrastructure is very high and cost benefit analyses should be undertaken before considering such an adaptation plan.

PERMANENT CROSSING OVER CREEK: GOVERNMENT OF NWT.



HTTPS://WWW.MUSHKEGOWUK.COM/?PAGE_ID=3577

Western James Bay All-Season Access Road
Preliminary Routes - Water Crossings

ROAD VARIANT "A" : ALBANY RIVER	From	To	Distance (km)
Kenogami and Albany Road (South Shore)	Hearst (Constance Lake)	Albany Bridge	306
Road "A" (inland, via MO-135 Trapline)	Albany Bridge	Attawapiskat	127
Community Access Road to Kashashewan	Road "A" : 32km	Kashashewan	40
Community Access Road to Fort Albany	Albany Bridge	Fort Albany	45
Coastal Transmission Corridor (East)	Fort Albany	Moosonee	158
TOTAL ROAD DISTANCE for "A"			**676 km**
ROAD VARIANT "B" : KWATA RIVER	From	To	Distance (km)
Kwataboahegan River Road	Hearst (Fushimi Lake)	Kwata River Bridge	275
Road "B" (inland, via MO-117 Trapline)	Kwata River Bridge	Fort Albany	135
Road "C" (inland, via MO-185 Trapline)	Kwata River Bridge	Moosonee	43
Road to Albany Bridge	Fort Albany	Albany Bridge	45
Road "A" (inland, via MO-135 Trapline)	Albany Bridge	Attawapiskat	127
Community Access Road to Kashashewan	Road "A" : 32km	Kashashewan	40
TOTAL ROAD DISTANCE for "B"			**665 km**
ROAD VARIANT "C-1" : MATAGAMI RIVER	From	To	Distance (km)
Road along the Matagami River	Harmon G.S.	Missinaibi Bridge	87
Road along existing railway (West Shore)	Missinaibi Bridge	Moosonee	90
Coastal Transmission Corridor (East)	Moosonee	Fort Albany	158
Road to Albany Bridge	Fort Albany	Albany Bridge	45
Road "A" (inland, via MO-135 Trapline)	Albany Bridge	Attawapiskat	127
Community Access Road to Kashashewan	Road "A" : 32km	Kashashewan	40
TOTAL ROAD DISTANCE for "C-1"			**547 km**
ROAD VARIANT "C-2" : ALONG RAILWAY	From	To	Distance (km)
Road along the Moose River	Otter Rapids	Moose River Bridge	97
Road along existing railway (West Shore)	Moose River Bridge	Moosonee	88
Coastal Transmission Corridor (East)	Moosonee	Fort Albany	158
Road to Albany Bridge	Fort Albany	Albany Bridge	45
Road "A" (inland, via MO-135 Trapline)	Albany Bridge	Attawapiskat	127
Community Access Road to Kashashewan	Road "A" : 32km	Kashashewan	40
TOTAL ROAD DISTANCE for "C-2"			**555 km**

TIM-00904080-00, Revision-00, August 17th 2010

Education and community alerting systems

Proper use of the winter road, especially over water crossings, will impact the integrity and safety of winter ice roads. The flexibility of the floating ice influences how fast vehicles can move on the ice and how far apart they should travel [10]. Vehicles (especially heavy-weight) should not park or remain stationary on water crossings as they fracture the ice, reducing its strength and integrity. In addition, speed limits are important to obey, especially over waterbodies. Vehicles travelling on ice generate waves in the ice. Below the critical speed, the ice will depress and flex with the movement of the vehicle; above the critical speed, secondary or dynamic waves are caused and can stress the ice, decreasing ice integrity and increasing the risk of travel over the ice covers [10]. If the vehicle is travelling too fast, the stress on the ice increases and can lead to extensive cracking, and blowouts may even break through the ice.

The speed vehicles can travel on ice depends on the depth of the water below, the thickness of the ice, the length of the crossing, and hazards [10]. For example, with 1m of ice and 15m of water, the critical speed is 50km/hr, and the best practice is to set the speed limit to half the critical speed, thus 25km/hr. In shallower waters, the speed limits should be reduced. If vehicles are passing each other on the winter road, they should reduce their speeds to 10km/hr. To enforce these best practices, residents need to be aware of them. A combination of signs and Facebook posts may help engage residents and transport drivers so they can follow best practices.

A slow-moving vehicle causes the ice to bend and forms a deflection bowl under the vehicle

A fast-moving vehicle causes the ice to bend and creates dynamic waves in the ice ahead and behind the vehicle

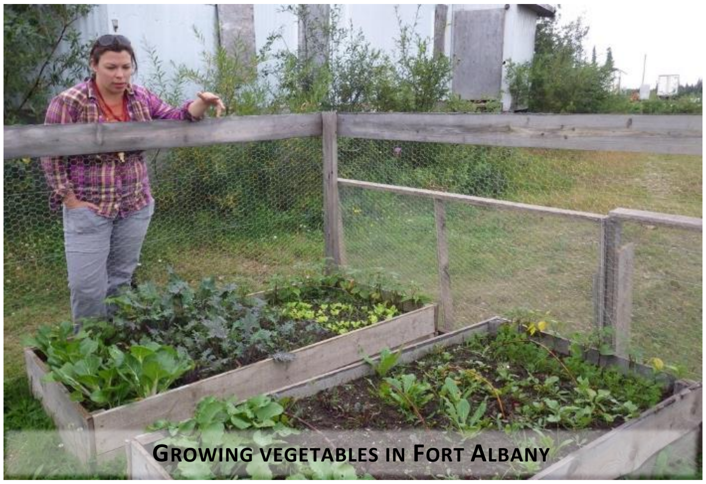
Taken from Best Practices for Building and Working Safely on Ice Covers in Ontario [10].

Reduce dependency on outside supplies

Fuel, food, and building supplies are some of the major goods transported on the winter road. However, by investing in green energy technologies and beginning local food production, communities can reduce some of their dependency on the winter road and season length.

Solar farm under construction in Fort Severn

Greenhouse in Sandy Lake, ON



Growing vegetables in Fort Albany

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Preparing for changes in transportation

Routes over land and water

- Monitor ice thickness and share information with community members.
- Modify equipment – lighter snow machines, modifying/replacing outboard motors.
- Consider building permanent roads or crossings if traditional routes are no longer safe/possible.
- Plan for safe travel – consider best times/weather for travel, bring supplies in case of emergency, inform someone of your travel plans.

All-weather road, Air and Rail Transport

- Consider alternate material made for freezing rain or extreme heat.
- De-icing for planes and runways.
- Be prepared to repair runways as needed.
- Increase the frequency of regular maintenance.

Winter Roads

- Improve construction techniques.
- Reroute/realign winter road corridors (generally to decrease water crossings).
- All season road construction may be considered by some communities.
- Promote proper use of winter roads – obeying speed limits, distance requirements, etc.
- Decrease dependence on outside supplies.

Preparing Youth

Today's students will be the future leaders of First Nation communities. Some will be in careers as environmental monitors; some as teachers; some in skilled jobs in the developing resource sector and some as community leaders. An early start is critical in igniting the sparks that leads to life-long love of the land and of science.

Communities may which to organize group hunting and gathering trips for youth and /or connect youth with Elders to learn traditional ways and to discuss how things have changed in their lifetime.

Scientists should engage youth when visiting a community with activities related to their research. Laurentian University's Up North On Climate group engages youth with hands-on activities related to Climate Change and the environment.

See more pictures on FACEBOOK:: Science Rocks the North
https://www.facebook.com/LWLYSOP/?ref=hl

Appendix: Traditional Ecological Knowledge

Interview results would appear here in a community report