UP NORTH ON CLIMATE

Climate Change Impact and Adaptation Study for the North of Ontario

CLIMATE CHANGE IMPACT & ADAPTATION INFOSHEETS

These Impact and Adaptation Infosheets were created by Up North on Climate (Laurentian University) in collaboration with

Prepared by:

Kim Fram, Cassidy McAuliffe, Chantal Sarrazin-Delay, and David Pearson (Laurentian University)

Thanks to:

Geneva Kejick (Grand Council Treaty #3), Chris Koostachin (Keewaytinook Okimakanak), Roxanne Metlin (Mushkegowuk Council), Cristina Ross (Matawa First Nations Management), Erica Tropea (Nokiiwin Tribal Council), Vivian Waswa (Shibogama First Nations Council), Barb Duffin (Mushkegowuk Council), Sarah Cockerton and Kim Jorgenson (Matawa First Nations Management), Dan Duckert and predecessor Donald Meekis (Keewaytinook Okimakanak), Lucas King (Grand Council Treaty #3), Roger Rozon and predecessor Tara Ingram (Nokiiwin Tribal Council), and Laura Sayers (Shibogama First Nations Council)

Developed with financial support from Natural Resources Canada's Building Regional Adaptation Capacity and Expertise (BRACE) Program as part of the co-lead project Building Climate Change Adaptation Capacity of First Nations in Far Northern Ontario Through Knowledge-Exchange and Collaboration.

INTRODUCTION

Climate change is a reality. Human-caused greenhouse gas emissions are pushing the Earth's climate toward a warmer world at a faster rate than ever before, with temperatures in the north rising at twice the rate of other regions. In northern Ontario, climate change will bring warmer temperatures, changes in rain and snow, and more storms, many of which will be intense. But the impacts of climate change don't stop with the weather. Forests and plants, lakes and rivers, animals, people, and communities are all affected by climate change. For First Nation communities, close traditional ties to the land can make these changes even more challenging.

Reflecting the impacts being seen and felt in northern Ontario First Nation communities, these 2-page information sheets (called "Infosheets") were designed to help build capacity and knowledge about climate change, its continued impacts on the land, and the possible ways people and communities can adapt and prepare. Infosheets are divided into themes with each infosheet covering a particular topic. Explore themes and topics with the list below.

CLIMATE CHANGE

- The Greenhouse Effect
- Global Warming and Climate Change
- Weather and Climate
- Climate Change and Carbon Dioxide
- Ice Cores and Milankovitch Cycles
- Climate Modelling
- Melting Ice
- Rising Sea Level and the Hudson Bay Coast
- Extreme Weather Events

DROUGHT

- Low Water
- Drinking Water
- Dry and Dusty Land
- Harvesting with More Dry Spells
- Drought Monitoring

ECOSYSTEMS

- Peatlands and Permafrost
- Forests of Northern Ontario
- Protecting our Dorests
- Climate Change and Invasive Species
- Aquatic Environments
- Protecting our Water
- Warming Water and Cold-water Fish

FLOODING

- Localized Flooding
- Ice Jams
- Major Flooding from Lakes and Rivers

FOOD SECURITY

- Geese, Duck and Grouse
- Shifting North: Berries and Plants
- Shifting North: Caribou, Moose and Deer
- Harvesting Fish

HEALTH

- Mental Health and Well-being
- Diseases Carried by Insects and Animals
- Blacklegged Ticks and Lyme Disease
- Airborne Allergens
- Extreme Heat
- Contaminated Drinking Water
- Foodborne Illness

INFRASTRUCTURE

- Winter Power Outages
- Water and Wastewater Systems
- Community Roads

TRANSPORTATION

- Changing Ice
- Reducing Dependence on Winter Roads
- Winter Road Construction
- Summer Travel over Water and Land

WILDFIRE

- Wildfire: Natural but Risky
- Protecting Infrastructure
- Wildfire and People

Climate Change

Capturing the Sun's energy in the atmosphere:

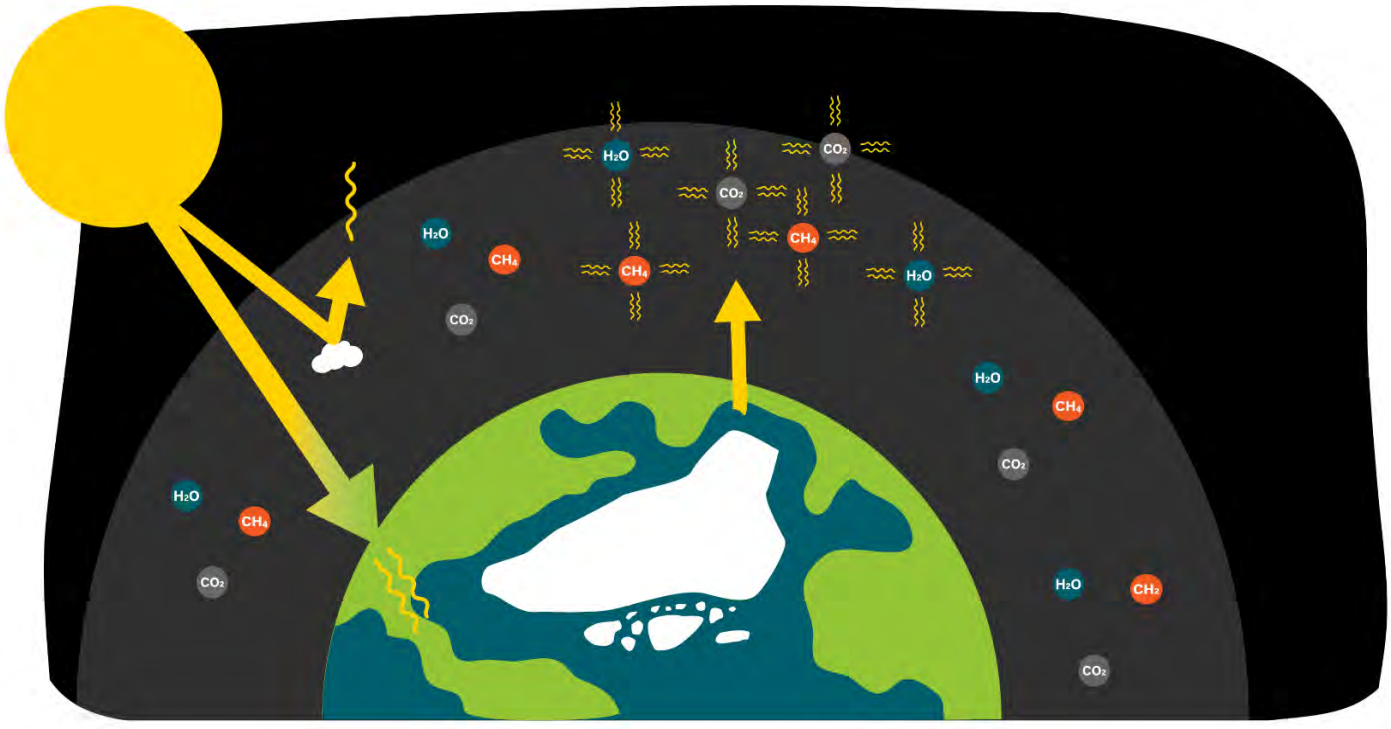
Earth's natural "greenhouse effect"

Earth's temperature begins with the Sun. Roughly a third of the 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, 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 what we call "greenhouse gases" such as carbon dioxide (CO_2) and methane (CH_4), and also by water vapour (H_2O). Greenhouse gases get that name because they keep the Earth warm, 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".

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.

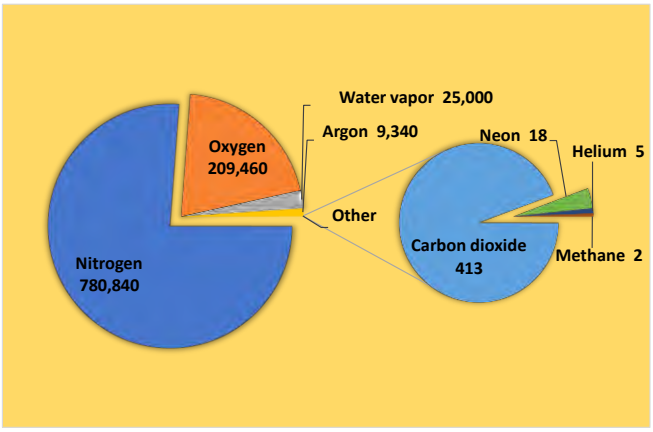


Why do greenhouse gases hold onto heat?

Although we can't see the atmosphere in front of us, we know that it contains gases. All gases and all materials around us are composed of atoms like oxygen (O), hydrogen (H) and carbon (C). Atoms combine to create complex arrangements called molecules, like water (H_2O) where 2 hydrogen atoms combine to 1 oxygen atom.

Earth's atmosphere contains gases like the oxygen (O_2) we breathe, and the carbon dioxide (CO_2) and nitrogen (N_2) that plants need.

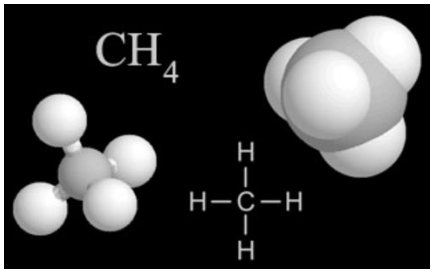
Some gases are considered greenhouse gases like carbon dioxide (CO_2), methane (CH_4) and water vapour (H_2O). Greenhouse gas molecules have more than 2 atoms bonded together. When infrared radiation (heat) from the ground hits them, the bonds begin to vibrate allowing them to hold on to the heat energy. Eventually the bonds stop vibrating and the molecule slowly releases the heat. The more bonds there are, the more a molecule can retain heat. A small molecule like oxygen (O_2) only has 1 bond so it does not retain much heat. Methane (CH_4) has 4 bonds and can retain 30 times more heat than carbon dioxide (CO_2) with only 2 bonds. Although CH_4 and CO_2 are both considered greenhouse gases for their ability to retain heat, there is more CO_2 in the atmosphere and so this molecule tends to be a bigger driver of the greenhouse effect. See animation of the vibrations here: https://www.chemtube3d.com/vibrationsco2/



Quantities of the most common gases in the atmosphere in parts per million. 1 part per million is like one wolf in a herd of one million caribou. Trace gases not shown. *Data from Haynes, H. M., ed. (2016–2017), CRC Handbook of Chemistry and Physics (97th ed.), CRC Press*

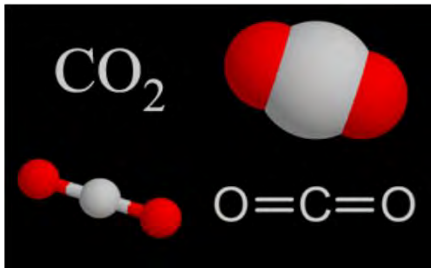
Know your greenhouse gases

Methane (CH_4), Carbon Dioxide (CO_2), Chlorofluorcarbons (CFCs), Hydrofluorocarbons (HCFCs), Water Vapour (H_2O), Nitrous Oxide (N_2O) and Ozone (O_3) are greenhouse gases. *https://scied.ucar.edu/carbon-dioxide*



Methane

- *Flammable and used as fuel known as natural gas*
- *Burning methane releases CO_2 and water*
- *Potent heat absorber (30X more than CO_2)*
- *Rise of 150% since 1750 because of human activity*
- *Natural sources: wetlands, oceans, termites*
- *Human sources: rice, landfills, cattle, energy*



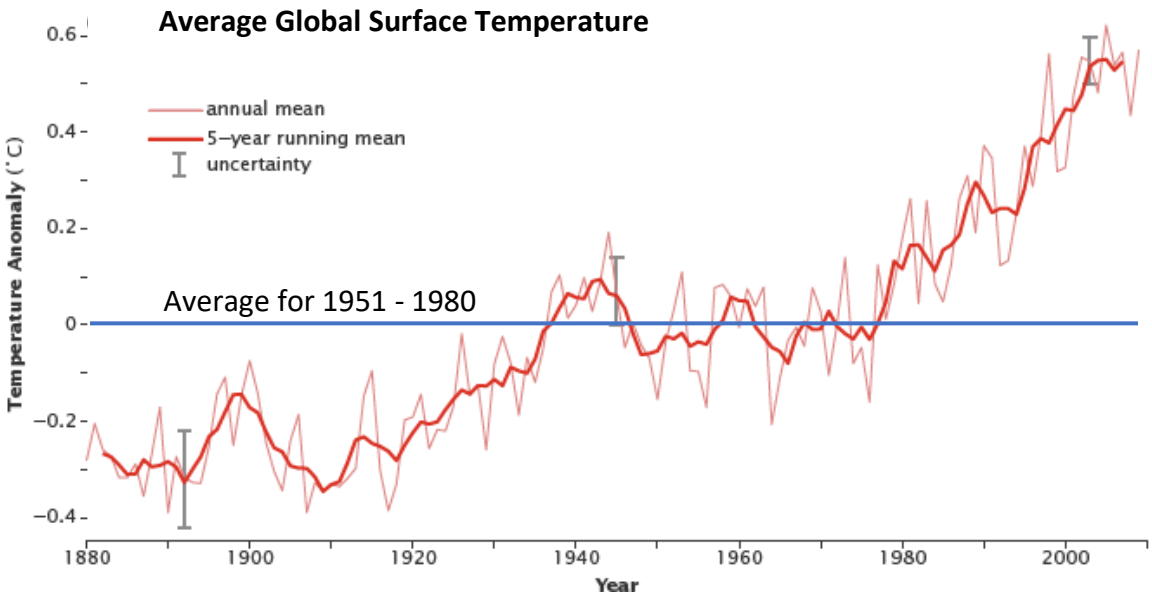
Carbon dioxide

- *Non-flammable gas, the fizz in your drink*
- *Heat absorber and an important driver of Earth's temperature*
- *Rise of 40% since 1750 because of human activity*
- *Natural sources: volcanos, wildfire, respiration*
- *Human sources: food, energy, transportation*

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

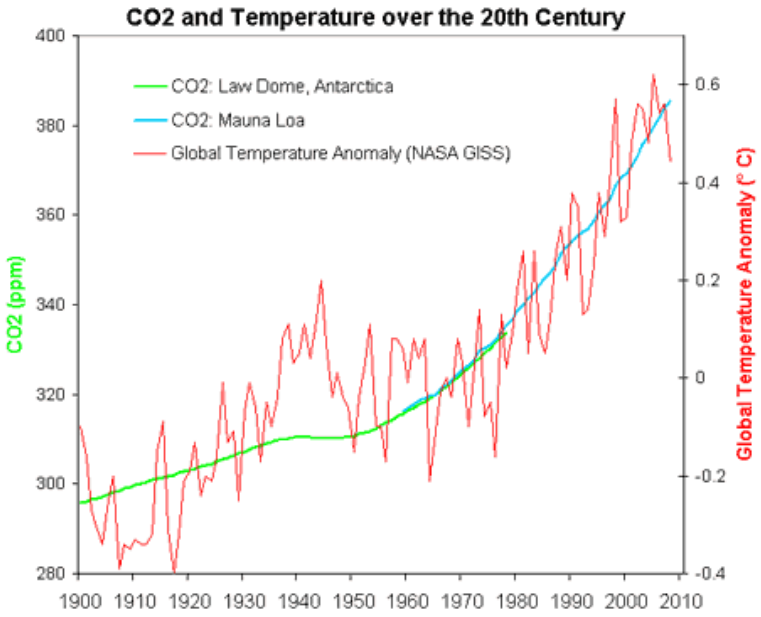
Global Warming and Climate Change

The greenhouse effect allows Earth to be a comfortable average temperature of 15°C. However, over the past 260 years the temperature of the Earth has been rising at an extremely unusual rate. Despite ups and downs from year to year, there is a clear pattern of increasing temperatures. By 2001, Earth's temperature was roughly 0.5 degrees Celsius above the average for 1951–1980.



This graph shows the difference of the average global annual temperature (the pink line) from the 1951-1980 average (the blue line) as well as the the running 5-year average. There is a clear increase in temperature since the 1050s-80s. NASA figure adapted from Goddard Institute for Space Studies Surface Temperature Analysis

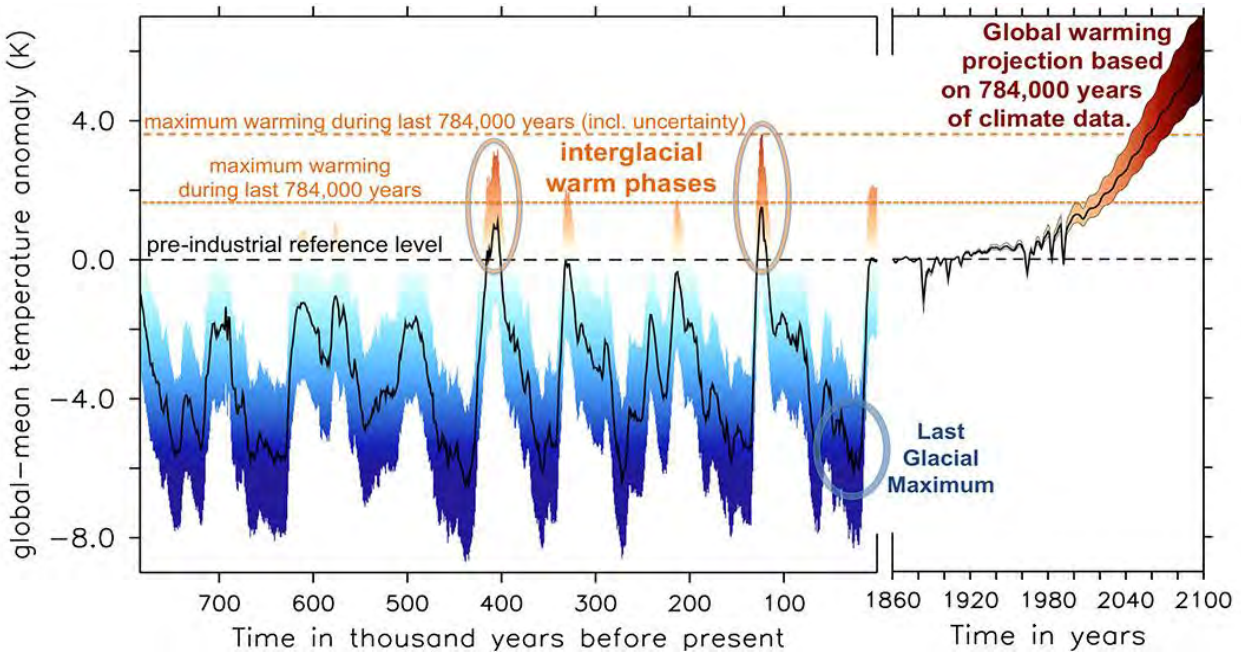
This increase in temperature coincides with the human-caused increase in greenhouse gas in the atmosphere, mostly through carbon dioxide (CO_2) in pollution released into the air from industries burning oil, natural gas, and coal, and from vehicles. Increasing atmospheric CO_2 concentrations cause an imbalance in the Earth's heat budget: more heat is retained than expelled, which in turn generates global surface warming. 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%.



This graph shows how the rise in global temperature (the red line) follows closely with the rise in atmospheric CO_2 (the blue and green lines). https://skepticalscience.com/The-CO2-Temperature-correlation-over-the-20th-Century.html

Global Warming

By looking at data from marine sediment cores, ice cores, and computer simulations covering the last eight glacial cycles, we know that in the past, it would take over 1,500 years for an increase of 1°C; we have now seen this rise happen in only 100 years. 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. Never in the last 784,000 years has there been an increase in temperature that happened so quickly.



This graph shows the difference of the global temperature from before the industrial revolution (1850-1900) reconstructed from information in marine sediment cores, ice cores, and computer simulations covering the last eight glacial cycles. It also shows the Global warming projection to 2100 based on newly calculated paleoclimate sensitivity. https://phys.org/news/2016-11-climate-sensitive-atmospheric-co2.html

Climate Change

Climate Change is the phrase used to describe the changes that we are experiencing here on Earth because of global warming. The increase in temperature is leading to a variety of changes in Earth's climate like more extreme weather, more storms, more winter rain, and changes in the length of seasons. These changes are impacting a variety of Earth's systems and the people that rely on them. We are already observing more intense fires, more flooding, changes on the land, impacts on animals and plants, and periods of drought. Human health, food security, infrastructure and transportation are also being affected.

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

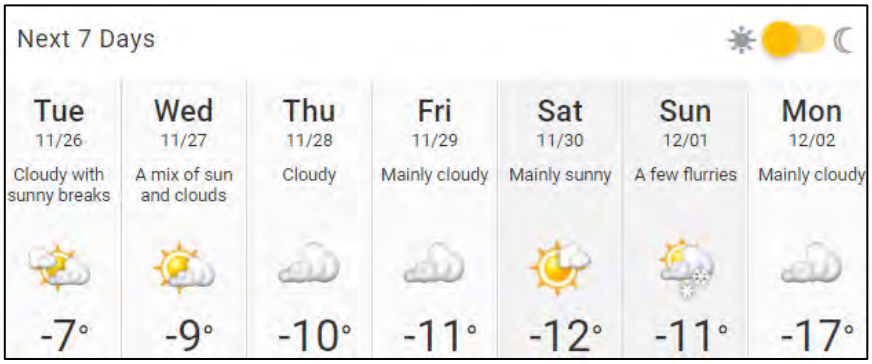
Weather and Climate –

What is the difference and why does it matter?

It's easy to confuse the concepts of "weather" and "climate." Both terms refer to the environment around us and both involve measures such as temperature, wind, and precipitation. The difference between weather and climate is one of scale.

What is weather?

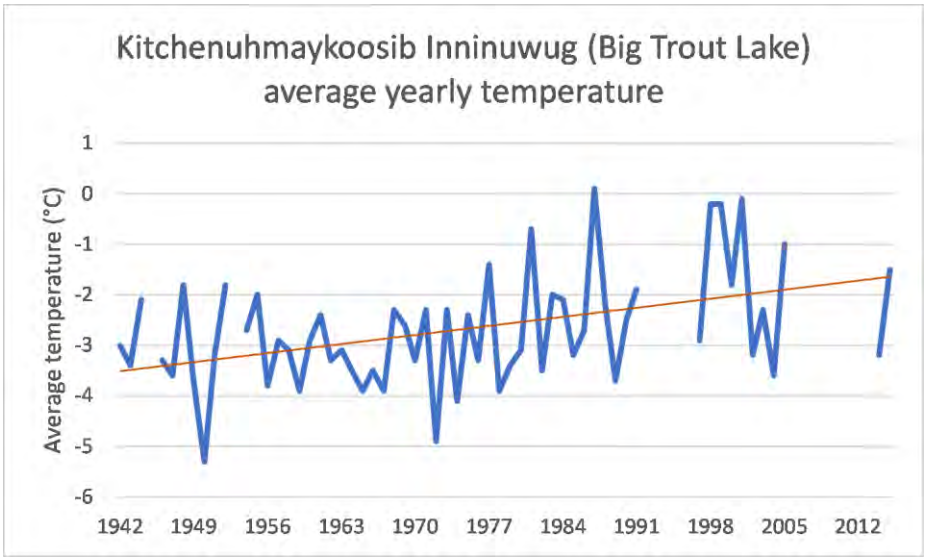
Weather refers to the day-to-day conditions that a given place experiences. When you ask, "How warm is it today?" or "Is it raining out?" you're asking about the weather. Weather fluctuates from day to day, or even hour to hour. Take a look at the weather forecast below. In Kitchenuhmaykoosib Inninuwug (KI), over this 7-day period, the temperature fluctuates by 10°C. Some days are likely to have cloud while others are likely to have sun. One day is expected to have snow.



This automated weather station, located in Neskantaga, Ontario, measures temperature, dew point, humidity, wind, precipitation, and snow depth.

What is climate?

Climate is the average weather a place experiences over a long period of time, like decades, or a lifetime, or a century. For example, take the graph to the right.



This graph shows the average yearly temperature in KI from 1942 through to 2015. The single temperature value given for a year is an average of all the temperature readings from the weather station in KI throughout all days of the year, from the coldest winter nights to the hottest summer days. The spikey blue line connects these dots and illustrates the variations in temperature that can happen from year to year.

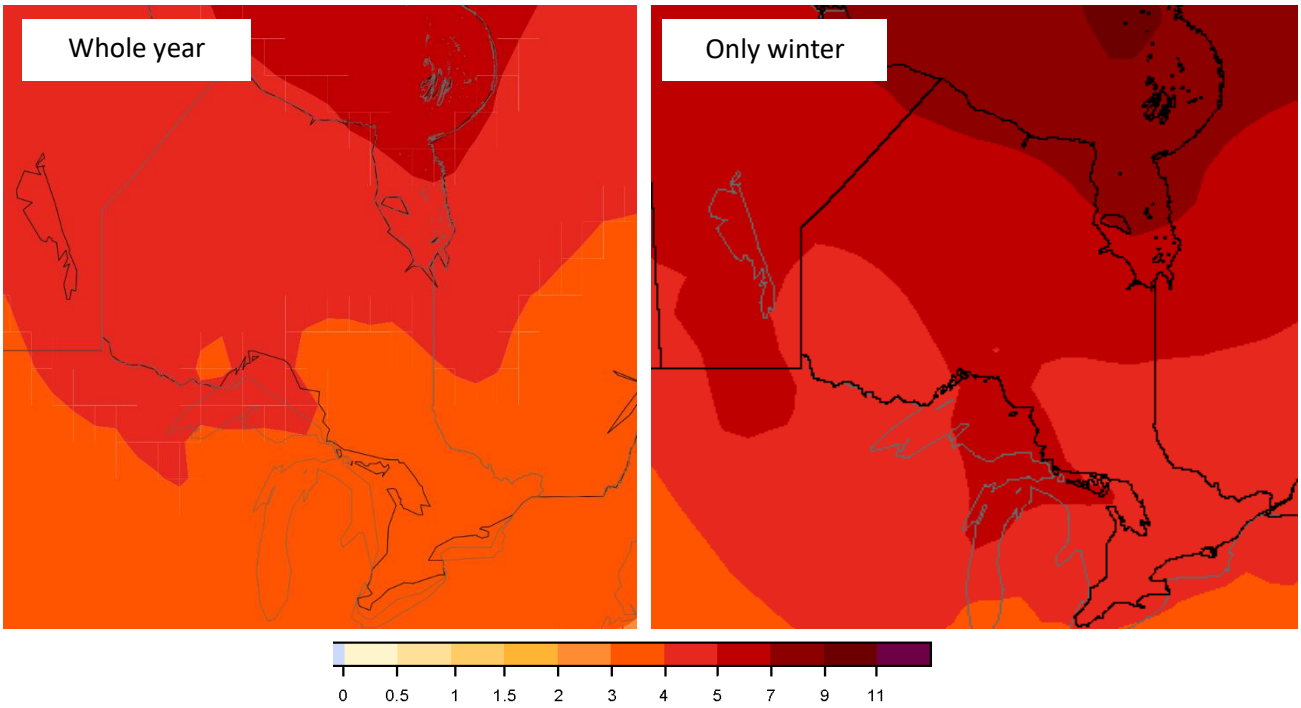
The orange line, on the other hand, is showing us the long-term trend in yearly average temperature in KI over the entire 73-year period. It's taking the temperatures that occurred each year and showing us how those temperatures have changed over more than 7 decades. The orange line is showing us a change in the climate.

Why is climate important?

Just like how knowing the weather forecast can help us prepare for our day or our week, knowing how the climate is changing can help us plan for our present and our future. How much rain a given place can expect throughout the summer, or what temperatures are likely to be seen in January, are based on our knowledge of the region's climate. Climate models, which are used to predict what conditions might be like by the 2050s or even the end of the century, can help us determine how we should design communities and buildings, so they endure into the future. Monitoring climate can help us see how things are changing.

How is climate changing?

All across the globe, temperatures are on the rise. In northern Ontario, the change is expected to be the most extreme in winter, with average temperatures increasing by as much as 9°C by the 2050s. In KI, the average temperature for the entire year is predicted to increase from -2°C experienced between 1986-2005 up to +3°C in the year 2050.



Predicted increase in temperature in Ontario by the 2050s relative to the 1986-2005 period, if greenhouse gas emissions continue to rise (RCP 8.5, 75th percentile). Map from http://climate-scenarios.canada.ca/?page=cmip5-intro

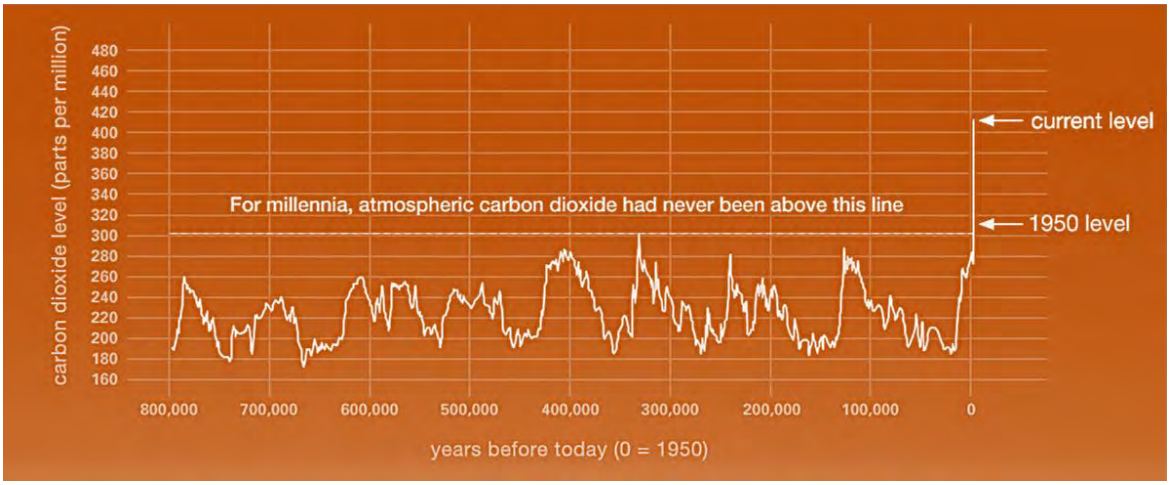
What about cold days?

On November 15, 2019, the temperature in Kitchenuhmaykoosib Inninuwug was -22°C, unusually cold weather for a fall day. But just because a given day is cold, it doesn't mean that the conditions over the last few decades (the climate) haven't gotten warmer. The normal ups and downs in weather can make it harder to see the long-term trend of the climate. It's important we remember to take a step back from the weather outside our front door and notice the bigger picture.

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

Climate change and the rise of Carbon Dioxide

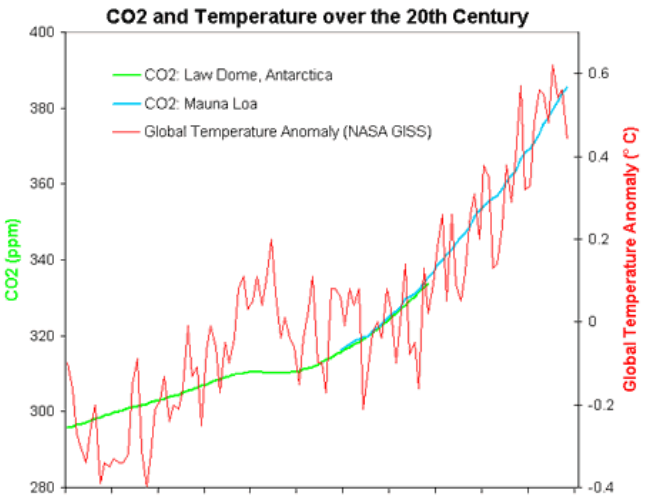
Carbon dioxide (CO_2) is a common gas. You encounter it every day. It's what you breathe out when you exhale, and it's what plants take in and use for photosynthesis. It's also released into the atmosphere in large amounts when we burn fossil fuels, like coal, gasoline, and natural gas. Carbon dioxide is what we call a "greenhouse gas", meaning it absorbs heat energy in the atmosphere and radiates it back towards the Earth, heating the land and oceans. Carbon dioxide levels in the atmosphere are climbing higher and higher, and this has big implications for the future of our planet.



This graph shows the level of carbon dioxide (CO_2) in the atmosphere for the last 800,000 years. Levels of CO_2 from the distant past were determined by analysing air bubbles from ice cores taken from ice sheets and glaciers. Although levels change over time, CO_2 stayed within a constant boundary for the vast majority of those 800,000 years. It's only after 1950 that levels skyrocket. Image from https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

How do we know CO_2 is causing warming?

There are multiple lines of evidence that illustrate the properties of CO_2 as a greenhouse gas and its role in Earth's greenhouse effect (to learn about these look at the suggestions for further reading). We can also look at the relationship between rising atmospheric CO_2 and rising global temperature over the last century (the graph on the right). Temperature (the red line) and CO_2 (the green and blue lines) follow the same trend.



This graph shows how temperature (the red line) and CO_2 in the atmosphere (the blue and green lines) have changed over time. Both follow the same trend. Image from https://skepticalscience.com/the-co2-temperature-correlation-over-the-20th-century.html

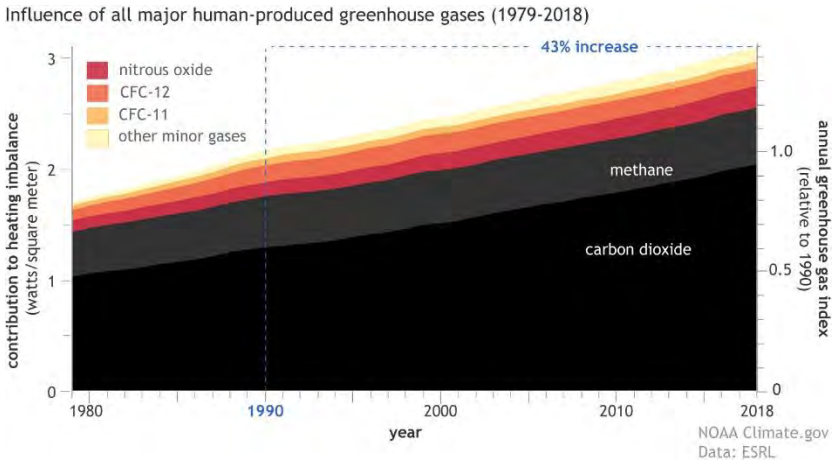
What about ice ages?

Historical shifts into and out of ice ages have been triggered by changes in the Earth's orbit (a combination of orbital eccentricity and axis tilt and wobble). But CO_2 still played a part in historic warming. Once changes in orbital cycles trigger warming, a positive CO_2 feedback loop occurs: warming oceans release CO_2 into the atmosphere, which leads to more warming, which leads to more CO_2 release, and so on. This CO_2 feedback cycle is necessary for the switch between glacial ice ages and interglacial phases.

What about other greenhouse gases?

It's true that carbon dioxide is not the only greenhouse gas in the atmosphere, but it is arguably the most important to global warming. The graph on the right shows the amount each of the major human-produced greenhouse gases contributes to global warming, and the impact of CO_2 is hard to miss.

Carbon dioxide stays in the atmosphere longer than other greenhouse gases, and it's much more abundant. It also absorbs types of heat energy that other natural greenhouse gases do not.

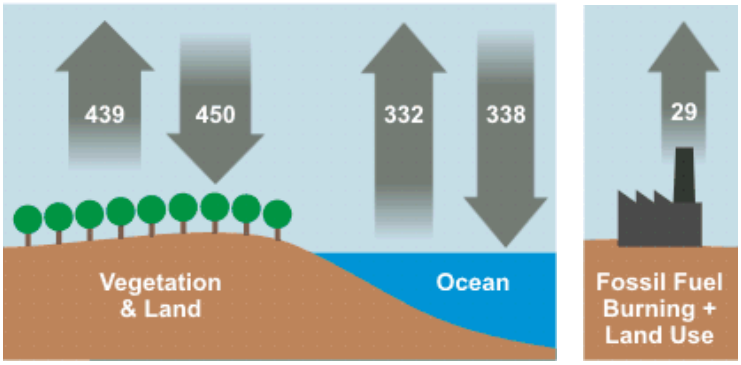


There is more than one greenhouse gas contributing to global warming, but carbon dioxide is by far the biggest influence on the heating imbalance. The combined heating influence of all major greenhouse gases has increased by 43% since 1990

Image from https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

But CO_2 is natural, how do human CO_2 contributions make any difference?

Before humans began burning coal and other fossil fuels at ever increasing rates, the carbon dioxide in the atmosphere was all part of a natural cycle. Some processes, like photosynthesis, absorb CO_2 and others, like respiration, emit it. Without the addition of human contributions, the rate of CO_2 absorbed and emitted by the land and oceans is roughly balanced, as illustrated by the figure to the right. But humans are currently adding another 29 billion tons of CO_2 per year into the atmosphere. This is more carbon than the natural cycle can absorb, and what can't be absorbed accumulates in the atmosphere. It is this extra carbon that has led to the spike in CO_2 levels in the atmosphere that we are seeing today.



The natural global carbon cycle, without extra human emissions, is fairly balanced, with amounts being emitted almost equal to amounts being absorbed.

Images from https://skepticalscience.com/human-co2-smaller-than-natural-emissions-basic.htm

Humans emit an extra 29 billion tons of CO_2 into the atmosphere a year, pushing CO_2 levels past what the natural cycle can handle.

Carbon dioxide from human impact is pushing global temperatures higher, and we're already starting to feel the effects. The level of CO_2 in the atmosphere is beyond anything seen in the last 800,000 years. If we hope to limit the extent of climate change, cutting our CO_2 emissions needs to be part of our plan.

Want to know more? Suggestions for further reading:

https://skepticalscience.com/empirical-evidence-for-co2-enhanced-greenhouse-effect-basic.htm
https://www.researchgate.net/publication/232750246_Anthropogenic_and_natural_warming_inferred_from_changes_in_Earth's_energy_balance

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

How do we know what the climate was like before we could measure it? -

Ice Cores and Milankovitch cycles

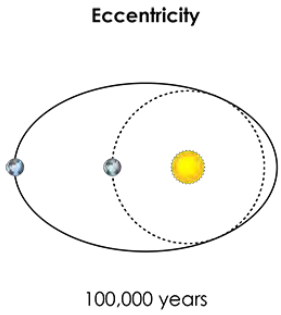
Scientists drill up to 3km into ice sheets and glaciers to collect cylinders of ice, called ice cores. Ice cores have layers that capture sediments and air, that tell us about the Earth's past climate. Layers were formed from falling snow in the winter that lasted through to the next winter. As the snow accumulated it became ice under its own weight. This can take thousands of years. Each layer is different in chemistry and texture providing a treasure trove of information about the climate each year. The longest record of Earth's history is contained in cores from the EPICA (European Project for Ice Coring in Antarctica) project in Antarctica spanning about 800,000 years. Careful study of the layers 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.

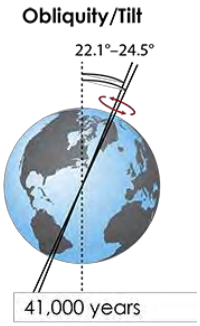
Ice core from the West Antarctic Ice Sheet Divide (WAIS Divide); The dark band in this core is a layer of volcanic ash that settled on the ice sheet approximately 21,000 years ago. — Credit: Heidi Roop, NSF https://icecores.org/about-ice-cores

What causes the ice ages?

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; we call this the Milankovitch cycles.

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 (**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 the angle of the tilt of the Earth causes a larger difference in temperature.



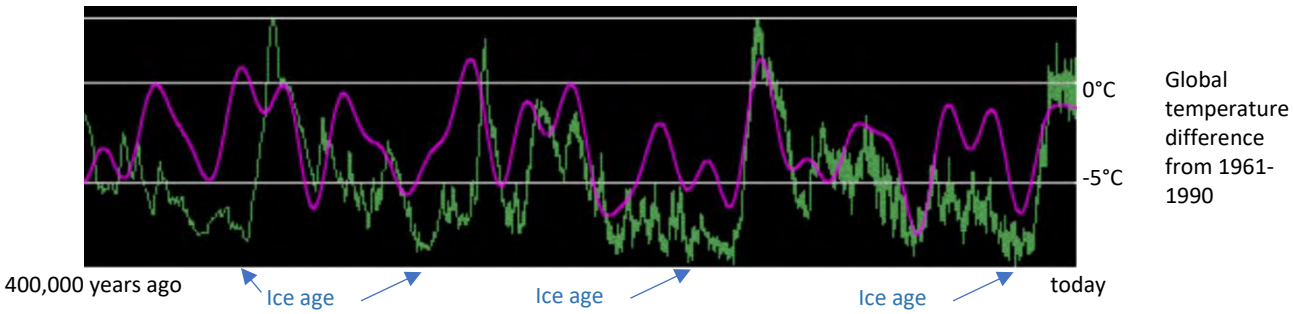


The reason lies in the changes in the **tilt** of the axis of the Earth around which we slowly spin like a spinning top. In Ontario, we are warmer in June because in that part of our orbit the axis of the Earth is pointing toward the Sun. We see the Sun more face on and we enjoy longer days. In the winter, 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. The angle of the tilt of the Earth towards the Sun changes by an extremely tiny amount every year, taking about 40,000 years to increase from just over 22 degrees to 24 ½ degrees and then back again.

To make things more complicated, the axis of the Earth slowly wobbles as it turns like a top that is slowing down (**Precession**). This can mean that it is tilted toward the Sun even more than we are used to today.

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. When the Earth is fully tilted away from the Sun (Obliquity and Precession) and farthest from the Sun (Eccentricity) it becomes colder in the north.

Careful calculations of how the very slow changes in the Earth's position affect the warmth of the Sun received in the north have shown that sometimes summer weather could become cool enough to very slowly, over hundreds of years, allow winter snow and ice to last all year round as far as the border between Canada and the US. 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.



In this graph, we see Eccentricity, Obliquity and Precession together (Milankovitch cycles) as a purple line and the EPICA ice core estimated temperatures in green. The Milankovitch cycles affect the amount of heat from the Sun that the Earth receives and leads to changes in global temperature. We are currently in a warming phase because the Earth is approaching its closest point to the Sun (low eccentricity, more circular orbit) and the north has been tilted toward the Sun allowing the Earth to capture more heat energy. From our understanding of the cycles of Earth's orbit and from looking at the ice cores in Antarctica (EPICA), we estimate that a cooling phase should soon begin.

What is going on now?

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.

Read more:
https://earthobservatory.nasa.gov/features/Paleoclimatology_IceCores
An interesting Milankovitch interactive:
cimss.ssec.wisc.edu/wxfest/Milankovitch/earthorbit.html

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

A look into the future –

Climate modelling and Representative Concentration Pathways

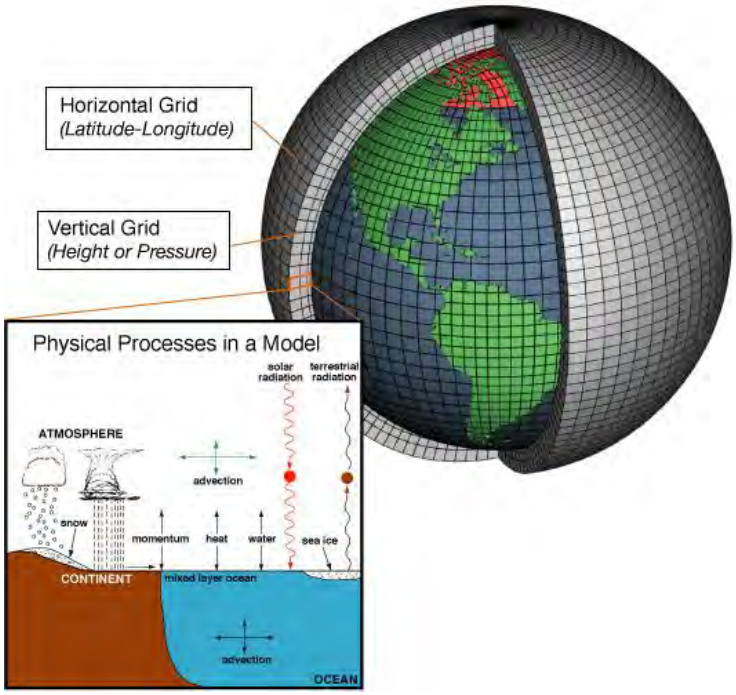
Knowing what conditions we can expect in the future is an important part of climate change adaptation. But how are these predictions made?

How do scientists predict future climate?

By modelling it. Models are used to visualize complex things like how a car, or the human body works. They are also used to understand and predict events like earthquakes and future climate.

Climate models are created by using what is already known about Earth's climate system, like the exchange of energy and material (such as carbon dioxide) between the oceans, the land, and the atmosphere. The Earth is divided into a grid and each of the thousands of cells is represented by a mathematical equation using everything that is known about Earth's systems. These complex calculations require super computers that can fill an entire school gymnasium.

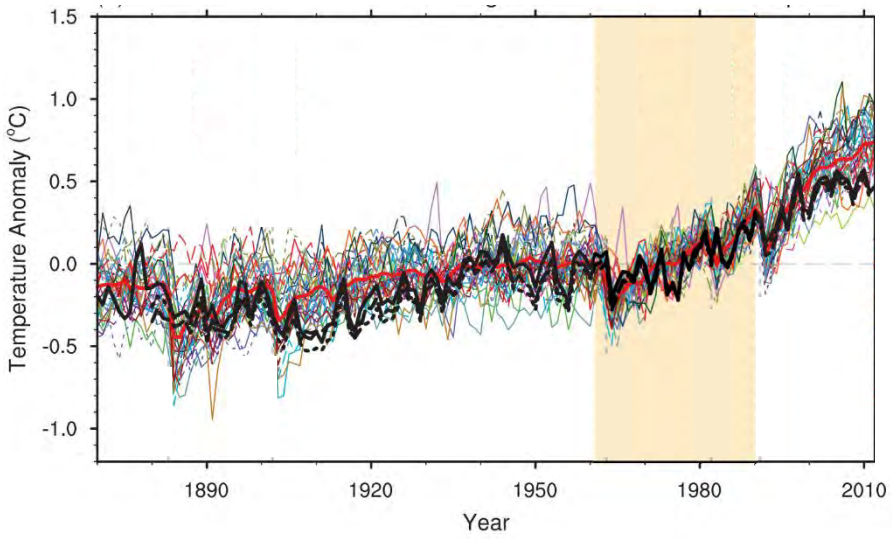
To "run" a model, scientists input a value that is expected to change like levels of carbon dioxide and have computers solve the equations for each cell. Climate models calculate winds, heat transfer, radiation, relative humidity, and surface hydrology within each grid and determine how each grid might interact with neighboring ones.



Adapted from https://celebrating200years.noaa.gov/breakthroughs/climate_model/modeling_schematic.html and https://www.climate.gov/maps-data/primer/climate-models

How do we know if models work?

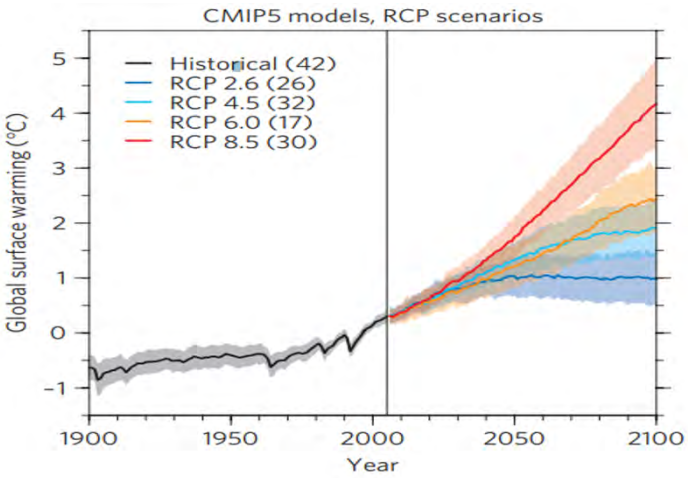
Scientists run their computer model to predict the past climate. If the climate information from their model matches the past climate, they run the same equations to predict future climate. Many working models are then averaged to get the best climate projections. In Canada, we use the CMIP5 group of models to project future climate and so does the IPCC (Intergovernmental Panel in Climate Change).



Measured global mean temperature (black lines) over the past 200 years with closely following CMIP5 multi model (thick red line) that is the average modeled temperature based on many models (all other lines). The temperature anomaly is produced by comparing values to the reference period of 1961-1990 (yellow shading). Adapted from https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter09_FINAL.pdf

Possible futures: What is a Representative Concentration Pathway (RCP) ?

Exactly how much the climate will change by the middle or the end of the century depends mostly on whether human activity will continue to produce as much greenhouse gas emissions. Generally, scientists refer to 4 possible paths when predicting the future climate. These are called Representative Concentration Pathways (RCP) and each models a different amount of human-caused greenhouse gases like CO_2.



Earth's average temperature in the past and projected into the future. If we cut our greenhouse gas emissions dramatically (RCP2.6), warming could be limited to 1°C. If we continue to increase emissions (RCP8.5), we will see an increase of 3°C to 5.5°C in global average temperature. Adapted from Knutti, R., Sedláček, J. Robustness and uncertainties in the new CMIP5 climate model projections. Nature Climate Change ***3,*** *369–373 (2013) doi:10.1038/nclimate1716*

RCP 2.6 *–assumes humans will dramatically lower our greenhouse gases emissions now; radiative forcing must peak at 3 w/m² around mid-century (the 2050s) and then decline to 2.6 w/m² by the year 2100, the equivalent of 490ppm of CO_2; an increase of about 1°C is expected.*

RCP 4.5 *– assumes that by 2050 human greenhouse gas emissions begin to reduce; radiative forcing will stabilize at 4.5 w/m² after the year 2100, the equivalent of 650ppm of CO_2; an increase of around 1.8°C is expected.*

RCP 6 *– assumes that by 2080 human greenhouse gas emissions begin to reduce; radiative forcing will stabilize at 6 w/m² after the year 2100, the equivalent of 850ppm of CO_2; an increase of around 2.4°C is expected.*

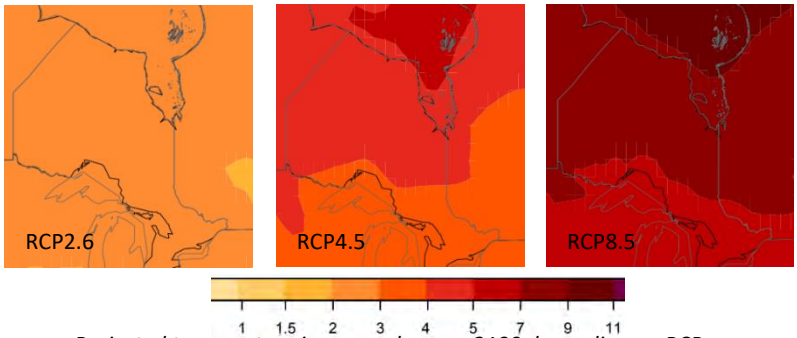
RCP 8.5 *–assumes that little to no effort is taken to lower our greenhouse gas emissions; radiative forcing will hit a maximum of 8.5 w/m² by 2100, the equivalent of 1370ppm of CO_2; an increase of about 3.7°C is expected.*

What is radiative forcing?

The number next to the letters "RCP" is the amount of radiative forcing that occurs in each path. Radiative forcing is dependant on the amount of greenhouse gases in the atmosphere. It is the difference between the amount of the Sun's energy that is absorbed by Earth and the amount that gets radiated back into space. A radiative forcing above 0 w/m² means there is more energy being absorbed than being released, which will cause the temperature of Earth to rise. During ice ages, the radiative forcing is below 0w/m².

Which path will we take?

The future of our climate depends on the choices that people make today. To have any hope of limiting global climate change, we need to start reducing our greenhouse gas emissions now and into the future. Emissions targets, governmental regulations, green technologies, and individual choices must all be part of the plan when it comes to reducing our global emissions. The time to act is now, and we must choose our path wisely.



Projected temperature increases by year 2100 depending on RCP

http://climate-scenarios.canada.ca/?page=main

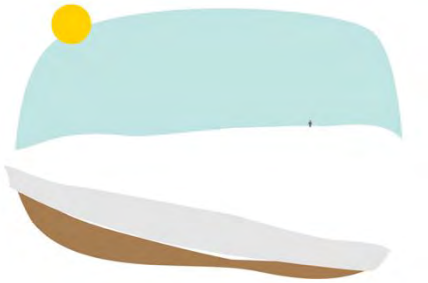
UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario

Melting Ice

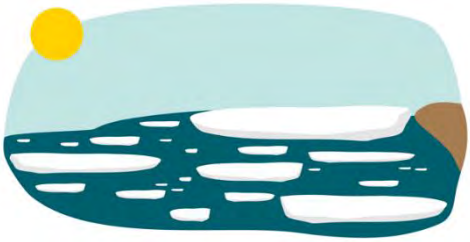
Ice is melting at accelerated rates in the Arctic, Antarctica, Greenland, and across the globe due to human caused climate change.

Glaciers, Ice Sheets & Sea Ice – What's the difference?

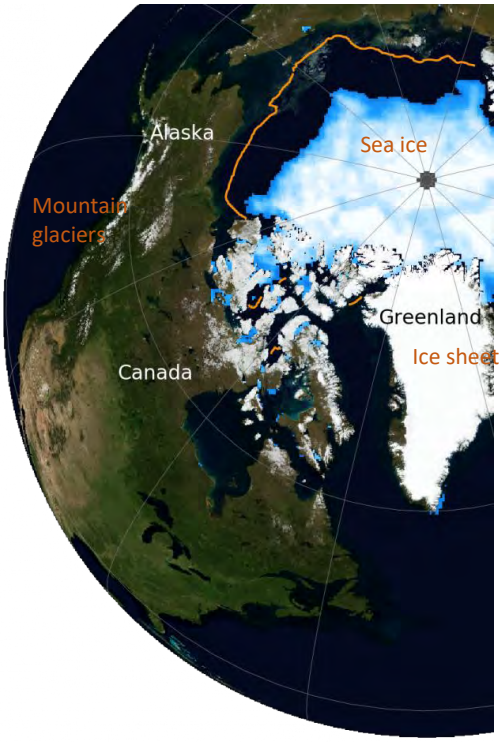
Glaciers are the accumulation of snowfall over many years that turns to ice under its own weight. Glaciers move over time as a result of gravity causing erosion of the rock beneath it and are found at the poles and mountains of every continent except Australia. Glaciers are sensitive to temperature changes and long-term trends show that about 90% of glaciers are shrinking worldwide.



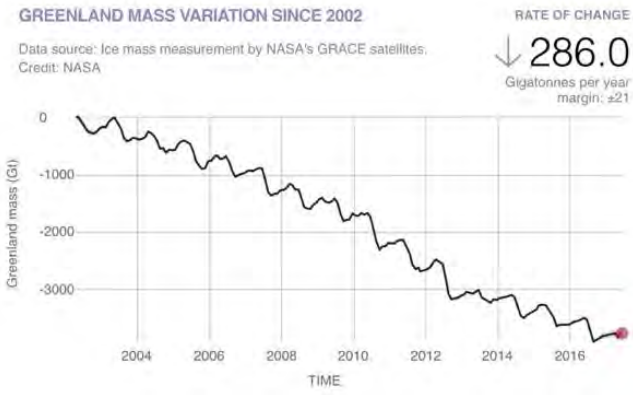
Ice sheets are a type of glacier. They are a thick layer of ice covering a large area of land for a long period of time. Ice sheets form when falling snow does not melt completely in the summer and accumulates over the years because of colder temperatures. The only ice sheets on Earth are in Antarctica and Greenland, and they are shrinking.



Sea ice is any form of ice found at sea that has come from the freezing of seawater. Sea ice can be chunks that move on the ocean surface by wind and currents, or a motionless sheet attached to the coast. Sea ice is mainly found in the North Pole between Canada and Russia and at the South Poles surrounding Antarctica. Sea ice less than one year old is called first-year ice, and sea ice that has survived at least one summer melt season is called multi-year ice.



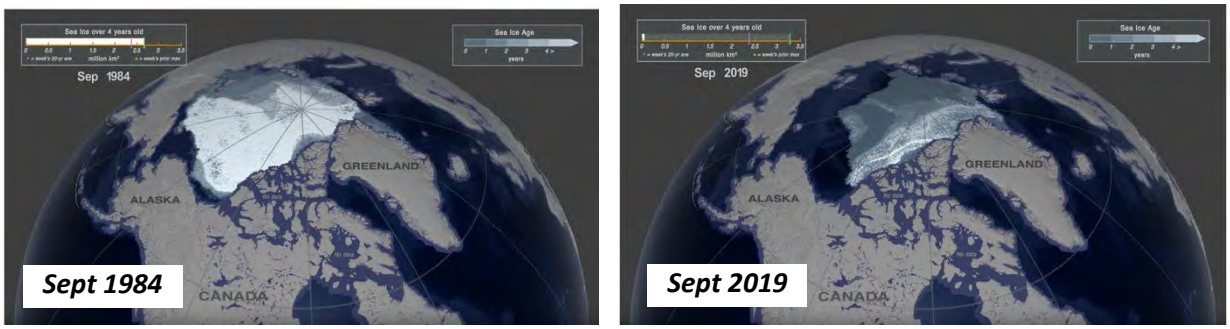
←Left image: Ice cover including sea ice, ice sheets and glaciers on Sept 18, 2019, the day of minimum amount of ice for the year. The average extent of sea ice for 1981-2000 is indicated as an orange line. https://nsidc.org/arcticseaicenews/



Greenland ice sheet mass variation in billions of tons, source: https://climate.nasa.gov/vital-signs/ice-sheets/

Northern Arctic Sea Ice Visualization: https://svs.gsfc.nasa.gov/4750

In this visualization of the North, sea ice less than one-year old is shown in a dark shade of blue, and sea ice that is four years old or older is shown in white. In recent years, there has been a rapid decline in multi-year ice, which is the portion of sea ice that survives the summer melt season. Multi-year ice may have a lifespan of nine years or more and represents the thickest component of the sea ice; it can grow up to four metres thick!



Weekly Arctic Sea Ice Age, Sept 1984 and 2019, source: https://svs.gsfc.nasa.gov/4750

Ice is melting, so what?

- Glaciers are an important natural resource; they hold the largest reservoir of fresh water on the surface of the planet and many people all over the world rely on the meltwater for drinking.
- As sea ice melts, darker patches of the ocean start showing which absorb more heat instead of reflecting it like the white snow and ice. Changing ocean temperatures and warmer air temperatures disrupt normal patterns of ocean circulation and the jet stream. Watch this illustrative video to learn more: *https://www.youtube.com/watch?v=TuHdPvnu3Ds*
- Melting ice sheets contribute to rising sea levels that can lead to coastal flooding. Hudson and James Bay coasts may not experience flooding because glacial rebound is happening more quickly than sea level rise. Sea level rise can also increase coastal erosion and elevates storm surge as warming air and ocean temperatures create more frequent and intense coastal storms. Melting ice sheets also add freshwater to the ocean and can change ocean currents impacting weather patterns worldwide. This will impact fisheries, coastal communities and animals that depend on sea ice.
- Far north communities may experience more polar bear encounters as they wander into communities looking for food due to lack of ice for hunting.

What can we do?

Number one, we can prepare for the changes that will come with melting ice, and number two, we need to cut our greenhouse gas emissions. Individually we can make changes that will reduce our emissions, but even more important, we need to demand action from local, provincial and federal governments to cut greenhouse gas emissions.

Global Ice Viewer: *Try this interactive tool to learn more about how climate change is affecting glaciers, ice sheets and sea ice worldwide: https://climate.nasa.gov/interactives/global-ice-viewer/#/.*
Read more here: *https://skepticalscience.com/melting-ice-global-warming-intermediate.htm*

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

Climate change, rising sea level, and what it means for the Hudson Bay coast

Sadly, there are many examples of how climate change is already impacting our planet. Rising ocean levels, often called sea level, is one such example. Exactly how rising sea levels will affect you will depend on where you are.

How is sea level impacted by climate change?

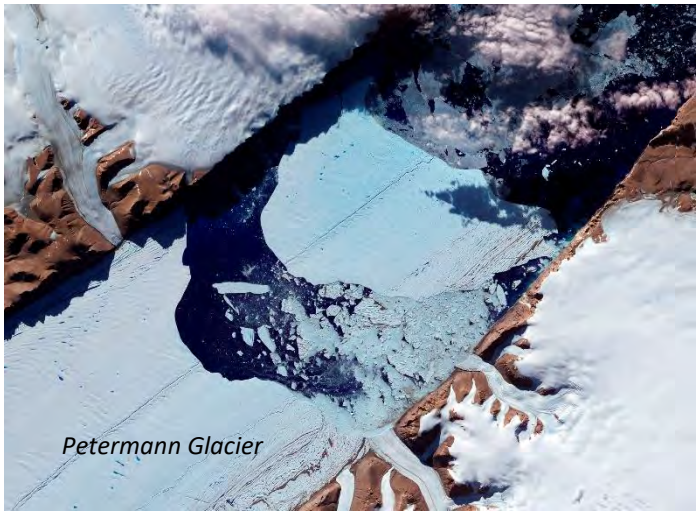
Rising global temperatures lead to sea level rise in two major ways: melting ice and thermal expansion.

Melting Ice

About 10% of land on Earth is covered by glacial ice, and that ice stores a lot of water. As temperatures have risen, these glaciers have started to break and melt. About two thirds of the sea level rise we have experienced has come from melting glaciers.

Thermal Expansion

Simply put, warm water takes up more space than cold water. This means that, as the greenhouse effect warms the oceans, the water expands to a greater volume and takes up more space. This phenomenon is responsible for one third of the sea level rise seen to date.

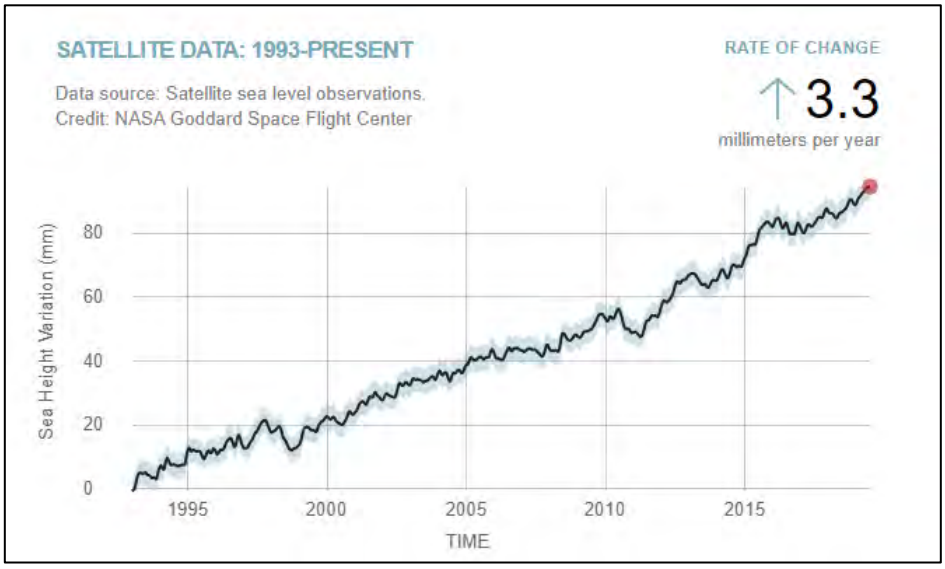


This NASA image from July 2012 shows a large chunk of ice that has broken from the Petermann Glacier in Greenland. https://earthobservatory.nasa.gov/images/78648/closeup-of-the-ice-island-from-petermann-glacier

What is happening with global sea level?

For the last 2,000 years or so, global sea level stayed relatively constant. It wasn't until the late 1800s, when humans started burning coal and other fossil fuels at increasingly higher rates, that sea level started to rise. Today, sea level is 13 to 20 centimeters (5 to 8 inches) higher than it was in 1900.

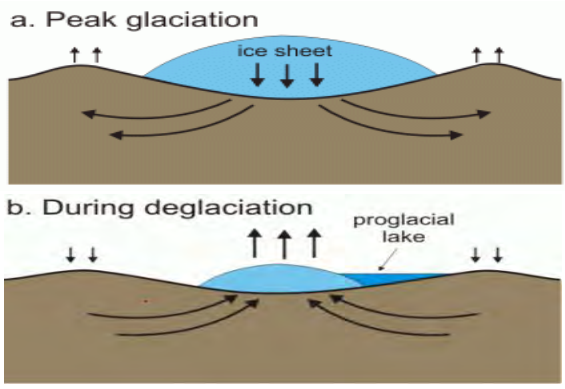
Not only is sea level increasing, but the rate at which it's increasing has become faster. Before 1990, the rate of sea level rise was about 1.5 millimeters per year. By the year 2000, that rate had increased to 3.2 millimeters per year. As of June, 2019, NASA has calculated the rate of sea level rise to be 3.3 millimeters per year.



Graph of sea level change since 1993 as tracked by satellites. As of June, 2019, the rate of change is 3.3 millimeters per year. Source: climate.nasa.gov

Sea level on the Hudson and James Bay Coast

The surface of the Earth is not the same everywhere, and neither is the surface of the ocean. As such, different places will experience sea level rise differently, with some locations seeing more rising than the global average and some seeing less. Presently, the Hudson and James Bay coasts are seeing a decrease in sea level due to a process called “isostatic rebound”.

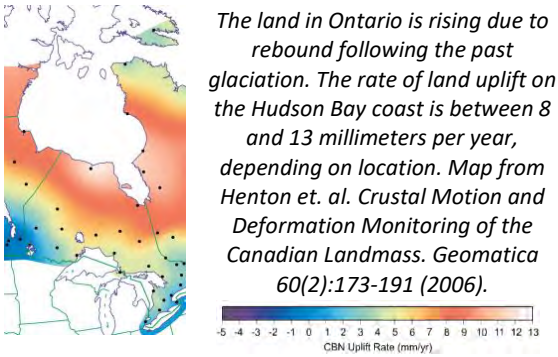


During the last ice age, most of what we now consider Canada was covered by a massive sheet of ice. The ice was so heavy that it squeezed the land beneath it, as illustrated in the drawing to the left.

As the ice began to melt, and the weight of the glacier disappeared, the land underneath began to rise up, or rebound, back to its original shape. This is the process we call isostatic rebound, and it’s still occurring in Ontario today.

The weight of an ice sheet squeezes the ground beneath it. When the ice melts, the ground slowly rebounds. Images from http://www.antarcticglaciers.org/glaciers-and-climate/sea-level-rise-2/recovering-from-an-ice-age/

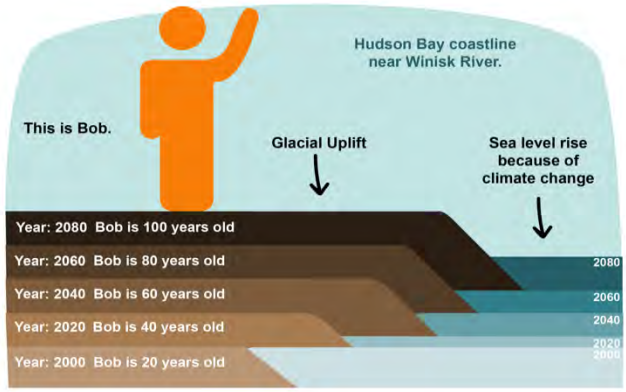
Currently, the land on the Hudson Bay coast is rising at a rate between 8 and 13 millimeters per year (or, to put it another way, 80 centimeters to 1.3 meters in about 100 years). You can see evidence of the land that was gained because of rebound when you fly near the Bay as beach ridges of high ground where the shoreline of the Bay was years ago.



The land in Ontario is rising due to rebound following the past glaciation. The rate of land uplift on the Hudson Bay coast is between 8 and 13 millimeters per year, depending on location. Map from Henton et. al. Crustal Motion and Deformation Monitoring of the Canadian Landmass. Geomatica 60(2):173-191 (2006).

Shrub covered ridges of beach sand running parallel to the shore of Hudson Bay seen as white ice in the background. The raised beaches mark the location of the former bay shoreline. The valley of the Severn River is visible in the foreground underneath the plane. Photo taken March 21, 2012.

This rise from rebound of 80cm to 1.3m far exceeds the current average rise in sea level of 33 centimeters in 100 years and likely will exceed even the most extreme projections of a global increase in sea levels of 1m by the year 2100. Sea level rise is expected to impact coastal communities all over the world. The water level of Hudson and James Bay coasts, however, is not expected to rise because of the effect of glacial rebound. In fact, the sea level along the bays has been and will continue to decrease.



For further information on sea level rise and rebound, check these out:

https://ocean.si.edu/through-time/ancient-seas/sea-level-rise
https://www.ontariobeneathourfeet.com/sea-level-rise-james-hudson-bay
http://pubs.aina.ucalgary.ca/arctic/Arctic62-4-458.pdf

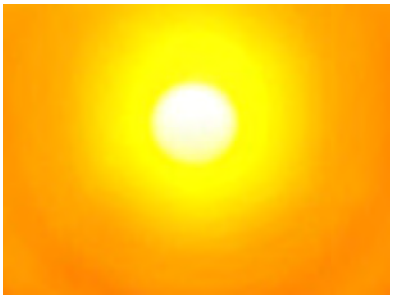
UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario

Extreme Weather Events

Extreme weather events have always happened, but the frequency and intensity are changing. Although it's not possible to say if a specific event was caused by global warming, there is strong evidence that a warming planet will make extreme events more frequent and/or intense. It's like playing a card game with extra jokers, by increasing global average temperature, you increase the chance of extreme weather events.

What are some examples of extreme weather events?

Heat waves



Thunderstorms

Wildfires

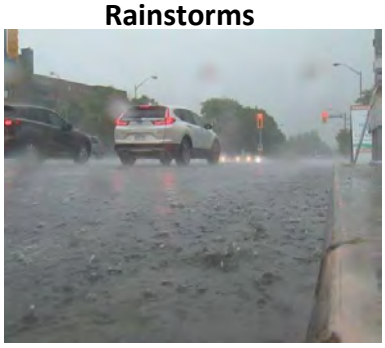
Snowstorms

Ice storms

Hailstorms

Windstorms

Rainstorms



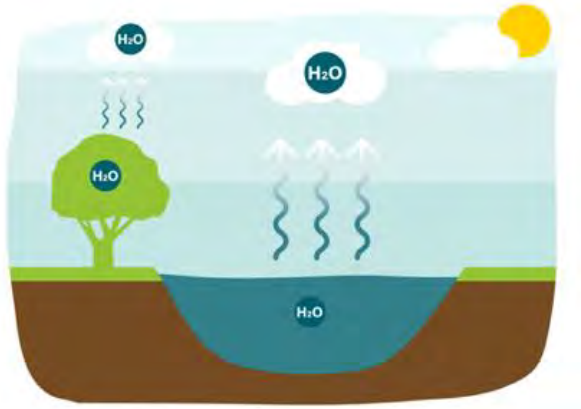
Flooding

Why can't we directly link extreme weather events to global warming?

Extreme weather events are unusual highs or lows based on the historical records of weather in a particular region. Detecting these trends takes time and is particularly difficult when observational records are rare in certain regions like northern Ontario. Community members, especially Elders, speak of more storms, more rain in the winter, and say that the weather is now more unpredictable. Although scientists can't tie global warming to a specific event, they are getting better at determining whether a warming planet made the event more severe or more likely to happen.

How does global warming make extreme weather events more frequent and/or intense?

Rising temperatures can increase the rate of evapotranspiration, which is the total evaporation of water from soil, plants and water bodies. This can have a direct effect on the frequency and intensity of droughts and make forests and fields more prone to catching fire, plus extend the fire season.



Rising temperatures mean a warmer atmosphere. A warmer atmosphere can hold more water vapour, and water vapour increases the risk of extreme rainfall and snowstorm events.

Rising temperatures change sea-surface temperature which then brings changes in atmospheric circulation and precipitation. This can cause more severe hurricanes and intensify droughts and floods.

Why is this important?

Understanding how global warming impacts extreme weather will help communities and individuals make informed decisions, such as where and how to build, to reduce their vulnerability to climate change. By being prepared for more frequent and intense extreme weather, we can keep our communities safe.

Contact us if you'd like to learn more about extreme weather and global warming.
We can provide access to this report: https://www.nature.com/articles/nclimate1452.

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

Drought

Low water in a changing climate

More hot and dry weather is expected because of climate change. Drought and periods of dry weather in the north can lead to lower water levels in lakes, rivers, and wetlands. What do lower water levels mean for people and for the environment?

How will climate change impact drought and low water?

As climate change brings hotter temperatures to the north, we can expect lakes, rivers, and wetlands to lose more water to evaporation. This means that water levels can lower even if the amount of rain an area gets stays the same. In northern Ontario, the summer months are predicted to see only small gains in rain, which may not be enough to offset how much water is lost to evaporation. It's possible that low water levels will happen more often as climate change continues.

What are the impacts of low water levels?

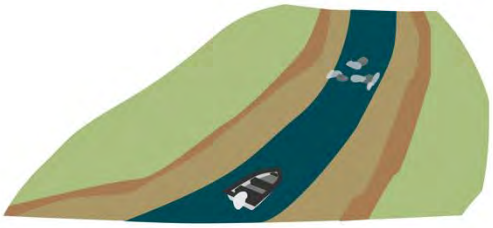
Wetlands

Wetlands are important ecosystems. Wetlands provide habitat for plants and animals, act as natural flood control by absorbing and holding rain and melt water, trap sediments and other contaminants to make water cleaner, and even store carbon. When wetlands shrink or dry completely, these important functions can be reduced or even lost entirely.

Plants and animals can lose habitat

Lakes and rivers

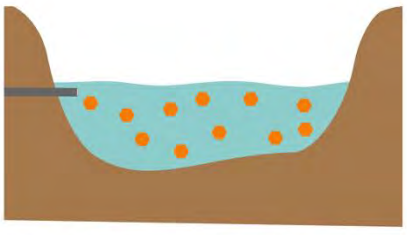
Low water in lakes and rivers can take away or limit important fish habitat like spawning areas, migration routes, and cold-water refuges. Low water can also make it harder for people to travel by boat and impact long-standing traditional travel routes.



Travel over water can be difficult

Drinking water

When water levels get low in lakes and rivers that supply drinking water, drinking water quality can be put at risk. Lower water levels can mean a higher concentration of contaminants, issues with drinking water intakes, and a greater chance for algae and pathogen growth.



Concern about contaminants in drinking water

What have people noticed?

Already, people in First Nation communities across the north have seen the impacts of low water. Some say traditional water routes are harder to travel in summer and can impact hunting and fishing even into the fall. Ponds, swamps, and small lakes in some areas have gotten drier. In some cases, the loss of swamps can mean the loss of traditionally harvested plants. Many people also feel that periods of drought or dry weather are happening more often now than they used to in the past.

How can we prepare?

Protect habitat

Take steps to protect the wetlands, lakes, and rivers in your area. You can:

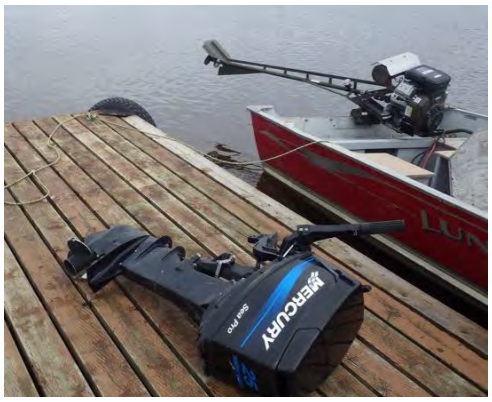
- Limit water removal or diversions of water in systems where low water is an issue.
- Make sure streams and tributaries that supply water to larger systems aren't blocked from flowing.
- Keep wetlands as part of your community. Avoid destroying wetlands when building or creating infrastructure.
- Monitor and protect fish habitat that may be sensitive to water level changes like spawning grounds, migration routes, and cold-water refuges.

Wetlands are important and diverse ecosystems. Keep wetlands as part of your community.

Adapt how you travel

Low water levels might make it necessary for people to change the way they travel. Changes could include:

- Finding new water routes
- Creating portage trails around areas of low water
- Using motors made for shallow water
- Carrying lighter loads in boats
- Traveling over land



Common outboard motors can be damaged when used in shallow water. Mud motors or jet motors may be better options.

Protect drinking water

Since low water can affect drinking water quality, it is important that drinking water systems be assessed for their vulnerability to low water conditions. An effective drinking water monitoring program should also be in place to ensure water continues to be safe to drink in times of low water. Rivers and lakes that are drinking water sources, including the land that drains into those systems, should be protected from potential contamination.

Water treatment plant in Attawapiskat.

Clean, safe drinking water is already an issue for many First Nation communities. Communities should continue to push for safe drinking water.

Want to know more?

Lakehead Region Conservation Authority Low Water Response

https://lakeheadca.com/flood-protection/low-water-response

Revitalize a wetland

https://cwf-fcf.org/en/resources/for-educators/resource-sheets/revitalize-a-wetland.html

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

Drinking water in a changing climate

More extremes in weather are expected with climate change. When the weather gets hot and dry, water levels in lakes and rivers can get low. What does this mean for the drinking water that communities need?

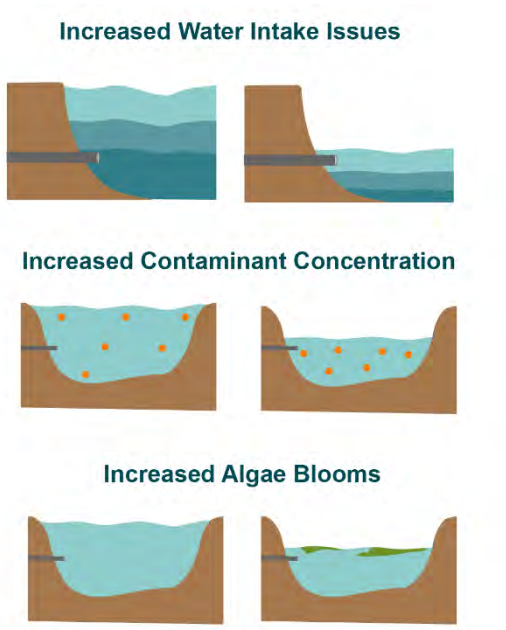
What does climate change mean for drought and dry periods in the north?

As temperatures continue to rise in the north, evaporation from the land and water will increase, leading to drier land and lower water levels in lakes and rivers, both of which can affect drinking water quality. While climate change is predicted to make northern Ontario wetter, the summer months will see only modest gains in rain, which may not be enough to offset the water lost to evaporation. Rain might also fall as heavy rain more often with long periods of little to no rain, leading to drought conditions.

How do drought and dry periods impact drinking water?

When the weather is abnormally dry for a period of time, water resources can be put under stress. In dry periods surface water can get warmer, water levels in lakes and rivers can lower, and water flow through streams and rivers can be reduced. Ground water can also be affected. These sorts of changes can impact the quality and quantity of drinking water. For example:

- Lower water levels may lead to problems with drinking water intakes
- Lower water levels can increase the concentration of contaminants
- When water gets lower, warmer, and has less flow, waterborne pathogens may be more likely to survive and grow
- When water gets lower, warmer, and has less flow, there may be an increase in algae blooms
- Lower ground water may lead wells to go dry
- Water treatment plants may experience loss of pressure, increasing the risk of contamination and requiring more intensive water treatment



Drought and dry weather can also impact the land, drying out soil and making it pack together more tightly. When heavy rain hits this dry, compacted soil, the water is less likely to absorb into the ground and instead runs over the land washing soils and contaminants into lakes and rivers that may be drinking water sources.

What have people noticed?

Low water levels in lakes, rivers, streams, and creeks are already being mentioned by people in First Nation communities throughout the north. Some people also say the water seems warmer than it used to be, and many have noticed more algae. Wells in some areas are said to have low water levels or even dry entirely in summer.

How can we prepare?

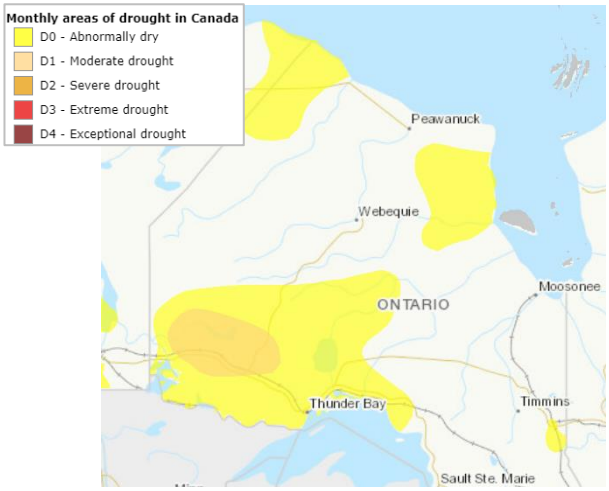
Vulnerability assessment

Clean, safe drinking water is already an issue for many First Nation communities. Drinking water infrastructure in all communities should be assessed to make sure it can function well now and under future climate conditions, including the potential for drought and low water levels. This type of assessment and upgrade planning may require the help of outside consultants. Communities should continue to push for safe drinking water.

Monitoring

Communities may wish to monitor for potential drought events by tracking weather, water levels, and moisture levels in the soil near a drinking water source. Since 2002, Agriculture and Agri-Food Canada has been sharing data online about drought conditions, soil moisture, and other parameters. The data is posted at the end of every month.

In communities that currently have drinkable tap water it is important to make sure the water continues to be safe to drink during drought events. An effective drinking water monitoring program needs to be in place. If the water is not safe to drink, communities should have an alerting system to notify members and have alternative water sources available (bottled water, boiled water, different water sources, etc.).



The Canadian Drought Monitor from Agriculture Canada tracks the extent and intensity of drought. Image for May 2020 https://www.agr.gc.ca/eng/agriculture-and-the-environment/drought-watch/canadian-drought-monitor/?id=1463575104513

Source water protection

Keep the lakes and rivers that supply drinking water healthy by preventing pollution. An effective community drainage plan can help limit the amount of surface runoff reaching source water lakes and rivers. Limiting development around source water and protecting the natural landscape can also help keep contaminants from entering these systems. Communities might also want to create an "intake protection zone" around their drinking water intake where boat traffic and other potential sources of contaminants are restricted.

Water conservation

Water conservation should be encouraged; provide water conservation tips to community members. Water conservation is always a good idea, but will be especially important in times of drought. Inform the community of drought conditions and of any water-use restrictions that may need to be put in place.

Save water in your home by:

- **Taking quick showers**
- **Fixing leaky taps or toilets**
- **Running washing appliances with full loads**
- **Collecting rainwater for watering gardens**

Want to know more?

What is an Intake Protection Zone?
http://trentsourceprotection.on.ca/protect-your-water/what-is-an-intake-protection-zone

Drought-Ready Communities – A guide to community drought preparedness
https://drought.unl.edu/archive/Documents/NDMC/Planning/DRC_Guide.pdf

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

Dry and Dusty Land in a changing climate

As climate change makes summer temperatures warmer, the land in the north will get drier impacting plants, animals, and people.

How will climate change impact drought?

Hotter summer temperatures that are expected with climate change draw more moisture out of plants and soils (an effect called evapotranspiration). Even though climate change will likely also bring more rain to Ontario, the land is expected to become drier in future conditions. Predicting where droughts will occur and how long they will last is difficult but it is thought that North America is likely to experience longer and more intense dry periods as climate changes.

Evapotranspiration: Drawing moisture out of plants and soils.

How does drought impact the land?

Erosion and sedimentation

Have you ever tried watering a house plant when the soil is very dry? If you give it too much water at once, it goes straight through the soil and into the plant saucer or the water sits on top for a while before absorbing. The same thing happens when the land goes through an abnormally dry period called a drought. Dry soils take longer to absorb water and so rainwater runs downs slopes into lakes and rivers. The soil that gets carried with the rain runoff, called sediments, can impact water quality. Wind can send dry soil particles into the air and into waterways.

Dry soil absorbs water slowly

Soil quality & shifting ecosystems

Soils that lack moisture can become compacted making it difficult for plants to grow. Low soil quality can result is loss of wildlife habitat as plants and trees are unable to survive in these conditions. Trees may start to die off and be replaced by grasslands that are able to withstand dry conditions. Community members may need to travel further in order to harvest and hunt and community gardens may be impacted.

Drought-induced damage to trees.

Wildfires

Although forest fires are natural part of the boreal forest, drought can increase the number and intensity of wildfires. Dry land can ignite and spread fire more easily and put people and communities at risk. Forest fire smoke can travel great distances and impact community members, especially elders, youth, those who work outside, and those who have respiratory issues.

Dust and respiratory issues

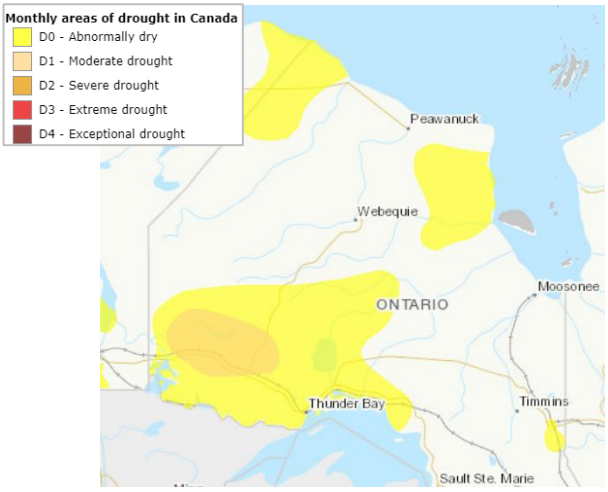
Dry conditions can lead to an increase in dust, pollen and allergens in the air, especially on a windy day. Dusty conditions can lower air quality and can impact breathing. Community members that have respiratory conditions like asthma, are at greater risk during these times. Dust can also cover plants and make it difficult for them to absorb sunlight to survive.

Drought can create dusty conditions that impact your health.

How can we prepare?

Monitor

Communities should monitor for potential drought events. It may be valuable to measure soil moisture and water levels and to keep record of any areas with large tree die-offs. Seeing changes in these measurements could give an early warning of coming drought. Knowing how drought conditions have been observed in the past can give direction on what areas to monitor. Incorporating traditional knowledge of landscape and weather can help. Agriculture and Agri-Food Canada shares data on drought conditions, soil moisture, and other parameters, on a monthly basis.



The Canadian Drought Monitor from Agriculture Canada https://www.agr.gc.ca/eng/agriculture-and-the-environment/drought-watch/canadian-drought-monitor/?id=1463575104513 can help communities monitor drought. Image for May 2020.

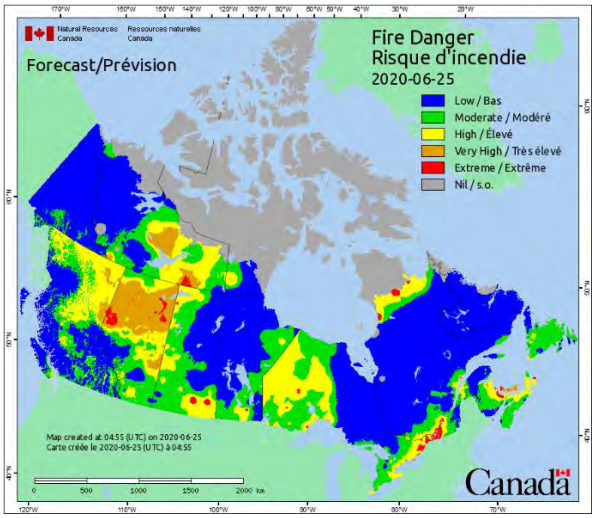
Protect natural habitats

Plants and trees help hold the soil together and prevent sediments from entering waterways that are important to fish and as drinking water sources. Protecting the land and wetlands will reduce impacts from climate change especially during periods of drought.

Prevent human-caused fires

Fire safety is always important, but as the land gets drier fires will more easily ignite and spread and so preventing human-caused fires will become even more critical.

- Monitor the fire hazard risk in your area. When fire risk is high, communities may want to restrict or ban outdoor burning.
- Promote safe fire practices in your community (campfire safety, guidelines for burning outdoors
- Promote safe fire practices when on the land (caution with potential causes of accidental fires (sparks, cigarette)



The Canadian Wildland Fire Information System (https://cwfis.cfs.nrcan.gc.ca/home) can help communities monitor their fire hazard risk.

Health, education and outreach

Drought can mean more breathing problems from dust, smoke, and pollen so it is important that people with asthma have the necessary medication and avoid being outdoors when air quality is poor. To reduce dust in the community, adding water to dirt and gravel roads and enforcing lower driving speeds could help. 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, or involving the community in drought-action planning.

Resources

Handbook of Drought Indicators and Indices:
www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

Drought Ready Communities: A Guide to Community Drought Preparedness
https://drought.unl.edu/archive/Documents/NDMC/Planning/DRC_Guide.pdf

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

Harvesting with More Dry Spells

With climate change will come more dry spells and drought. When an area gets drier than usual, it can push plants and animals beyond their limit of adapting and impact the communities that rely on them.

How will climate change impact drought?

In northern Ontario, the summer months are predicted to see only small gains in rain, which may not be enough to offset the amount of moisture drawn out of plants and soils due to hotter temperatures. However, predicting where drought and dry spells might occur and how long they could last is difficult. It is thought that North America will likely experience more intense and longer lasting dry periods due to climate change.

Evapotranspiration: *Drawing moisture out of plants and soils.*

How does drought impact harvesting?

Fishing

Low water can take away or limit important fish habitat like spawning areas, migration routes, and cold-water refuges. It can also make it difficult to travel traditional routes by boat. No longer being able to travel long-standing traditional routes can impact mental health and well-being.

Plants

Extreme droughts can greatly impact important traditional and medicinal plants as well as berries. For example, wetland plants like wild rice, cedar, cranberries, cloudberries and labrador tea will be impacted by changing water levels. In some instances, climate change may benefit key berry producing plants or expand the types of berries and plants that can be grown in northern regions. Community gardens may also experience plant loss and require additional watering during drought periods.

Wetland plants like Labrador tea and wild rice are sensitive to changing water levels.

Berry plant ranges are shifting northward.
More here: http://www.planthardiness.gc.ca/?m=2b

Shifting habitat, shifting wildlife

Plants and animals are well adapted for the environments that they live in, but droughts can stress these environments and make survial more difficult. Drought can dry out soils and make it difficult for plants to grow. Vegetation ranges may begin to shift in order for plants to survive. As plants shift and habitat changes, so will the wildlife that relies on it. Community members may need to travel further in order to harvest and hunt which increases time, effort and travel costs. Gathering wood could also be impacted because dry forest conditions can make trees and plants more susceptible to disease and insect attacks and can, in extreme cases, cause their death.

Plants and animals can loose habitat

What are people noticing?

Drought and shifting habitats are already affecting communities across the north. People on the James and Hudson Bay coasts are reporting that willows are growing more than ever before and communities across the north are noticing dryer conditions in the bush, which is leading to fewer berries for harvesting.

How can we prepare?

Assessing and reducing risk

The impact of drought on a community will depend on a region's exposure to drought and its ability to react and recover. Knutson et al. (1998) outlines a 6-step process to assess and potentially reduce the risk of drought events in communities, see the box for a summary.

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

Step 1: Assemble a group of people (community leaders, community members, & researchers/consultant if necessary) to conduct the drought impact assessment & gather info.

Step 2: Identify consequences of drought relevant to your community (ex. Impacts on traditional food sources etc.)

Step 3: Rank consequences by level of priority.

Step 4: Consider the underlying causes for the impacts and determine if it is possible to mitigate those causes.

Step 5/6: Identify & prioritize realistic and cost-effective actions that can be taken to address the issues.

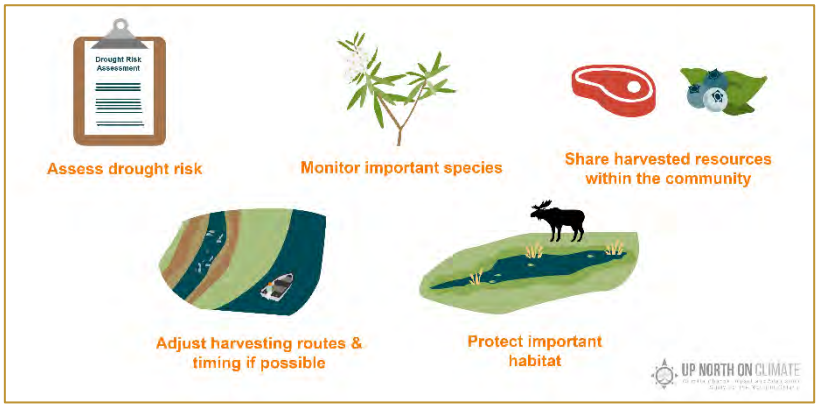
Monitor

Monitoring allows us to gather information about the environment and the changes that are occurring. A community-based monitoring approach can involve hunters, trappers, gatherers, and other land users in data collection and may include the following steps:

- Identify important species in your community (e.g. sources of food, has traditional value, are part of the economy) and how drought might impact them.
- Use traditional knowledge to learn how drought conditions have been observed in the past to create a community baseline.
- Collect data while out on the land and monitor changes (location, abundance, health, etc.).
- Protect important habitat in the community. Protect habitat as it shifts over time.

Communities may also consider collaborations with universities, governments or other groups to merge traditional knowledge with scientific study and/or consider using an online science app.

Adjusting harvesting practices and community initiatives



Many harvesters are already saying they have had to adjust their time and methods to access traditional areas. Sharing harvested resources within the community can help ensure food security for those without the resources to harvest berries or plants. Communities should provide information to community members about the potential of drought in their area and how drought can impact them.

Resources

Knutson et al. (1998). How to reduce drought risk: https://drought.unl.edu/archive/Documents/NDMC/Planning/risk.pdf

Online citizen science apps: https://siku.org/#/about & www.inaturalist.org

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

Drought Monitoring

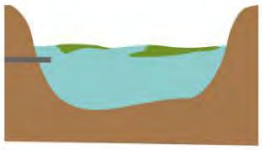
Periods of drought can happen in the north and climate change could make them happen more often. Monitoring for drought events is one way that communities can be prepared for drought and its impacts.

How will climate change impact drought?

Climate change could mean that drought events and dry periods will happen more often than they did in the past especially in summer and fall[1]. Warmer temperatures brought on by climate change will increase evaporation from the land and water, leading to drier land and lower water levels. Already, many people in First Nation communities in the north say that periods of dry weather are happening more often.

What are the impacts of drought?

Drought and dry conditions can impact people, communities, and the land.



Low water levels can impact drinking water quality

Drought can affect our food

Drought can increase the chance of wildfire

How can drought monitoring help?

Drought and dry conditions come about slowly. The drying of the land and lower water levels in lakes and rivers happen gradually over time. This slow onset means that it is important to monitor to provide an early warning system of climate, as well as land and water conditions that can lead to drought. Ideally, early warning systems have both a monitoring component and a forecasting component (weather, for example).

Drought monitoring is most effective if it is paired with a community drought response plan that is triggered when drought indicators reach a certain threshold. A drought response plan would outline actions the community could take like water conservation or fire restrictions. Monitoring is especially important in a slow-onset hazard like drought to reduce impacts.

What are some ways to create a monitoring program?

Community-based monitoring

Knowing how drought conditions have been observed in the past could help communities know what areas to monitor for future drought. Traditional Knowledge might also provide traditional indicators for drought in the area, like water levels in local lakes or rivers, the loss of certain plants, or dry conditions on the land.

A community-based monitoring program begins with choosing what to monitor. There isn't one "right way" to monitor for drought. Different drought indicators measure drought in different ways, and which indicators are most appropriate to use will vary. Deciding which indicators work best in your area will take time and possibly some trial and error. Some things to consider when choosing indicators could include:

- How easy is the indicator to measure?
- Is historical data available for this indicator?
- Is the indicator sensitive enough to detect when drought starts or stops?
- Will the same indicator(s) be used to detect moving into drought AND moving out of drought?

Communities may choose to measure indicators like rain or snow amounts, temperature, water flow in streams, soil moisture, or snowpack. Measuring these indicators over time should allow communities to see trends and prepare when a drought is coming. These indicators are sometimes also measured by Environment Canada with data available online.

[1]*Tam, B. Y. et al. CMIP5 drought projections in Canada based on the Standardized Precipitation Evapotranspiration Index. Can. Water Resour. J. 44, 90–107 (2019)*

Drought indicators are sometimes used to create drought indices. The **Handbook of Drought Indicators and Indices** has complied information on drought indicators and indices in use around the world and could be a useful resource. The handbook classifies drought indicators by type (meteorological, hydrological, etc.) and gives an idea of how easy or difficult each indicator or indice might be to use.
https://www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

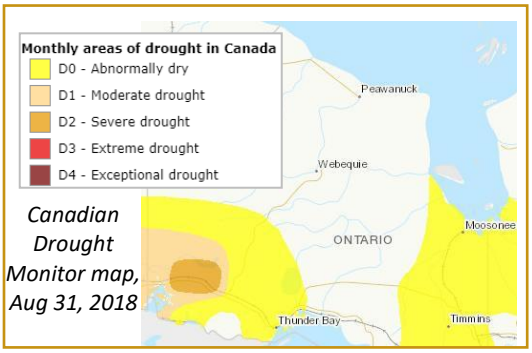
Drought indicators or drought indices are often used to track drought

Drought Indicators are the measurements used to see if drought is occurring and describe drought conditions
Drought Indices use calculations to examine one or more measured indicators as well as modeling to assess drought severity and probability to anticipate drought-related impacts

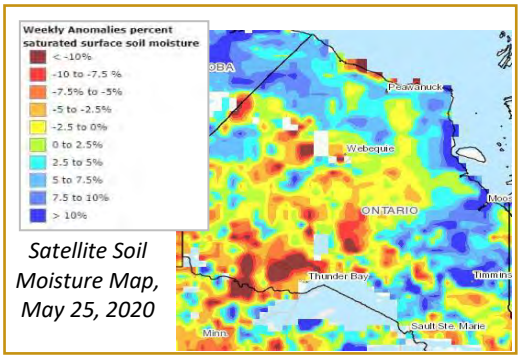
Examples of Drought Indicators	Examples of Drought Indices
- Rain or snow amounts - Temperature - Water flow in streams - Soil moisture - Snowpack	- Standardized Precipitation Index (SPI) - based on precipitation - Aridity index (AI) -based on precipitation and temperature - Vegetation Drought Response Index (VegDRI) - based on Satellite imagery, precipitation, temperature, available water content, land cover, ecoregion)

Online drought monitoring tools

Your community drought monitoring program can be supplemented with some online tools. Agriculture and Agri-Food Canada hosts the **Canadian Drought Monitor** (CDM) which combines data from federal, provincial, and regional sources and looks at a number of drought indicators and indices including temperature and precipitation, vegetation indices, stream flow values, and the Palmer Drought Index. Agriculture and Agri-Food Canada also shares data on other drought parameters including **Satellite Soil Moisture** (SSM) levels. CDM and SSM are available online at www.agr.gc.ca/eng/agriculture-and-climate/drought-watch/ .



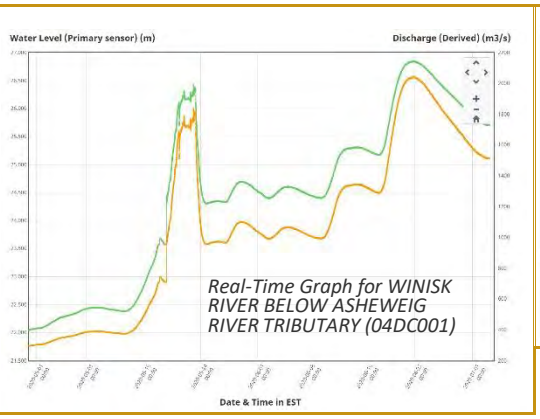
Canadian Drought Monitor map, Aug 31, 2018



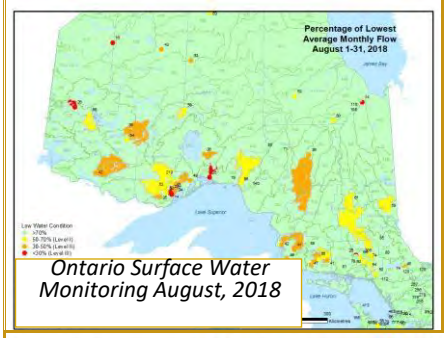
Satellite Soil Moisture Map, May 25, 2020

Online tools for surface water are also available. Real-time water levels for a number of stations can be found at EC's **Water Office** https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time. The **Surface Water Monitoring Centre** also provides information on low water levels and average precipitation for Ontario. Data is gathered from a number of stream gauge stations maintained throughout the province and can be found online at www.ontario.ca/page/surface-water-monitoring-centre#.

Water Office clickable water station map



Real-Time Graph for WINISK RIVER BELOW ASHEWEIG RIVER TRIBUTARY (04DC001)



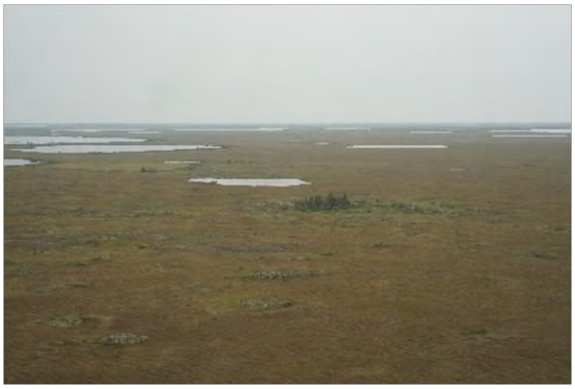
Ontario Surface Water Monitoring August, 2018

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

Ecosystems

Peatlands and Permafrost in a Changing Climate

The far north of Ontario has a unique and beautiful landscape. It is home to the Hudson Bay Lowlands, the largest peatland in North America, and boasts some of the southern-most lowland permafrost in the northern hemisphere. Climate warming is happening everywhere, but temperatures in the north are rising at twice the rate of other areas. What does this mean for Ontario's peatlands and permafrost?



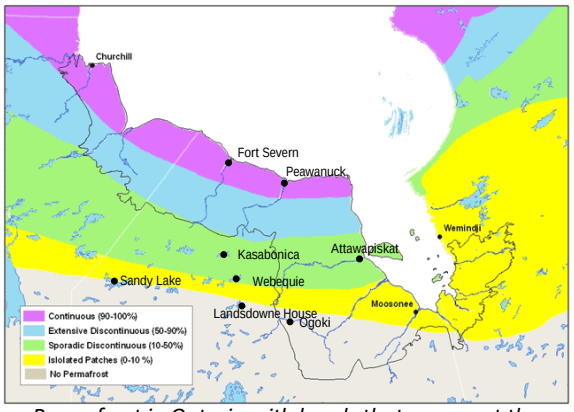
The Hudson Bay Lowlands is the largest peatland in North America

What are peatlands?

Peatlands are wetlands where the soil is made almost entirely from dead and decaying plants. In these constantly wet areas, decomposition happens slowly and dead plants accumulate, storing a lot of carbon. Peatlands also play an important role in regulating water flow (since they retain water like a sponge), and water filtration (by trapping pollutants and storing materials).

What is permafrost?

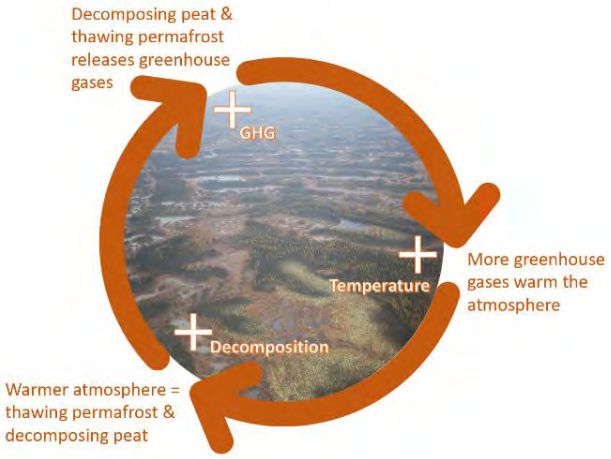
Permafrost is ground that stays frozen for two years or more. Due to the cooling effect of Hudson Bay, permafrost in Ontario extends further south than in other areas of Canada. In the Hudson Bay Lowlands, permafrost contains peat and has stored carbon for thousands of years.



Permafrost in Ontario with bands that represent the percentage of land that has permafrost

How will climate change impact peatlands and permafrost?

The north and its peatlands are predicted to warm which will cause decomposition to speed up. Climate change will be made worst by the fact that once you start to warm the peatlands, a positive feedback loop begins. Warming temperatures can cause the dead vegetation that makes up the peatland to decompose, releasing the stored carbon as greenhouse gases (carbon dioxide and methane) which causes more warming, which leads to more decomposition, and so on. Any permafrost within the peatland that thaws will increase this effect. A warming world means thawing permafrost which can affect the stability of the land. For instance, the land surface may sink, dry areas may become wet, bank erosion can accelerate, and slumping can occur. All of this affects plants and animals, complicates overland travel, and threatens infrastructure.



What have people noticed?

Changes in the land are already being noticed by people across the north. In places like Peawanuk and Fort Severn, thawing permafrost is said to be changing the landscape as palsas disappear and riverbanks erode. Along the coast of James Bay, people say the wetlands are now growing more shrubs, like willows. In communities across the northwest of Ontario, people say swamps and muskeg are drying up.

How can we prepare?

Identify and Protect Important Areas

Peatlands and the underlying permafrost are vulnerable to disturbance like ATV travel, deforestation, pollution and changes in water level. Removing shade-providing trees and disturbing insulating mosses can lead to permafrost loss and damage the ecosystem for years. Peatlands that are well connected to aquatic systems, those that house important wildlife or plants, or peatlands that may be especially sensitive to climate change are examples of areas that should be identified and offered extra protection. Protection may mean limiting logging, industrial activities, road development, and restricting ATV travel to roads and well used trails. Increasing public awareness of the significance of peatlands is also an important step in protecting these sensitive ecosystems.

Sphagnum mosses are a common feature of healthy peatlands in northern areas.

Monitor

Monitor the land for signs of changes. In peatlands, features such as height of the water table, dryness, and which plants, animals or insects are found there can be important in assessing the health of these systems.

Changes in the landscape can indicate permafrost loss. Palsas (frost heaves with an underlying ice lens) may collapse and leave an area wetter. Along slopes and hillsides, thawing permafrost can lead to landslides and thaw slumps. On flatter areas, the ground may become uneven and wetter. Roads can become wavy and houses can shift and crack when the permafrost underneath them thaws.

Possible indications of permafrost loss.

Fire and Contaminant 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 can't survive fires. Burning decreases the cover of mosses and affects the ability of the peatland to recover, which leaves underlying permafrost at risk of faster thawing.

Many species found in peatlands are sensitive to contamination and pollutants. Prevent contaminants from entering peatlands ecosystem by keeping garbage and other waste away from these areas.

Proper Engineering

Living and building on permafrost can be challenging. Properly engineering buildings and roads can prevent the thaw of permafrost and keep infrastructure from being damaged.

Peatland and the underlying permafrost are important to the well being of plants, animals and people. These sensitive areas are under threat of climate change and monitoring and protection are necessary.

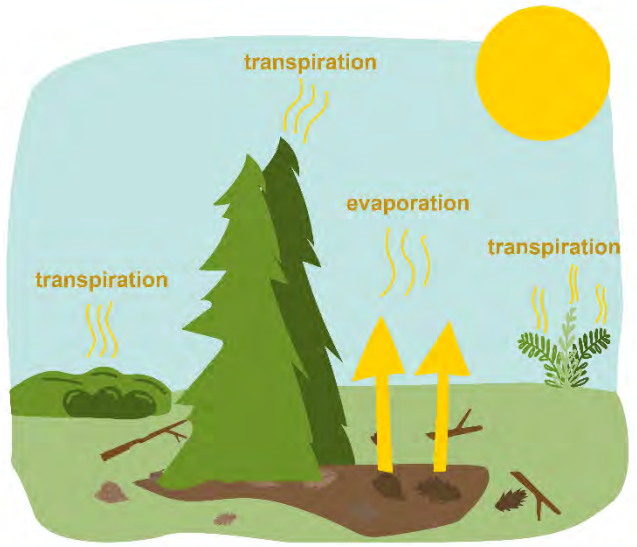
UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario

Forests of northern Ontario and climate change

Forests are home to an abundance of plants, animals and insects, providing traditional food, medicine, and resources like black spruce for canoes, roots, moss, and firewood. Forests are also an important part of the economy in many regions. How will climate change impact the forests of northern Ontario? And what effects are people already seeing?

Drier forests

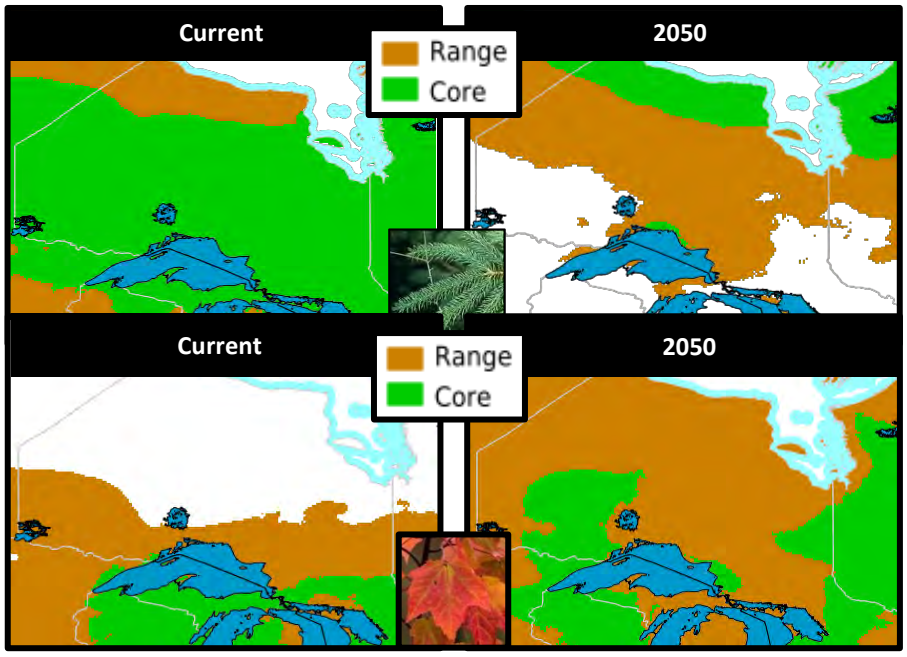
Even though climate change will likely bring more rain to Ontario, forests are predicted to become drier under future conditions. This is because hotter temperatures are also predicted. Heat draws moisture out of plants and soils, an effect called **evapotranspiration**. The hotter it is, the more the plants and soil will dry. Changing climate is also predicted to bring more days of heavy rain. When a lot of rain falls in a short period of time, the land can't absorb it all, and much runs off into lakes, rivers, and wetlands. One study of Canadian forests suggests that for every 1°C of warming that occurs, as much as 15% more precipitation is needed to maintain the moisture levels in forest fire fuels (dead leaves, sticks etc.)[1]. According to the Canadian Climate Atlas, Fort Hope, for example, can expect average summer temperatures to rise by about 2°C by the 2050s, while summer rain is only predicted to rise by 3%. Not only do drier forest conditions increase the risk of wildfire, but drought stress can also make trees and plants more susceptible to disease and insect attacks and can in extreme cases cause their death.



Evaporation (from soil, dead leaves, etc.) + Transpiration (from plants) = Evapotranspiration

Range Shifts

Plants and animals are well adapted for the environments that they live in. But as climate changes, the areas where species can live (their habitat range) is also going to change. Many species, like the white spruce, are predicted to shift north because the new conditions in the south will mean that they simply won't survive there anymore. This northward shift in the range of plants could lead to a forest that looks quite different to the boreal forest in northern Ontario of today with less spruce, pine and fir and more oaks, ash, and maples.



Core range (species is abundant) and range (species is found) of white spruce and red maple in the recent past (1970-2000) and projected to the year 2050. Maps from www.planthardiness.gc.ca

[1]*Flannigan, M. D. et al. Fuel moisture sensitivity to temperature and precipitation: climate change implications. Clim. Change 134, 59–71 (2016).*

Change in timing of events

Many biological processes in both plants and animals are driven by environmental cues. These cues, like temperature, amount of daylight, and precipitation, influence 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, and events could occur at different times than they have in the past. This could mean that species won't emerge at the same time as their food sources, or that conditions won't be right at breeding time. Changes like these can have big impacts on the health and survival of forest species.

Plants and insects have an important relationship. Flowers provide nectar to insects and while gathering the nectar, pollen sticks to insect bodies and gets transferred from one flower to another. As warmer springs push flowering earlier, the insects that pollinate them will need to keep up.

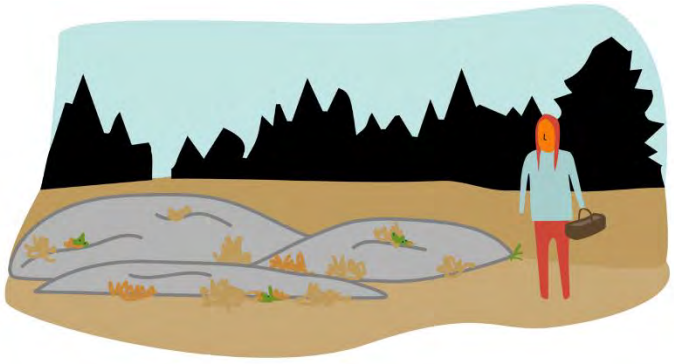
The caribou breeding cycle is timed by the sun and occurs steadily at the same time each year before the spring thaw. But as the north warms and ponds are thawing earlier, pests like mosquitos can emerge at the same time as the calves are born, stressing both mothers and calves.

Changes in tree disease and insect pests

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 exactly how is hard to predict. Most important tree diseases in Ontario, like root rot, are predicted to increase with climate change[2]. Warmer winter temperatures may allow the survival of pathogens, like stem canker fungi, and forest pests that are usually killed by the cold. Changing conditions could also mean new insects and diseases entering northern forests from the south.

Economic Impacts

Many communities in northern Ontario rely on the forestry industry but shifting habitat ranges may mean that species currently harvested for profit won't grow in the same areas that they do now. This could mean job and economic losses for some communities. On the other hand, warm weather could be a boost for the tourism industry with more opportunities for outdoor recreation.



What are people noticing?

Climate change is already affecting the forests of the north. Plants like Canada thistle are being seen in new areas. People on the James and Hudson Bay coasts are reporting that willows are growing more than ever before. And people in First Nation communities across the province are noticing dryer conditions in the bush, which is leading to fewer berries for harvesting.

Forests are changing in northern Ontario and that will impact the plants and animals that live there and the people that rely on the land. Read more

About forests: http://www.climateontario.ca/MNR_Publications/276928.pdf
About pollinators: https://www.neefusa.org/nature/plants-and-animals/buzz-changing-climate
https://www.sciencedirect.com/science/article/pii/S0960982212000103#bib8
About caribou https://www.theatlantic.com/science/archive/2015/09/arctic-mosquitoes-and-the-chaos-of-climate-change/405322/
https://royalsocietypublishing.org/doi/full/10.1098/rspb.2015.1549

[2]*Colombo, S. J. Ontario's forests and forestry in a changing climate. Climate Change Research Report CCRR-12. (2008).*

Protecting our forests – actions for climate change

The boreal forests of the north are an important and iconic part of our landscape. These forests are home to thousands of species of plants, animals and insects, and provide food, medicines, and materials for the people of the region. Climate change will have an impact on forest ecosystems, but there are actions we can take to help protect these places and the resources we rely on.

Identify Important Species and Important Areas

Forest area near Eabametoong First Nation

When deciding where adaptation efforts should go, communities may want to look at what species are most important to them and which might be the most at risk. Species might be considered important if they are a source of food, have traditional value or are part of the economy. At risk species could be ones that are already struggling, or those that are least able to withstand changing conditions. Important forest areas, like breeding grounds, important species habitat, economic areas, or traditional grounds, could be good places to create habitat protection plans or to update any measures that already exist. If forest fire is a threat to important areas, consider a FireSmart plan www.firesmartcanada.ca.

Monitor

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 done by environmental stewards, researchers, and community members. Community-based monitoring is when a community decides what to monitor and implements a monitoring program with or without a researcher as a partner. When community members gather information on their own 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. iNaturalist.ca is a good site that people in your community can use to share information as well as see what others have observed.

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

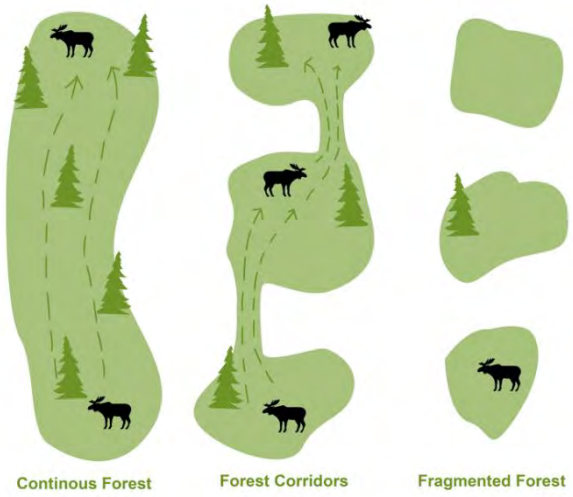
Protect and Improve Habitat

Healthy forests help support all species. Encourage good stewardship of forest areas and make sure that species have the habitat they need to live and thrive. Installing bird houses and bat boxes, or planting milkweed for monarch butterflies are common examples of how habitat can be improved for some species.

These bat boxes were assembled by Mushkegowuk youth at Camp Chikepak to be brought back and used in their community

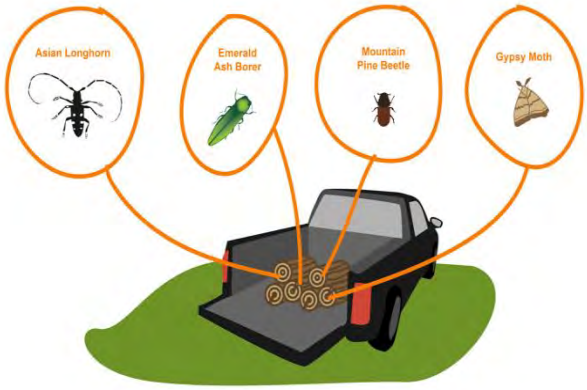
Keep Forests Connected

As climate change alters the landscape, some species will have to move to new areas where the habitat meets their needs. A fragmented landscape (where patches of forest are disconnected from each other) makes it difficult for species to move into new places. Keeping forests continuous or maintaining corridors between forest landscapes can help species that need to move to new areas. Make land use planning decisions that keep forests connected. Since forests can span large areas and cross regional boundaries, decisions to keep them protected and connected may require cooperation between communities, industries, and governments.



Prevent Invasive Species

Climate change is allowing forest pests to live in areas that they couldn't live in before. The first line of defense against invasive species is always prevention. People can take actions to prevent invasive species like not moving firewood (which could contain insect hitchhikers) from one area to another or planting native plants instead of the plants that are sold in greenhouses. Communities can also monitor for potential invaders in their area and have a control plan in place in case they arrive.



Assisted Migration

Climate change is happening quickly, so quickly in fact that not all species will be able to keep up. Trees may be especially vulnerable to rapid change since they are long-lived and their seeds land and germinate quite close to the parent tree. Programs where humans help species move to new areas in response to climate change is called 'assisted migration'. Assisted migration could mean: moving a species within its current range (like planting tree seedlings in the northern end of their range), moving a species to an area just outside its current range, or moving a species far outside its current range.

The movement of any species into a new location is not without risks. Species could become invasive or introduce pests and diseases. All risks need to be weighed carefully before using assisted migration.

Forest are changing! Let's help them out: identify, monitor and protect important species and places, keep forests connected, prevent invasive species and assist vulnerable plants with assisted migration.

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

Climate Change and Invasive Species

What are invasive species?

An invasive species is a plant, insect, or animal that is not native to a particular area (in other words, it hasn't lived there in the past). Invasive species have the potential to change the natural balance of an area.

How do invasive species get to new areas?

All species move around; animals and insects walk, fly or swim in search of suitable habitats; plant species expand their range by releasing seeds that float in the wind or attach to animals. This sort of movement tends to happen slowly over time and species will only establish themselves in areas of suitable habitat (temperature, moisture, nutrients, etc.). As the north becomes warmer due to climate change, the area where new species can survive is expanding. In addition, people are moving plants, animals and insects, knowingly or unknowingly, much farther and faster than natural movements.

People spread invasive species by:

- Moving boats and motors between lakes without cleaning them
- Releasing bait fish into local waterways
- Moving wood that could be carrying forest pests
- Planting non-native species
- Releasing unwanted pets
- Carrying them on your clothes, shoes, or wheels

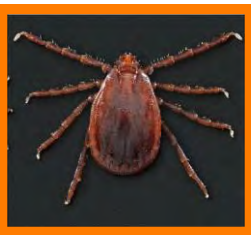
Are invasive species always a concern?

Not every new species that enters an area is going to have the same impact on the local environment. Some may cause little disruption, while others will have big impacts. Some invasive species are concerning because they drive out the native species in the region; others because they can impact local industries, like forestry. Some invasive species are concerning because they can impact human health.

Zebra Mussels, native to Russia, introduced through ship ballast water; they can create colonies so large that they take over fish spawning areas and beaches and can clog water intakes.

Mountain Pine Beetle; native to western North America but has been expanding its range. These insects bore into trees and, in large numbers, can lead to massive tree loss.

Giant Hogweed; native to Eurasia, introduced as a garden plant; has sap that can cause burns. It can be 2-5.5 m tall and resembles smaller native species like Angelica and Cow Parsnip.



Asian Longhorned Tick, native to Asia, arrived in the US through animal importation; it is predicted to be able to survive as far north as Ottawa and beyond with a changing climate.

How is climate change impacting invasive species?

As temperatures rise, plants and animals can move farther north; they may even be pushed out of more southern parts of their habitat 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. Fewer frost days in spring and fall are increasing the growing season and allowing plants to thrive in new areas.

What new species are people seeing in the north?

- Turkey vultures
- Pelicans
- Cormorants
- Bass
- Blacklegged (deer) ticks

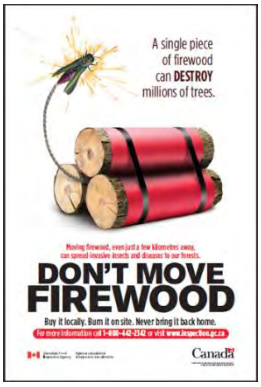
How can we prepare?

Prevention is key

People can do their part to prevent the spread of invasive species by:

- Cleaning boats and gear before bringing them from one waterway to another
- Disposing of baitfish on land
- Using local wood
- Planting native plants in gardens
- Cleaning mud and seeds off shoes and tires

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. Ways to spread information can include signage at boat launches and other vulnerable locations, posters and brochures in public areas, education in schools, and radio and television campaigns.



Monitor

Know what is new to your area and what has the potential to come into your area. Some invasive species are monitored by provincial, federal, or community programs, but monitoring for new species is really a group effort. Within these programs and outside of them, citizen science (when area residents record or report environmental information) is an important component.

Report invasive species in your area:

- Invading Species Hotline 1-800-563-7711 www.invadingspecies.com
- Early Detection and Distribution Mapping System for Ontario (EDDMapS) www.eddmaps.org/ontario or as an app

Control measures

When a new species causes or has the potential to cause major damage or disruption to the ecosystem, control measures may be needed. Control measures can be simple (like pulling and disposing of invasive plants found growing on your property) or extensive (like the sea lamprey protocol in the Great Lakes basin). How your community might deal with an invasive species can be discussed and decided before a species enters the area. That way, if a destructive invasive species does enter the region, response can be quick and, hopefully, effective.

Want to know more?

Check out http://www.invadingspecies.com/ and https://www.invasivespeciescentre.ca/

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

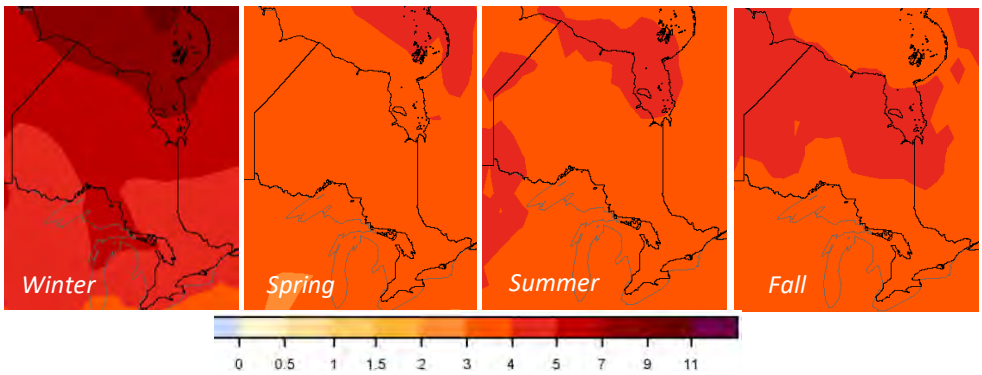
In Hot Water –

How climate change impacts our aquatic environments

Aquatic environments like lakes, rivers, and wetlands, are important for animals and humans alike. The impact of climate change on these systems is already being noticed in the north, a trend that will likely continue. Knowing how climate influences these systems can be a helpful step in determining adaptation approaches moving forward.

The impacts of higher temperature

Climate change is expected to bring higher temperatures in all seasons, with northern areas often seeing the biggest increases. As the air warms, so does the water. As such, we can expect to see increases in water temperature in lakes, rivers, and wetlands across the north.



Projected temperatures increase (in °C) for 2050 compared to the average for 1986-2005 assuming little to no reduction in carbon emissions (RCP 8.5, 75th percentile). From http://climate-scenarios.canada.ca/?page=download-cmip5

In aquatic systems, water temperature is a major determinant of habitat suitability (where plants and animals can live). Fish are a good example of this. Being cold-blooded (meaning their body is the same temperature as their environment), fish are very dependant on the temperature of the water around them and will seek out areas with the right water temperature. This means that where fish species can live and thrive is likely to change as the climate warms. This is especially an issue for coldwater species, like trout, that may find it difficult to find cold water.

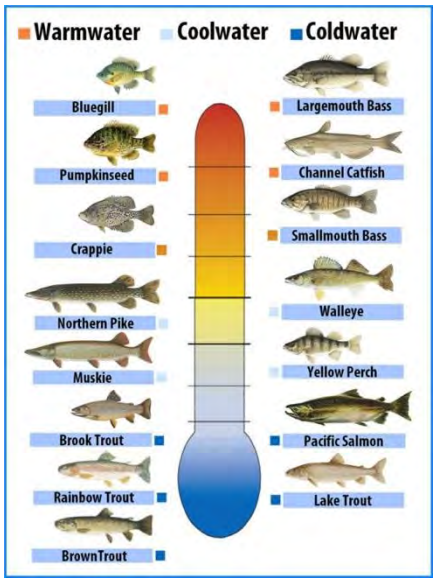
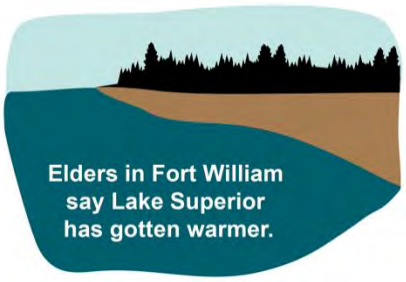


Chart of relative water temperature preferences for fish found in Ontario

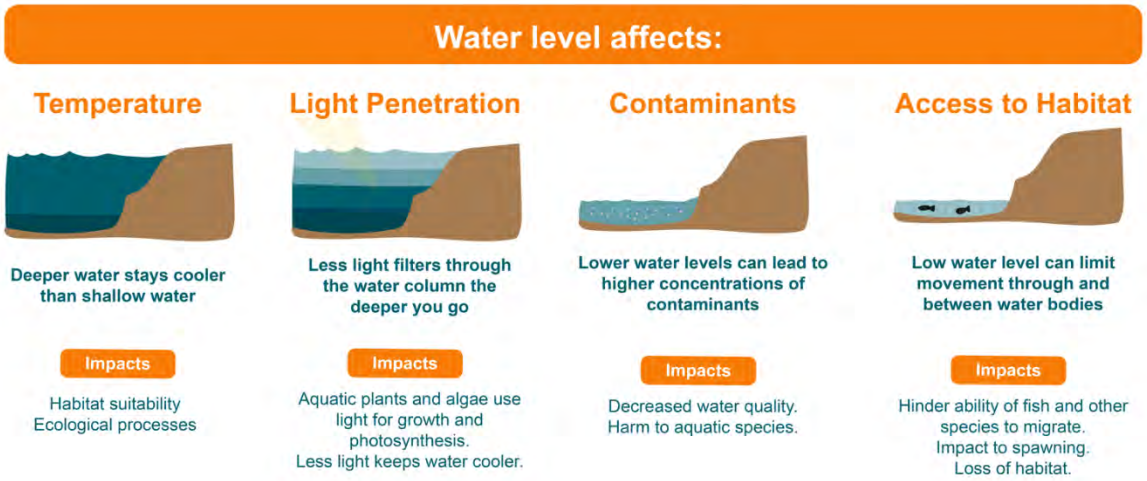
Water temperature can also impact ecological processes like nutrient cycling (how elements like carbon, oxygen, and nitrogen move through the environment). Warmer temperatures increase how quickly algae and aquatic plants grow and as they go through their life cycle they increase the cycling of nutrients. In some lakes, this sort of increase could lead to eutrophication (an increase of nutrients in a lake) which can lead to algal blooms When these algae decompose under the ice in winter, oxygen is used up and lead to fish kill in winter.



Warmer conditions may also open the door to invasive species who can take advantage of this new environment. For example, plants like Eurasian milfoil will grow quickly and shade other plants preventing them from growing.

The impacts of water level changes

Water levels in lakes, rivers, and wetlands are influenced by factors like precipitation, inflow, and evaporation, all of which can be impacted by climate change. Warmer air is an important factor increasing the rate of evaporation. As lakes, rivers, and wetlands lose water to the atmosphere, their water levels can decrease. How much precipitation falls, when it falls, the intensity of the event, and whether the precipitation comes as rain or snow, all impact water levels as well. In general, Ontario is predicted to get wetter but exactly how and where that precipitation will fall is harder to predict. Current research suggests that intense rain falls could become more frequent. Winter snow depth is also predicted to decrease, which can impact water levels even in subsequent seasons. Water level can have a big impact on aquatic systems, influencing water temperature, light penetration, contaminant levels, and access to habitat for animals.



The impacts of less ice

Climate change is already leading to shorter ice-on seasons in the north. For lakes, decreased periods of ice and longer periods of open water mean an increase in evaporation, affecting water levels. Lake ice cover also serves to protect shorelines from erosion in shoulder periods (late fall and early spring) when strong winds can increase wave action. However, shorter ice cover can also have positive effects on lake and river systems by allowing more oxygen into the water in shoulder seasons and reducing the chance of winterkill of fish.

The impacts of wind

Wind is an important factor in lake ecosystems. Increases in wind have the potential to increase evaporation, speed ice-out, deepen thermocline (the transition between the hot water layer at the top and the cold water layer near the bottom of lakes in summer), and increase sediment deposition. In summer, near surface wind speeds are predicted to decrease by up to 10% across most of Ontario while increasing by up to 10% the rest of the year.

Higher temperatures are impacting aquatic systems and the animals and plants that live there.
Read more: A Summary of the Effects of Climate Change on Ontario's Aquatic Ecosystems, MNRF-CCRR11
https://files.ontario.ca/environment-and-energy/aquatics-climate/stdprod_088243.pdf

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

Protecting our Water:

Adaptations for aquatic ecosystems

Aquatic systems, like lakes, rivers and wetlands, are vital resources. Not only are these rich environments home to many important species, they also provide freshwater, food, and other resources. Changes in climate are already making a mark of these ecosystems, with more change predicted to come. But there are actions we can take to help protect these important places and, hopefully, lessen the impact of climate related changes.

Monitoring

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

Water quality parameters

There is a lot that water can tell us about an aquatic system. Some qualities, like temperature, can be measured quite easily on site with a simple thermometer. Other properties, like pH, oxygen levels, and conductivity, can be measured on site with the help of a scientific instrument like a multiprobe. Other parameters, like amounts of metals, nutrients, and other components can be determined from water samples sent to qualified labs.

These probes can be used to measure water parameters like pH, oxygenation, and conductivity.

Systems trends

Water levels, freeze-up and break-up dates, and migration or spawning times are all examples of trends in aquatic systems that are likely to be impacted by climate change. Communities can decide what trends to monitor based on their specific interests and needs.

Species monitoring

There are many reasons you may want to monitor species in aquatic environments, and many different kinds of species that may be of interest. You may want to monitor because of an impact, like mining, or a concern about overfishing, or simply to get an idea of the current status of species. Monitoring might be aimed at fish, benthic invertebrates (bugs in the sediments), species at risk, or invasive species. Communities can decide what species to monitor based on their specific interests and concerns.

Identify Important Areas

Areas that are ecologically important or vulnerable to change are a good place to use your resources. These might include: wetlands, spawning grounds, cold water refuges for fish, migration routes, or habitat for vulnerable species. Plans of action for these areas might include restoration, enhancement, protection, or increased monitoring.

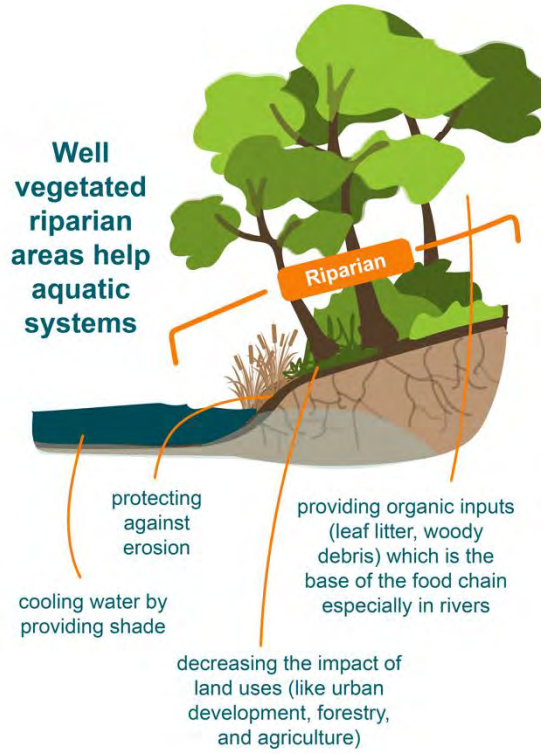
Manitoulin Streams Improvement Association is a grass-routes organization dedicated to the rehabilitation of important fish habitat that has been damaged due to human activity. Learn more about their work at www.manitoulinstreams.com

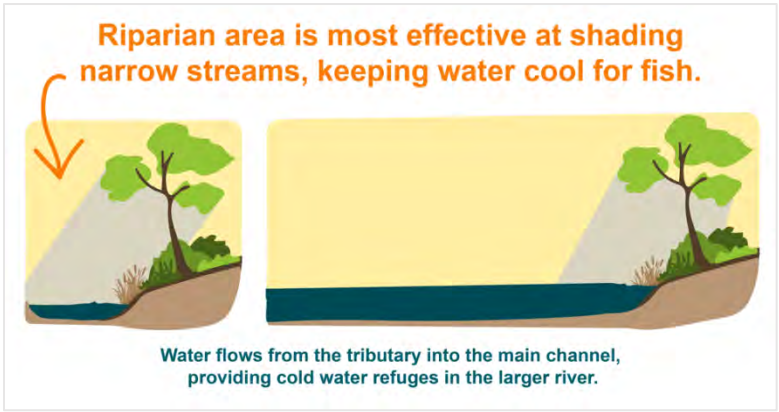
Improve System Health

A system that is already stressed or degraded may be more vulnerable to the impacts of climate change. It is important to protect the land as well as the water habitats. This, in turn, will protect water quality and the plants and animals that live there. Improve or rehabilitate habitats that have been damaged and decrease non-climate stressors on aquatic systems such as: pollution, deforestation, water extractions, over harvesting, and wetland destruction. 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.

Establish or increase vegetation in riparian zones

Riparian zones are the areas along the banks of waterbodies. The health of the water system greatly depends on this area. A well vegetated riparian zone with native trees, shrubs and grasses can greatly benefit aquatic environments by cooling water, limiting erosion, and providing important nutrients to the aquatic ecosystem in the form of leaves. Riparian areas that help protect a waterway from nearby land uses is sometimes called a buffer zone. Buffer zones help waterways by filtering surface runoff water and capturing sediment, nutrients, and pollutants.





Youth learning about Aquatic environments in Fort Severn and Attawapiskat

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.

Our lakes, rivers and wetlands are facing important challenges. Help them by protecting them and the land around them, monitoring them and advocating for them.

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

Warming Water and Cold-Water Fish

Many fish species that are harvested across the north need cool or cold water to live and thrive. What does a warming climate mean for these fish? And how can people prepare?

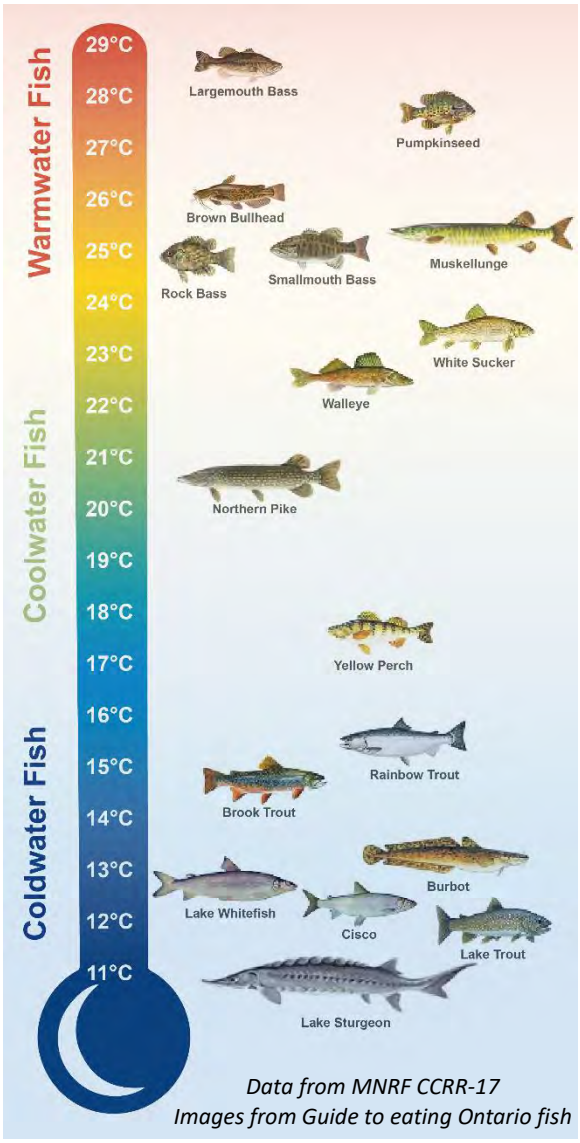
Why is water temperature important to fish?

Water temperature is important to fish because they are cold-blooded animals, meaning their body temperature depends on the temperature of the water surrounding them. Temperature influences many of their biological processes, like spawning and growth. Exactly what water temperature a fish prefers varies from species to species but, in general, fish in this region are categorized as either warm-water fish, cool-water fish, or cold-water fish.

What does climate change mean for cold-water fish?

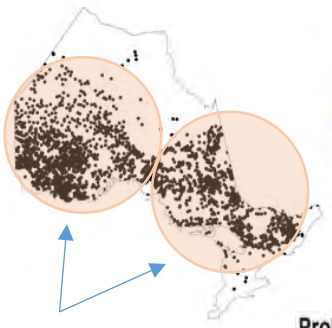
Climate change is predicted to bring warmer temperatures across Ontario. This means that there will likely be fewer places where cold-water fish (like brook trout, cisco, and lake whitefish) can live, and they will be found less in the south as they thrive more in the north where cold water will remain. Cool-water fish (like walleye and northern pike) will be affected in the same way.

Warm-water fish (like smallmouth bass and rock bass) on the other hand, will likely be able to live in more Ontario lakes than they do now, and will be able to survive further north than they have before.



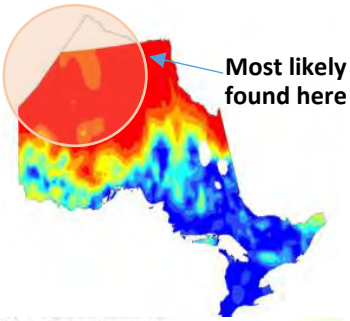
Data from MNRF CCRR-17
Images from Guide to eating Ontario fish

Walleye 1957-2012



Mostly found in these areas

Walleye in 2050



Probability of occurrence

Highly unlikely — **Very likely**

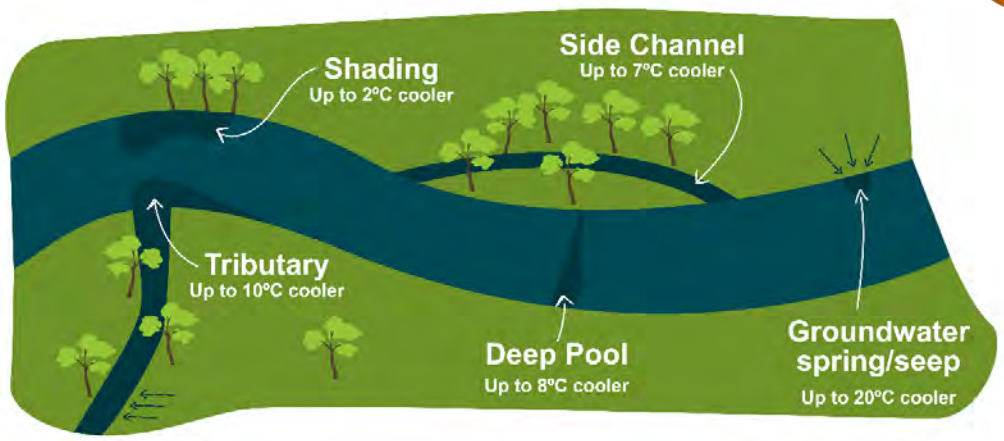
The maps show how the habitat range of walleye is predicted to shift as climate changes. These cool-water fish will survive better further north as water temperatures rise in the areas where they were found in the past.

What have people noticed? In First Nation communities across northern Ontario, people are already noticing warmer water in lakes and rivers. In northeastern Ontario, many communities say they've seen more bass, with bass being reported as far north as the James Bay coast.

**Maps modified from: Van Zuiden, T.M., et al. (2016). Projected impacts of climate change on three freshwater fishes and potential novel competitive interactions*. Diversity and Distributions*, 22(5), 603-614*

How can we prepare?

Identify and protect cold water refuges



Areas of differing temperatures within a stream. I with cooler water shown as a darker colour. Graphic modified from Kurylyk, B.L. et al. (2014). Preserving, augmenting, and creating cold-water thermal refugia in rivers: concepts derived from research on the Miramichi River, New Brunswick (Canada). Ecohydrology, 8(6), 1095-1108.

When temperatures get too hot, cool-water fish and cold-water fish will seek out cooler water. In lakes, this can mean going deeper. In streams, it can mean finding spots called cold water refuges. Cold water refuges can occur in shaded or deeper spots, or where cooler water is coming into the main channel through smaller streams or groundwater sources. Looking at maps or traveling the land can be useful for scouting areas where cold water refuges may be located. Local traditional knowledge might also give insight about where cooler water can be found. High tech methods, like remote sensing (using satellite, aerial, or thermal images to get information about the land) could also be used.

Once cold-water refuges are identified, they should be protected. Avoid taking water out of these systems, keep the trees and other vegetation that provide shade, limit development, and make sure tributaries and groundwater sources aren't blocked from entering the main channel. It's also important to keep nutrients, like those that come from fertilizer, septic systems, and household detergents, out of deep water lakes. These nutrients promote the growth of plants like algae that use up lake oxygen when they decompose, making less oxygen available for fish especially in winter. Some in-stream structures, like weirs, deflectors, and pools, may also be able to offer some temperature-related benefits to a stream or river.

Create or improve riparian areas

Shoreline vegetation (called riparian vegetation) provides shade allowing for cooler water. Riparian vegetation can be especially effective on smaller streams, like tributaries and side channels, because shading can cover a larger proportion of the water. The plants and trees of riparian areas should be protected. If there are few trees, consider planting some.

Water flows from the tributary into the main channel, providing cold water refuges in the larger river.

Protect migration routes

Whether it's for finding a cold water refuge, for spawning, or for moving northward as habitats change, fish have to be able to get from one spot to another. Protect fish migration routes and the waterways that connect lakes and rivers. Low water in rivers, streams, and creeks can also make it harder for fish to move between and within river systems. Avoid taking water out of these systems. In some cases, water control structures, like dams, could be useful in controlling water levels but fish ladders must be provided to allow fish movement.

Cool and cold water fish will be challenged by the increasing temperatures predicted with climate change. Help them by protecting their habitat especially cold water refuges, riparian areas, and migration routes.

Read more https://files.ontario.ca/environment-and-energy/aquatics-climate/stdprod_088243.pdf

Flooding

When the Snow Melts: Preparing for Localized Flooding

After the chill of winter, many people look forward to the arrival of spring. But snowmelt and spring rain can cause troublesome flooding in some communities. In some areas, climate change may worsen localized flooding in winter and spring.

What is localized flooding?

Localized flooding refers to flooding in a particular area that happens because of a specific event, like snow melt or heavy rain. Often, this sort of flooding occurs because the infrastructure that is supposed to move water away from the community (like ditches) gets overwhelmed and water stays in the community, pooling in low-lying areas. Localized flooding can cause damage to buildings (through flooded basements or sewer backups), roads (causing washouts), and other infrastructure. Any low-lying area in a community is at risk of localized flooding.

The runoff from spring snow melt pools around homes in Fort Hope.

This road in Northern Ontario floods every spring, leading to closure. Photo from https://www.cbc.ca/news/canada/sudbury/hwy-537-mto-rehabilitation-1.4573211

Why does localized flooding happen in spring?

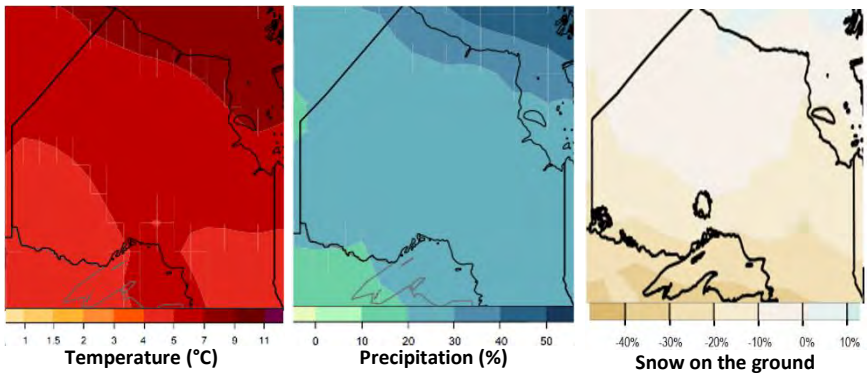
As temperatures warm, melting snow can mean a lot of water on the landscape. If the ground or local waterways are still frozen, this can mean that there is nowhere for that water to go and, instead of draining away, it pools, causing flooding. This can be a bigger problem if snow melts very quickly. Spring rains can also cause localized flooding because the rain can't seep into the frozen ground and stays on the surface. The same problem can happen when rain events happen in the winter.

What have people noticed?

Already, many people feel that spring is warmer than it used to be, and that rain arrives earlier. The weather station in Kitchenuhmaykoosib Inninuwug (Big Trout Lake) has also recorded warmer spring and winter temperatures. People in the north also speak of experiencing more rain in the winter than they used to.

Will localized flooding change because of climate change?

Climate change is expected to bring warmer winter temperatures and more snowfall meaning that there will be thinner layer of dense snow on the ground (that holds more water). This can lead to faster surge of melt in spring. More rain is also expected in winter and spring which can increase the chance of localized flooding.



Northern Ontario will see an increase in winter temperature (°C) and precipitation (%) as well as a decrease in snow on the ground (%) by the 2050s compared to the average from 1986-2015 (CMIP5, RCP8.5, 75th percentile). http://climate-scenarios.canada.ca/?page=download-cmip5

How can we prepare?

Improve community drainage

Flooded buildings and roads, as well as pools of standing water are all indications that a community drainage system isn't working as well as it should. Make sure ditches and culverts are clear from blockages and are big enough to handle the amount of water that comes with spring melt. Drainage systems should follow the natural slope of the land, so gravity can help take the water away from buildings and roads. A good drainage plan should also include water storage areas, like wetlands.

Damaged or blocked culverts and ditches can't carry water away like they should.

Drain water away from buildings

Keep water from making its way into homes and buildings by sloping the ground around a foundation so water flows away. If the ground around a home or building is level, consider trenching or grading the property to manage melt water and rain. Homes and community buildings can also have their own drainage systems which can include weeping tile, a sump pump, and eavestrough with drain pipes, all to promote drainage away from the house.

Sloping the ground around houses helps water drains away from the foundation into the ditch.

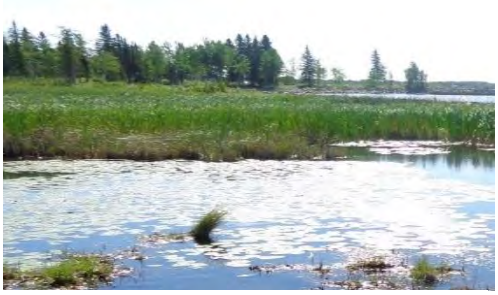
Manage snow

When clearing snow from driveways and parking lots, keep snow melt in mind. Make sure snow is piled away from buildings, preferably in an area where melt water can drain away safely. In some cases, this may mean moving the snow to another location. Snow can also be removed from roadside ditches before the spring melt begins. This allows the ditches to more effectively carry water away from the community, promoting drainage and, hopefully, reducing flooding.

Taking snow out of ditches allows water to flow away in spring Photo from www.plowsite.com

Wetlands and greenspace

Natural areas in communities can help absorb the water from spring rain and snowmelt. Surfaces like packed gravel, pavement, and concrete don't allow water to absorb; water that hits those surfaces either pools on top or runs off following the slope of the land. Natural areas on the other hand, like lawns, parks, or forest, absorb water and keep it from causing flooding. Wetlands can be especially good at this and can provide natural flood mitigation by storing the water from rain and melt events and releasing it slowly.



Wetlands act as natural sponges that trap and slowly release water, helping prevent flooding.

Climate change will likely continue to bring warmer springs with fast snowmelt and more rain on frozen ground. Communities need to prepare by sloping the ground away from buildings, making sure drainage systems work well, managing snow and preserving natural areas like wetlands.

Want to know more?

The Northern Infrastructure Standardization Initiative can be a good resource www.scc.ca/en/nisi

Ice Jams: How will they change? And how can we prepare?

What is an ice jam and how does it cause flooding?

Ice jams are caused when pieces of river ice that are moving downstream with the current build up against an obstruction, like a more solid sheet of ice. That ice builds up then grows or thickens enough to slow the flow of water. As a result, water levels upstream of the jam increase.

These events, which can occur during freeze up, break up, 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 jam floods can be particularity dangerous since water levels can rise quickly and large pieces of ice can cause additional damage.

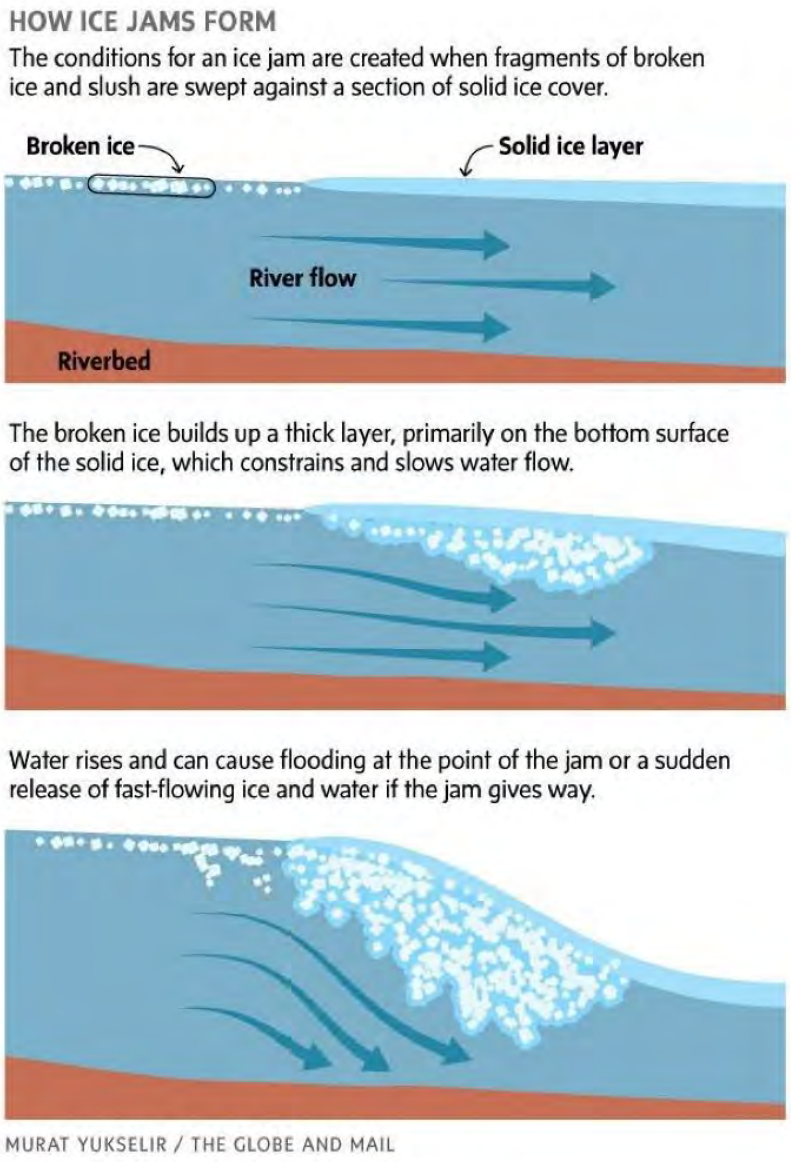


Image from https://www.theglobeandmail.com/technology/science/winter-flooding-risk-in-canada-expected-to-increase-as-climate-warms/article38078061/

How will climate change impact ice jam flooding?

The formation of an ice jam depends on a number of factors, including the thickness of the ice, the flow of the water, and the shape of the river channel. Because these factors are site-specific, it's difficult to make a single statement about how the frequency of ice jams will change with climate. Scientists do know that climate factors, such as temperature, amount of precipitation, and type of precipitation (whether it falls as rain or snow) are a big influence on ice break up and jam formation.

The impact of climate change on ice jam formation will likely vary depending on where you are, and from season to season. For example, warmer regions might have thinner ice and more mid-winter break ups. In more northern areas, temperatures and ice thickness might allow for only small mid-winter thaws, but these small thaws could cause broken ice to be swept downstream against patches of thicker ice which can then freeze together, thickening the ice increase the risk of jams in the spring. This is especially true of the large rivers that begin in the south and drain into Hudson and James Bay.

How can we prepare?

Monitor

Monitor river conditions, especially during break up. This could be particularly important for rivers that have had ice jams in the past. Traditional Ecological Knowledge (TEK) could be an important component for determining if ice jams have happened in the area and where they might have occurred.

Land use planning

Knowledge of flood plains and past high-water levels can help identify areas of communities that may be vulnerable to flooding. These areas should be avoided when new development is considered. In some cases, communities may want to consider relocating structures built in areas prone to flooding.

It should be noted that ice jam flooding can result in even higher water levels than other open-water flooding events. Knowledge of past ice jam flooding from TEK or local memory can be helpful in determining the extent of flooding that could be expected.

Promote ice decay

In areas where jams are common, reducing the quality of the ice to promote melting can prevent a jam or reduce its severity. Some examples of this include ice cutting (slots cut into large sections of ice), hole drilling (drilling holes into the ice at equal intervals) and ice dusting (spreading dark material across the ice to absorb sunlight). On some rivers, like the Red River in Manitoba, ice-breaking vessels are deployed to reduce the chance of large ice pieces causing jams.

Ice dusting can promote melting. Snow was covered with sticks and has melted about 30cm below the surrounding snow.

Amphibex machines (icebreakers) on the Red River in Manitoba, March 2019. Image from https://www.cbc.ca/news/canada/manitoba/amphibex-ice-breaker-manitoba-flood-1.5072933

Fixed structures

Structures for ice jam prevention can be quite effective but are also more expensive and not always feasible for remote areas. Structures can include dykes (for holding back flood water), ice booms (man-made barriers with floating sections installed across the channel to control the movement of ice), and ice-retention structures (such as rows of concrete piers to stop the downstream movement of ice).

Dyke along the Albany River, South Channel [1]

Ice boom on the Rupert River, James Bay region [1]

Erindale Park ice retention structure on the Lower Credit River[2]

[1] *Abdelnour, R. Albany River 2008 Ice breakup: forecasting the Flood Event, Observations of the River during the Spring breakup and the Potential for mitigating the Flooding Risk of the Kashechewan and Fort Albany First Nation. Proc. 17th Work. River Ice 16 pages (2013).* [2] *https://cvc.ca/news/story/cvc-clears-debris-in-river-to-help-prevent-future-flooding/*

Although it is difficult to predict if ice jams will happen more often because of climate change, we know that the climate will change. Northern rivers may be at higher risk of ice jams because they begin in the south where ice melts more quickly than it does where communities are located along the Hudson and James bays.

Want to know more?

Read this paper: https://www.sciencedirect.com/science/article/pii/S0165232X07001796

You can contact UpNorthOnClimate@laurentian.ca to get a copy

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

Major Flooding around Lakes and Rivers

When lakes and rivers overflow their banks, homes, roads, and communities can be flooded. This major flooding can have big impacts infrastructure in communities and the safety of people who live there. Major flooding could get worse with climate change. How can communities prepare?

What causes major flooding?

Major flooding from waterbodies like lakes and rivers happens when there is more water flowing into the system than there is flowing out. This extra water can overflow the banks of the lake or river and flood the surrounding land. Large amounts of rain, runoff from snow and ice melt, or a blockage in the system (like an ice jam) can all cause major flooding. In coastal communities, storm surges can also lead to major flooding. Storm surges happen when windy conditions push ocean water past the shoreline and onto the land.

Low-lying Kashechewan First Nation often floods in the spring because of melting upstream on the Albany River. Photo from Albany FB group

How will climate change impact major flooding?

Across Ontario, climate change is likely to make major flooding events occur more often. With climate change, Ontario is expecting more rain and snow, with heavy rain events (50-150 millimetres of rain falling in 24 hours) predicted to happen more often. Less snow on the ground and warmer spring temperatures could mean a quicker spring melt, which can also overflow lakes and rivers. An increase in storm severity could make storm surges more likely to happen, increasing the risk of flooding in coastal communities.

What are people noticing?

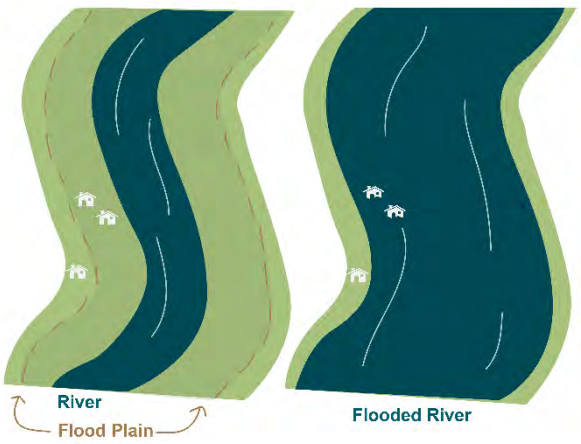
Many First Nation communities have been established near lakes and rivers. Lakes and rivers provide drinking water, food, and transportation corridors but building near water can make communities vulnerable to major flooding events. Already, flooding is a problem for some First Nations communities. On the James Bay coast, Kashechewan First Nation is evacuated on an almost yearly basis because of the threat of flooding. In other communities, lake levels have gone up higher than in the past.

The threat of flooding in Kashechewan has recently led to yearly evacuations of community members. Photo from **https://nationalpost.com/news/canada/we-cannot-continue-to-live-this-way-flood-risk-forces-kashechewan-evacuation-for-fourth-year-in-a-row**

How can we prepare?

Avoid building on flood plains

A flood plain is an area of low-lying ground next to a lake, river, or other waterway. These areas are susceptible to flooding and should be avoided when planning new development, including housing and roads. Since many remote communities do not have flood plain maps or water level records, traditional knowledge about high water levels and past floods are a valuable tool for future planning. In some cases, communities may want to relocate infrastructure that has already been built to higher ground



Monitoring and forecasting

Monitoring for the conditions that can lead to flooding (like weather, water levels, etc.) can help communities be prepared for potential flood events. Communities can take ownership of their own monitoring with systems like NetAtmo, weather stations with online software for recording local weather. Provincial and federal programs also collect data related to flooding and flood prediction, including real-time monitoring of water levels and water flow, and a flood forecasting and warning program.

Water level monitoring stations. https://wateroffice.ec.gc.ca/

Flood forecast mapping in Ontario. https://www.gisapplication.lrc.gov.on.ca/webapps/flood/

Traditional knowledge, together with measurements of past climate, can also help to build a better understanding of flooding trends in remote areas. Communities that experience regular flooding may want to partner with consultants to create a flood forecasting model for their area to look at the conditions that have caused flooding in the past to predict conditions that are likely to result in a flood in the future. Flood forecasting models can potentially give communities advanced warning of a flood event, allowing time for emergency measures such as evacuations.

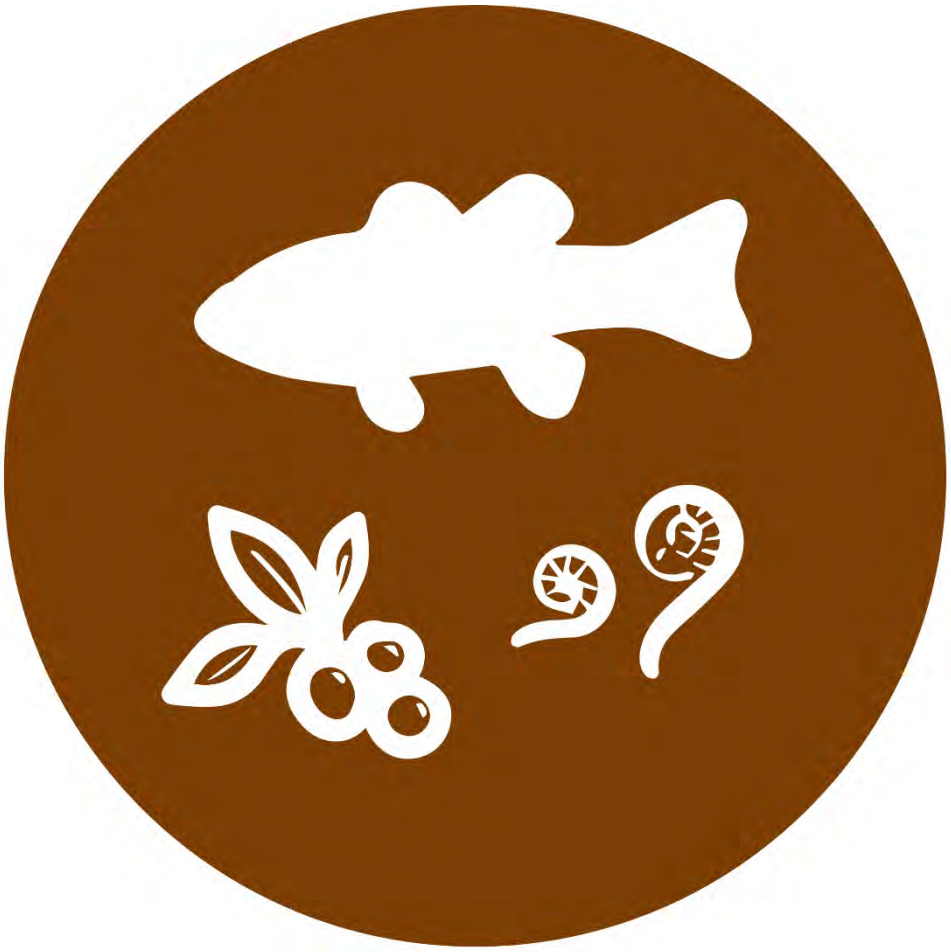
Emergency Planning

An emergency plan can lower the risk to people and infrastructure in the event of a flood. A community plan could include measures for community protection (like sandbags), a list of vulnerable residents, evacuation plans, and/or a refuge center. Communities can also encourage households to be ready for emergencies by providing information, like a packing list for evacuation or a list of supplies that might be useful.

Structures for water level regulation

Structures like dams, dikes and berms are sometimes used for flood control in areas where floods have happened in the past. Other structures like ice booms, and ice retention structures, are used to prevent ice jams, which can be a cause of major flooding.

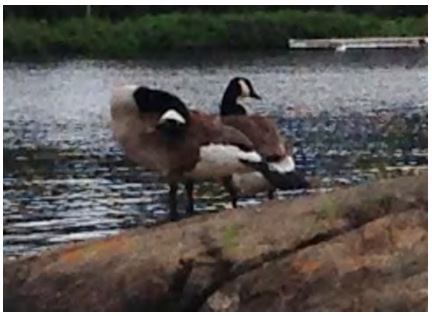
Climate change could make major flooding events more common in Ontario because of faster snow melt and heavy rain in the spring. People and communities should prepare by building above past high-water levels, monitoring water levels and rain events, listening for flood warnings and creating an emergency plan.



Food Security

Geese, Duck and Grouse in a Changing Climate

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. Ducks return to the north in the spring as well. Grouse and Ptarmigan don't migrate but instead survive the cold northern winters by eating buds and some hide under the snow. These birds are important country foods for communities in the north.

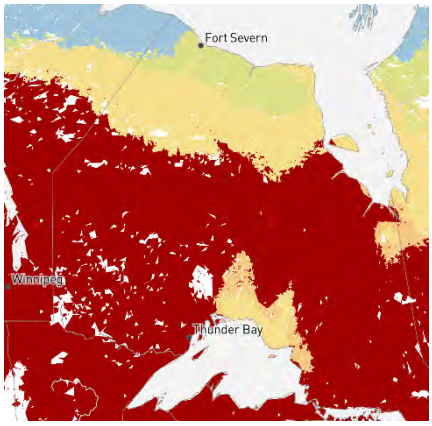


What have people noticed?

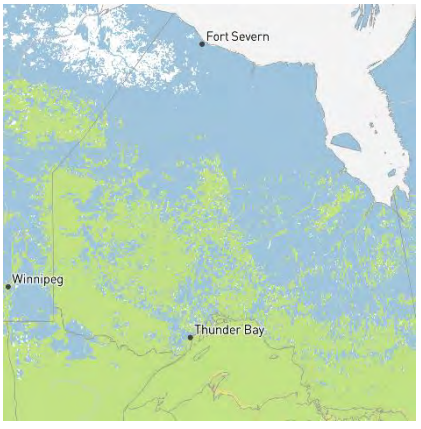
Several communities have noticed changes in vegetation in their area including a disappearance of certain grasses and increased growth of willows that may be impacting important feeding and nesting habitat for the geese. People have also noticed a change in the migration patterns of geese. Snow geese have been observed migrating south in the fall earlier than they used to, leaving around mid-August or early September, as opposed to the third week of October, while the spring migration route of Canada geese is seen as becoming more inland and less coastal. Many people report that there are fewer geese and ducks than there used to be, and some have said that duck meat doesn't taste the same as it used to. Some communities say they have found fewer grouse or partridge.

How could climate change impact these animals?

Ducks and grouse are 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.



Ruffed Grouse (summer)



Mallard (winter)

These maps show the predicted change of habitat range ruffed grouse in summer and mallard in winter by the year 2080 when the temperature is predicted to increase by 3°C. https://www.audubon.org/bird-guide

How can we prepare?

Adjust Harvesting Practices

Many First Nations hunters have already needed to adjust their harvest time and methods, particularly in the fall and early winter. Many community members have said they now have to travel further to hunt or gather traditional foods. This may require more costly means of transportation, such as a vehicle, ATV or snowmobile or even helicopters that some communities are now organizing for goose hunting. As some birds become less common on the land and others become more common, perhaps hunters can switch which species they hunt.

Community Initiatives

Community coolers can help lower the risk of meat spoilage by providing people with a cool place to butcher or store meat they harvest. Sharing harvested meat within a community and starting community gardens can also help increase food security for everyone.

Community garden in Fort Albany FN

Community cooler in Chapleau Cree FN. Photo by D. Souliere

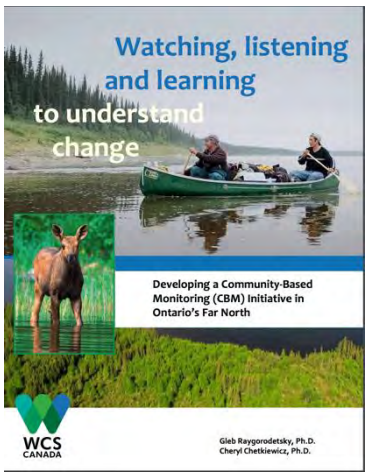
Habitat Restoration and Protected Areas

Important habitats for geese and duck are staging areas for resting during migration, nesting sites for successful production of chicks and wetlands to keep their chicks safe. Identifying these areas 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.

Monitoring

Understanding what is happening with the geese, ducks, and grouse in your area can be an important step towards developing adaptation plans now and into the future.

Monitoring activities can take many forms and can be conducted by environmental stewards, researchers, and community members, alone or in partnerships. It can involve hunters, trappers, and other land users collecting observations while out on the land, or more high-tech methods like GPS tracking. Many communities have created their own monitoring programs, often called “Community-based monitoring”. These community-led programs are often driven by local information needs and guided by the values of the community.



Want to know more?

Community-based monitoring:
https://www.wcscanada.org/Portals/96/Documents/WCSCanada_CommunityBasedMonitoring_2017%20(1).pdf?ver=2018-02-21-090420-447

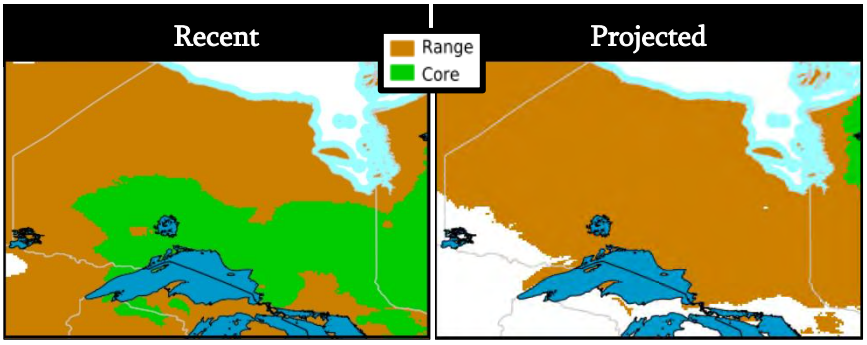
Range prediction maps for birds in Ontario,
https://www.audubon.org/climate/survivalbydegrees

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

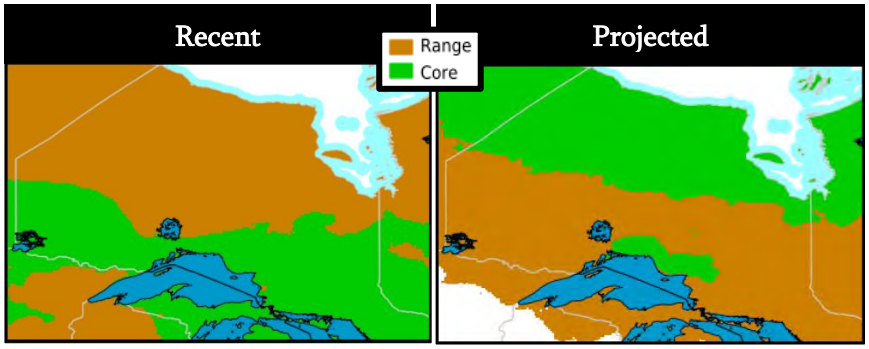
Shifting North: Berries & Plants

Climate change is likely to impact important traditional and medicinal plants as well as berries. For example, wetland plants like wild rice, cedar, cranberries, cloudberries and Labrador tea will be impacted by changing water levels, 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. In some instances, climate change may benefit key berry producing plants or expand the types of berries and plants that can be cultivated in northern regions.

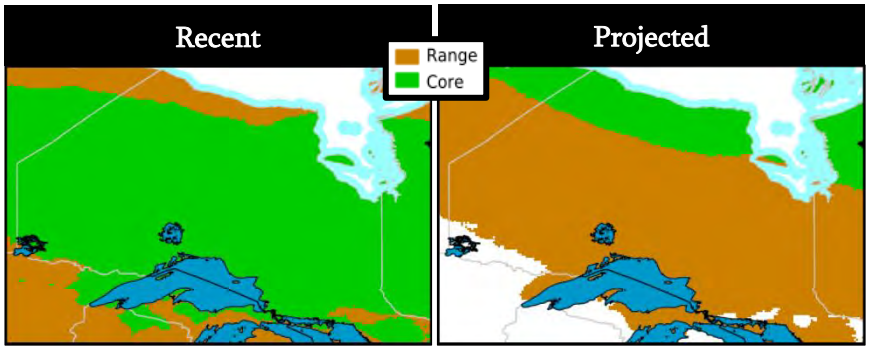
Lowbush Blueberry



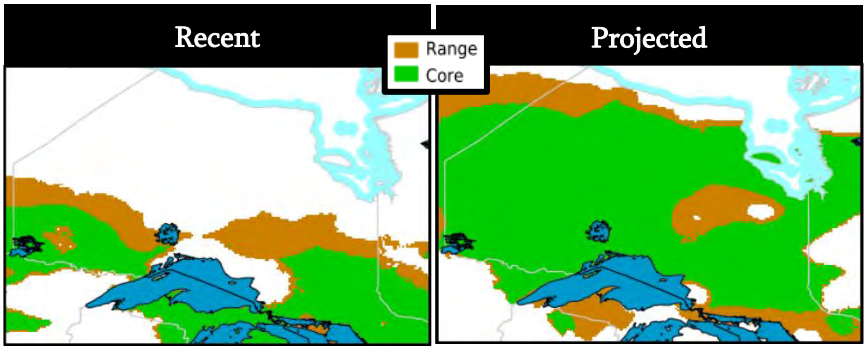
Wild Strawberry



Labrador Tea



Wild Rice



Core range (species is abundant) and range (species is found) in the recent past (1970-2000) and projected (2041-2070) of berries and plants with continued greenhouse gas emissions (Composite AR5 model RCP8.5). More info: http://www.planthardiness.gc.ca/?m=2b

How can we prepare?

Monitoring

Understanding the status of medicinal and berry plants and the threats to their continued availability is the first step in developing adaptation strategies. Targets and goals can be established by the community, as well as decisions about what needs to be monitored and how to monitor. A community-based monitoring approach can involve hunters, trappers, gatherers, and other land users in data collection and may include the following steps:

- Identify important plants and potential threats
- Use traditional knowledge to create a community baseline
- Collect data while out on the land and monitor changes (location, abundance, health, etc.)
- Consider collaborations with universities, governments or other groups to merge traditional knowledge with scientific study
- Consider using an online citizen science app (see box)

Citizen science apps

The Indigenous Knowledge Social Network created to facilitate self-determination for Indigenous communities. https://siku.org/#/about

iNaturalist

Create specialized projects, track your observations, connect with others. www.inaturalist.org

Habitat protection

The protection of areas where important plants are found should be considered. Plants often prefer specific conditions to grow, such as water depth, amount of light, and soil requirements. As climate changes, plants 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.

Assisted Migration

Assisted migration helps to establish plants that may grow and survive well in a warmer future climate. 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 transplanted. A more extreme case would be planting a blueberry species that grows in a more southern range, e.g. highbush blueberries, that may now survive further north. The movement of any plant species into a new location is not without risks; the plant could become invasive displacing native plants. 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.

Adjusting harvesting practices and community initiatives

Many harvesters are already saying they have had to adjust their time and methods to access traditional areas due to low water or trails being blocked by trees from downbursts. Many in First Nations communities have said they now have to travel further to gather traditional foods. This may require more costly means of transportation, such as a vehicle or ATV. Sharing harvested resources within the community can help ensure food security for those without the resources to harvest berries or plants.

The range of berry and medicinal plants is predicted to move further north in the next 50 years with the changing climate. If harvesting is to continue, communities should consider monitoring, protecting habitat, assisted migration and adjusting harvesting practices.

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

Shifting North: Caribou, Moose and Deer

Moose, caribou, and deer are important country food in Ontario. The hunting of these large animals is also of cultural significance having been traditionally harvested through generations. In these changing times, hunting of wild game can help ensure local food security, especially in remote communities.

Photo by Xavier Sagutch

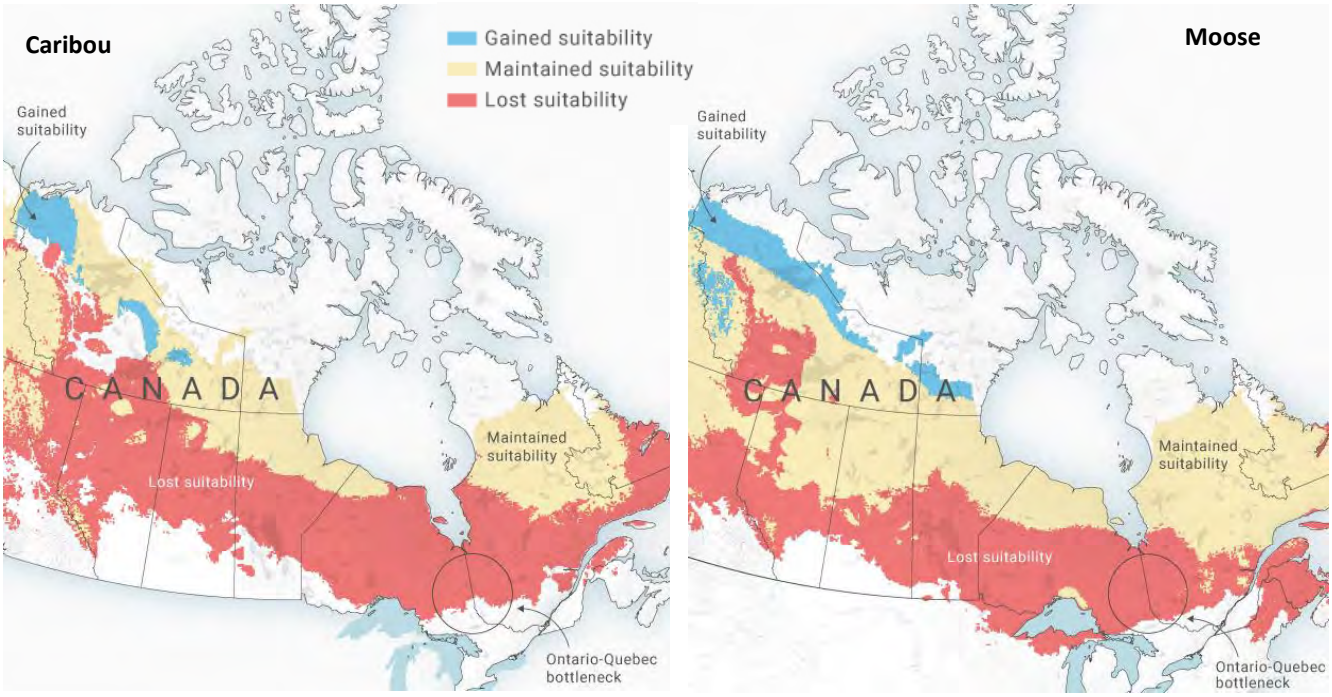
What have people noticed?

In the northwest, First Nation's Elders speak of seeing caribou in the hundreds or even thousands during their childhoods. Now, these large herds of the 1930s and 1940s are no longer seen on their traditional lands. Many across the province speak of moose being harder to find and some express concerns about their health. Harvesting has also become more challenging, with further travel sometimes required for harvest and freeze-up impacting travel over land. Warmer fall temperatures can also make it harder to keep harvested meat cool.

How could climate change impact these animals?

Climate change will impact where animals can live and thrive. Moose, for example, are a cold weather species and suffer heat stress when temperatures get too high. Moose and other cold adapted species are likely to shift their ranges further north. Landscape changes, such as permafrost loss, wildfire, or changes in vegetation, will also change where animals like moose, caribou, and deer can survive.

As the habitat for moose and caribou shrink toward the northern coast, the territory for deer will likely grow, as warmer temperatures and less snow in winter allow these animals to live further north than they're found today.



These maps show the predicted change of habitat range for caribou (left) and moose (right) in the boreal forest by the year 2080. Maps were featured in the Toronto Star and are based on the information presented in a scientific paper by Murray, et al. (2017). Toronto Star article found at https://projects.thestar.com/climate-change-global-species-shakeup/

How can we prepare?

Adjust Harvesting Practices

Many First Nations hunters have already had to adjust their harvest time and methods, particularly in the fall and early winter. Warmer fall temperatures can mean a greater chance of harvested meat spoiling, and hunting trips must sometimes wait for cooler weather. Less snow in winter means that snowmobiles must sometimes be swapped for ATVs. When hunters need to travel further from their communities to find game, transportation can become more expensive. Ride-sharing could be an option to help lower costs.

As some animals become less common on the land and others become more common, perhaps hunters can switch target species, like hunting deer instead of moose.

Community Initiatives

Sharing knowledge and harvests can help increase food security in a community. Community coolers can also help, lowering the risk of meat spoilage by providing people with a cool place to butcher or store meat they have harvested.

Community cooler in Chapleau Cree FN. Photo by Dakota Souliere

Habitat Restoration and Protected Areas

Protecting or restoring the habitat that moose and caribou need can help protect these populations in your area. Caribou, especially, need uninterrupted tracts of undisturbed land.

Monitoring

Understanding what is happening with the moose, deer, and caribou in your area can be an important step towards developing adaptation plans now and into the future.

Community-based monitoring is a monitoring initiative that is community-led and often driven by local information needs and guided by the values of the community. Monitoring activities can take many forms and can be conducted by environmental stewards, researchers, and community members. Monitoring can include having hunters, trappers, and other land users collecting data and observations while they're out on the land or can be high-tech where animals are tracked using GPS collars or recorded on trail cameras. It can be done as a single group or in partnership with other communities, organizations, or scientists.

Want to know more? Check out these examples:

A community-based monitoring program for moose was carried out in the Mayo region of the Yukon. This program had local hunters record their observations while they were out on the land to provide information about the local moose population. The final report can be found at:
http://www.env.gov.yk.ca/publications-maps/documents/MayoEarlyWinterMooseSurvey_2011.pdf

The Naskapi Nation of Kawawachikamach, in partnership with researchers and consultants, conducted an assessment of climate change impacts on their traditional lands and the caribou that reside there. The work incorporated TEK, mapping, and caribou surveys and set out priority actions for adaptation. The final report can be found at:
https://www.ouranos.ca/publication-scientifique/RapportMameamskum2014_EN.pdf

Climate change is affecting caribou, moose, and deer in Ontario. We need to prepare for the shift in their range by monitoring, protecting habitat and adjusting hunting practices.

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

Climate Change and Harvesting Fish

Fish are a staple in the traditional diet of many First Nations people, but climate change in the north is having an impact on this important group of animals.

How will climate change impact fish in northern Ontario?

With increasing air temperature, the lakes and rivers in Ontario are becoming warmer, and this can have a big impact on fish. Being cold-blooded, fish are directly affected by the temperature of the water that they're in. Water temperature can affect where fish are able to live, how they grow, and can even impact when they spawn. As climate continues to change, warmer lakes and rivers could mean:

- Fewer places where cool-water fish and cold-water fish can live (range contraction).
- More places where warm-water fish can live (range expansion).
- New invasive species that can live in warmer conditions.
- New fish diseases and parasites that can live in warmer conditions.
- A possible advantage for fish diseases and parasites already in lakes and rivers (many do better in warmer temperatures[1]).

Warmer air temperatures will also drive more evaporation from lakes and rivers and could cause water levels to fall. Lower water levels can change important fish habitat like spawning grounds and cold-water refuges and make it harder for fish to migrate or move from one place to another.

In lakes, the changes in water levels and increase temperature can lead to a deepening of the thermocline (the transition layer between hot water on the surface and cold water beneath) leaving less cold water for cold-water fish like cisco and trout.

Warm-water fish like smallmouth bass will likely become more common in the north as climate change makes lakes and rivers warmer

The predicted increase in extreme storms can have an impact on water quality. Heavy rain can carry contaminants and sediment into lakes and rivers impacting fish. The change in ice cover will also affect fish growth and survival.

What are people noticing?

Changes in fish have been noticed by people across the north. People say bass are becoming more common, especially in northeastern Ontario. Others have observed that spawning times have changed or become unpredictable. Important events, like the fish run, are sometimes missed by harvesters because they are now happening at unexpected times. Fish health is a concern for many, with people saying they've seen fish with sores, spots, bumps, or worms. Some people also say they find that the meat of harvested fish is softer than it used to be.

Cisco are harvested by many First Nations in the north. Cisco need cold water to live and thrive.

Climate change can also make it harder to harvest fish. Lower water levels can cut off traditional routes and limit access to fishing areas. A shorter ice-on season and ice that is thinner or poor quality is limiting travel and ice fishing. In some cases, these difficulties in harvesting have led to people in First Nations communities eating less fish than they used to.

How do we prepare?

Monitor

Monitoring allows us to gather information about the environment and the changes that are occurring. Monitoring can be done by environmental stewards, researchers, and community members, and can be guided by traditional knowledge. Community-based monitoring is when a community decides what to monitor and implements a monitoring program with or without a researcher as a partner. When community members gather information on their own it is sometimes termed "citizen science". Citizen science is a growing field due to the availability of apps and websites that make it easy to collect and share data, like Fish ON-Line (www.ontario.ca/page/how-use-fish-line) or iNaturalist (www.inaturalist.org). Citizen science is also a good way to engage people in environmental issues and encourage good stewardship.

Fish monitoring

- What species are in the area
- Number of fish in the area
- When and where fish spawn
- Fish migration and movement
- Fish health

Protect and restore fish habitat

Protect the places fish need to live and thrive, like cold water refuges, spawning grounds, near-shore areas, and migration routes. As the climate warms, the areas of cooler water that cool-water fish and cold-water fish need (called cold water refuges) are particularly threatened. Protect these areas by maintaining water levels, keeping shoreline vegetation to create shade, and making sure any cool water inputs (like groundwater springs or cooler tributaries) are uninterrupted.

Protecting spawning areas helps protect fish. Photo: Cooperative Freshwater Ecology Unit

Keep lakes and rivers healthy

Healthy lakes and rivers benefit all species, including fish. Keep the lakes and rivers in your area healthy by limiting pollution, protecting wetlands, and maintaining vegetation on the shoreline and in the watershed. Take steps to keep invasive species out of your area. Many invasive species, like zebra mussels or spiny water flea, are carried between waterbodies by people who unknowingly have them on their boats or fishing gear. One study that looked at lakes in northern Minnesota (including two that span the Ontario/Minnesota border) found that in lakes where zebra mussels or spiny water flea had invaded, walleye grew more slowly in their first year of life compared to walleye in lakes that didn't have those invasive species. Walleye in those invaded lakes were also smaller at the end of their first summer, lowering their chance of survival[2].

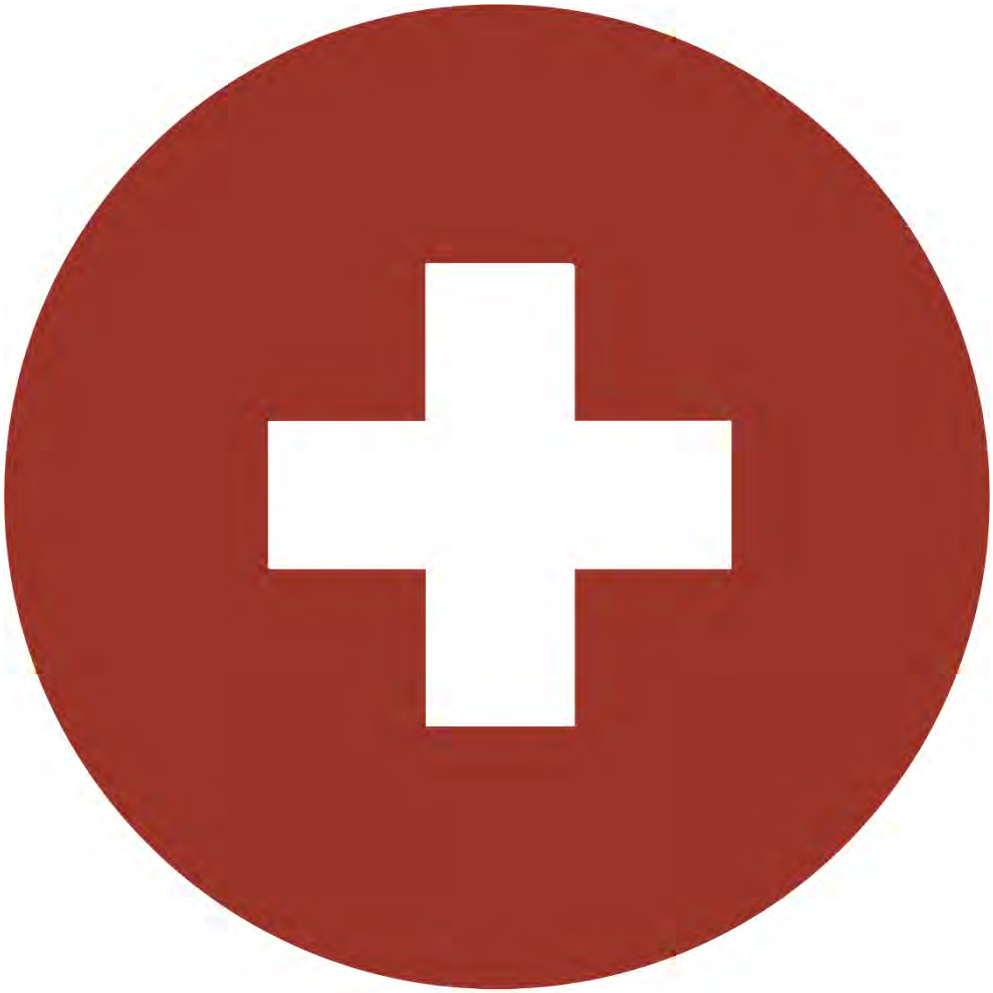
Make changes to harvesting

Many in the north have already had to make changes to when and where they harvest fish because of changes in climate. In winter, ice fishing might be delayed until the ice is safe to travel on. In summer, low water levels might mean shallower boats are needed, or motors need pivoting brackets so they can be quickly raised out of the water. Climate change might also mean making changes to the type of fish that are harvested, like shifting away from fish species that are under threat. Consider catching fish new to the area like smallmouth bass.

Want to know more? Check out the research mentioned in this write-up!

[1]Chetkiewicz, C., McDermid, J., Cross, M. & Rowland, E. *Climate Change and Freshwater Fish in Ontario's Far North*. (2012)
[2]Hansen, G. J. A., Ahrenstorff, T. D., Bethke, B. J., Dumke, J. D., Hirsch, J., Kovalenko, K. E., LeDuc, J. F., Maki, R. P., Rantala, H. M., & Wagner, T. (2020). Walleye growth declines following zebra mussel and Bythotrephes invasion. Biological Invasions, 22(4), 1481–1495. https://link.springer.com/article/10.1007/s10530-020-02198-5

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



Health

Mental Health, Well-Being and Climate Change

From changing land to damaged belongings to evacuations, climate change can directly and indirectly impact mental health and wellbeing.

Changing Land and Ecological Grief

Changes to the land, the water, the ice, the snow, and the weather can impact a person's sense of place and threaten traditional practices that support well-being. Loss of land-based activities and work because of climate change can impact personal and community income and disrupt a person's sense of belonging and cultural identity. It can also lead to reduced food security as it becomes more difficult to get out on the land and find the animals and plants that they traditionally harvest. This may be especially true in areas where land-based activities are an essential part of tradition and where changes are occurring faster such as in the North, including the far north of Ontario.

First Nations in the North speak of how being out on the land keeps them grounded and is part of their identity. They are worried that the changes will continue and stop them from practicing long-lived traditions. The voices of Inuit in the video "Lament for the Land" may echo what you feel and have heard in your community, that climate change is affecting culture, leading to fear, worry, sadness and mental illness.

Severe Weather, Floods, Fires and Evacuations

Severe weather, flooding and wildfire are all becoming more common because of climate change. The threat of natural disasters and uncertainty of the future can leave people feeling stressed and worried. These natural disasters can cause personal injury, damage to belongings and buildings and require evacuation especially of vulnerable people. People can feel defeated when they are always recovering from a loss. Evacuations lead to cultural disruption and displacement all of which has been shown to lead to mental health disorders. Mental health impacts from climate change are also expected to magnify existing stresses like food insecurity. Some community members will be more vulnerable to mental health issues depending on age, gender, social and economic factors, and pre-existing disorders.

Evacuation of Fort Hope in 2011 due to wildfires.

What can we do?

Finding ways to continue cultural activities

The best way to prevent the sense of loss of a way of life is to make sure that it is not lost. If you can't get out to a traditional area because of downed trees from a severe windstorm, try to find a different route to get there. Or, if there are no berries where you used to go, search for new patches and share the findings with community members. It's about minimizing impacts to cultural activities and working around them. It's also about sharing your knowledge with others, especially youth. By organizing cultural activities, you are keeping traditions alive and strengthening your sense of value. Supporting each other in a time of change is important; talking to friends and family about your feelings increases the sense of community and togetherness, so you know you are not alone in a difficult situation.

Birthing of the drum, Camp Chikepak 2017

Taking action: Active Hope

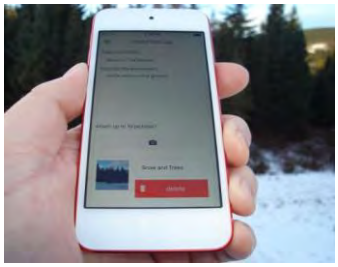
Active hope is the concept of moving hopeful intentions from an inactive state to an active process of taking action on climate change adaptation. It starts by accepting the reality of the problem, then setting goals to address the problem, and then engaging in actions to reach the goals. In other words, accept that things are changing, set goals to fix it and then do it! By taking action, people feel like they are making a difference. This might mean activism like Autumn Peltier of Wikwemikong First Nation, addressing world leaders at the United Nations about protecting water. Or, planning and building a sustainable energy grid in your community. Or, speaking up when you see someone being reckless with a campfire. The key is to take action to make the world a better place. This will give you and the people around you, especially youth, some hope for the future.

Advocating for More Services

Addressing mental health impacts requires a support system of mental health professionals, resources, and services. Mental health services are already lacking in many areas of the north. Communities should continue to push for the resources they need, build mental health response into emergency preparedness planning and climate action plans, as well as help community members see how climate change and mental health is relevant to them. It is also important to end the stigma surrounding mental health issues. People in need of mental health services may be more willing to ask for help if mental illness is accepted as an illness like any other, like cancer, for example.

Environment and Health Monitoring

Monitoring of the land and public health is a possible strategy for responding and adapting to changes. For example, a community in Rigolet, Nunatsiavut Labrador has developed a community-led, and community-designed environment and health monitoring strategy called the "eNuk Program". An important part of the program is the eNuk app, which is a tool for community members to record their observations while on the land. Observations like thin sea ice or poor trail conditions can be shared to help community members make decisions when planning their travel routes, increasing safety.



Charlie Flowers, a research lead and community member in Rigolet, demonstrating the eNuk app.
https://enuk.ca

More Reading

Examining relationships between climate change and mental health in the Circumpolar North
http://www.lamentfortheland.ca/wp-content/uploads/2014/09/CC-Circumpolar-MH_Cunsolo-Willox-et-al.-Online.pdf
Climate change and mental health: risks, impacts and priority actions
https://tspace.library.utoronto.ca/bitstream/1807/88223/1/13033_2018_Article_210.pdf

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

Shifting North: Insects, Animals & Diseases They Can Carry

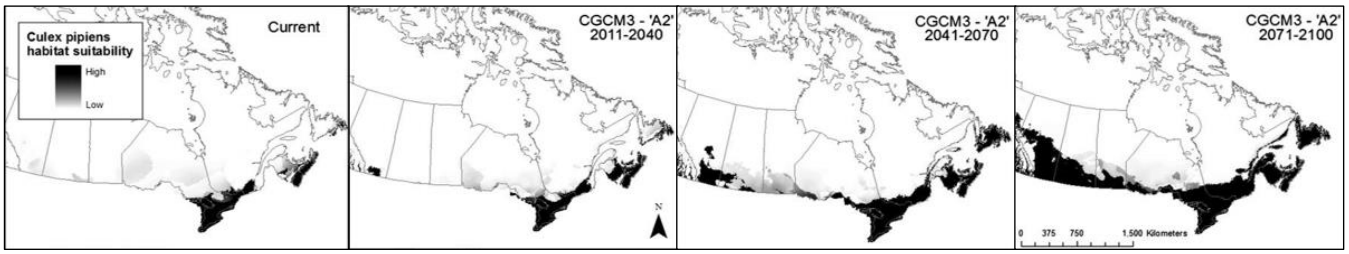
The occurrence of diseases transmitted by animals (called zoonotic diseases) is predicted to change with the changing climate.

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 zoonotic diseases. 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. West Nile virus (carried by mosquitoes), Lyme disease (carried by ticks) and rabies (carried by mammals) are examples of vector-borne diseases that have the potential to spread north.

West Nile Virus (WNV)

West Nile Virus was introduced into Canada in 2001 and is transmitted by infected Culex mosquitos. It is expected that the range of the Culex mosquito will expand northward. Very few people have severe illness from being infected by WNV; 80% of people have no symptoms at all. Of those who do show symptoms (fever, headache, fatigue, skin rash), most experience only mild illness, however, when WNV causes severe illness (1% of cases) it involves the brain and nerves. So, as the range of the mosquito that carries it moves north, it is important that people in more northern areas are aware of WNV and the steps that can be taken to avoid infection.

Culex mosquito 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.

Lyme Disease

The blacklegged tick (also called the deer tick) is the vector responsible for carrying the bacteria *Borrelia burgdorferi*, which is 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. 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. With the range potentially pushing to the far north of Ontario, it will be necessary to be aware of the potential risk of Lyme disease in your community and what can be done to mitigate the risk of exposure.

*B*lack-legged tick *https://www.ontario.ca/page/lyme-disease*

Potential range expansion of the blacklegged tick with continued climate change. Taken from Greer et al., 2008.

Adapt and prepare

Preventing bites

The best way to prevent infection from vector-borne diseases is to prevent bites.
To avoid rabies, do not handle injured wild animals like bats, foxes, raccoons and skunks.
To prevent insect bites, the Ontario Ministry of Health recommends:

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

If you find a tick on your body, remove the entire tick including the head. See here for instructions: https://www.ontario.ca/page/lyme-disease

Remove or limit habitat

Ticks:

- 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.

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.

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

Climate change has the potential to allow species to live in areas where they couldn't live before. Monitoring can help alert communities when new species have entered their area. Consider including tick (https://www.youtube.com/watch?v=t7rwiofSuKc) and mosquito monitoring in your community-based monitoring program.

Animals that can carry diseases transmissible to humans are predicted to move north with climate change. People in northern Ontario should be aware of the risk, protect themselves from bites and monitor changes on the land.

Find out more:https://www.publichealthontario.ca/en/diseases-and-conditions/infectious-diseases/vector-borne-zoonotic-diseases

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

Blacklegged Ticks & Lyme Disease Moving North

The blacklegged tick, also known as the deer tick, is a small animal that feeds on the blood of birds, reptiles, amphibians, and mammals including humans. Once limited to the southern parts of Ontario, climate change is shifting where they can live and thrive. What makes them a big concern is their potential to carry the bacteria that causes Lyme disease, a potentially serious illness in humans.

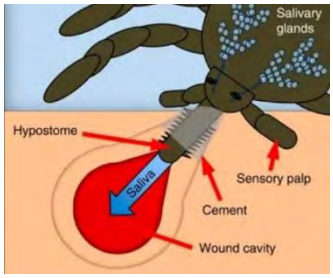
The life history of ticks and how they spread disease

The life of a blacklegged tick (*Ixodes scapularis)* generally lasts two years. They go through four life stages: egg, larva, nymph, and adult. At each life stage except for the egg, they must have a blood meal from a new host to survive.

Ticks find their animal host by "questing"; they hang on to a short branch or blade of grass with their back legs and reach out with their front legs. When they sense an animal either by its breath, smell, body heat, moisture, or vibrations, they climb on. Then they might attach to the animal within a few minutes or wander for an hour or two looking for an area of thinner skin like in the armpit.

When they attach, they cut the skin and insert a feeding tube full of spikes and secrete cement that both serve to hold them in place. They "spit out" saliva and painkillers so the animal doesn't notice them. The tick then sucks blood for several days. If the host animal has the bacteria that causes Lyme disease (*Borrelia burgdorferi)*, the tick takes it up with the blood. After feeding, the tick will drop off and go to the next life stage where it will feed from another animal. If the tick picked up the bacteria from its first host, it can transmit it to the second host when it "spits out" saliva into the wound.

A blacklegged tick "questing" for a host on a blade of grass. CDC



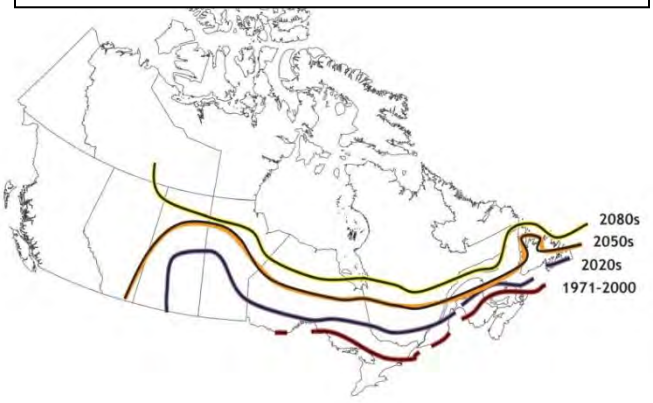
A blacklegged tick feeding https://www.nature.com/articles/ncomms10507

How is climate change impacting blacklegged ticks and Lyme disease?

Changing climate conditions, such as warmer winter temperatures means ticks can now survive through the winter further north. With growing blacklegged tick, populations they are being found further north than where they have been found in the past.

On the map to the right, the red line shows the northern limit of blacklegged ticks that was seen between 1971 and 2000. With predicted changes in climate, we can expect to see the edge of their range change over time. In 30 years (2050 - the orange line), blacklegged ticks could be found in more than half of Ontario and with them the risk of Lyme disease.

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

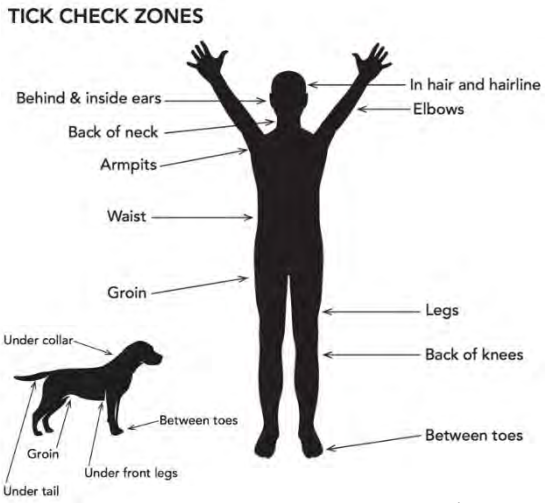


What have people noticed about blacklegged ticks and Lyme disease?

Lyme disease is a growing concern, especially in the more southern areas of northwestern Ontario. Already, areas in and around Kenora, Rainy River, and Thunder Bay are considered risk areas for Lyme disease because 10% of blacklegged ticks tested were positive for *Borrelia burgdorferi,* the bacteria that causes Lyme disease.

Greer, A., Ng, V. & Fisman, D. Climate change and infectious diseases in North America: the road ahead. Can. Med. Assoc. J. 178, (2008)

How can we prepare?



Tick check from: TBDHU.COM/ticks

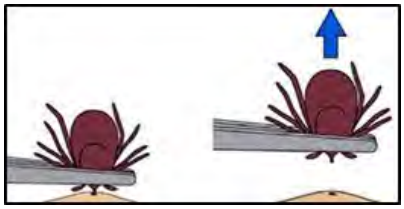
Prevent bites

Covering your skin and using bug spray can help stop ticks and insects from biting. When in the bush, try to stay on trails if possible. Make your property less inviting for ticks by keeping your grass mowed short and removing brush and leaf litter. After being outdoors, check yourself, your children, and your pets for any ticks that may have attached.

Tick Checks

Check for ticks on your body, paying special attention to the groin area, belly button, armpits, head and behind ears and knees. Use a mirror to check the back of your body or have someone else check for you. Don't forget to check for ticks on your children and your pets.

Removing ticks


REMOVING A TICK WITH TWEEZERS FROM WWW.CDC.GOV/LYME

If you find a tick, be sure to remove it properly. The tick will have embedded its mouth parts into the skin and so it will be necessary to grab the tick near its head and pull up gently to be sure to remove the entire tick. You can submit it to your local health unit to be tested for the Lyme causing bacteria.

Be aware of Lyme disease and its symptoms

Know what the symptoms of Lyme disease are so you can seek treatment as quickly as possible. Most symptoms of Lyme disease in humans usually appear between 3 and 30 days after a bite from an infected blacklegged tick. You should contact your local public health unit or speak to a health care professional right away if you have been bitten by a blacklegged tick, or if you have been in an area that ticks might live and experience **any** of the following symptoms: rash (typically a bull's-eye rash or a bruise-like rash (usually on darker skin tones), another type of unusual rash, fever, chills, headache, stiff neck, muscle aches and joint pains, fatigue (more tired than usual), swollen lymph nodes, spasms, numbness or tingling or facial paralysis. If not treated, Lyme disease can make you feel tired and weak and, if it gets really bad, it can even harm your heart, nerves, liver and joints. Symptoms from untreated Lyme disease can last years and include recurring arthritis and neurological problems, numbness, paralysis and, in very rare cases, death.

Monitor for ticks in your area

Knowing if blacklegged ticks are in your area can help you understand your risk for Lyme disease. While there are other species of tick in Ontario, only the blacklegged tick transmits Lyme disease. Consider including tick dragging to your community-based monitoring program (https://www.youtube.com/watch?v=t7rwiofSuKc).

Read more:https://www.tbdhu.com/health-topics/insects-rodents-other-pests/ticks-lyme-disease; https://www.ontario.ca/page/lyme-disease

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

Airborne Allergens & Climate Change

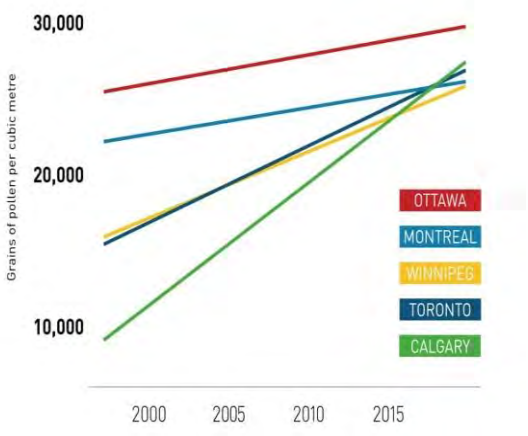
Climate change is expected to have substantial effects on airborne allergens, such as pollen and mould spores, and will impact those with asthma, hay fever and other respiratory diseases.

Pollen on the rise

Pollen is a yellow powder produced by the male part of a flower that serves to fertilize the female part of the same species to produce seeds that germinate into new plants. Pollen is transported by the wind, insects, or other animals. When pollen is transported through the air in large quantities, it can cause irritation to the nose, eyes, and lungs of people especially those who are allergic to pollen and those with asthma or other respiratory diseases.

Male White Pine flowers

The changes in temperature and precipitation that are predicted to occur due to climate change will increase the growing season of plants. With a longer growing season, plants may produce more pollen and for longer periods each year. Warmer temperatures have already resulted in an earlier onset of the pollen season in many locations in Ontario. Warmer temperatures could also mean a longer pollen season, new plants entering the area, and an increase in plant pollen production overall.



*Change in number of grains of pollen per cubic metre over time in 5 Canadian cities from:*https://www.cbc.ca/news/canada/toronto/cities-seasonal-allergies-symptoms-worsening-climate-change-1.5256496

Air quality

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. Poor air quality further irritates the lungs and can increase the risks of respiratory events like asthma attacks in vulnerable people.

Mould is a threat

Mould is a microscopic fungus that grows in moist environments. As it spreads and becomes larger it can have a fuzzy appearance like on rotting bread or a dark stain like black mold on drywall in a damp house. Increased precipitation and humidity can raise moisture content in the forest and increase the growth of mould affecting air quality. Heavy rainfall or rain in winter may lead to flooded homes, which can also increase the risk of mould growth. When mature, moulds release spore into the air to reproduce. It is these spores that irritate the nose and lungs of people. Some moulds also produce toxins that can be dangerous and even fatal.

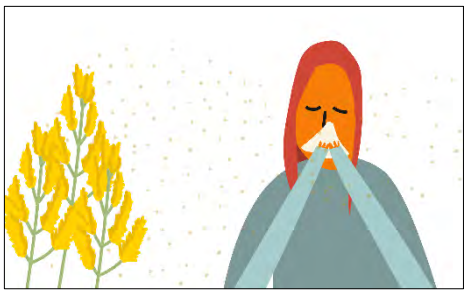
Mould on an orange and in a on walls. Photos from https://en.wikipedia.org/wiki/Mold

More intense and longer exposure to airborne allergens like pollen and mould can lead to more cases of reactions to allergens and/or respiratory diseases and cause existing conditions to become more severe and ultimately lead to higher death from asthma and other respiratory diseases

How can we prepare?

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 can include:

- Closing windows during pollen season
- Removing shoes and leaving them in the entrance 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
- Use medication before exposure

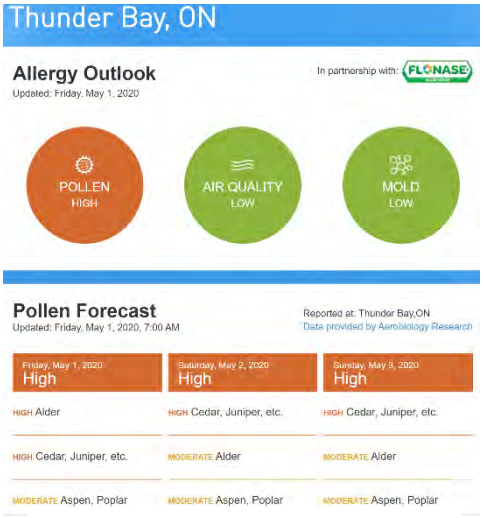
To prevent mould growth in your home:

- If things get wet, remove water and dry immediately
- Ventilate your home (especially damp 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.)
- Repair leaky roofs, windows and plumbing
- Prevent water from entering your home (slope ground so rainwater/snow melt runs away)

The Government of Canada offers a First Nation-based report that can be used to inform your community about the health risks of mould, identifying mould and how to prevent and/or remove mould from the home (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)

Monitoring

Communities can monitor when the pollen season begins in their area by noting when plants and trees begin to bloom or when pollen starts to collect in lakes and on vehicles. 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. More remote communities may want to investigate the possibility of creating a pollen count program for their area. Regardless of the source of information, it should be shared with community members.



Allergy report from Weather Network

Adequate Healthcare

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

Hospital in Attawapiskat

Airborne allergens are predicted to increase because of climate change. People should prepare by limiting their contact to allergens, monitor pollen in the community and advocate for good healthcare.

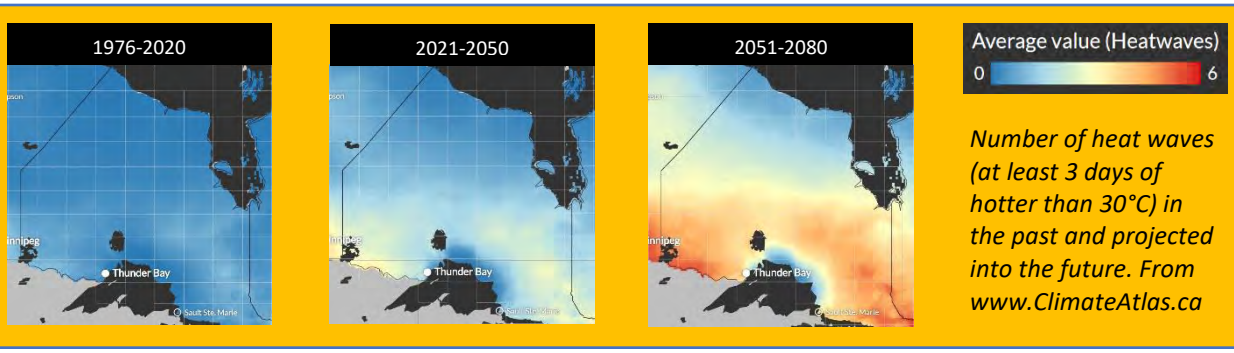
UP NORTH ON CLIMATE
Climate Change Impact and Adaptation Study for the North of Ontario

Extreme Heat & Health

Temperatures are expected to increase for all seasons in northern Ontario because of climate change. In summer, extreme heat events and heat waves are projected to happen more often and to be more extreme. These heat events may lead to heat-related illness in people especially the vulnerable.

What is considered an extreme heat event?

What is classified as an extreme heat event varies depending on the region. In northern Ontario, where temperatures are generally cooler, an unusually hot period might be defined as temperatures over 25°C, whereas southern Ontario might use days over 30°C. Extreme heat 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). 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. An extreme heat warning is often called when there is the potential for an unacceptable level of health effects, including increased mortality. A "heat wave" is generally defined as three consecutive days of extreme heat.



Number of heat waves (at least 3 days of hotter than 30°C) in the past and projected into the future. From www.ClimateAtlas.ca

What is heat illness?

Heat illness is when your body is unable to cool down and can lead to conditions such as heat rash, heat cramps, heat edema (swelling of the hand/feet/ankles), heat exhaustion and heat stroke. Heat stroke is a medical emergency, it is when a person's core temperature reaches 40°C. Heat can also affect mental health and community well-being. Heat waves can increase irritability and aggression. Domestic violence and violent crimes have been shown to spike during heat events.

Populations at the greatest risk for heat illnesses are:

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

How can we prepare?

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 and symptoms of heat illness, so they know when they or someone around them 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, continue through the summer season, and especially during extreme heat events.

Prevent heat-related illness

- ✓ **Avoid direct sun and use sunscreen**
- ✓ **Wear breathable, loose fitting, light coloured clothing**
- ✓ **Keep hydrated (drink often, avoid alcohol and caffeinated beverages)**
- ✓ **Plan outdoor activities 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**

Emergency action plan

Communities may also wish to develop an emergency plan for extreme heat events. It should include roles and responsibilities of the key people who will roll out the emergency plan as well as a list of vulnerable community members with contact information. The plan should also include a monitoring and alerting system and cooling centers.

Community monitoring and alerting system

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.

Cooling centres

Community cooling centres 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 centres 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.

Heat waves are projected to happen more often in the north. Prepare by raising awareness of heat related illness and having an emergency plan for vulnerable people in your community.

More information:

https://www.canada.ca/en/health-canada/services/sun-safety/extreme-heat-heat-waves.html
https://climateatlas.ca/sites/default/files/PCC%20-%20Heat%20Waves%20and%20Health%20-%20Nov%202019.pdf

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

More Rain, More Risk of Contaminated Drinking Water

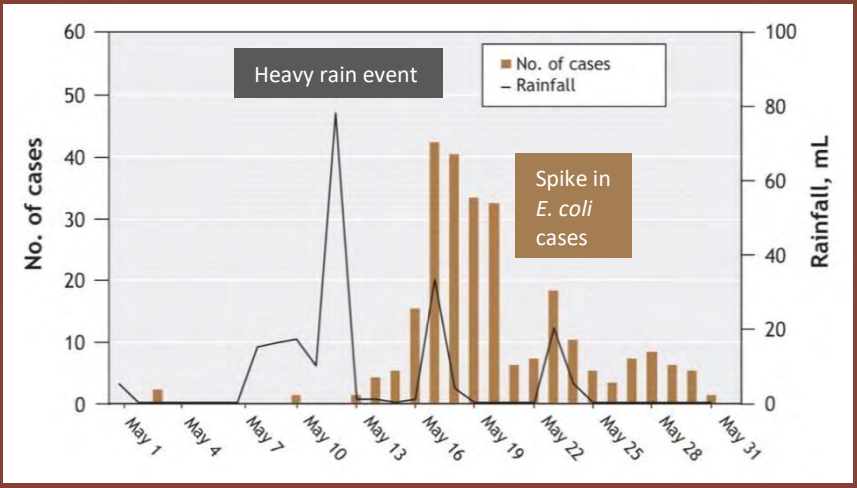
Rain can wash contaminants into drinking water sources. More rain, especially heavy rains, are expected with climate change increasing the risk of contamination.

How do floods or heavy rain events impact drinking water?

Flood waters and heavy rain events can carry contaminants into drinking water supplies like lakes, streams and ground water, causing waterborne illness. These illnesses are caused by pathogens (microbes like bacteria, viruses), bio-toxins (toxins produced by living things like algae) and toxic contaminants. The majority of waterborne diseases are gastrointestinal (diarrheal diseases), however they can also impact the kidneys, the lungs, the brain, and metabolic processes.

In 2000, Walkerton, Ontario had a large rain event (about 130 ml over 5 days ending with a day of heavy rain on May 12th where 80 mL fell in 24 hours) and a few days after the community had a massive surge of people with *E. coli* bacteria infection. It is thought that *Escherichia coli* bacteria from cattle manure fertilizer spread on a farmer's field was washed into the municipal water supply where other oversights left the water inadequately treated.

CASE STUDY: WALKERTON, ON
Heavy rainfall and *Escherichia coli*



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*.

How are drinking water sources impacted by climate change?

With climate change, large rain events (50mm to 150mm of rain in one day) are expected to happen more often. This could present more chances for contaminants to enter drinking water sources. Climate change is also expected to bring higher temperatures which will increase water temperatures which can also increase the risk of algal blooms and certain waterborne pathogens.

*Greer, A., Ng, V. & Fisman, D. Climate change and infectious diseases in North America: the road ahead. *Can. Med. Assoc. J.* **178,** (2008)

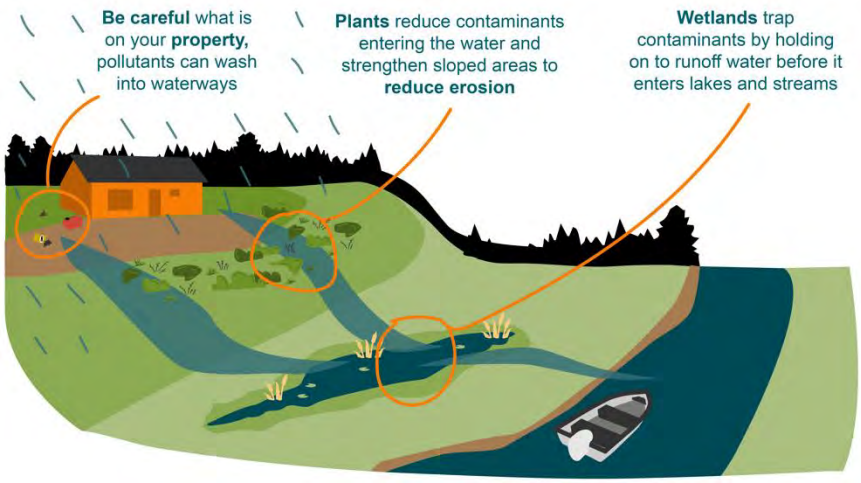
How can we prepare?

Advocate for safe drinking water

Clean, safe drinking water is already an issue for many First Nations communities. Communities should continue to push for safe drinking water and effective training for water treatment staff. In communities that do have drinkable tap water, make sure effective monitoring programs are in place and that the water continues to be safe to drink. During times that water is not safe to drink, communities should have an alerting system to notify members and provide alternative sources of water (bottled water, boiled water, different water sources, etc.).

Manage stormwater runoff

When stormwater flows over the landscape, it can pick up debris, chemicals, bacteria, and other pollutants that can then end up in lakes and rivers that provide drinking water. Keep drinking water sources safe by managing stormwater runoff with a good drainage plan. This can include ditches and culverts to direct water flow, green spaces to soak up rainwater, and holding areas (like ponds or wetlands) for excess water.



Sourcewater protection

A watershed is the area of land that drains into a waterway like a stream or lake. Your house may not be on the shore of a lake but the water that runs off your yard eventually makes it to the nearby lake. Limiting pollutants on the landscape can help keep water systems healthy. This can include steps like:

- Locate sewage lagoons and garbage dumps far and downstream of drinking water sources
- Keep plants and trees near the shore to prevent erosion and trap contaminants before they reach the water
- Avoid using chemicals (like pesticides) or fertilizers
- Be careful not to spill gas or oil when pouring into tanks
- Don't use or reduce the use of road salt
- Reduce the area with hard surfaces and lawns, instead leave wetlands or plant a rain garden
- Maintain septic and waste systems
- Pick up garbage and dog poop especially near the water

Best-practices for home wells

Drinking water wells can be at risk of contamination during flooding events. If your home well has flooded, or you find your well water has changed in colour, taste, or smell, the water should be tested before you drink it. Your well and plumbing systems may also need to be disinfected.

Heavy rain events are predicted to happen more often because of climate change will put drinking water at risk. Protect the source of your drinking water and monitor its quality.

Resources

https://conservationontario.ca/conservation-authorities/source-water-protection/
https://www.gov.mb.ca/asset_library/en/spring_outlook/wellwater_safety_factsheet.pdf

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

Rising Temperatures & Foodborne Illness

Climate change will challenge food security and traditional harvesting in many First Nation communities. Higher temperatures can increase the risk of food spoilage and foodborne pathogens, like *Salmonella* bacteria and parasites. This danger can extend to wild-harvested foods and can have far-reaching effects on the health, nutrition, and mental wellbeing of those in First Nation communities.

What are foodborne illnesses?

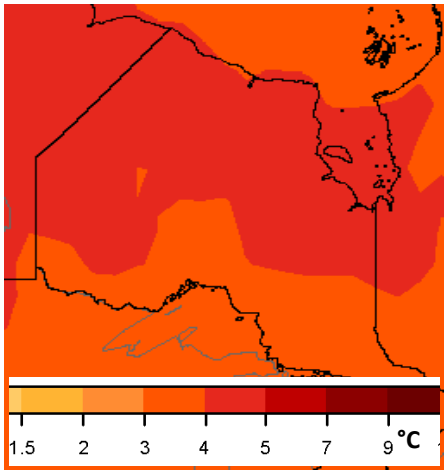
Foodborne illness is the term used to describe when people become sick after eating food that contains harmful bacteria (like E. coli or Salmonella), parasites (like roundworm), viruses (like Norovirus), toxic mushrooms or other chemicals. You might have heard it described as "food poisoning". Common foodborne illness symptoms include vomiting, diarrhea, abdominal pain, fever, and chills. Most foodborne illnesses are acute, meaning they happen suddenly and last a short time, and most people recover on their own without treatment. Occasionally, foodborne illness may lead to more serious complications.

Magnified image of E. coli

Roundworms (arrows) in the intestines of a harvested grouse. Photo provided by Isabell Souliere

How will the odds of getting foodborne illness change with climate change?

Climate, like air temperature, water temperature, and rain patterns, can affect how quickly pathogens grow and spread. In warmer temperatures, like we are expecting with climate change, food can spoil more quickly both when harvested and once in the kitchen. For example, research has found that outbreaks of *E. Coli* and *Salmonella* in Canada occur more often in warmer temperatures. Foodborne pathogens like parasites will also grow and spread more quickly and infect more of the game species that are harvested.



Predicted rise in fall temperatures by the 2050s (compared to the average for 1986-2005) (RCP8.5, 75th percentile, CMIP5) http://climate-scenarios.canada.ca/?page=download-cmip5

What have people noticed?

Already, during the fall or early winter season when many people are setting out fish nets, or hunting moose and partridge, temperatures are warmer than in the past. This has made it harder for people to keep harvested meat cool, which is necessary to stop it from spoiling. People speak of seeing more worms as wells as other diseases in fish, partridge and moose, making them wonder if the animals are safe to eat. Burying meat in the ground is not as effective at keeping meat cool as it was in the past because the ground is much hotter.

How can we prepare?

Harvested game

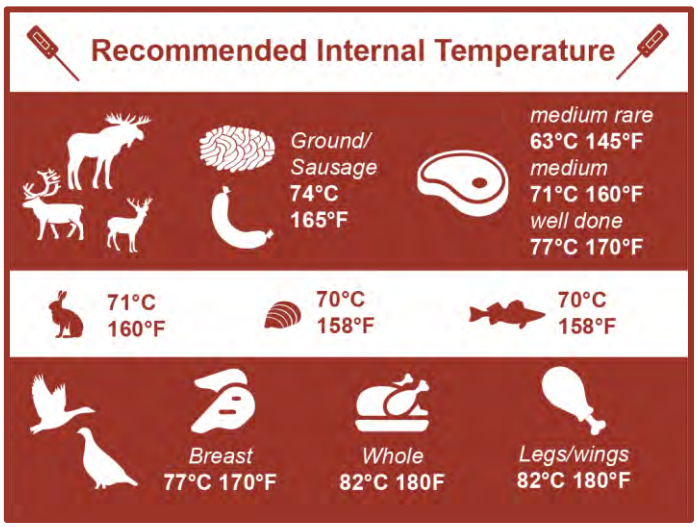
Ice and coolers can keep harvested fish cool while they are transported. Photo https://lakeofthewoodsmn.com

Hotter temperatures can pose a special challenge for harvesting wild game. Keeping meat, fish, and even harvested berries cool from the time they are collected in the bush until harvesters return home is important for preventing the growth of bacteria that can contaminate food and make people sick. Some hunters have adapted to changing temperatures by waiting for cooler weather later in fall or earlier in spring to hunt.

Small game, like fish and birds, can be kept in coolers for transport. Keeping harvested berries cool and out of the sun will help stop them from spoiling. For keeping large game cool in warm weather:

- have a plan in place to get game out of the bush as quickly as possible
- field dressing (removing the intestines and stomach) should be done as soon as possible
- removing the hide (skinning) can help cool game that have a thick coat, like moose
- harvested game can be kept cool during transport by packing ice inside the body and keeping it where air can circulate, such as the back of a pickup truck

Proper food-handling



Proper thawing, chilling, and storage of food can help prevent food spoilage and dangerous bacterial growth that could lead to foodborne illnesses. Hand washing and cleaning work surfaces and utensils can also help prevent other foods and surfaces from being contaminated. Meat, including wild game, should be cooked to a temperature high enough to kill potential bacteria and parasites. Meat thermometers are a useful tool for this.

Community initiatives

Some communities have already begun taking steps to prevent food spoilage in light of warmer temperatures. Chapleau Cree First Nation, for example, created a community moose cooler, where harvested moose can be hung and butchered in a cool space. In the Hudson Bay area, two Nunavut communities, Sanikiluaq and Arviat, completed community freezer projects in 2016. These large freezers can store a lot of game and are open for members of the community to use.

Inside of community cooler in Chapleau Cree First Nation Photos by Dakota Souliere.

Want to know more?

Health Canada's *Food Safety for First Nations People of Canada*
https://www.gov.mb.ca/inr/pdf/pubs/nhfi_food_safety_for_first_nations_people_of_canada.pdf

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

Infrastructure

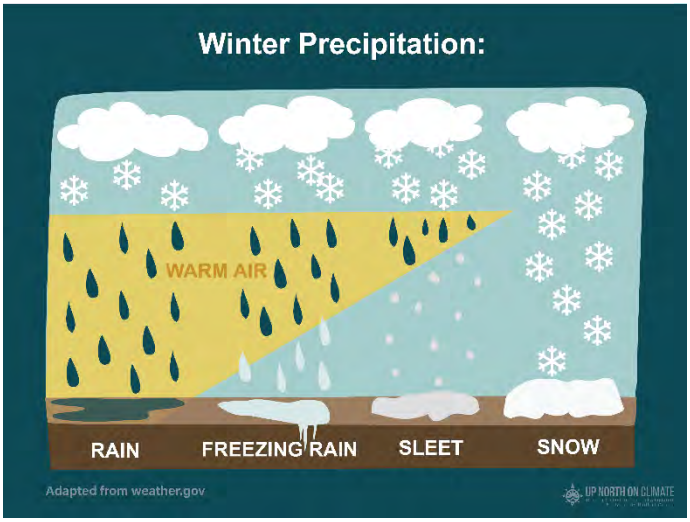
Preparing for Winter Power Outages

Climate change will impact energy infrastructure and we can expect winter conditions to create a number of challenges, especially in the north.

How will a changing winter impact energy infrastructure?

Climate change is projected to bring warmer winter temperatures and more winter precipitation to all regions in Ontario. The temperature impacts the types of precipitation that we experience, and warmer conditions could mean areas see more rain, freezing rain, and ice storms in winter. Warmer air also leads to more heavy, wet snow which can weigh down power lines, transmission poles, and trees.

Ice accumulation can also add a lot of weight to power lines and equipment, causing damage. In windy conditions, icy lines can move so much that they snap wires and wooden poles or even cause steel transmission structures to crumble.



Air temperature influences if precipitation falls as rain, freezing rain, sleet, or snow. Image modified from https://www.weather.gov/rnk/Measure_Icing

What do winter power outages mean for people and communities?

The impact of a power outage on people and communities depends on how long the outage lasts and how much the community's heat relies on electricity. A short power outage might only be an inconvenience. But when power outages drag on in winter, houses will become cold and people will need to seek out warm spaces and worry about freezing pipes. Power outages in cold temperatures are considered an emergency by many communities.

How can our community prepare?

Community Emergency Planning

Winter power outages can be a great risk for northern communities. Communities can benefit from having an emergency plan in place. Plans can include:

- Well defined conditions to call an emergency
- List of roles and responsibilities for community leaders during an emergency
- Written response plans and how to implement them
- Methods for alerting the community
- Plan to support the most vulnerable community members

Community Warming Centres

Making community warming centres available during long power outages can help protect community members in cold conditions. The city of Yellowknife uses the chart shown on the right as a guideline for deciding when to open emergency warming centres. Outdoor temperature and the duration of the power outage are used to determine the need.

A warming center should be in a large building that has its own backup power generator in case of a community-wide power outage.

Risk Assessment Matrix					
	Duration of the full power outage				
Temperature	0-2 hours	3-4 hours	4-5 hours	5-7 hours	8+ hours
+10°C or more					
0°C					
-10°C					
-20°C					
-30°C					
-40°C					

No warming centre needed
Warming centre "**MAY**" be needed (situational)
Warming centre **will** open

Decision chart for opening warming centres in Yellowknife, NWT, in response to a winter power outage. Yellowknife's Emergency Measures Plan (available online)

Maintenance of Power Infrastructure

Power transmission infrastructure (like hydro poles, transmission towers, etc.) that is well maintained may be less likely to be damaged by weather events. Communities may consider having their power grid assessed and advocating for necessary maintenance. This can include the replacement of damaged or aging structure and/or clearing trees that could damage infrastructure if they fall.

Solar power microgrids can help with energy independnce

Image from https://scitechdaily.com/no-more-blackouts-new-framework-guarantees-the-stability-of-microgrids/

Communities may also want to consider creating their own electricity with a local microgrid. Microgrids can be done with renewable energy, like wind, solar or nuclear, which can reduce dependence on diesel generators. They also allow communities to be more independent.

How can people prepare?

Emergency Supplies

Households can be prepared for winter power outages by keeping supplies such as canned food, candles, flashlights and batteries. A crank or battery powered radio can be handy, so you get news and alerts. Communities can help households by providing information on how to get prepared and by supplying provisions that may be hard to get because of cost or availability.

Example emergency supply kit.
Image from https://prrd.bc.ca/services/emergency-services/get-prepared/

Prepare your Home

Other heat sources, like woodstoves, can heat your home when the electricity is out but be sure that chimneys and stoves are working and maintained regularly. Never use fuel stoves, BBQs, or any other outdoor appliance inside your house because exhaust fumes, like carbon monoxide, can build up and make you sick or even cause death. Gas/diesel generators can provide short term electricity, but they too should be kept outdoors and away from windows and vents that could draw exhaust inside the house. If you don't have a way to keep your house warm, take steps to prevent water pipes from freezing; if you are on a well, drain your pipes; if you are on community water, leave taps on a little.

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

Water & Wastewater Systems in a Changing Climate

Many First Nation communities face existing challenges with water and wastewater infrastructure. Climate change is likely to add additional stress.

How will more precipitation impact water and wastewater systems?

Contaminants

Attawapiskat water treatment plant.

Climate change is expected to increase precipitation in northern Ontario and large rain events (50mm to 150mm in one day) are projected to happen more often. Increased snow loads and heavier rains can cause more runoff (when water flows over the land) and flooding, which can carry contaminants like animal and human waste and oil into waterbodies contaminating drinking water. This can stress water treatment plants.

More precipitation can increase the amount of water entering the wastewater lagoon, requiring infrastructure to cope with larger volumes of water than before. If a wastewater lagoon is too full, it may need to be dumped before the wastewater has been held for the amount of time required for treatment, increasing the risk of contaminating the surrounding ecosystem or drinking water source. Overwhelmed sewer systems can result in sewer backups into homes and buildings that flood and damage basements and may even require evacuations.

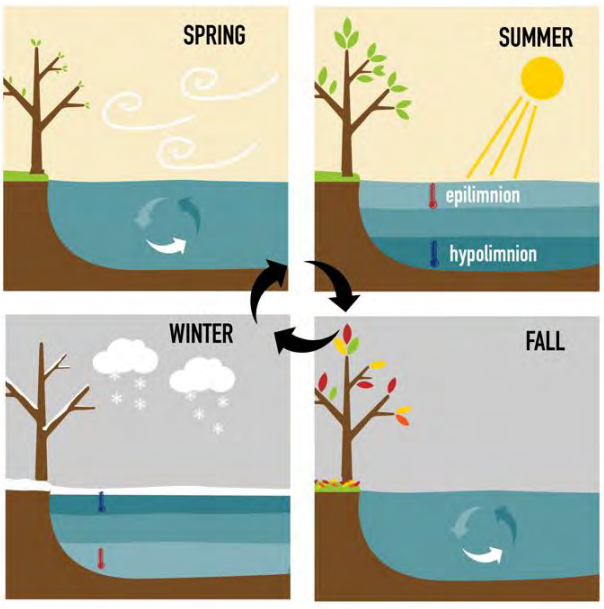
Erosion and sedimentation

Heavy rains may also lead to erosion, increased sediment entering the waterways as well as water cloudiness (turbidity) that may require more chlorine for water treatment, clog filters, or wear out pumps and turbines, increasing maintenance costs of drinking water systems.

How will higher temperatures impact water and wastewater systems?

Warming Lakes

Lakes go through a yearly cycle of mixing and layering. In spring, after the ice is gone, strong winds mix the water so the entire lake has the same water temperature and quality. In summer, as the sun warms the surface of the lake, the warmer water is less dense and begins to create a layer, the epilimnion, that doesn't mix with the water below, the hypolimnion; this is called stratification. In fall, the water cools and the layering disappears and the whole lake mixes again to then gets iced over in winter.



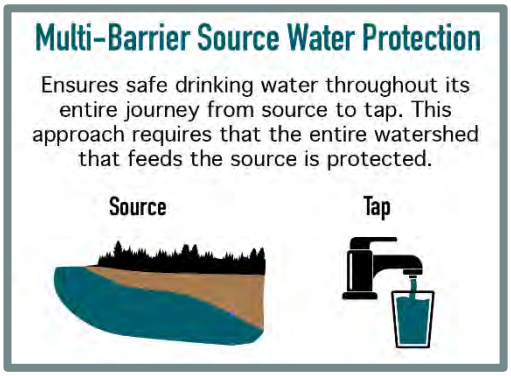
Yearly lake cycle

The top layer in summer, the epilimnion, becomes quite warm and tends to hold onto contaminants that runoff from the land and harbour algae blooms, making it less than ideal for a drinking water intake. Water intakes are preferably placed in the deep hypolimnion where colder, cleaner water makes for easier treatment. Climate change is expected to bring higher temperatures that will warm the waters of lakes and streams. The top layer of warm water in lakes, the epilimnion, will become deeper and therefore water intakes will need to be deeper to access cold, cleaner water.

How can we prepare?

Advocate for safe drinking water

Clean, safe drinking water is already an issue for many First Nation communities. Communities should continue to push for safe drinking water. In communities that do have drinkable tap water, make sure effective monitoring programs are in place and that the water continues to be safe to drink. During times that water is not safe to drink, communities should have an alerting system to notify members and have alternative water sources available (bottled water, boiled water, different water sources, etc.).



Assessing risk and vulnerability

Planning for infrastructure upgrades will require professional assistance/assessment, but an initial assessment of the current and potential climate change impacts can help identify priorities for adaptation planning. Ecology North developed a protocol to assess the vulnerability of northern water and wastewater systems to climate change impacts for communities in the Northwest Territories that may be useful for communities in northern Ontario. The guide includes a list of questions that will help determine the likelihood of an impact occurring and the severity of that impact to help prioritize action.

Assessing source water threats should consider regionally projected climate change impacts including potential for:

- increased flooding
- increased erosion
- increased turbidity
- melting permafrost (if applicable)

Community planning

Community planning can help protect drinking water sources as well as drinking water and wastewater infrastructure. Community planning actions could include:

- Limit building in sensitive areas, like riverbanks or shorelines, that could result in erosion.
- Manage hazardous waste at landfills to prevent contaminated runoff.
- Implement a drainage plan to manage stormwater; a good drainage plan can reduce the chance of flooding, and slow runoff to avoid erosion, sedimentation and contamination.
- Protect and divert water into green spaces like wetlands or ponds.
- Consider moving sewage treatment lagoons if they are upstream from water intake.

Climate change is likely to add additional stress on infrastructure. Identifying potential climate change impacts can help communities determine what actions should be taken now or in the future.

Resources

- The Northern Infrastructure Standardization Initiative (NISI) Community Systems: From Start to Finish: https://www.scc.ca/en/nisi/community-systems
- Protocol to Assess the Vulnerability of Northern Water and Wastewater Systems to Climate Change Impacts (2010): https://ecologynorth.ca/wp-content/uploads/2020/02/Vulnerability-Assessment-Protocol-03-10-Compressed.pdf
- Integrating Climate Change Measures into Municipal Planning and Decision-Making: A Guide for Northern Communities (2014): https://ecologynorth.ca/wp-content/uploads/2020/02/IntegratingClimateChange-book-Lowres-Feb2015.pdf
- Guidance For Providing Safe Drinking Water in Areas of Federal Jurisdiction: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-providing-safe-drinking-water-areas-federal-jurisdiction-version-2.html

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

Community Roads & Climate Change

Community roads are essential links that people use every day, but changing climate can damage the roads in the north by bringing more mid-winter thaws, more heavy rain, and other extreme weather events to the region. How can communities prepare?

How can climate change impact roads?

Weather can be hard on the roads of northern Ontario. Heat, rain, and freeze-thaw cycles can damage both paved and gravel roads, and climate change will likely intensify these weather events in the north. With climate change, we can expect warmer temperatures, more heatwaves, an increase in heavy rain events, and milder winters with more freeze-thaw cycles.

What are people noticing?

Already, people in many First Nation communities across the north say that heavy rains are damaging their roads, causing potholes and even washouts. In some cases, people point to poor road drainage as the problem. Washouts on provincial highways have also impacted people's ability to travel to other cities and communities.

How can we prepare?

Know what roads in your community are most at risk

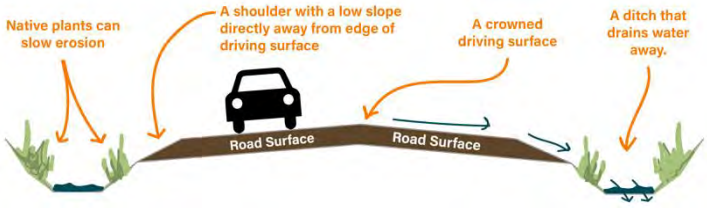
Knowing which roads could use improvement and which could be vulnerable to climate change impacts in the future is a good place to start the adaptation process. Roads that already have problems with flooding or washouts, or roads in low lying areas, could all be considered. Roads for emergency access and evacuation should also be prioritized. Keep climate change in mind when planning future community roads; for instance, plan new roads on high ground to reduce the risk of flooding.

Dirt and gravel roads can become marked with potholes when water doesn't drain away properly.

Culverts and water control

Heavy rain and excess water can cause a lot of problems for both paved and gravel roads. Make sure drainage and culvert systems can handle the amount of rain and snow melt expected for your region now and into the future. Keep ditches and culverts clear of blockages and repair or replace pieces as needed. Where roads cross streams and creeks, make sure culverts are big enough for the width of the stream and work with the natural flow of the water instead of trying to divert it elsewhere.

When water gets under the surface of roadways, potholes can form. To help promote drainage, roads are slightly higher in the middle (called the 'crown') and sloped down towards the edges to help water flow off the road surface. This sloping is especially important for dirt and gravel roads, which absorb water more readily than paved ones. The crown on gravel and dirt roads will need to be maintained and a machine with a grader blade is a good way to do that.



Limit erosion

As water from rainfall runs over the land, it can move soil, sand, and other materials along with it. This process is called erosion, and slopes and embankments along roadsides can be particularly vulnerable. When erosion happens on a large scale, road washouts can be the result. One cost-effective way to help limit erosion is by planting native plants. Plants help by slowing down the flow of water over the land, letting more soak into the ground, while their roots help hold the soil in position preventing it from being washed away. Keeping the slopes of roadside ditches as gentle as possible can also help lessen erosion.

Dust control

Traffic on dirt and gravel roads produces dust, a problem that can be made worse by periods of dry weather. If dust is a problem on local roads, communities can try: limiting traffic, suggesting people drive more slowly, watering the roads, changing road materials, or using a chemical to bind the road material together.

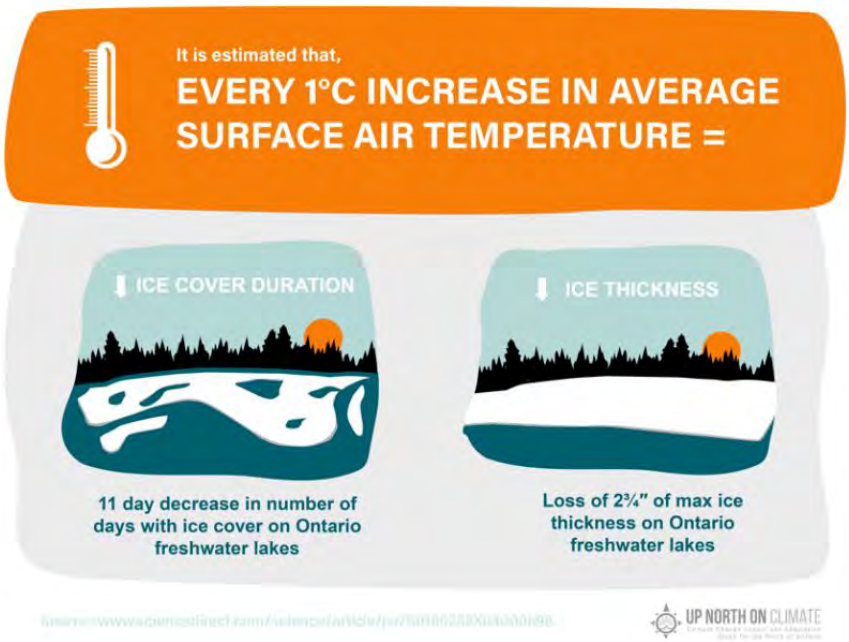
Want to know more about gravel roads? https://westfordvt.us/wp-content/uploads/2014/09/Appendix-B-Answers-to-Frequently-Asked-Questions-About-Gravel-Roads.pdf

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

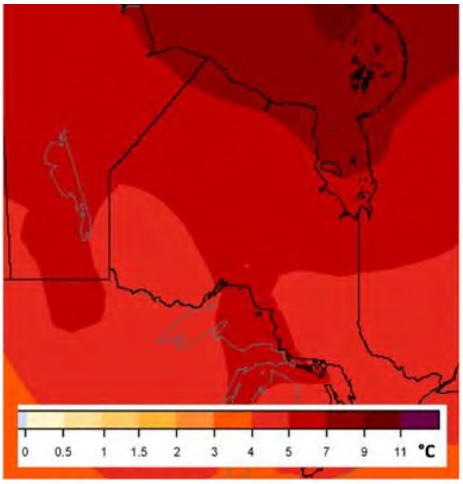
Transportation

Changing Ice

The winter season is projected to have the greatest temperature increase, and warmer winters are already being felt and seen in communities. In reality, changes in temperature are even more pronounced in some regions and can vary year to year.



What are the projected changes for Winter?



The projected change in winter temperature (°C) in Ontario is 4°C to 9°C by the 2050s, compared to the average for 1986-2005, assuming little reduction in carbon emissions (RCP8.5; 75th percentile). Source: http://climate-scenarios.canada.ca/index.php?page=download-cmip5

How will this impact the ice?

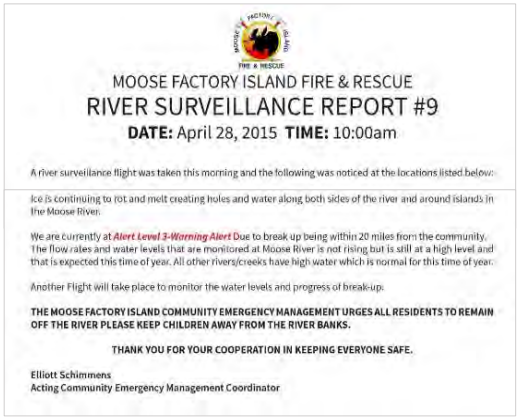
Ice growth and strength is directly linked to the weather in the area and this is especially important in the fall, when ice forms, and in the spring, when ice begins to lose its strength. In late fall, ice grows with cold days and colder nights (without snow to slow down freezing). Warming trends in fall and winter can delay ice freeze-up time making traditional routes unsafe when they would have been safe at that time in the past. This impacts people's ability to travel or hunt.

A faster spring melt of ice and snow can also create unsafe ice conditions earlier than when they have occurred in the past. Changes in ice thickness especially in the spring and fall can be a hazard to people's safety, and incidents of break-through could become more frequent.

What can we do?

Monitoring and community alerting systems

Ice thickness monitoring on traditional routes can increase the safety of community members. In some towns, a community person is hired to check ice thickness regularly on commonly used travel ways or waterbodies. Usually, an axe or an auger is used to measure ice depth, but some places have invested in ground-penetrating radar systems.



Sharing information about ice is vital and should 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. Lake Simcoe has a Facebook page and the Moose Factory Island Fire & Rescue put out regular reports to inform community members.

Equipment modifications and changing routes

In some regions, people have already needed to change the snowmobiles they drive to lighter weight machines for safer ice travel. Changing routes to avoid water crossings may be considered for safer access to traditional areas.

Emergency planning and preparedness

Emergency planning for safe travel is always a good idea, but especially in the winter. Telling a reliable community member where you are going and when you expect to return can ensure that someone will come looking for you if you don't return. Safety equipment and supplies like a floater suit, throw rope and ice picks in case you fall through the ice should always be a part of a packing list. Emergency planning information and a complete packing list should be available to community members either as a poster or on a community website.

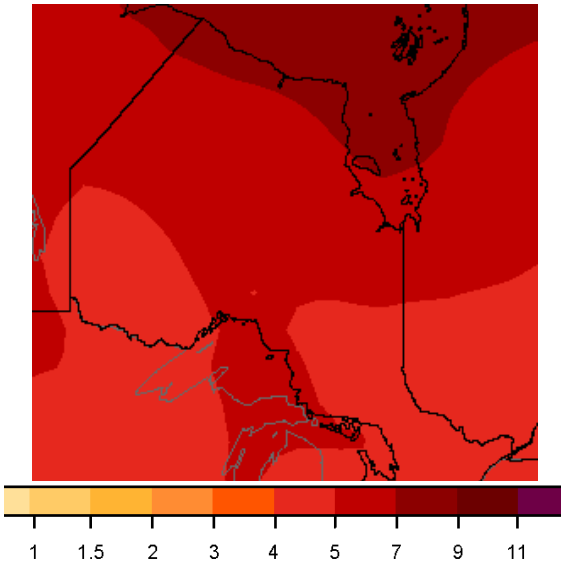
Learn more:

https://www.sciencedirect.com/science/article/pii/S0165232X04000898
http://lakeice.squarespace.com/bearing-strength/
https://www.ihsa.ca/PDFs/Products/Id/IHSA029.pdf

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

Off Road Thinking –
How local production can reduce dependence on winter roads

Most communities in northern Ontario rely on winter roads to receive goods and supplies. Warmer winters and changes in spring and fall weather are challenging winter road systems. As the climate continues to change, one way that communities can prepare is by becoming less dependent on goods shipped from other places.



Predicted changes in winter temperatures (°C) by the 2050s compared to the average for 1985-2005 (RCP8.5, 75th percentile) From http://climate-scenarios.canada.ca/?page=download-cmip5

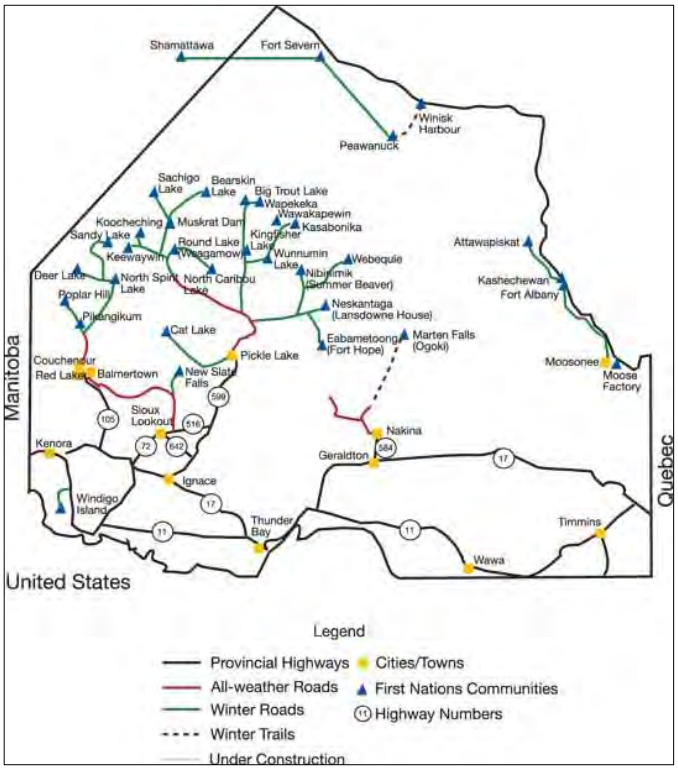
How is climate change impacting winter roads?

Climate change is expected to bring higher temperatures in every season, but temperature changes in winter are predicted to be the most dramatic of all. Winter temperatures in the far north are predicted to be as much as 5°C to 9°C higher in the 2050s as compared to the average for 1985-2005.

Snowfall, which can play a big part in winter road construction, is also predicted to change. The amount of winter precipitation an area can expect, when it falls, and whether it falls as rain or snow, can all impact winter road construction, quality, and lifespan.

For winter roads, these changes in climate can mean:

- Delays in opening dates
- Earlier closing dates
- Weaker, thinner ice
- Rivers freezing later or not at all
- Rivers break-up earlier and ice melts faster
- More slush
- Poor quality roads
- Melting of underlying permafrost
- Muskeg no longer freezes well



Map from https://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/assessments/2008/ch6/10363

What are people noticing?

In First Nations communities across Ontario people agree that the winter road season has gotten shorter. In some communities, people say that this shorter season has meant a shortage of goods and supplies, as fewer trucks can arrive or loads need to be lighter. Many people also have concerns with the safety of their winter road, saying they now limit their travel to February since January and March conditions are too unpredictable.

How can communities become less dependent on goods shipped over winter roads?

Less diesel, more green energy

Fuel for the diesel generators that power many remote communities is a big portion of the goods hauled over winter roads. When winter road seasons are short or the road quality only allows for partial loads, communities can face fuel shortages and are often forced to fly in fuel at much higher costs.

Adding green energy technology, such as solar and wind power, to the existing power grid can help communities reduce their use of diesel fuel. Not only does this lessen the need for costly fuel and fuel delivery, but it also reduces the community's overall greenhouse gas emissions and can improve air quality. As green technologies continue to improve, so does the potential for these energy sources to replace traditional, non-renewable energy!

Kotzebue Alaska

https://www.youtube.com/watch?v=4xna4-PSlUU

A remote community in northern Alaska installed its first turbine in 1997 and has since integrated a wind farm into the diesel generating system. Since 2015, excess wind energy is captured to heat the water in a boiler for the local hospital. In 2016, a bank of lithium ion batteries was installed.

Kiashke Zaaging Anishinaabek

https://montreal.ctvnews.ca/from-shore-to-sky-a-reconciliation-story

In August of 2019, the diesel generators that powered the community of KZA in Ontario for 60 years were turned off and the community's new solar powered micro grid was turned on. Since its launch, solar power in the community has saved over 20,000 litres of diesel fuel!

Local food production

Food is an important good shipped into remote communities on winter roads. Shortening of the winter road season can have a big impact on food security in the north. Growing food locally is one way to reduce dependence on outside supplies and improve access to food.

Berries and vegetables can be grown in outdoor gardens planted by individuals or by community members in shared community. Community gardens can help ensure that all community members have access to healthy foods, without the price tag that comes from shipping costs and retail markup. Greenhouses can extend the growing season even further and can be built fairly inexpensively. Hydroponics (using water instead of soil to grow plants) and aquaponics (growing fish for the waste they provide for growing plants) can be used to grow food indoors year-round or outdoors in summer in areas with poor soil.

FROM THIS:

TO THIS:

Aquaponics

Community Garden

Greenhouse

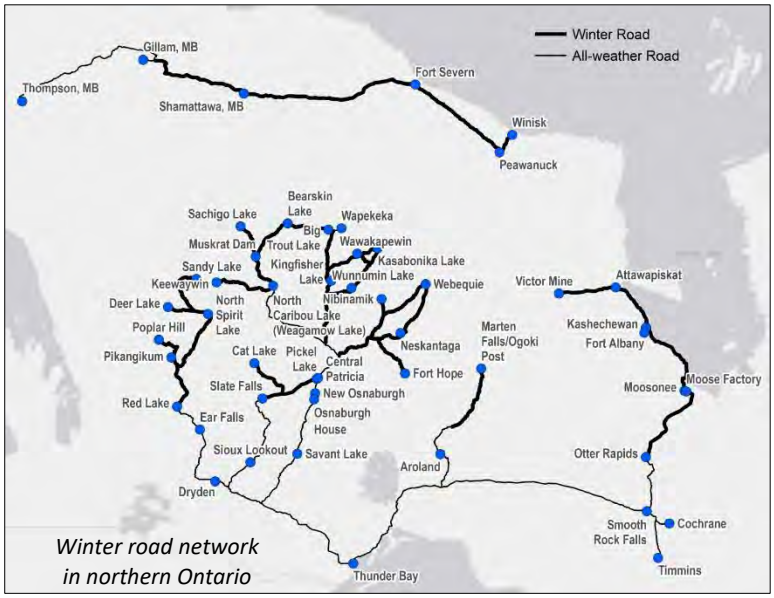
Although the changing climate threatens the longevity of winter roads, communities can prepare by reducing their reliance on shipping goods like food and supplies like diesel. Green energy and local gardening may be the answer. In fact, thanks to climate change, a longer growing season in northern Ontario will make it possible to grow a wider variety of berries and vegetables.

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

Winter Road Construction

In the far north of Ontario, winter roads connect 31 First Nation communities to an all-season road system further south or west. The winter road season in the far north typically runs about 3 months, from January to March, and connects First Nations to each other and to urban centres, allowing for transportation of goods and access to special services. The climate is changing, and winter roads have and will continue to be affected.

- Weaker, thinner ice
- Delays in winter road opening dates
- Reduction in winter road quality
- More slush
- Melting of underlying permafrost
- Roads may have air pockets and earth patches
- Muskeg no longer freezing well
- Rivers freezing later or not completely, river ice melts faster and break-ups are earlier



Winter road network in northern Ontario


Winter road near Peawanuck, March 2014, JLH3Photography

Winter road connecting KI and Wapekeka

What are some construction options?

Change/improve ice road flooding technique

Flooding roads is a common practice to increase the thickness of the ice road and technique varies based on local practice, but the strength of the ice can vary depending on flooding method. Thickening of the ice is usually done with high volume pumps which pump water from beneath the ice onto the surface. The water is applied in layers about 3 cm thick and allowed to freeze before another layer is applied. Read about construction methods in "State of the art of ice bearing capacity and ice construction" by D.M. Masterson.


Flooding pump with submersible auger. (Masterson, 2009)

Reroute roads to avoid water or add bridges over water

To reduce the number of times that the road goes over water where ice can be unsafe, consider moving existing routes away from major rivers to high ground like beach ridges. Extensive consultation and assessments of the land are required similar to what is being done for Webequie's Supply Road http://www.supplyroad.ca/. Another option is to build a bridge over rivers and creeks.


Permanent crossing over creek: Government of NWT.

All-season road

As the length of the winter road season continues to shorten, consider building an all-season road. This option can be very expensive and social aspects of connecting remote communities must be considered. Follow the progress of the western James Bay all season road on Facebook: Mushkegowuk Council All Season Road Feasibility Study

Winter Road Best Practices

Follow the rules!

Proper use of the winter road, especially over water crossings, will help to road last as long as possible. The rules are in place to extend the life of the road. Not following the rules will impact the integrity and safety of winter ice roads.

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

Vehicles (especially heavy ones) should not park on water crossings as they fracture the ice, reducing its strength. It is also important to follow the speed limit and to keep your distance from the vehicle ahead of you.

Speed limits are not just for the safety of the vehicles and the people in them. Going too fast damages the road. Vehicles travelling on ice generate waves in the ice. When staying below the speed limit, the ice sinks and flexes with the movement of the vehicle. If you speed, waves are formed in the ice which can stress and break it. If the vehicle is travelling too fast, the stress on the ice increases and can lead to extensive cracking, and blowouts that may even break through the ice. The speed vehicles can travel on ice depends on the thickness of the ice, the depth of the water below it and the length of the crossing. More information in Best Practices for Building and Working Safely on Ice Covers in Ontario.

Alert system for unsafe conditions/closure of road

To enforce these best practices, users need to be aware of them. A combination of signs on the road and Facebook posts may help residents and transport drivers follow best practices. Wetum Road, among others, have a Facebook page to keep everyone informed: https://www.facebook.com/wetumroad/

Next Steps?

Assess vulnerability of winter roads currently and in the future with changing climate. Consider the alternative construction options and make an action plan to implement them. Communities can also look to incorporate safety training as part of the construction costs.

Resources:

Findings from CIER and Manitoba First Nations research on climate change impacts on winter roads: http://www.yourcier.org/uploads/2/5/6/1/25611440/findings_pamphlet2_3.pdf

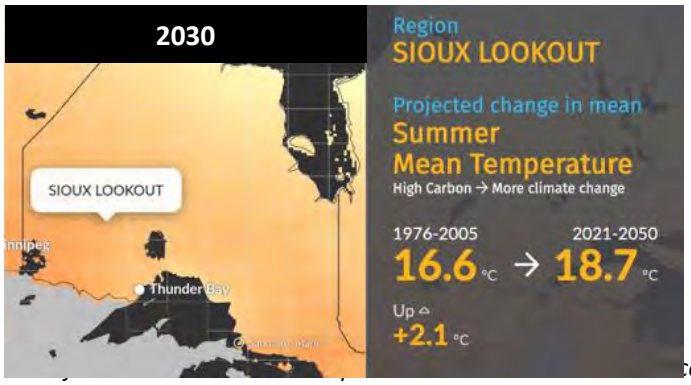
Impact of Climate Change on Winter Road Systems in Ontario's Far North: First Nations' and Climatological Perspectives on the Changing Viability and Longevity of Winter Roads. (Hori, Y., University of Toronto, 2016): https://tspace.library.utoronto.ca/bitstream/1807/76442/3/Hori_Yukari_201611_PhD_thesis.pdf

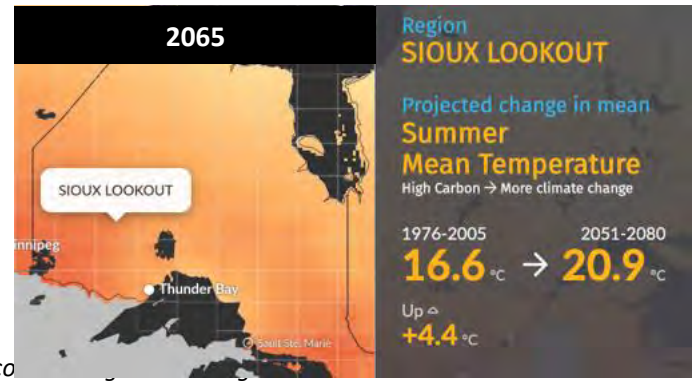
Traditional Routes: Summer travel over water and land

Rivers and lakes provide transportation corridors as do traditional routes on the land in summer, but as the climate changes these traditional routes are becoming more challenging to navigate.

How can climate change impact travel on land and on water?

Northern Ontario is getting warmer and will continue to warm with climate change. More heat waves in summer are expected and more droughts. The increased frequency and duration of droughts due to increased temperature may lower 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. When travelling over land, increased windstorms and extreme weather may down trees making it difficult to navigate traditional routes.





What are people noticing?

Across the north, people are finding that low water levels in summer is making travel across the land more difficult. Near Lake Nipigon, for example, travelers needed to portage in spots where the water was too low to paddle. On the James Bay coast, low water in summer has meant that some travelers are unable to reach their destinations. When trails near Wunnumin get blocked by fallen trees, chainsaws are needed to clear them out.

Low water levels make navigating streams difficult. Photo of stream entering Eabamet Lake.

Forests are drying out and being downed by high winds making travelling on land difficult. Photo near Dowling.

How can we prepare?

Equipment modifications

In communities along rivers, some traditional routes are no longer accessible during parts of the summer. 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 could include motors designed for shallow water like long shaft mud motors where the prop stays near the surface or jet drive motors that does not use a propeller.

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

Community initiatives

Where river waters are shallow near a community, the construction of a permanent road along the river would give residents the option of driving to their boats that are shored further downstream to avoid the shallowest waters. Where traditional trails are blocked by downed trees, communities can band together to do the hard work of removing the trees to allow passage to community members once again

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.

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

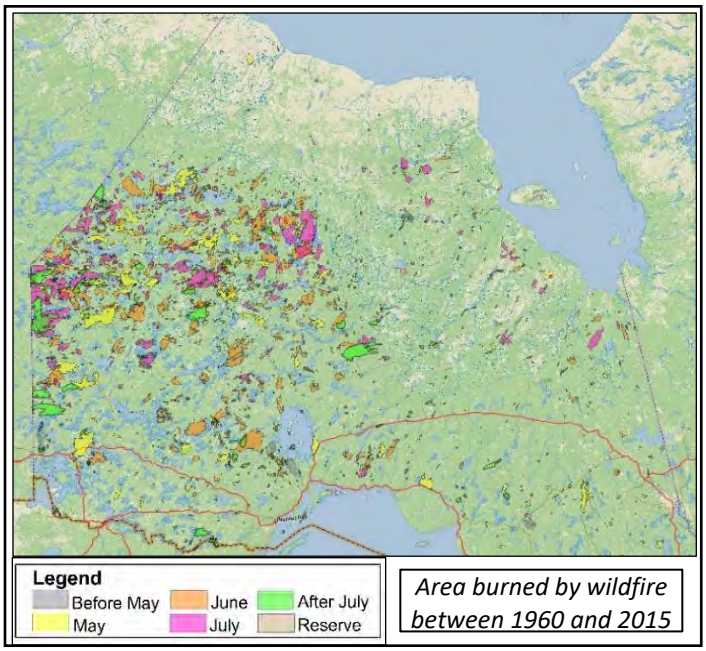
Wildfire

Wildfire – Natural but Risky

Fire is a natural and essential part of many ecosystems including the boreal forest in northern Ontario. It can also, sometimes, be a threat to people and communities. So, it is critical to explore how climate change may change wildfires on the land.

Why are there wildfires and why are they important?

In many of Earth's ecosystems, fire plays an important role. In fire-adapted environments like the boreal forest, natural wildfires are frequent and serve to renew the forest by clearing away dead material, like branches, that have collected over time allowing for the growth of new plants and trees. After a fire, trees like aspen and birch come back quickly because they grow from their stumps. Jack pine cones open from the heat of the fire and release seeds to grow the next generation of trees. Some animals like moose are attracted to this new forest of young trees. Fire creates a pattern of forest of various ages which provides habitat for a large variety of plants and animals. In northwestern Ontario, a high proportion of the forest has burned at some point in the last 50 years.



Area burned by wildfire between 1960 and 2015

How is climate change impacting wildfires?

Warmer temperatures

Climate change is bringing warmer temperatures to all regions of Canada. In Ontario, summer temperatures in 2050 are predicted to be as much as 3°C to 5°C warmer than the average summer temperatures in 1985-2005. Hotter temperatures draw more moisture out of plants and soils (an effect called evapotranspiration), and these drier conditions cause wildfires to ignite and spread more easily. Changes in other seasons, like warmer winters with less snow, warmer springs and faster spring melt, and warmer fall weather, can also influence the wildfire season. In many places, the wildfire season now starts earlier in the year and lasts longer into the fall than it has before. Climate change is impacting the timing, frequency, and intensity of wildfires on the land.

Evapotranspiration

Insect damage

Trees that are severely damaged or die in insect outbreaks can increase wildfire risk by becoming potential wildfire fuel. Climate change is predicted to make some forest insect outbreaks, like eastern spruce budworm, more severe. Eastern spruce budworm is a native moth; the caterpillar life stage of the budworm feeds on the needles of balsam fir and white spruce and can cause widespread tree damage in the boreal forest. One study predicted that climate change will lead to eastern spruce budworm outbreaks lasting longer and causing more damage, especially in the northern portion of its range[1].

Defoliation caused by the spruce budworm Photo https://www.nrcan.gc.ca/.

Severe Weather

Climate change has the potential to make storms happen more often and be more severe than in the past. Many people in First Nation communities across the north have already noticed a change, saying wind storms are stronger now than they used to be, and hearing of tornados in their area for the first time in living memory. Storms and severe weather can impact wildfire through:

Micro bursts and tornados

When trees are blown down by strong winds or tornados, the dead wood becomes fuel for forest fires as it dries out. As these events become more common, the amount of forest fire fuel across the landscape can also increase.

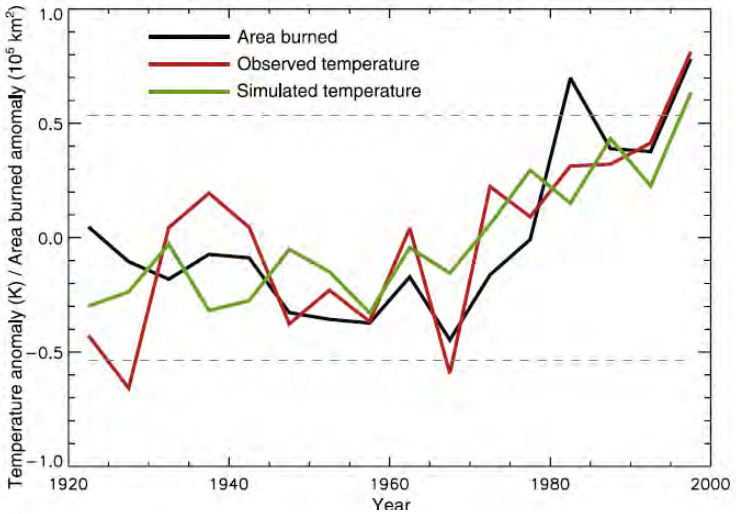
Severe weather blew over trees near Pickle Lake, ON. Photo Dave Cleaveley.

More lightning and more lightning-caused fires

More storms bring the possibility of more lightning, a trend some say they are already seeing. Lightning is how most natural wildfires start. Drier conditions on the land also mean that lightning strikes are more likely to ignite wildfires, making the impact of increased lightning strikes even more significant.

How do we know that the change in fires is because of climate change?

There are, of course, multiple factors that contribute to the ignition and growth of wildfires. Some people may use this fact to try to downplay the relationship between human-caused warming and wildfire occurrence. However, when researchers look at wildfires over a long period of time, like decades, many have found a clear and stable trend between wildfire and temperature. The graph to the right, looking at Canadian forest fires from 1920 to 1999, is an example of this, with temperature (the red line) and area burned in forest fires (the black line) following each other closely. Trends like this are good evidence that warmer temperatures are leading to more wildfires. It also means that, as warming continues, we will likely see even more wildfire activity in the future.



This graph shows the relationship between temperature (the red line) and area burned by wildfire (the black line) in Canada over time. The two lines follow each other closely, illustrating their relationship. The green line is the trend predicted by a computer model, which also follows the two lines closely. Graph from Gillett, N. P. et al 2004[2].

Wildfire is natural but the fire season is changing. Warmer temperatures are drying forests, severe weather and insect outbreaks are happening more often all increasing the risk of fire. We need to ask ourselves if animals and plants can adapt and how will these changes impact people.

Want to know more? https://sites.ualberta.ca/~flanniga/climatechange.html

[1]*Gray, D. R.2008 The relationship between climate and outbreak characteristics of the spruce budworm in eastern Canada. Clim. Change 87, 361–383 .*

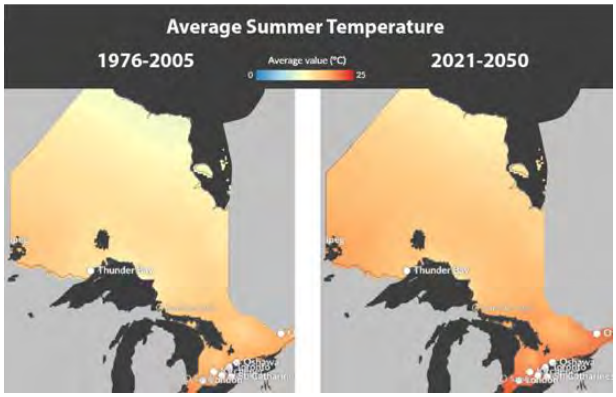
[2]*Gillett, N. P., Weaver, A. J., Zwiers, F. W. & Flannigan, M. D. 2004. Detecting the effect of climate change on Canadian forest fires. Geophys. Res. Lett. 31.*

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

Protecting Infrastructure from Wildfire

Climate change is impacting the timing, frequency, and intensity of wildfires on the land and putting infrastructure at risk, but fire prevention and policies can be put in place to keep communities, homes and people safe.

How is climate change impacting wildfires?



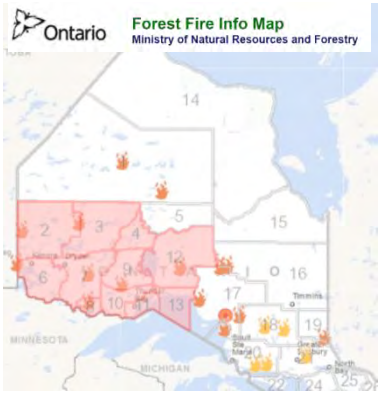
Climate change is bringing warmer temperatures to summers in Ontario which can lead to drier conditions that cause wildfires to ignite and spread more easily. In many places, the wildfire season now starts earlier in the year and lasts longer into the fall than it has before.

How can we prepare?

Community emergency plan

Having a community emergency plan is critical in order to be prepared for a wildfire, but community members must be aware of and have access to this information in order for it to be useful. A community emergency plan should outline:

- An emergency meeting place.
- List of contacts within the community.
- List of who is responsible for a given task, such as ensuring hazardous materials like fuel tanks are protected and who can act as a back-up if those individuals are unavailable.
- Inventory of the fire suppression equipment and a continually updated supply inspection log.
- Information on the location of sprinklers, power pumps, hose lines, fire alarms, and 2-way valves for splitting a single water supply within each community to protect valuables.
- An outline of hazard zones that exist around the community.



Monitor fire risk and smoke

Hot, dry conditions can make fires more likely to start and spread. Communities can monitor the fire hazard risk for their area with tools like Ontario's Forest Fire Info Map (https://www.ontario.ca/page/forest-fires). When fire risk is high, communities may want to restrict or ban outdoor burning, like campfires and encourage to butt out cigarettes before throwing them into the trash. Information on safe fire practices could also be shared with the community to lower the risk of human-caused fires. Communities may also wish to monitor for smoke and air quality. (https://firesmoke.ca/forecasts/current/)

Vegetation management

Managing the trees and plants near a community and your home can help reduce risk. Vegetation management will differ the closer you are to a building (priority zone). No vegetation should be within 1.5m (5ft) of a building. As you move away from the building, more and more vegetation can be left intact. Forest stands near the community can be thinned to reduce the spread of fire into a community. This preventative work can employ local people and provide firewood for community members.

Buffer zones & 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. Encouraging less flammable deciduous trees like birch, poplar, or maples can reduce the risk of fire spreading toward the community.

Fireguards act as barriers to potential fires.
Photo from www.livefiresmart.ca/community

Building with fire in mind

Changing how homes and buildings are constructed can make them more resistant to damage from wildfires. For example, roofing materials like asphalt, metal, or slate, are good choices for fire resistance. Fire resistant materials for siding include stucco, metal siding, brick, or concrete.

FireSmart Canada has many helpful resources and programs on how to reduce fire risk including vegetation and building management.

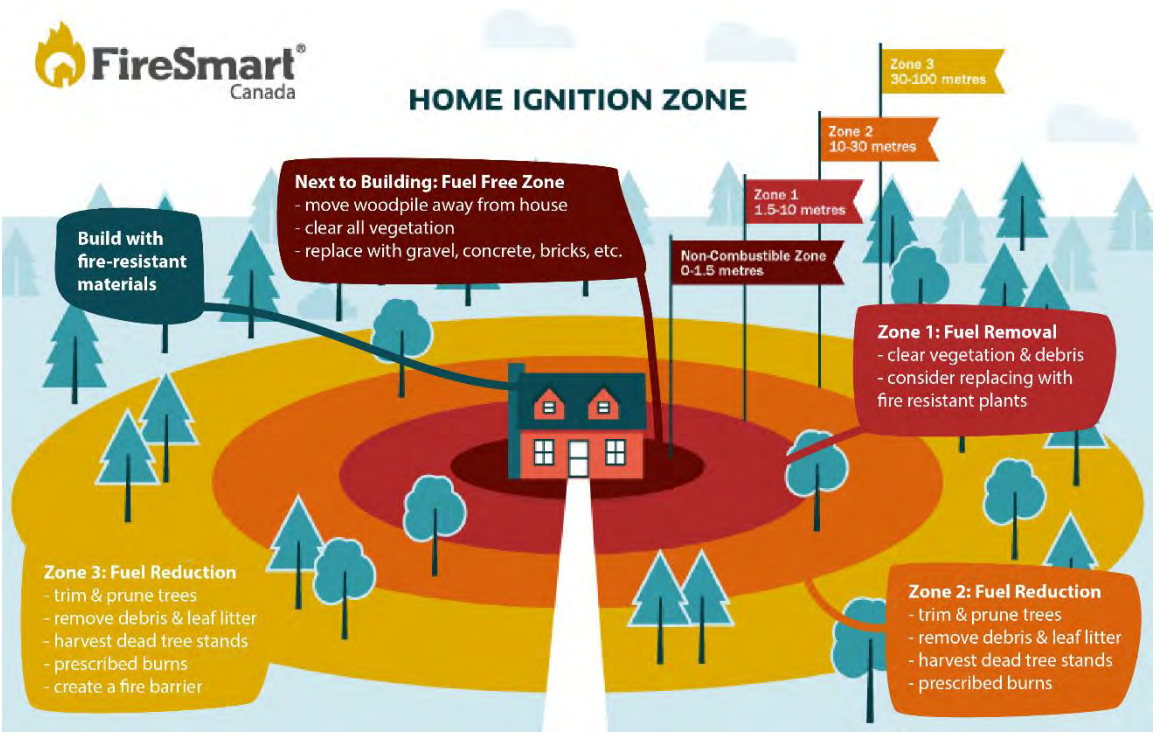


Image modified from FireSmart Canada's original image:
https://firesmartcanada.ca/wp-content/uploads/2018/10/FireSmart-

Fighting fire with fire

The Boreal forest is naturally shaped by fire. Lightning starts small regular fires that clear away dead material reducing fuel available for large damaging wildfires that can be especially risky for communities. This is the reason that fires that are not at risk of reaching a community, are left to burn themselves out. In many regions, controlled burns are set by government agencies to mimic the natural fire cycle. Clearing sections of the forest through controlled and prescribed burns were performed at nine First Nation communities across Ontario in 2017 to help reduce risk to those communities.

Fire risk is increasing because of climate change. Communities can prepare by having an emergency plan, monitoring the risk, and managing the land to reduce the risk.

For more information https://firesmartcanada.ca/programs-and-education/

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

Wildfire and the People in Your Community

Wildfire is a natural and essential part of the boreal forest ecosystem, renewing the land by clearing away dead material and prompting the growth of new plants and trees. However, wildfires can impact people when they happen close to communities. With climate change predicted to bring more wildfires to the north, the people who live there can prepare.

How are people impacted by wildfires?

Wildfires can have a wide range of impacts on people and communities. Fires burning close to communities can threaten homes and trigger evacuations. People may find their mental health is impacted as they experience worry or fear about having to leave their communities or the possibility of losing their homes.

Smoke from wildfires can also impact people in the north. Smoke can lower the air quality in and around communities and can cause breathing problems in vulnerable people, like elders, children, and those with asthma. Smoke can affect air quality enough that people need to stay indoors, which can lead to feelings of isolation and anxiety. Sometimes, smoke can become so severe that community evacuations are needed.

Map of active fires in northern Ontario on July 29, 2019. Map from Ontario Ministry of Natural Resources and Forestry, shared by CBC news.

How will climate change impact wildfires?

Climate change is already bringing hotter summers to the north, with more days over 30°C and more heatwaves than in the past. Hotter temperatures draw more moisture out of plants and soils drying the land which leads to more wildfire ignitions and greater spread. Changes in other seasons, like warmer winters with less snow, warmer springs and faster spring melt, and warmer fall weather, are also impacting the wildfire season, causing it to start earlier in the year and last longer into the fall than it has before.

What have people noticed?

Evacuations of First Nation communities due to wildfire or smoke danger happen nearly every year. Some recent examples:

- 2019: Pikangikum First Nation was evacuated twice in one season (first in late May, then again in July) as wildfires burned dangerously close to the community.
- 2019: Keewaywin First Nation was evacuated as a fire burned only 8 km away from the community.
- 2018: 80 residents of Wabaseemong Independent First Nations were evacuated for 12 days in July due to heavy smoke from a wildfire in the area.
- 2017: smoke from multiple wildfires lead to the evacuation of over 200 residents from Nibinamik First Nation.

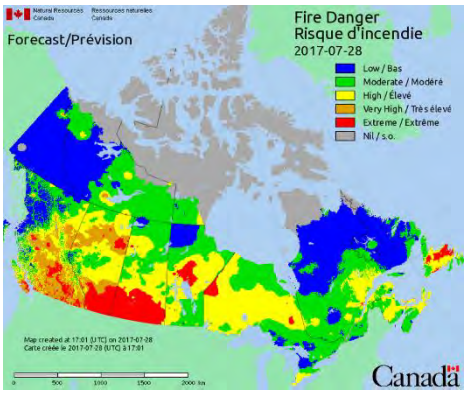
Forest fire outside Pikangikum First Nation on May 30, 2019. Photo: Twitter/OPP IndigenousBureau

How can we prepare?

Prevent human-caused fires

Fire safety is always important, but as the land gets drier causing fires to ignite and spread more easily, preventing human-caused fires becomes even more critical.

- Promote safe fire practices in your community (campfire safety, guidelines for burning grass and yard trimmings, etc.)
- Promote safe fire practices when on the land and point out actions that can cause accidental fires (sparks, cigarette butts)
- Monitor the fire hazard risk in your area. When fire risk is high, communities may want to restrict or ban outdoor burning.



Tools like the Canadian Wildland Fire Information System (https://cwfis.cfs.nrcan.gc.ca/home) can help communities monitor their fire hazard risk.

Monitor for air quality

Monitoring the air quality is important because people can be impacted by wildfire smoke even if the fire is burning at a safe distance away from the community. Tools like FireSmoke Canada (https://firesmoke.ca/forecasts/current/) and Canada's Wildfire Smoke Prediction System (https://weather.gc.ca/firework) offer maps of current and predicted smoke plumes from wildfire allowing people to take action if necessary. Community alerts can be issued when air quality is poor so people can take precautions. Elders, children, or those with medical conditions can be particularly at risk. Those with a preexisting condition like asthma, should make sure to keep medication on hand if needed.

When air quality is poor people can:

- *Limit outdoor activity*
- *Keep windows and doors closed at home (as long as it's not too hot)*
- *Keep car windows closed when driving*
- *Drink plenty of water*
- *Leave the area if necessary and possible*

Emergency preparedness

Being prepared for emergencies can help events like evacuations happen smoothly and effectively. The "Summer of Smoke" study found that people felt better in emergency situations if they also felt prepared. If your community doesn't have an emergency plan in place, programs like FireSmart can help you create one. Community members and households can also get prepared by:

- Being familiar with the community emergency plan, such as where the emergency meeting places are and what evacuation routes to use.
- Preparing a "Grab & Go Bag" that you can quickly grab in case of an evacuation.
- Knowing how to prepare your home before you leave.

Red Cross Canada has checklists of what can go in your Grab & Go bag.

Mental Health Support

The stress of evacuations, the feeling of displacement, and the worry about losing your home can all take a toll on mental health. When smoke advisories keep people inside their homes, feelings of isolation can build. Check in on family and neighbours and continue to push for the mental health services.

Want to know more?

FireSmart (www.firesmartcanada.ca), Summer of Smoke (https://ecologynorth.ca/project/summer-of-smoke/), Red Cross (redcross.ca), Wildfire smoke air quality and health (https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/wildfire-smoke.html)

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

UP NORTH ON CLIMATE

Climate Change Impact and Adaptation Study for the North of Ontario

www.upnorthonclimate.ca