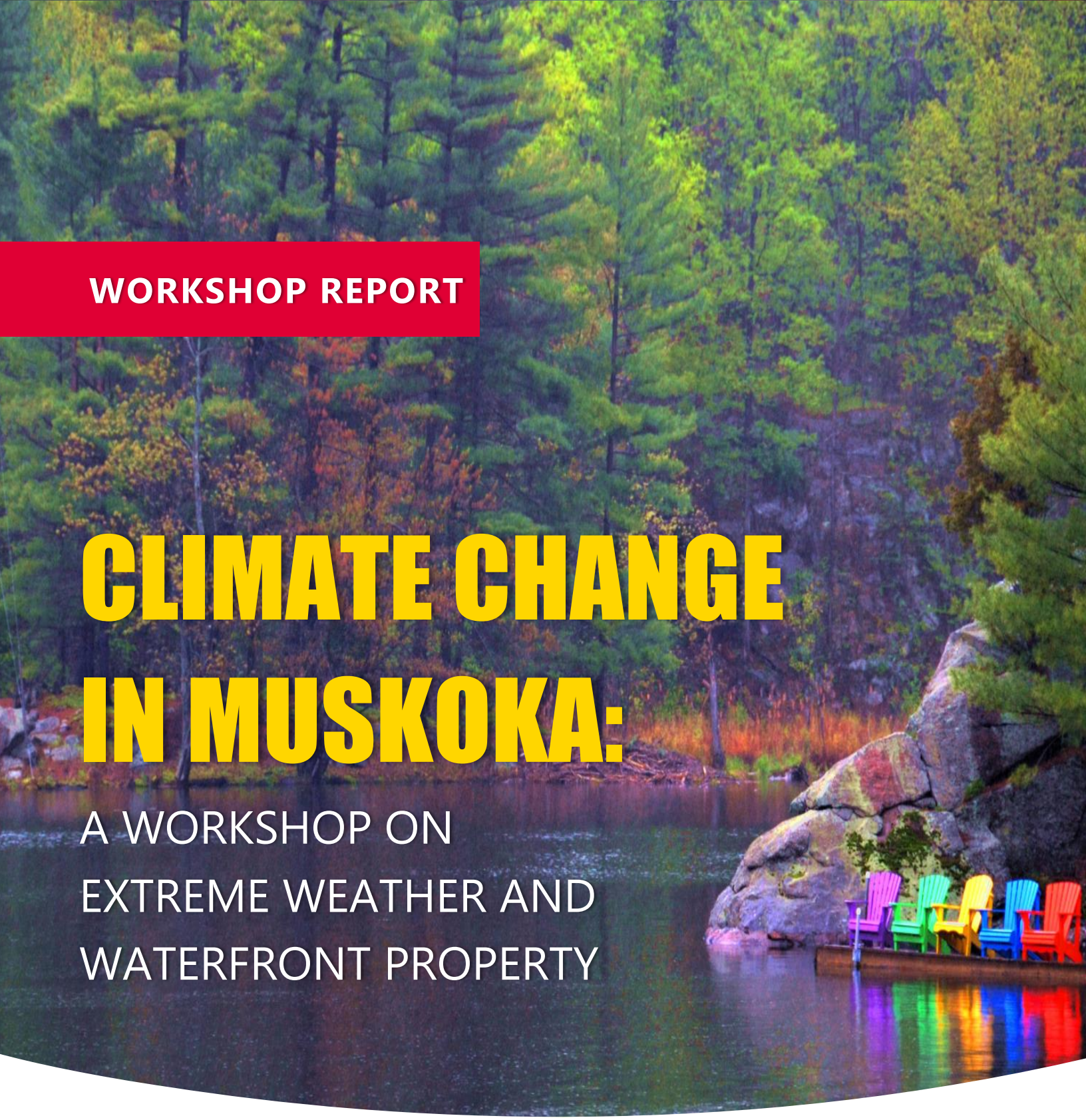

WORKSHOP REPORT

CLIMATE CHANGE IN MUSKOKA:

A WORKSHOP ON EXTREME WEATHER AND WATERFRONT PROPERTY

AUGUST 8, 2017
WATERLOO SUMMIT CENTRE FOR THE ENVIRONMENT
87 FORBES HILL DR, HUNTSVILLE, ONTARIO

OCCIAR
Ontario Centre for Climate Impacts and Adaptation Resources

Ontario
Ministry of Natural Resources and Forestry

Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR)

OCCIAR is a university-based resource hub for researchers and stakeholders and provides information on climate change impacts and adaptation. The Centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development and application of tools to assist with municipal adaptation. The Centre is also a hub for climate change impacts and adaptation activities, events and resources.
www.climateOntario.ca

For more information, please contact:
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Ministry of Natural Resources and Forestry – Parry Sound District

The purpose of the Ministry of Natural Resources and Forestry is to provide opportunities for resource development and outdoor recreation for the continuous economic and social benefit of the people of Ontario, and to administer, protect, and conserve public lands and waters. The ministry's programs are concerned with the use of the physical resources such as land, water, trees, fish, animals and certain minerals for resource utilization and recreation.

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Natural Resources Canada Ressources naturelles Canada
Canada

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Table of Contents

1.0 About the Workshop

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) and the Ontario Ministry of Natural Resources and Forestry (MNRF) Parry Sound District Office were pleased to present this special one-day workshop – *Climate Change in Muskoka: A Workshop on Extreme Weather and Waterfront Property*.

Climate change continues to bring challenges that require government and residents need to face head-on and manage proactively. The effects of climate change have already been felt across Ontario, as the province has experienced warmer temperatures, changing precipitation patterns, and is facing more extreme weather events with unparalleled damage. These changes in our weather have resulted in a variety of environmental, social and economic impacts. For example, the increasing frequency and intensity of weather extremes has especially impacted shoreline infrastructure in the Muskoka region.

Everyone will be impacted by climate change and will have a role to play in adapting to the challenges it will bring. This workshop introduced participants to the science of climate change, the impacts of climate change on the ecology and natural amenities of the lakes and rivers we enjoy, and considerations for a more resilient waterfront.

1.1 Workshop objectives and expected outcomes

The overall goal of the workshop was to increase participants' knowledge of climate change science, impacts and adaptations and to provide them with the information and tools needed to help them increase their shoreline resilience to extreme weather events. The workshop introduced participants to:

- The science of climate change, and what future climate models are projecting for temperature and precipitation in the area;
- The impacts that climate change will bring to the Muskoka region, including the increasing frequency of extreme rain events (resulting in high water levels/floods), drought (resulting in low water levels), wind, etc.;
- The effect that these impacts will have on aquatic ecosystems;
- How water is managed in the Muskoka watershed; and
- The information available to help incorporate resiliency into shoreline property management.

In order to accomplish these objectives, participants listened to seven presentations from experts (these presentations are summarized in Section 4.0) and received an Attendee Handout (see Appendix).

1.2 Who was in attendance?

This workshop was attended by 50 participants representing each of the 20 cottage associations for lakes with water control structures managed under the Muskoka River Water Management Plan, who were interested in the unique issues that climate change will bring to the Muskoka area.

2.0 Agenda

9:30am – 10:00am	**Registration and Light Refreshments**
10:00am - 10:15am	**Welcome and Opening Remarks** Al Douglas (Ontario Centre for Climate Impacts and Adaptation Resources)
10:15am - 11:00am	**Planning for the Changing Climate in Muskoka Watersheds** Heather Auld (Risk Sciences International)
11:00am - 11:30am	**Extreme Weather and Emergency Preparedness** Geoff Coulson (Environment and Climate Change Canada)
11:30am - 12:00pm	**Flood Risk Mitigation – Properties & Property** Dan Sandink (Institute for Catastrophic Loss Reduction)
12:00pm - 12:40pm	**Lunch**
12:40pm - 1:20pm	**The Muskoka River Watershed, the Muskoka River Water Management Plan and MNRF Water Management** Mara Kerry and Amanda Vincent (Ministry of Natural Resources and Forestry, Parry Sound District Office)
1:20pm - 1:50pm	**Effects of Climate Change on Ontario's Aquatic Ecosystems** Cindy Chu (Ministry of Natural Resources and Forestry)
1:50pm - 2:00pm	**Short Break**
2:00pm - 2:30pm	**Improving Resiliency for your Shoreline Property** Rebecca Willison (Muskoka Watershed Council)
2:30pm - 3:00pm	**Climate Change in Cottage Country: Get Ready** Terry Rees (Federation of Ontario Cottagers' Associations)
3:00pm - 3:15pm	**Workshop wrap up and farewell**

3.0 Presenters

HEATHER AULD – Principal Climate Scientist, Risk Sciences International

Heather Auld joined Risk Sciences International in 2011 as a Principal Climate Scientist after 32 years with Canada's Federal Government. She has worked both with Environment Canada and the Department of National Defence across Canada in climate science, climate services and climate change adaptation, weather forecasting and operations, training, and stakeholder consultations.

As one of Canada's foremost engineering climatologists, Heather brings nationally- and internationally-recognized expertise in climate change impacts and adaptation research, engineering climatology for national codes and standards, energy-climate research, extreme event and forensic analyses, disaster risk reduction planning, and science-policy linkages. She has served on both World Meteorological Organization and International Panel on Climate Change expert groups.

In Canada, Ms. Auld is a main climate science advisor to Canada's National Codes Commission, is routinely called upon by industry groups and built infrastructure design standards committees for expert advice, and has provided climate risk-related training to a range of industrial players as well as public sector agencies. She has developed weather hazards information for disaster risk reduction and provided expert testimony to many disaster-related inquiries including the Walkerton Inquiry into water contamination.

Ms. Auld has been central to the development of decision-support applications for the interpretation and use of historical climate information, forensic data, and climate model outputs for the purpose of "on-the-ground" decision-making. Ms. Auld has worked with practitioners and decision makers across a range of sectors, including but not limited to: municipal planning, engineering design, emergency response; airport management and operations; forest management; and, electricity systems, water resources and other infrastructure.

GEOFF COULSON – Warning Preparedness Meteorologist, Environment and Climate Change Canada

Geoff Coulson has been a meteorologist with Environment and Climate Change Canada for over 33 years. During his career he has been involved in weather forecasting, training, software development and outreach activities. For the last 13 years, Geoff has been a Warning Preparedness Meteorologist providing weather information to all levels of government, the media and the private sector. He also sits on the Provincial Flood Forecast and Warning Committee and manages the CANWARN storm spotter program in Ontario.

DAN SANDINK – Director of Research, Institute for Catastrophic Loss Reduction

Dan Sandink has led a significant portion of the Institute for Catastrophic Loss Reduction's (ICLR's) urban flood risk reduction work, and has authored or co-authored dozens of reports and articles on topics related to urban flooding and natural hazards. Dan's work has focused on public risk perceptions, adoption of lot-level disaster mitigation practices, insurance, climate change adaptation, lot-level flood protection technologies, inflow/infiltration, construction codes, wildland-urban interface fire risk reduction, among other topics. Dan is a graduate of the geography and planning programs at the universities of Guelph, Western Ontario and Toronto.

MARA KERRY – a/Resource Management Supervisor, Ministry of Natural Resources and Forestry (Parry Sound District)

Mara Kerry is a first generation Canadian of Welsh descent. Born and raised in Toronto, she obtained an undergraduate degree in International Development and a graduate degree in Forest Ecology, both from the University of Toronto. Mara has a keen interest in the intersection of conservation and sustainable development objectives. A seasoned conservation professional, Mara has experience in biodiversity conservation, sustainable development and climate change impacts on natural systems. Her specialized expertise in integrated conservation and development led to work with BirdLife International in the Americas. For 11 years, Mara worked in Latin America to advance migratory bird conservation with southern partner organizations. She spent 3 years at the David Suzuki Foundation and is currently advancing partnerships on behalf of the Ontario government.

AMANDA VINCENT – a/Partnership Specialist, Ministry of Natural Resources and Forestry (Parry Sound District)

Amanda Vincent has been a resource technician with the Ministry of Natural Resources and Forestry (MNRF) since 2001. Over the past 16 years she has been involved with fisheries monitoring and assessment, rabies research and abatement as well as lands and waters management. Amanda is extremely familiar with the Muskoka River watershed spending the past nine years focused on dam operations and water management for the Parry Sound District.

CINDY CHU – Research Scientist, Ministry of Natural Resources and Forestry

Cindy Chu is a Research Scientist with the Aquatic Research and Monitoring Section of the Ontario Ministry of Natural Resources and Forestry. She is also an Adjunct Professor at the University of Toronto in the Ecology and Evolutionary Biology Department. Cindy studies the impacts of human activities (e.g., urbanization, exploitation, climate change) on aquatic habitats, freshwater fish biodiversity, and fisheries resources. She also researches the regulations, actions, and protected area network designs that can aid in the conservation and management of fisheries resources.

REBECCA WILLISON – Watershed Planning Technician, Muskoka Watershed Council

Rebecca Willison has been the Watershed Planning Technician for the Muskoka Watershed Council since 2002 and the District of Muskoka since 2003, where she coordinates the Lake System Health Recreational Water Quality Monitoring Program. She has a degree in Zoology and a certificate in Environmental Conservation from the University of Guelph, as well as a certificate in Restoration Ecology from Niagara College. Since moving to Muskoka in 2001, she has enjoyed hiking the many excellent trails found in the area and recently began volunteering with the Muskoka Trails Council. Through her work with the District and the Muskoka Watershed Council, Rebecca is active in promoting good stewardship practices across the district, with an emphasis on maintaining good water quality.

TERRY REES – Executive Director, Federation of Ontario Cottagers' Associations

Terry Rees has worked across Canada and North America for small community groups and large multi-nationals and has a history of progressive resource management experience within Canada's petroleum and mining sectors, including roles related to hazardous materials recycling, forest fire fighting, and environmental risk management and policy. Throughout his 20-year affiliation with the Federation of Ontario Cottagers' Associations (13 as Executive Director) Terry has been an outspoken champion for rural communities and the protection of freshwater environments. Terry has been an advocate for proactive community action and emergency preparedness for many years. Terry spends his most precious "shore time" at his island property northeast of Peterborough that his family has enjoyed since the 1950's.

3.1 Workshop facilitator

AL DOUGLAS – Director, Ontario Centre for Climate Impacts and Adaptation Resources

Al Douglas is the Director of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR), located at Laurentian University in Sudbury, Ontario. He has been working in the field of climate change impacts and adaptation for over 15 years and has partnered with many different organizations in Ontario and Canada to develop and deliver adaptation resources and strategies.

4.0 Presentation Summaries

This section provides brief summaries of the seven presentations given at the workshop. Copies of the presentations (in PDF format) are available for download at www.climateontario.ca/w_CCinMuskoka_WP.php.

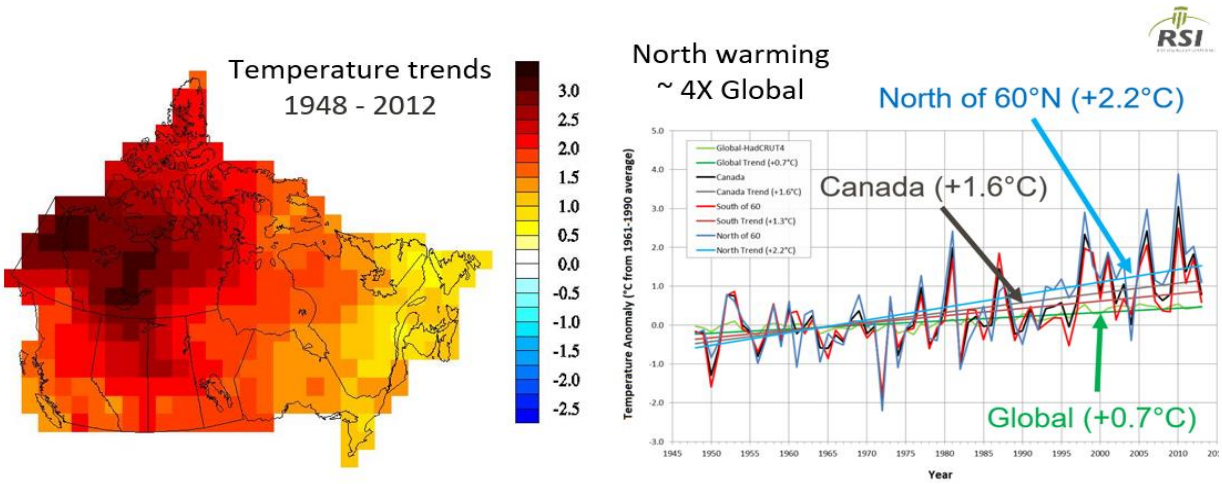
4.1 Planning for the Changing Climate in Muskoka Watersheds

Presented by: Heather Auld (Principal Climate Scientist, Risk Sciences International)

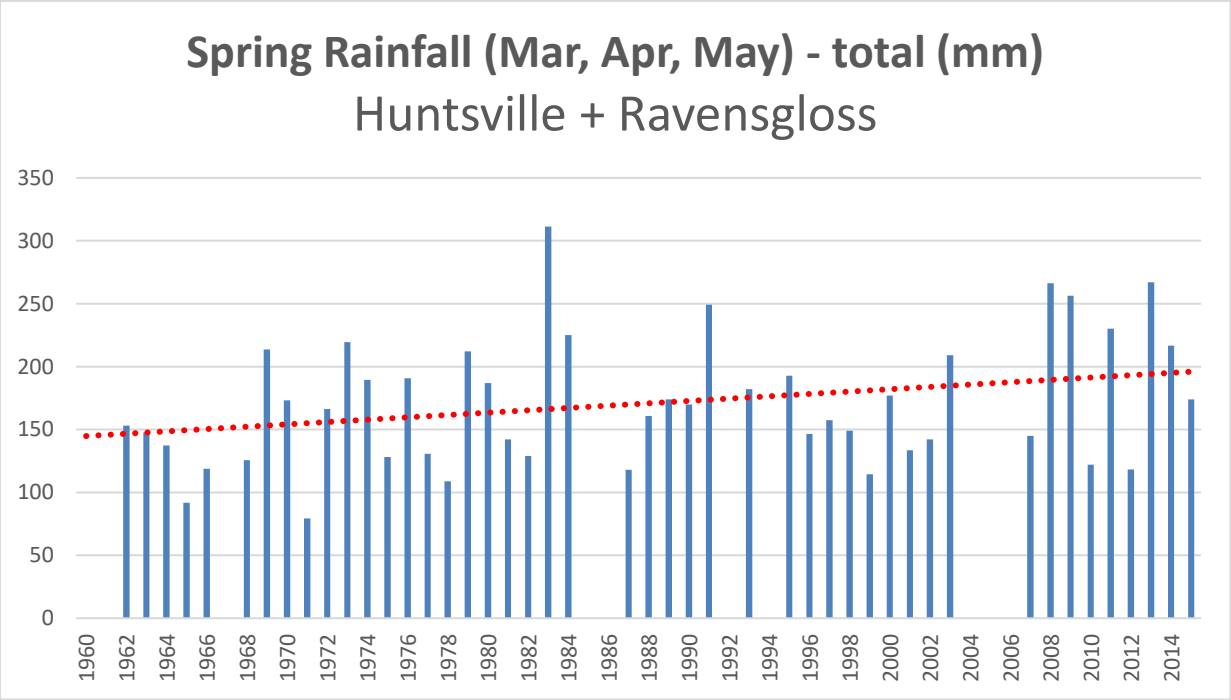
Climate change and extreme weather have been making the news more and more these days, and the Muskoka area has seen its fair share of extreme weather events (e.g. floods, fires, snowstorms and tornadoes). It used to be easy to tell the difference between weather (what you get) and climate (what you expect); however, this is becoming pretty muddy these days. The climate is changing and impacting the weather patterns that we get.

Climate change is related to increasing atmospheric greenhouse gas (GHG) emissions, and emissions are expected to continue to accumulate into the future. Therefore, we do not expect that climate change will stop anytime soon. In fact, 97-98% of scientists agree that climate change is happening and humans are the cause. The remaining 2% of scientists that deny climate change are often funded by companies with high levels of GHG emissions.

In Canada, temperatures have been warming at twice the global rate, with the Arctic experiencing the greatest warming (see image below). Precipitation has also been changing and the country is getting wetter. Although this change in precipitation has been variable (up and down each year), we are seeing wetter conditions overall.



In the Muskoka region, temperatures are warming in all seasons (particularly in the winter) and the area is experiencing more hot days over 30°C; these trends will continue into the future. This warming has implications for species, forest fires, algae blooms, etc. Precipitation has also been increasing in the Muskoka region. In the winter, the Muskoka region is experiencing more snowfall and more frequent and intense snowstorms. The reason for this is because warmer air can hold more moisture and the Great Lakes are staying open longer during the winter months, meaning that the areas in the Snowbelt are seeing more lake-effect snow. Spring rainfall is also increasing in the Muskoka area (see graph below). With increasing winter and spring rainfall around the time of the spring freshet, the area can expect to see more flooding conditions in March, April and May. Additionally, short duration, high intensity rainfall events are increasing in the Muskoka region and are projected to increase into the future.



Disappearing Arctic ice is affecting weather patterns across North America due to the slowing down of the jet stream. As a result, the Muskoka area is at risk of experiencing more 'stuck' weather patterns. For example, during the summer of 2017 Ontario experienced very wet conditions, the Prairies and British Columbia experienced very dry conditions, and Europe experienced very hot conditions. Some research suggests that we may see more of these 'stuck' weather patterns into the future.

Currently, there is good confidence about projected average temperature changes into the future that are derived from global climate models; however, climate models are less accurate at predicting extreme weather events. For example, snow, ice and wind are extremely difficult to model. Therefore, we are less certain about how extreme weather events will change into the future, but there is enough certainty that we know that if we do nothing the costs will be high.

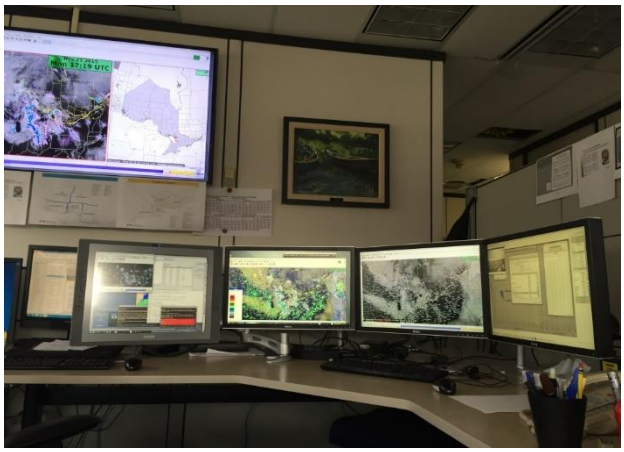
Adapting to climate change involves taking actions to reduce the risks posed by a changing climate or taking advantage of any opportunities that may arise. You can use a technological/ecosystems approach

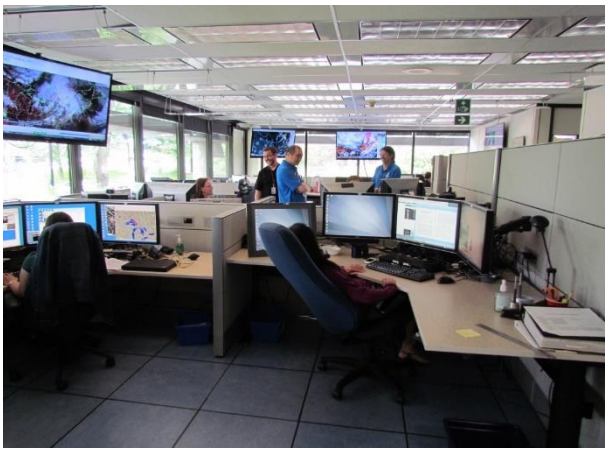
to adaptation (e.g. water management, flood protection barriers, shoreline resilience) or a strategic/regulatory approach (e.g. restrict building in current high-risk areas, incorporating climate change into land-use plans). The technological options are often expensive, while the regulatory options are politically hard to do; that is the challenge of adaptation. In between all of the possible adaptive actions is the importance of monitoring changes in temperature, precipitation and impacts. No single agency has the capacity to do all of the monitoring in Ontario; thus, we need to focus on collaborating in order to effectively gather data needed to address climate change.

4.2 Extreme Weather and Emergency Preparedness

Presented by: Geoff Coulson (Warning Preparedness Meteorologist, Environment and Climate Change Canada)

On Friday August 4, 2017 there were two tornadoes in the Muskoka region – one southwest of Huntsville and one to the northeast of Huntsville. It is clear that extreme weather is something we have to deal with now, but trends will be are changing as we go into the coming decades. The Ontario Storm Prediction Centre in Toronto is a 24/7 operation (see images below). The Centre handles media calls during weather situations for weather statements and warnings. The Centre offers a variety of ways to get information out to the public including special weather statements (used year-round to communicate weather events that might have some type of impacts but are a few days away), special weather advisories (for more specific types of weather events like freezing drizzle), and weather watches or warnings (for more significant weather events like large snowfall events, snowsqualls, thunderstorms, etc.)





Extreme winter weather kills and injures more Canadians than extreme summer weather. For example, snowfalls usually affect a large geographic area and can cause traffic collisions, health problems due to snow shoveling, slips and falls, etc. Conversely, when we talk about summer weather events it is mainly localized storms. When it comes to flood forecasting in Ontario, flood watches/warnings are provided by Conservation Authorities and the Ontario Ministry of Natural Resources and Forestry (i.e. spring run-off, ice jams, floods, etc.), while Environment and Climate Change Canada (ECCC) supports their activities through provision of temperature and precipitation forecasts.

Large-scale storm systems can bring significant rainfall over a number of hours/days and can combine with snowmelt to exacerbate spring-time flooding. Flash floods are floods that rise and fall rapidly with little or no advance warning, usually as the result of intense rainfall over a relatively small area. Currently, there is no flash flood warning in Canada per se, but ECCC issues severe thunderstorm warnings that may mention the possibility of flash flooding. It is then up to the provincial district offices to send out messages to their districts. Some small scale storms can develop and move quickly, making it difficult to give lead time on those types of short-fuse events (often only minutes). Thus, it is important for people to pay attention to special weather statements and weather watches.

There are a number of great online resources to help individuals prepare for extreme weather events:

- Public Safety Canada developed the Get Prepared website with a stepped process to help individuals plan for different types of weather they could experience and build an emergency preparedness kit.
- LightningMaps.org provides free, real-time lightning information almost down to the street level.
- Intellicast.com is an interactive weather map that allows you to overlay certain weather information on a map. It is scalable to the Muskoka area.
- Wundermap provides weather data from volunteers who own weather measurement equipment. Good weather measurement kits can be purchase for under $1,000 and have good accuracy.
- Windy.com is a website that includes precipitation, cloud, temperature and wind forecasts up to 17 days in the future.

There are also a number of smartphone apps that are used by weather forecasters. For example, Radarscope is a storm application for smartphones that locates you via satellite and provides you with radar imagery of the weather around you. Another example is Météo, a Canadian startup that also sends weather watches/warnings directly to your phone.

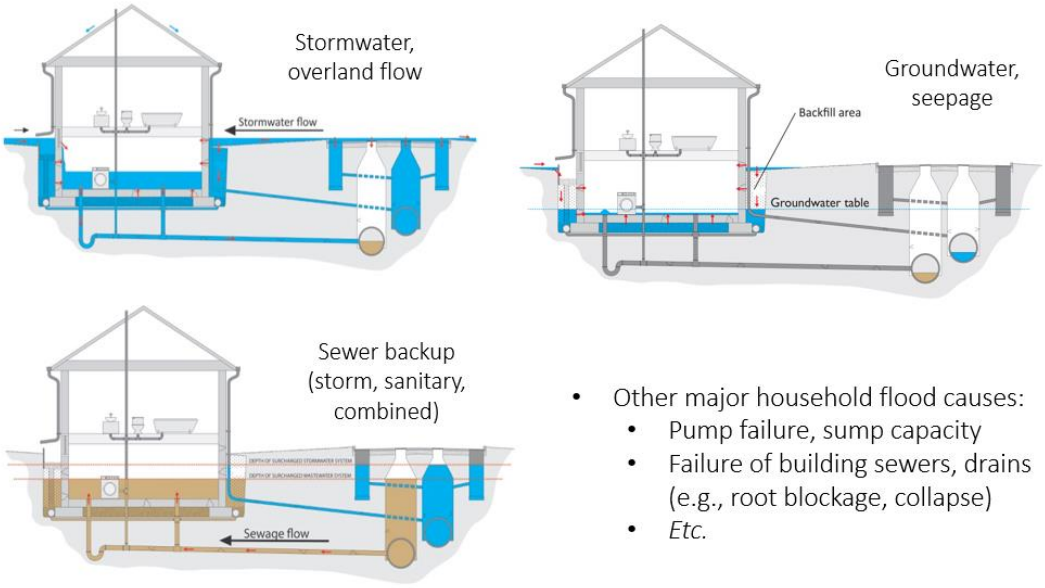
Additionally, ECCC offers the CANWARN program for volunteers who watch the sky and report occurrences of significant weather to ECCC all year long. These training sessions are free and are held across the province each spring between April and June. Over the past 10 years, over 6,500 volunteers have been trained.

4.3 Flood Risk Mitigation – Properties & Property

Presented by: Dan Sandink (Director of Research, Institute for Catastrophic Loss Reduction)

Flooding is the most common disaster in Canada. When the public thinks about flooding, they think about river flooding; however, the major drivers of flood losses is short duration intense rainfalls in urban areas that overwhelm water systems. For example, in August 2014, the City of Burlington experienced 120mm of rainfall in 2 hours and 200mm over 8 hours. This amount of rainfall in such a short period of time overwhelmed the city's infrastructure and caused widespread flooding. Additionally, in 2016 there were 17 extreme rain related catastrophic events across Canada.

When these types of rain events occur, individual homes can be flooded through different mechanisms, including: overland flow (when water flows over the land and enters through doors, windows, basement stairwells, etc.); groundwater seepage (when surface water seeps into the backfill area of a home causing basement flooding); and sewer backups (see image below).



- Other major household flood causes:
  - Pump failure, sump capacity
  - Failure of building sewers, drains (e.g., root blockage, collapse)
  - *Etc.*

Sewer backup and sump pump/plumbing failure are both widely insured, coverage for infiltration flooding is variable, and coverage for overland flooding (pluvial) is variable but increasing. River flooding is difficult to insure for the following reasons:

- Adverse selection
- Lack of randomness
- Size of the insured community
- High concentration (time and space)
- Inconsistent hazard assessment in Canada

Public disaster relief programs can help fill this insurance void. Ontario's disaster relief program compares well to all other provincial programs and covers 90% of eligible coverage up to $250,000 with a $500 deductible. However, this only covers primary residences and excludes secondary residences/cottages. Since the Alberta floods in 2013, the public has become more aware that overland flooding is not covered by most insurance companies. Most insurers will not offer overland flooding coverage to high risk properties, and of the very few that do cover overland flooding, they include variable deductibles, high premiums, and can use caps (no full coverage). Since coverage is so variable, it is important to think of what you can do on your property in order to reduce the risk of flooding.

Currently, the Canadian Standards Association (CSA) is developing a guideline for flood protection from extreme, short-duration rainfall events that can overwhelm systems and cause seepage in homes. The CSA guidelines will include practical measures appropriate for new or existing homes in Canada (e.g. how to grade your property to make sure that water is going away from the foundation). However, it will not focus on river flooding (deep, fast water). Generally, Ontario has done a good job of limiting development

on floodplain areas; however, there are some exceptions. If building on floodplain areas, you must consider specific building requirements and mitigation options. For non-riverine flooding, there are many things you can consider, including: site grading and drainage; infiltration/groundwater; entry-points for overland water; foundation openings and penetrations; foundation drainage and sump pumps; eavestroughs/downspouts; sewer connection maintenance and/or replacement; and wet flood proofing.

From an insurer's perspective in the Muskoka area, they are seeing: more damage to breakwalls causing flooding; high water levels lifting boats off their lifts and causing damage to boathouses/boats; storms/extreme precipitation overwhelming boats and causing them to sink; damage to docks during flood conditions; damage from debris floating in the water, etc. It is important to note that insurers do not differentiate between "natural" high water levels and high water levels that might result from dam operations. Generally, it is too difficult to differentiate the cause of high water levels.

From an adaptation point of view, there are a number of things property owners can do to minimize damage to property: do not put your boat in the water unless you are regularly using it or have a dependable neighbor to keep an eye on it; understand how high the water could potential get on your shoreline and adjust/build docks and breakwalls to suit the highest likely water levels; manage risk of debris in water (i.e. move items on your property above expected high water levels); and understand your water damage coverage (i.e. greater willingness to purchase overland flood coverage for homes, rather than secondary residences).

4.4 The Muskoka River Watershed, the Muskoka River Water Management Plan and MNRF Water Management

Presented by: Mara Kerry (a/Resource Management Supervisor, Ministry of Natural Resources and Forestry) and Amanda Vincent (a/Partnership Specialist, Ministry of Natural Resources and Forestry)

The Muskoka River Watershed is 5,100 sq/km in size, composed of 19 sub-watersheds, and includes more than 2,000 lakes. It receives more than 1,000mm of annual precipitation making it one of the wettest locations in Ontario. Annual precipitation includes more than 300cm of snowfall, typically representing about 25% of the annual precipitation amount.

The Muskoka River Watershed Management Plan (MRWMP) came into effect in June, 2006 and can be accessed from the *Muskoka Water Web*: www.muskokawaterweb.ca. The goal of the MRWMP is to contribute to the environmental, social and economic well-being of people through the sustainable development of waterpower resources and to manage these resources in an ecologically sustainable way for present and future generations. This is achieved through management of water levels and flows as they are affected or controlled by the operation of both waterpower facilities and MNRF dams.

There are 43 water control structures on the Muskoka River system, including 10 waterpower facilities and 31 MNRF dams. Waterpower facilities and dams each have an annual operating plan for flow and level requirements, and it is important to notes that none of the dams regulating the 23 major lakes were built for flood control purposes. Although seasonal flooding is normal and a healthy part of watershed ecology, when water inputs exceed the capacity of the watershed to discharge water, the result is high water levels and potential flooding.

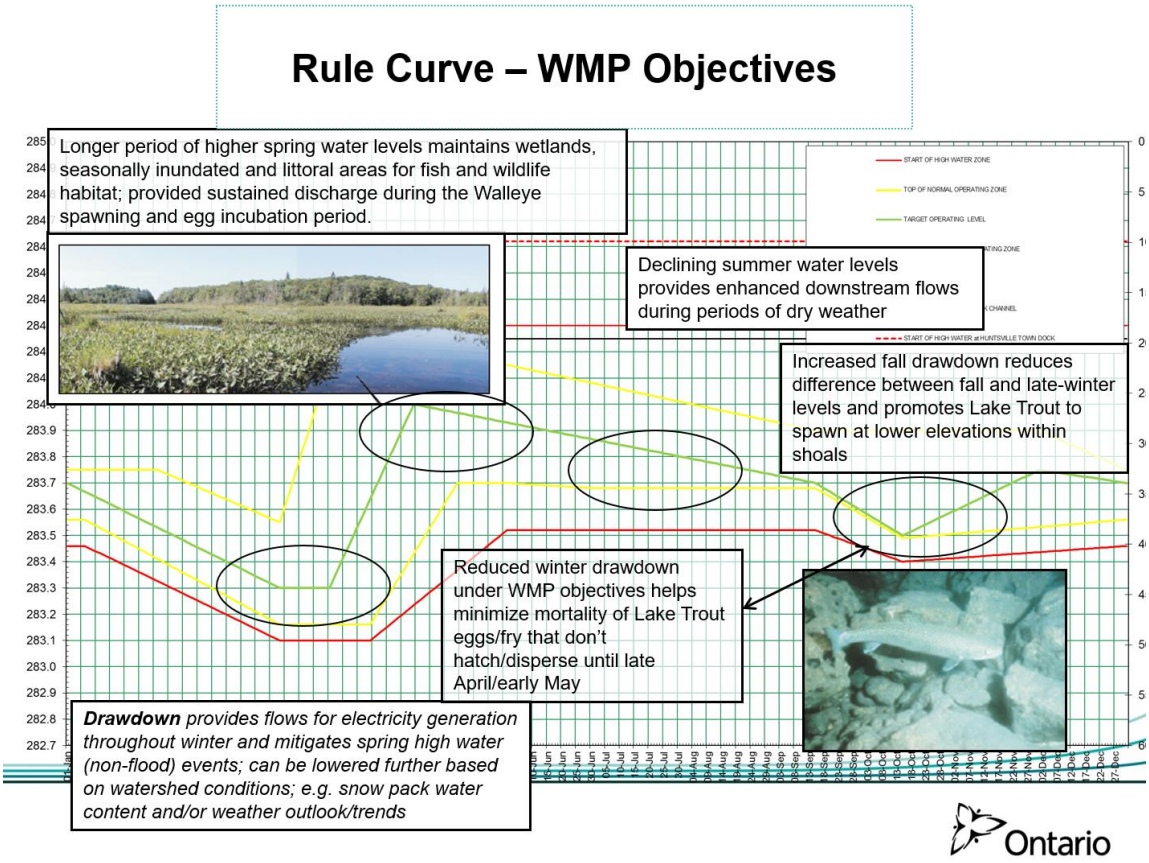
The normal operating zones of the MNRF dams have remained relatively unchanged over the past 50 years. Data from water flow and water level gauges are plotted on hydrographs and provide real-time and historical pictures of water flow dynamics. Water levels are allowed to fluctuate within the normal operating zone of the lake in response to average weather events; however, when the MNRF expects that water levels will stray outside of the normal operating zone, they can take action.

In order to manage water levels in the Muskoka Watershed, MNRF water management technicians complete a daily planning cycle for water management. They gather information on watershed conditions and trends and then assess the daily observations against the management plan for the lake (also called a rule curve) which includes the overall MRWMP objectives for the system. Based on those observations, they will calculate changes considering the flows and levels throughout the system and then calculate individual dam operations (i.e. where and how many stop logs to take out or put in).

Water Levels in Parry Sound District lakes are directed using a rule curve approach (see image on next page). Observed water levels are plotted onto the rule curves which guides operators when adjusting lake levels to meet the needs of different stakeholders at different times of the year as outlined in the MRWMP. Stakeholders include: residents, cottagers, businesses, municipalities and hydropower companies. Stakeholder interests are also balanced with the needs of the flora and fauna that live in the lake.

The Muskoka River Watershed is a cascading system; meaning that operations or influences such as isolated storms at one dam or lake usually affect the ones below it. The MNRF communicates planned flow changes with partners before and after dam operations. The MNRF also sends out various flood messages to stakeholders including:

- *Watershed Conditions Statements (water safety)*: high flows, melting ice or other factors that could be dangerous for boaters, anglers and swimmers but flooding is not expected.
- *Watershed Conditions Statement (flood outlook)*: very early notice that there is a potential for flooding based on current conditions and weather forecasts.
- *Flood Watch*: potential for flooding exists within specific watercourses and municipalities.
- *Flood Warning*: flooding is imminent or occurring within specific water courses and municipalities.



It is important to note that the operation of MNRF dams can mitigate the impacts of high water that occur at any time of the year, but cannot prevent a flood event. Many of the dams were originally constructed in the late 1800's to early 1900's to facilitate the transport of logs to sawmills, for hydroelectric generation, and for helping with commercial navigation. The damns are not designed as flood control structures and have finite discharge capacity within a lake's normal operating zone.

The frequency or severity of floods (and drought) will increase into the future due to climate change; thus, adapting to these changes is important. For example, avoid infilling or building within floodplains along rivers; protect wetlands; build boathouses and docks at an appropriate elevation above normal summer lake levels; "flood-proof" boathouses; consider portable or cantilevered docks; operate boats in a manner to reduce wake (boat wake is significantly more damaging to shorelines/infrastructure than wind-driven waves); follow good shoreline management practices to minimize erosion; and safeguard other values associated with our lakes and rivers.

Local water managers are also responding to the impacts of climate change. More extreme rainfall means that timely distribution of watershed messaging will be even more critical, and the MNRF will work with municipal partners on warning thresholds and undertake more targeted messaging. Another important piece is creating awareness of the expected impacts of climate change. Finally, the MNRF will continue to balance the needs of social, environmental and economic interests on the watershed through an adaptive management approach to operating dams as outlined in the MRWMP.

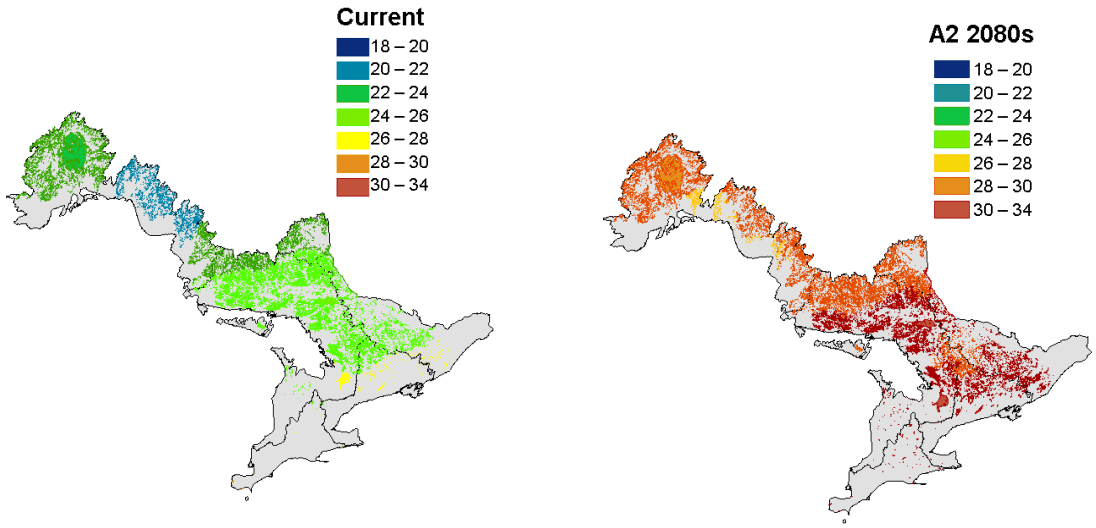
4.5 Effects of Climate Change on Ontario's Aquatic Ecosystems

Presented by: Cindy Chu (Research Scientist, Ministry of Natural Resources and Forestry)

Precipitation and temperature drive the physical characteristics of our ecosystems. Precipitation impacts the amount of water that is available and changes in air temperature impact the quality of the water for organisms that live in the lakes, streams and rivers. When we look at trends in North American rivers, we can see that water temperature has been increasing. There is a similar trend happening with lakes as well; when looking at trends in global lake surface temperatures, there has been an increase of 0.45°C per decade from 1985-2009. This is evidence that our rivers and lakes are warming up, and this trend is expected to continue into the future and have significant impacts on our ecosystems.

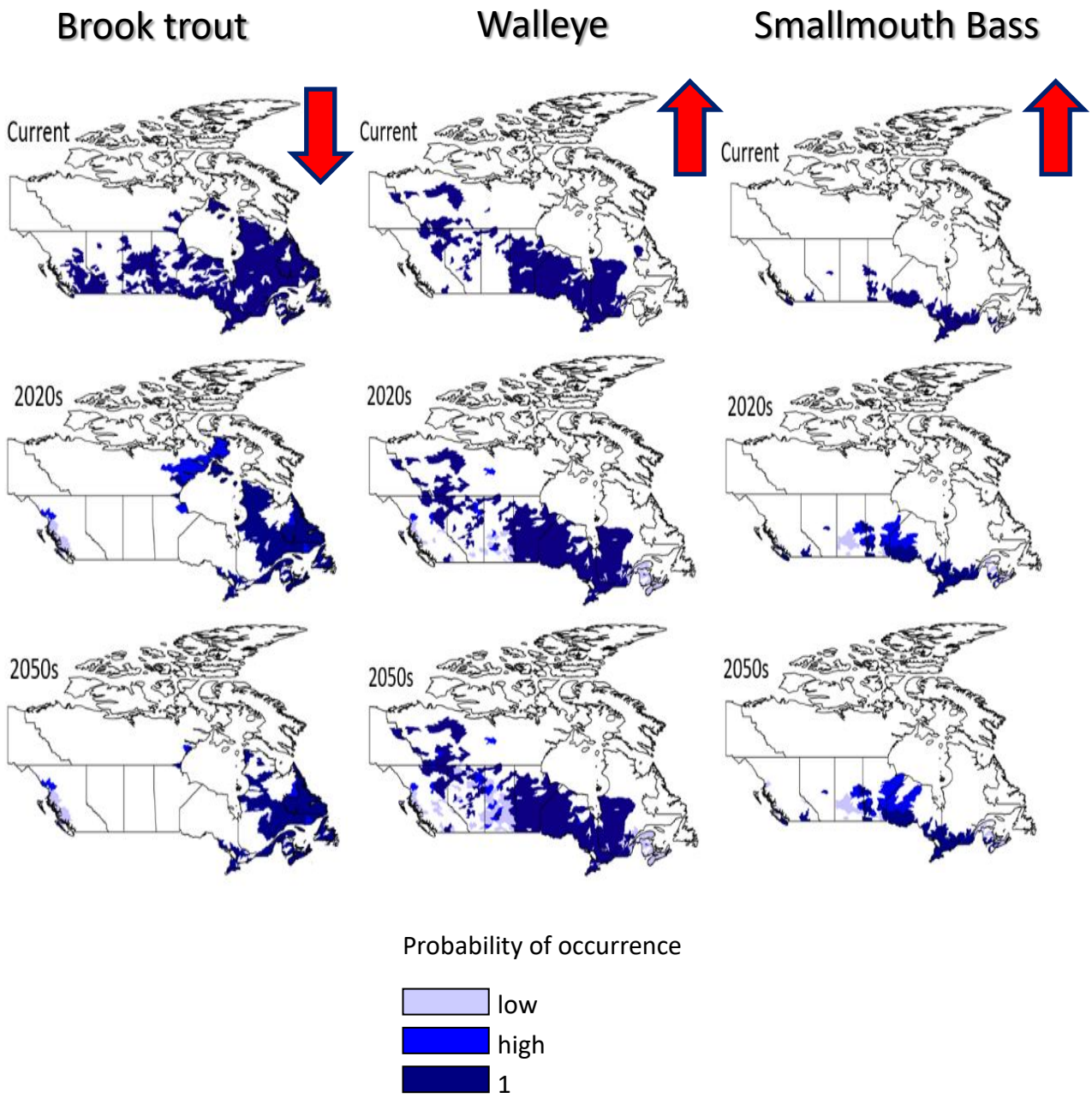
In stream ecosystems, water moves from headwaters (high elevation areas with narrow streams) downstream where you get bigger flows and wider systems. Headwater streams are usually in forested areas so they are shaded and cool, and as water flows downstream it picks up heat and becomes warmer. There is also a change in nutrients as you move downstream; in the headwaters, nutrients come from leaf litter and in the bigger outlets, there is a lot of photosynthesis happening and phytoplankton.

A study was conducted in the Great Lakes basin looking at maximum average weekly river temperatures. Every organism can handle cold conditions (since we live in Canada and experience cold winters) but not every organism can handle heat. Heat can really limit the type of species you find in your streams. Additionally, another study looked at the temperature of lakes in the Great Lakes basin and as we move into the 2080s, it is clear that surface temperature of lakes will increase under a high greenhouse gas emissions scenario (see below).



Different fish species have their own thermal preferences: there are warmwater species (e.g. bluegill, pumpkinseed and largemouth bass), coolwater species (e.g. northern pike, muskie and walleye), and coldwater species (e.g. brook trout, rainbow trout and brown trout). Changes in water temperature will

affect these fish species differently. For example, a study was conducted for the Mississippi-Rideau Conservation Authority to find out how climate change will impact habitats for northern pike (a coolwater species). Results show that by the 2050s, the area will see an increase in northern pike habitat from 34% of the watershed to 46% of the watershed. However, the modeling also showed a decrease in habitat for coldwater species (from 65% to 49% of the watershed). Additionally, a study conducted in 2005 looked at how climate change will affect species ranges and distribution across Canada. Results indicate that habitats for brook trout (coldwater species) will decrease, habitats for walleye (coolwater species) will increase, and habitats for smallmouth bass (warmwater species) will also increase (see image below).



Climate change also affects fisheries catches. Recreational fishing in Ontario is a $2.2 billion dollar industry. Data taken from Lake Ontario between 1970-1990 was used as a baseline to find out how warming water temperatures will affect fisheries catches. For warmwater species, warmer water temperatures increase the number of young (i.e. climate change will be beneficial for warmwater species such as smallmouth bass). For coolwater species who like the range between 19-25°C, rising temperatures initially increase the number of young but then it starts to decline as water temperatures get too warm for survival. Species that like it cold (less than 19°C) will experience a decline in the survival of their young wen water temperatures get too warm.

When it comes to climate change adaptation, there are a number of actions that can be taken:

1) Raise awareness (e.g. there are many MNRF resources available for download on the OCCIAR website, including a video that summarizes climate change vulnerability of inland aquatic ecosystems in the Great Lakes basin).
2) Restore or expand shoreline forests and vegetation and improve shading and cooling of streams.
3) Keep or restore natural shorelines in lakes (e.g. vegetation will cool nearshore areas and act as a filter to improve water quality).
4) Restore natural channels.
5) Convert dams to release cool water downstream and remove dams.
6) Limit surface and groundwater withdrawals to maintain flow and temperature.
7) Conduct vulnerability assessments to help prioritize where more research should be conducted or where place-based adaptation should take place.
8) Adjust fishing regulations such as catch limits, slot size limits, season lengths and protected areas.

4.6 Improving Resilience for your Shoreline Property

Presented by: Rebecca Willison (Watershed Planning Technician, Muskoka Watershed Council)

The Muskoka Watershed Council released a paper in 2016 that identified some of the changes we can expect to see in the future and how these changes will impact our lakes and rivers, forests, wetlands and lives. By mid-century, the area will be 3-4°C warmer, have slightly wetter and later fall seasons, see earlier summer seasons, experience many more winter days above freezing, many more summer days above 30°C, fewer but more pronounced storm events, and drier soils in the summer.

The Federation of Ontario Cottagers' Association (FOCA) released a document called *Managing your Waterfront Property in a Changing Climate*, and it offers a series of actions that not only help protect water quality and improve wildlife habitat on waterfront properties, but also help to combat the effects of extreme weather events. The document outlines the following actions:

1. Keep your shoreline natural and enhance it if possible.
2. Keep aquatic plant populations intact.
3. Maintain and improve your waterfront property's health and biodiversity.
4. Manage pests and disease.
5. Stay informed

Four out of the five actions can be addressed through waterfront buffers. A healthy buffer provides food and habitat for various species, prevents soil erosion, reduces the impacts of flooding, provides a source of enjoyment and protects water quality. A lack of waterfront buffer can lead to accelerated runoff, increased erosion and excessive nutrients entering the water. When we talk about buffers there are three zones that are equally important in creating a healthy shoreline, not just for water quality but also to protect property during extreme weather events:

- **Upland zone** – usually where cottages are located. This area tends to be higher and drier, with vegetation that takes advantage of the better drainage.
- **Riparian zone** – the transitional area between water and land. Vegetation in this area is adapted to changing water levels and can tolerate periods of flooding.
- **Littoral zone** – this zone begins at the water's edge and extends into the water until sunlight can no longer penetrate to the bottom. This is where aquatic plants and organisms that form the base of the food chain are located.

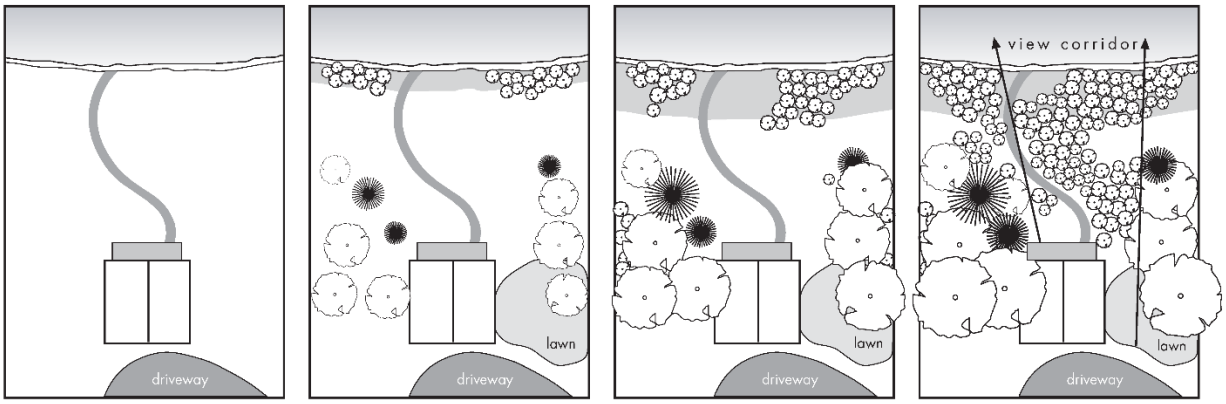
As we begin to realize how many different functions shorelines have, it becomes clear that it is to our advantage to protect these areas and maintain healthy shorelines. A healthy shoreline includes: an abundance of native vegetation; varying levels of vegetation; dead snags and stones; a 'wild' and natural look; as well as birds, fish and other wildlife. In the event of a storm, healthy shorelines help to slow down runoff, allowing water to soak into the ground and filter out sediments, nutrients and chemicals. Additionally, during flood events healthy shorelines provide a barrier against moving water (i.e. it slows down and reduces the force, height and volume of floodwaters by allowing them to spread out horizontally across the floodplain. Healthy shorelines also help to alleviate extreme heat and drought by providing shade and keeping the area cool and moist. Conversely, it is likely you have an unhealthy shoreline if: it is cleared of vegetation; the lawn extends to the water's edge; it has a hardened and artificial shoreline; there is shoreline erosion; there is excessive plant growth in the water; and there is evidence of poor water quality.

Whether you currently have little or no shoreline buffer, you can start to improve this by simply doing nothing. Stop mowing along the shoreline and watch taller grasses, wildflowers and ferns start to grow. Keep an eye on what is growing and remove any invasive species that try to take root. After a couple of years, more shrubs will become established as well as some trees (see image on next page). It is a slow process but it is simple and easy. Re-naturalizing your shoreline does not have to be a long, difficult process. Here are 5 steps to help you through the process:

- Step 1: Assess your property (identify areas/issues of concern, note access points, etc.)
- Step 2: Sketch your property (include trees and other vegetation, docks, soil type, sunlight, etc.)
- Step 3: Take photos
- Step 4: Take measurements
- Step 5: Create a planting plan (how many plants, what to plant, where, etc.)

Restoring Your Shoreline Buffer

Adapted from On the Living Edge: Your Handbook for Waterfront Living



Year 1
Large lawn area down to the water, minimal trees, appealing habitat for Canada geese.

Year 2
Grass left unmowed along the shoreline, native trees & shrubs planted, invasive species weeded out.

Year 4
Larger area is left un-mowed, more trees and shrubs planted, invasive species weeded out.

Year 6
Healthy buffer zone re-established with trees and shrubs providing wildlife habitat, shade & privacy.

It is important to try and plant native plants in your shoreline re-naturalization efforts because they: are tolerant of variable conditions and our harsh weather extremes; can out-compete most annual weeds; provide habitat and food for wildlife; are resistant to local pests and diseases; and are at a low risk of becoming invasive. The Muskoka Conservancy provides a low cost way to help re-naturalize your property through their annual native plant sale. You can also reference the Evergreen Native Plants Database at https://nativeplants.evergreen.ca.

4.7 Climate Change in Cottage Country: Get Ready

Presented by: Terry Rees (Executive Director, Federation of Ontario Cottagers' Associations)

The Federation of Ontario Cottagers' Association (FOCA) has members all over Ontario including 500 lake associations (both small and large) and 50,000 families. FOCA's mission is to protect thriving and sustainable waterfronts across Ontario, mainly focusing on the environment and water and how cottager's interact with nature. That being said, building sustainable communities (i.e. communities that are safe, healthy, have somewhat predictable amenities and are affordable) is also important to FOCA.

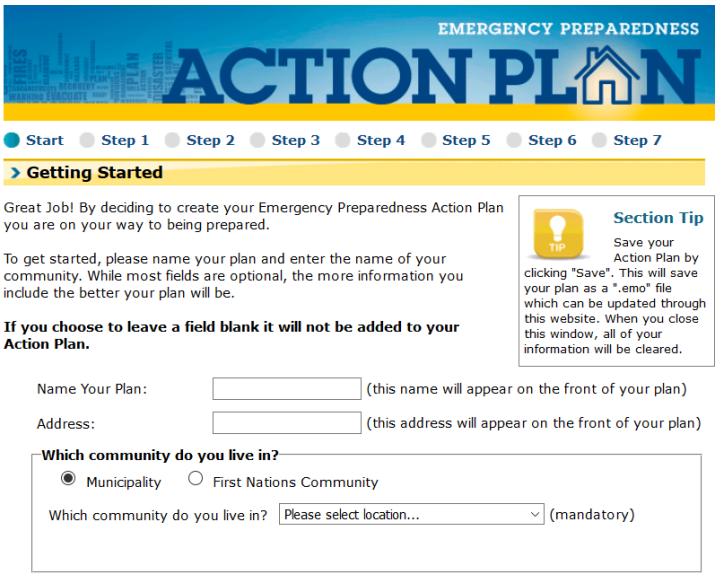
FOCA deals with many initiatives related to biodiversity and knows that there are three things that are threatening our waterfronts: loss of habitat, the impact of invasive species and climate change (which acts as a multiplier). Threats that we will see in the Muskoka area as a result of climate change include:

- Changes in precipitation patterns
- Shorter, wetter winters
- Changes in water quantity
- Longer, drier summers
- Drought
- Fires
- Severe weather and water events
- Changes in fauna
- Blue green algae
- Ticks and Lyme Disease
- Mosquitos and West Nile Virus

What can you do to make sure you are prepared for an emergency situation? Public Safety Canada put forward the following three steps to help families prepare for emergencies: know the risks, make a plan and get a kit. Emergency Management Ontario suggests that seasonal residents need to know how to access information during emergency situations. For example, know your municipal enquiry lines and websites, listen to local radio stations and other media, and do not abuse the 911 system. As well, every municipality has an emergency management coordinator. It would be best to know who that is in your community and how to access emergency services if you need them. Additionally, cottage country is often very remote, making roads and access to locations a critical piece in emergency situations. Roads can sometimes washout due to extreme weather events, therefore it is very important to be mindful of road maintenance in order to make sure you can get in and out of your property and allow access to first response vehicles (i.e. fire and ambulance).

A great first step in your emergency preparedness planning is to visit the Emergency Management Ontario website where you can make your own emergency preparedness action plan and get tips on how to create a 72 hour kit. This online tool will:

- List the specific steps you need to take to get prepared;
- Provide tips on hazards that might affect your community; and
- Include information related to special needs you may have.



What can you do as a cottage owner? First, keep your shoreline natural and do what you can to protect and enhance natural biodiversity on your property. Second, use appropriate building materials and consider climate-smart site planning. Third, stay informed about severe weather and long term climate changes. Fourth, report changes in your local community and become a citizen scientist. And fifth, have an emergency plan and be prepared.

6.0 Concluding Thoughts

Overall the workshop was a great success. Climate change continues to bring challenges that shoreline property owners and government need to face head-on and manage proactively and this workshop increased participants' knowledge of the unique issues that climate change will bring to the Muskoka region, the importance of considering climate change in shoreline property management, and what adaptation strategies and resources are available to help increase shoreline resilience. It is hoped that each representative from the cottage associations will take the information and lessons learned at this workshop and share them with their respective members.

Appendix 1: Attendee Handout

1.0 Climate Change: A Brief Introduction

Over the course of the past few decades the science behind climate change has become increasingly clear – our climate is changing in a way that is unlike any other time in Earth's history. The Intergovernmental Panel on Climate Change (IPCC), the leading international body for the assessment of climate change, states that the degree of warming that the Earth has experienced since the 1950s is unequivocal, and many of the changes are unprecedented over decades to millennia. The evidence of this warming as all around us: the atmosphere and oceans have warmed, snow and ice cover have diminished, sea levels have risen, and the concentration of greenhouse gas emissions (GHGs) has increased (IPCC, 2013).

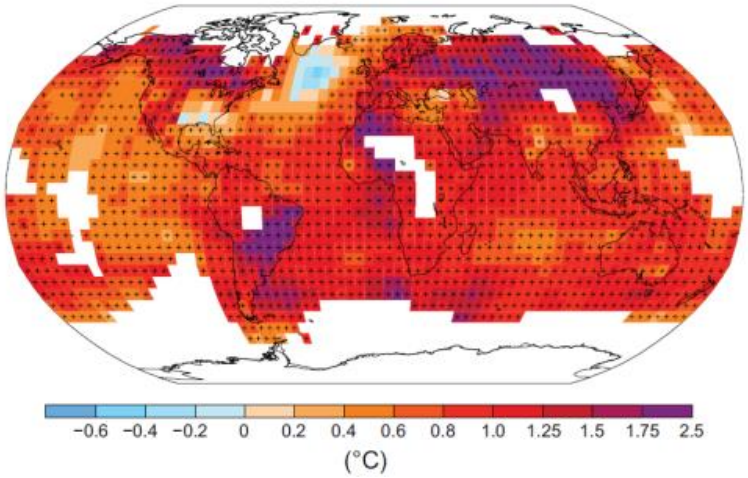


Figure 1: Observed change in global surface temperature 1901-2012 (source: IPCC, 2013).

The globally averaged combined land and ocean surface temperature shows a warming of 0.85°C over the period of 1880 to 2012. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 and in the Northern Hemisphere, 1983-2012 was likely the warmest 30-year period of the last 1,400 years (IPCC, 2013). The IPCC states that it is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century, particularly through carbon dioxide (CO_2) emissions. If we continue along the path that we are currently on (i.e. no significant effort is made to reduce our consumption of fossil fuels), global surface temperature could rise by another 4.8°C by 2100 (IPCC, 2013).

CO_2 LEVELS ARE AT THEIR HIGHEST IN 650,000 YEARS.

\- NASA

4.1 Climate change in Canada

Over the last six decades, Canada has become warmer, with average temperatures over land increasing by 1.5°C between 1950 and 2010 (see Figure 2). This rate of warming is about double the global average reported over the same time period. Warming has been occurring even faster in many areas of northern Canada, and has been observed in all seasons, although the greatest warming has occurred in winter and spring. The annual number of extreme warm days has also risen, which the number of cold nights has declined (Warren and Lemmen, 2014), Over the same time period (1950-2010), Canada as a whole has become wetter, with increasing annual average precipitation trends in many parts of the country and for the nation as a whole. Trends in annual precipitation have been less uniform across the Canadian landmass than those of annual air temperature (see Figure 3).

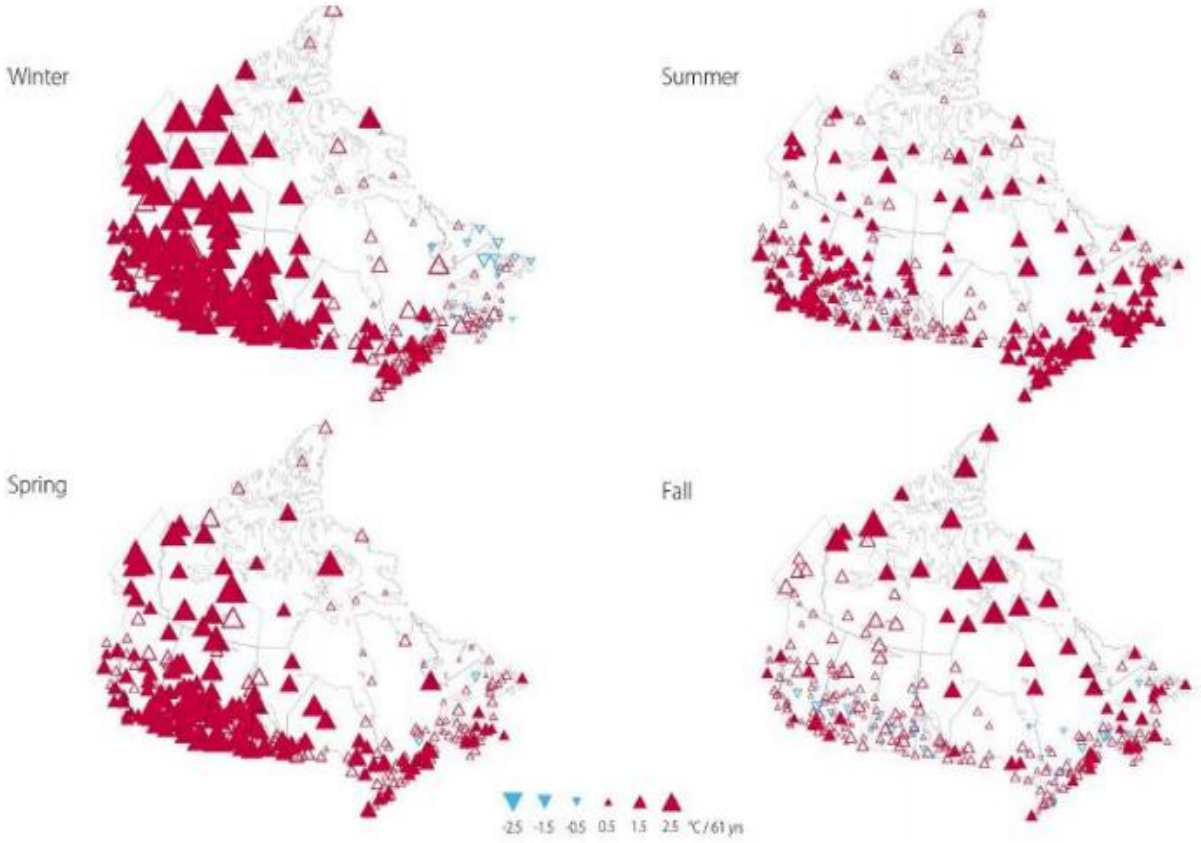


Figure 2: The average annual surface temperature in Canada has increased by 1.5°C between 1950 and 2010, with the greatest warming in the winter and spring (the triangle size is proportional to the magnitude of the trend) (Warren and Lemmen, 2014).

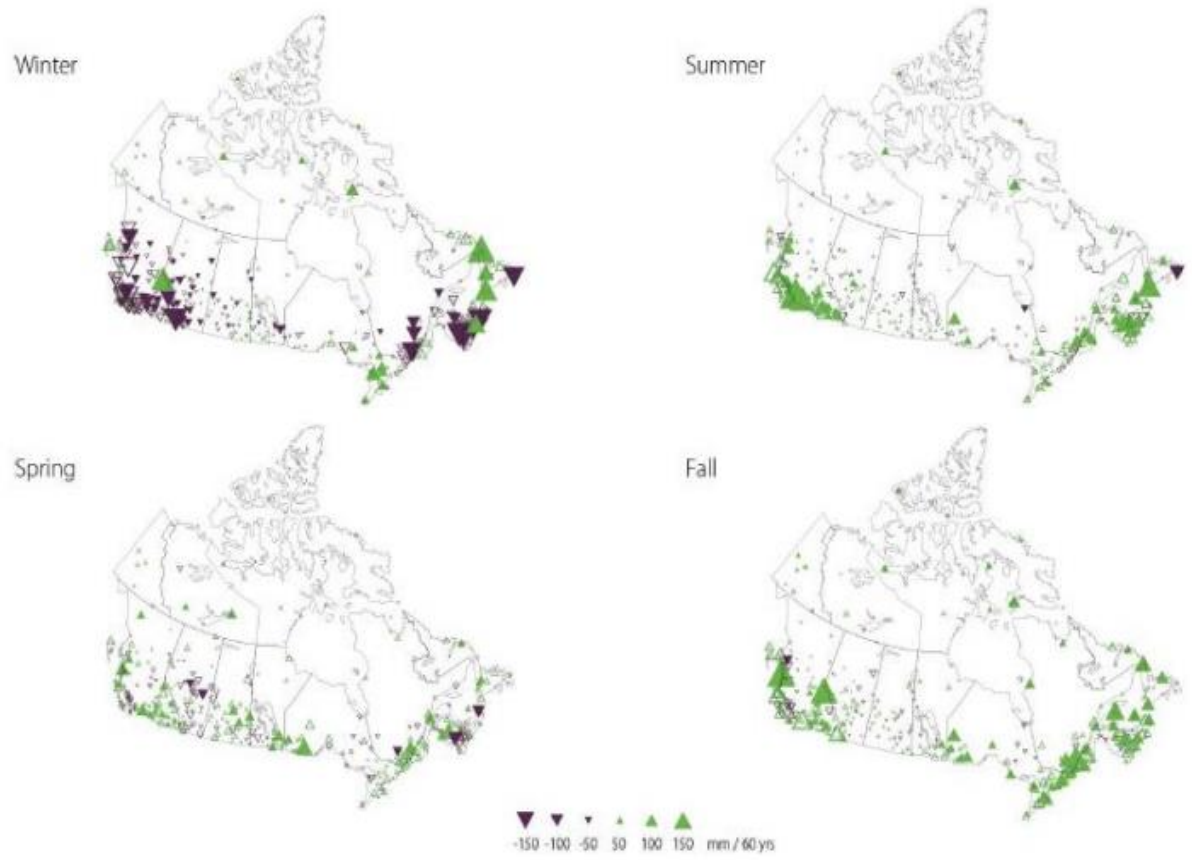


Figure 3: Average annual precipitation has increased by 16% in Canada between 1950 and 2010. This includes an increase in heavy rainfall and extreme events (the triangle size is proportional to the magnitude of the trend) (Warren and Lemmen, 2014).

4.2 Climate change in Ontario

Relative to a 1961-1990 baseline, almost every region in Ontario has experienced an increasing temperature trend (see Figure 4). Across the province, mean annual temperature has increased by 1.5°C since 1948 – nearly double the global average. This seemingly small number may look insignificant, but relatively small changes in average temperatures can result in significant impacts.

As you can see from Figure 5, precipitation patterns in Ontario are already changing. The annual precipitation difference between two normals periods (1951-1980 and 1971-2000) shows that some areas of the province, including the Muskoka region, have seen increases in precipitation of between 150mm and 250mm per year.

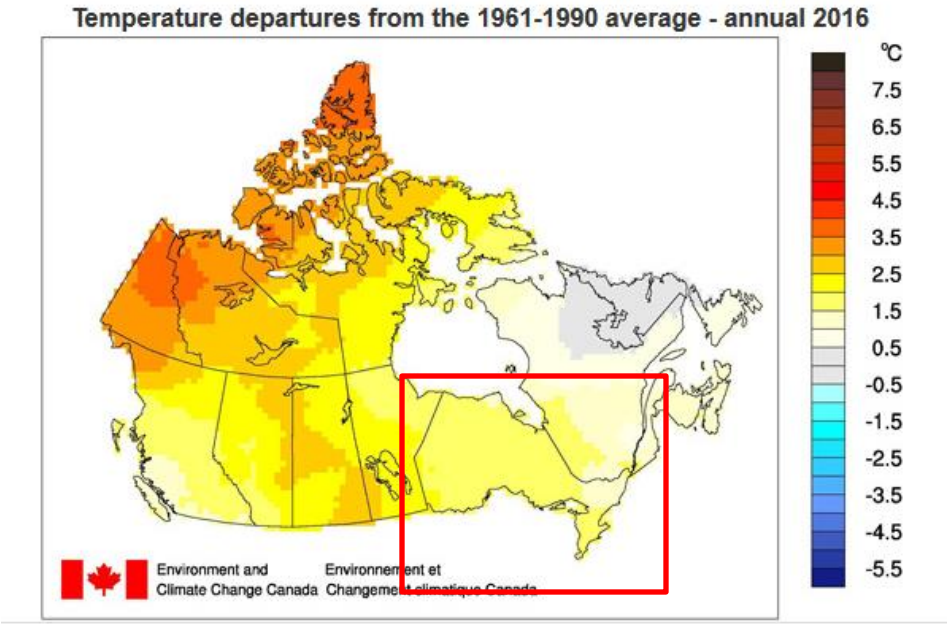


Figure 4: Relative to a 1961-1990 baseline, average annual temperatures across Canada have increased by 1.7°C, and Ontario by 1.5°C (source: ECCC, 2017).

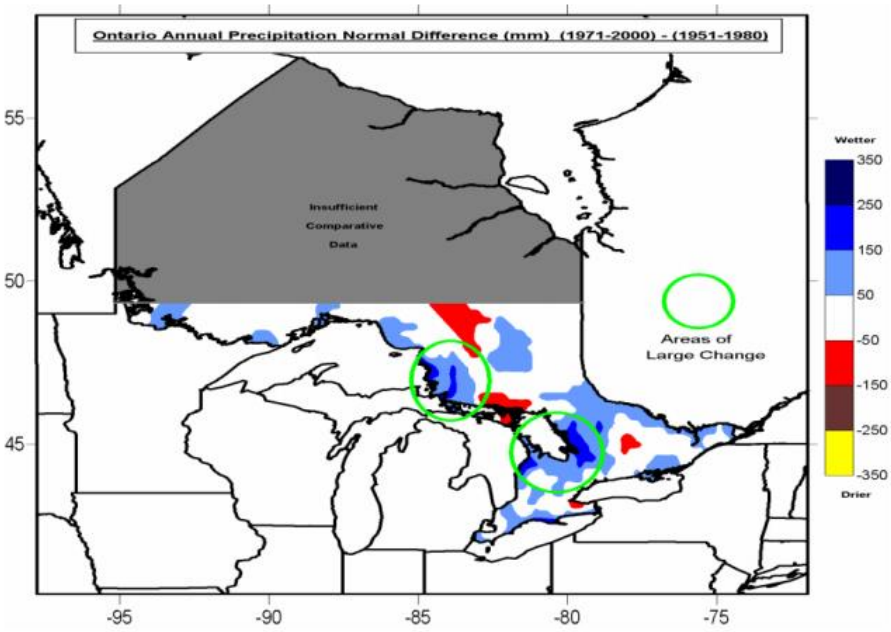


Figure 5: Annual precipitation difference between two normals periods (1951-1980 and 1971-2000) (Comer, 2011).

Figure 6 provides an example of temperature and precipitation changes at a local scale. Between 1979 and 2008, Barrie experienced an average annual mean temperature increase of 1.5°C, right in line with the provincial average. One of the many impacts of a warming climate is changes to precipitation patterns; Barrie saw a total annual precipitation increase of 42mm between 1979 and 2008.

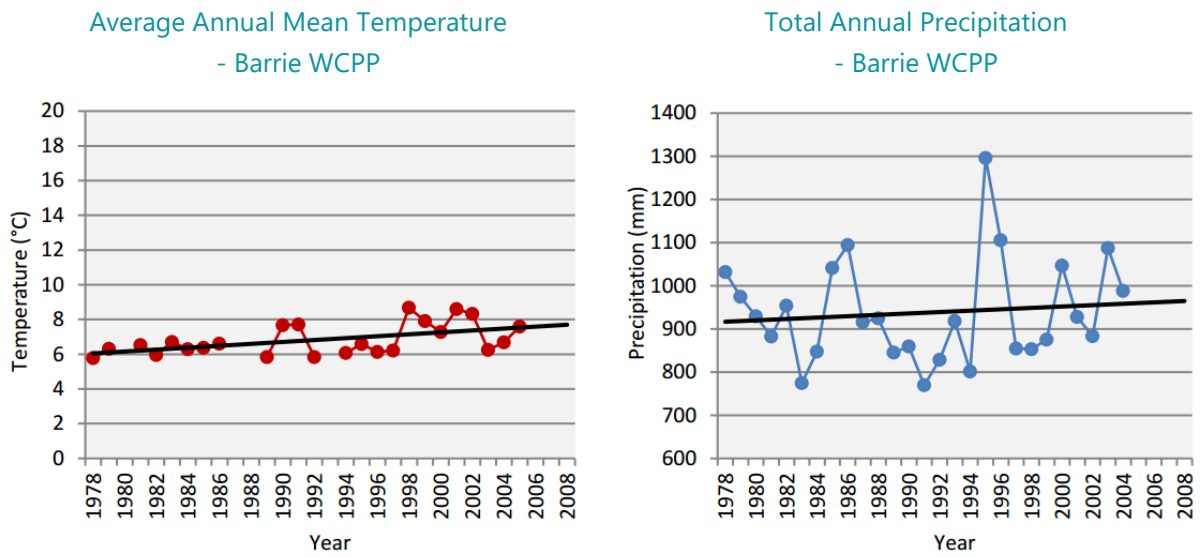


Figure 6: Barrie has seen a 1.5°C increase in average annual mean temperature and a total annual precipitation increase of 42mm between 1979 and 2008.

With help of global climate change models, scientists are able to simulate changes in climate based on a set of scenarios of anthropogenic forcings. Figure 7 represents projections in surface air temperature and relative precipitation changes for the winter season in Ontario for the middle of the century relative to the reference period (1986-2005) (ECCC, 2015). In northern countries such as Canada, the largest temperature change is likely to occur during the winter season.

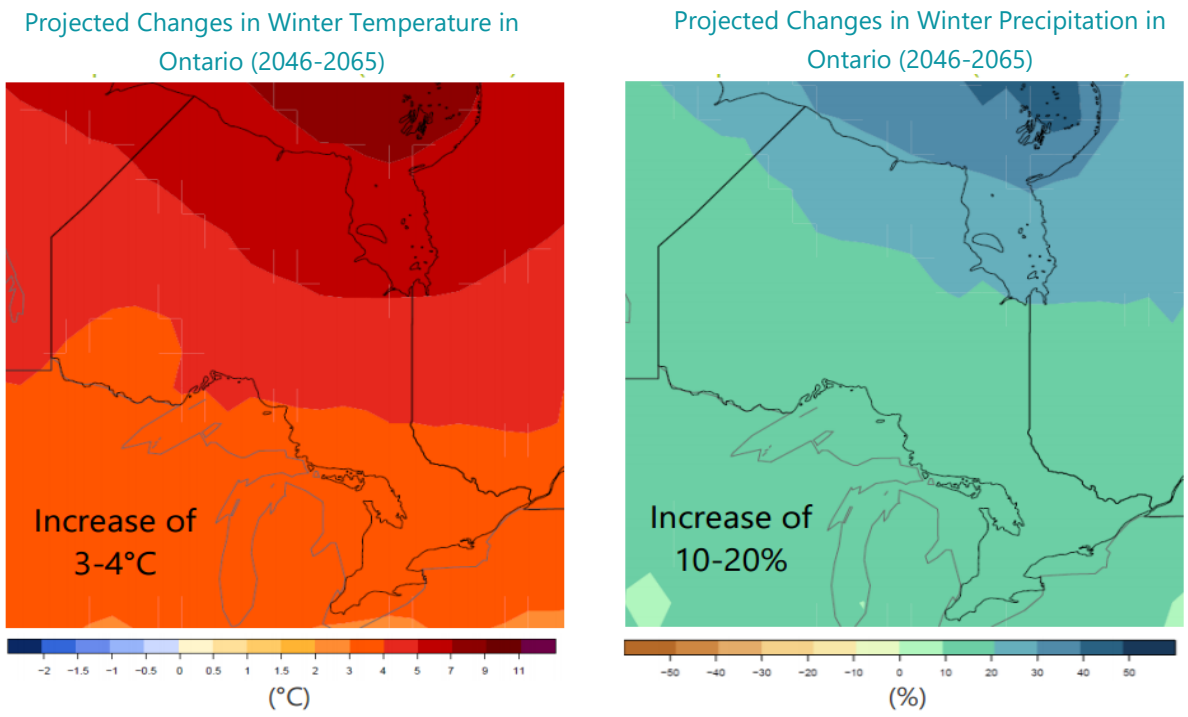


Figure 7: Temperature change and precipitation change for RCP8.5 in 2046-2065 for the winter season (December – February), 50th percentile (source: Adapted from ECCC, 2015).

4.3 The impacts of climate change

In Ontario, warming temperatures and changing precipitation patterns are expected to result in a variety of environmental, social and economic impacts. Some of these impacts include: reduced ice cover on the great lakes; increased snowfall; increased ice storms; increased freeze-thaw cycles; increased viability of pests and diseases; increased flooding; increased soil erosion; degraded water quality; earlier peak flow in streams and rivers; decreased total flow in streams and rivers; potential for drought conditions and forest fires.


Toronto, 2005


Brampton, 2013


Wawa, 2013


Tecumseh, 2016

Since warmer air holds more moisture, climate change will result in more frequent and intense extreme weather events (Warren and Lemmen, 2014). The increasing frequency and intensity of weather extremes poses risks to infrastructure, buildings, drinking water, communication, energy and shorelines. The effects of climate change have already been felt in Ontario, as the province has faced more frequent and intense weather events over the past decade with unparalleled damage (ECO, 2014):

- On July 14-15, 2004 a state of emergency was declared in Peterborough after 175mm of rain fell in the city, resulting in $95M in insured losses.
- On August 19, 2005 150mm of rain fell in Toronto, causing $647M in damages, washing out part of Finch Avenue and causing flash flooding across the city.
- On August 20, 2009 19 tornadoes touched down in southern Ontario, causing extensive damage to homes and one death.
- On April 28, 2011 a severe wind storm with 150km/hr winds hit southern Ontario, resulting in sweeping power outages and one death.
- On October 25, 2012 Wawa declared a state of emergency as 133mm of rain fell in 9 hours, causing the washout of five major roads and the destruction of one business.
- In April, 2013 the Muskoka region experienced extreme flooding due to a combination of partially frozen ground, later-than-usual snowmelt, persistent lake ice, and largely heavy, warm rains. Eight regions across the area declared a state of emergency.
- On July 8, 2013 126mm of rain fell in Toronto in only two hours, resulting in close to $1B in insured property damage and $60M in uninsured costs to the City (to date, it is the most expensive natural disaster in Ontario's history).
- From December 20-22, 2013 waves of freezing rain hit southern Ontario, resulting in up to 3cm of ice accumulation and over 600,000 power outage due to fallen trees, branches and utility poles.
- On May 11, 2014 rising flood waters forced the evacuation of 2,000 residents in the northern Ontario First Nation communities of Kashechewan and Attawapiskat, where 40 homes and

buildings were damaged by sewage and flood waters. It marked the third straight year an evacuation was required because of flooding concerns.

- On August 4, 2014 over 150mm of rain fell in Burlington, Ontario which led to flooded basements and intersections and forced the closure of many roads.
- On November 19-20, 2014 strong cold winds and relatively warm waters off the Great Lakes combined to produce intense snow squalls. The strongest affected regions near Georgian Bay, dumping snow amounts of 90cm near Parry Sound, 40cm in Huntsville, and 20cm in Bracebridge and Barrie.
- During the last week of March and the first week of April 2016, Muskoka received three significant rain events, depositing 171.5mm of rain into the watershed. These rain events were preceded by an unusually early spring freshet that began in early March, about a month earlier than normal, causing flooding in the area.
- On September 28, 2016 between 135mm and 195mm of rain fell in the Windsor and Tecumseh regions respectively. The mayors of Windsor and Tecumseh declared states of emergency due to flooding of streets and upwards of 2,500 flooded basements.
- Spring 2017 saw abnormally wet weather across the province resulting in high water and flooding across central Ontario. Communities along the Ottawa and St. Lawrence Rivers declared states of emergencies while Lake Ontario water levels reached the highest recorded in 100 years.

These events appear to be on an upwards trend, not only in Ontario but around the world (see Figure 8).

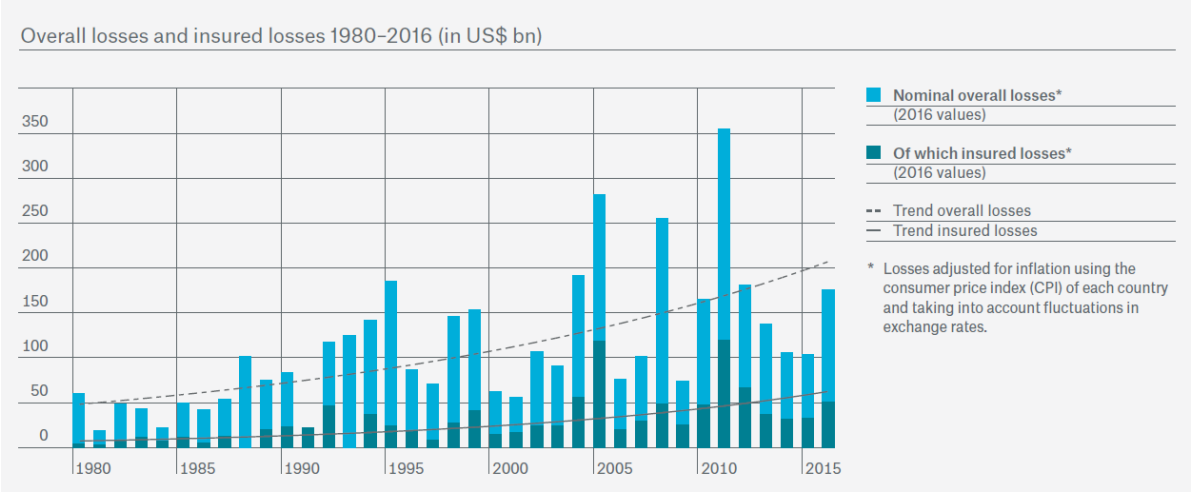


Figure 8: Natural catastrophes worldwide from 1980-2016 (source: Munich RE, 2017).

4.4 Response to climate change

Taking action at the federal, provincial and municipal government levels in important. Most levels of government are taking steps to respond to climate change through mitigation (i.e. reducing GHG emissions) (CAP, 2011). However, adaptation is gaining momentum in many communities and local governments across Canada as an essential response to climate change that complements mitigation

efforts (Warren and Lemmen, 2014). Businesses and residents can also incorporate climate change adaptation into their planning and activities.

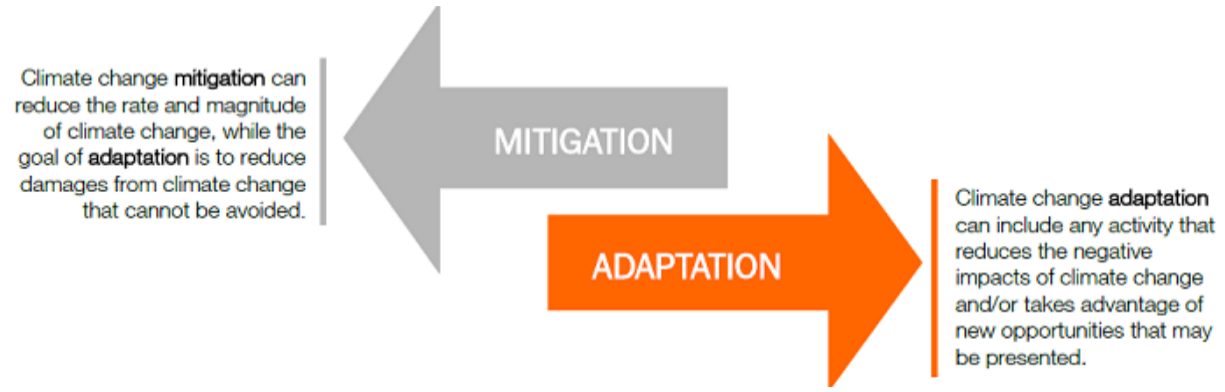


Figure 9: Communities can respond to climate change in two ways: mitigation and adaptation (source: Vaughan, 2012).

Adaptation involves making adjustments in our decisions, activities and ways of thinking in response to observed or expected changes in climate, with the goals of reducing harm and taking advantage of potential opportunities (see Figure 9) (IPCC, 2013). This can include behavioural changes, operational modifications, technological interventions, planning changes and revised investment practices, regulations and legislation. All levels of government, researchers, the private sector and non-governmental organizations now view adaptation as an essential complement to mitigation (Warren and Lemmen, 2014).

The provincial government is also taking action on climate change. In 2016, the Government of Ontario released its Climate Change Action Plan, a 5-year plan that will help Ontario fight climate change over the long-term by reducing GHG emissions and helping to move us to a prosperous low-carbon economy. Building on Ontario's new Climate Change Mitigation and Low-Carbon Economy Act, the plan will ensure that proceeds from the province's recently finalized cap and trade program are invested in a transparent and accountable way back into green projects that will help households and businesses reduce GHG emissions and save on energy costs (MOECC, 2016).

While the primary focus is on mitigation of GHGs, Ontario's plan for adapting to climate change and becoming more resilient will be released in 2017. The upcoming climate change adaptation plan will build on *Climate Ready: Ontario's Adaptation Strategy and Action Plan*, which was released in 2011, and was Ontario's first public commitment to address climate impacts across government (MOECC, 2016). The new adaptation plan will provide details of a new climate modelling collaborative which will help decision-makers understand potential climate impacts so they can make effective, climate-resilient decisions. The collaborative will be useful for provincial and municipal governments, Crown agencies, utilities, conservation authorities, the private sector, First Nations and Métis communities, and others (MOECC, 2016).

4.5 Climate change resources

In 2016, the Muskoka Watershed Council released a report (Sale et al., 2016) which provides an in-depth look at how climate change will impact the Muskoka area by mid-century. The report, 'Planning for Climate Change in Muskoka', is a follow-up to the Council's first report on climate change published in 2010 (Muskoka Watershed Council, 2010). It suggests that a typical year by mid-century will be characterized by approximately half the number of extremely cold winter nights (<-20°C), four times the number of winter nights that remain above freezing, half the number of winter days in which maximum temperatures breaks through 0°C (from 36 days to 56 days), and seven times as many days in which the maximum temperature exceeds 30°C (from 4 days to 27 days). The Muskoka region is also likely to see a 10% - 20% increase in the total amount of precipitation, most of which is likely to occur in late fall/early spring. This increase in precipitation during November to April will largely be driven by the Muskoka's proximity to Georgian Bay, as warmer winter temperatures will result in less ice coverage and more evaporation, which can bring rain or snow squalls to the Muskoka region (Sale et al., 2016).

The report also suggests that what is needed is long-term adaptation planning by individuals, businesses, community groups and local governments in order to prepare Muskoka communities for climate change. It outlines 15 recommendations around four types of action:

1. Actions to improve understanding of ecological functioning of the Muskoka environment
2. Actions to address anticipated impacts of climate change on the Muskoka environment
3. Actions to prepare our built infrastructure and its management for the climate of mid-century
4. Actions to facilitate the effective implementation of these recommendations

Also published in 2016 is a resource from the Federation of Ontario Cottagers' Associations on 'Managing Your Waterfront Property in a Changing Climate' (FOCA, 2016). The document provides information on climate change impacts and adaptation options for waterfront properties owners to help them increase the resiliency of their shoreline. This particular topic is important to the Muskoka region as the large lakes in particular are very developed with cottages, commercial tourism, and marinas. In some cases (Lake Muskoka, Lake Joseph and Lake Rosseau), virtually all the shoreline is privately owned with extensive shoreline development including docks and boathouses. The amount of shoreline development within Muskoka makes the area unique when compared with other regions. The FOCA resource offers 5 top actions shoreline owners can take:

1) Keep your shoreline natural and enhance it if possible;
2) Keep aquatic plant populations intact;
3) Maintain and improve your waterfront property's health and biodiversity;
4) Manage pests and diseases; and
5) Stay informed.

There is a large number of resource to help waterfront property owners understand climate change impacts and how to reduce their vulnerability. See the Appendix for a list of useful resources.

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Appendix: Useful Websites

Climate Change Adaptation Organizations

Great Lakes Adaptation Assessment for Cities brings together researchers and practitioners to develop actionable climate adaptation programs for cities in the Great Lakes region: www.graham.umich.edu/glaac

Great Lakes Integrated Sciences and Assessments contributes to the long-term sustainability of the region in the face of a changing climate and facilitates smart decision-making backed by scientific knowledge: www.glisa.umich.edu

ICLEI – Local Governments for Sustainability provides technical consulting, training, networking opportunities, and information services to build capacity, share knowledge, and support local governments in becoming more sustainable and resilient: www.icleicanada.org

Institute for Catastrophic Loss Reduction is a world-class centre for multi-disciplinary disaster prevention research and communications: www.iclr.org

Ontario Centre for Climate Impacts and Adaptation Resources is a university-based resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation: www.climateOntario.ca

Ontario Climate Consortium works collaboratively with university researchers and partners from the public, private and NGO sectors on projects aimed at answering specific questions related to climate change and creating the intelligence necessary to address climate risk: www.climateconnections.ca

Ouranos acquires and develops knowledge on climate change, its impact and related socioeconomic and environmental vulnerabilities, in order to inform decision makers about probable climate trends and advise them on identifying, assessing, promoting and implementing local and regional adaptation strategies: www.ouranos.ca/en

General Adaptation Resources

Adaptation Library is a publicly accessible and searchable collection of community, forestry, and energy related adaptation products: www.adaptationlibrary.ca

Adaptation Wizard is a 5-step process that provides a framework and resources to help you generate information to inform your own adaptation strategy: www.ukcip.org.uk/wizard

Building Adaptive & Resilient Communities, offered through ICLEI, is a program that offers a comprehensive way to respond to the impacts of climate change, develop and implement an adaptation

plan, and protect the people, property, and prosperity of your community: www.icleicanada.org/programs/adaptation/barc

Canadian Institute of Planners climate change resource library provides access to a variety of tools and resources that have been produced to date from CIP climate change initiatives: www.cip-icu.ca/ClimateChangePolicy#

Climate Adaptation Knowledge Exchange aims to build a shared knowledge base for managing natural and built systems in the face of rapid climate change and is intended to help build an innovative community of practice: www.cakex.org

Canadian Climate Change Adaptation Community of Practice is an interactive online community dedicated to advancing knowledge and action in the area of climate change adaptation, and serves as a location where members can come together to ask questions, generate ideas, share knowledge, and communicate with others on the topic of climate change adaptation: www.ccadaptation.ca

Climate Resilience Framework helps clarify factors that need to be included in the diagnosis of climate vulnerability, structures the systematic analysis of vulnerability in ways that clearly identify the entry points for responding, and supports strategic planning to build resilience to climate change: http://i-s-e-t.org/resources/training/climate-resilience-framework.html

Federation of Canadian Municipalities offers a variety of climate change adaptation resources for municipalities: https://fcm.ca/home/issues/climate-change-and-resiliency/climate-change-adaptation.htm

Georgetown Climate Center seeks to advance effective climate, energy, and transportation policies in order to help communities adapt to climate change: www.georgetownclimate.org

Great Lakes Coastal Resilience Planning Guide aims to connect planners and coastal, floodplain and stormwater managers with the tools and data they need to account for natural hazards and climate change in the Great Lakes: www.greatlakesresilience.org

Flood/water resources

FloodSmart Canada is a hub of information related to floods, flood risks, and emergency preparedness: www.floodsmartcanada.ca

Muskoka Watershed Council provides information to decision-makers, managers and the general public on ways to protect and restore the resources of our watersheds: www.muskokawatershed.org

Muskoka Water Web was developed by The District Municipality of Muskoka to provide a portal to information about Muskoka's most cherished resource – water: www.muskokawaterweb.ca

Partners for Action is an applied research network advancing flood resiliency in Canada in the face of a changing climate and extreme weather: www.uwaterloo.ca/partners-for-action

WaterBudget.ca is an invaluable resource for anyone interested in water quantity within Ontario and beyond, and is designed to communicate advancements in water quantity assessment: www.waterbudget.ca

Real-Time Hydrometric Data Map Search provides public access to real-time hydrometric data collected at over 1800 locations and access to historical data collected at over 7600 stations (active and discontinued) in Canada: https://wateroffice.ec.gc.ca/google_map/google_map_e.html?searchBy=p&province=ON&doSearch=Go

The Umbrella is an online tool to share knowledge about green stormwater infrastructure. All members have free access to resources and discussions: www.theumbrella.ca

Climate data resources

Canadian Climate Data and Scenarios supports climate change impact and adaptation research in Canada through the provision of climate model and observational data: www.cccsn.ec.gc.ca

Climate Change Hazards Information Portal is a web-based tool that helps empower organizations of all sizes and capacities to integrate climate change impacts into their planning and design decisions to help protect private and public infrastructure, resources and public health: www.cchip.ca

National Climate Data and Information Archive provides practitioners with historical climate data that can be used to determine a baseline and be used in planning, design and implementation activities: www.climate.weather.gc.ca

Ontario Climate Change Data Portal was launched to ensure technical or non-technical end-users (e.g. municipalities, private sector) have easy and intuitive access to the latest climate data over the Province of Ontario: www.ontarioccdp.ca

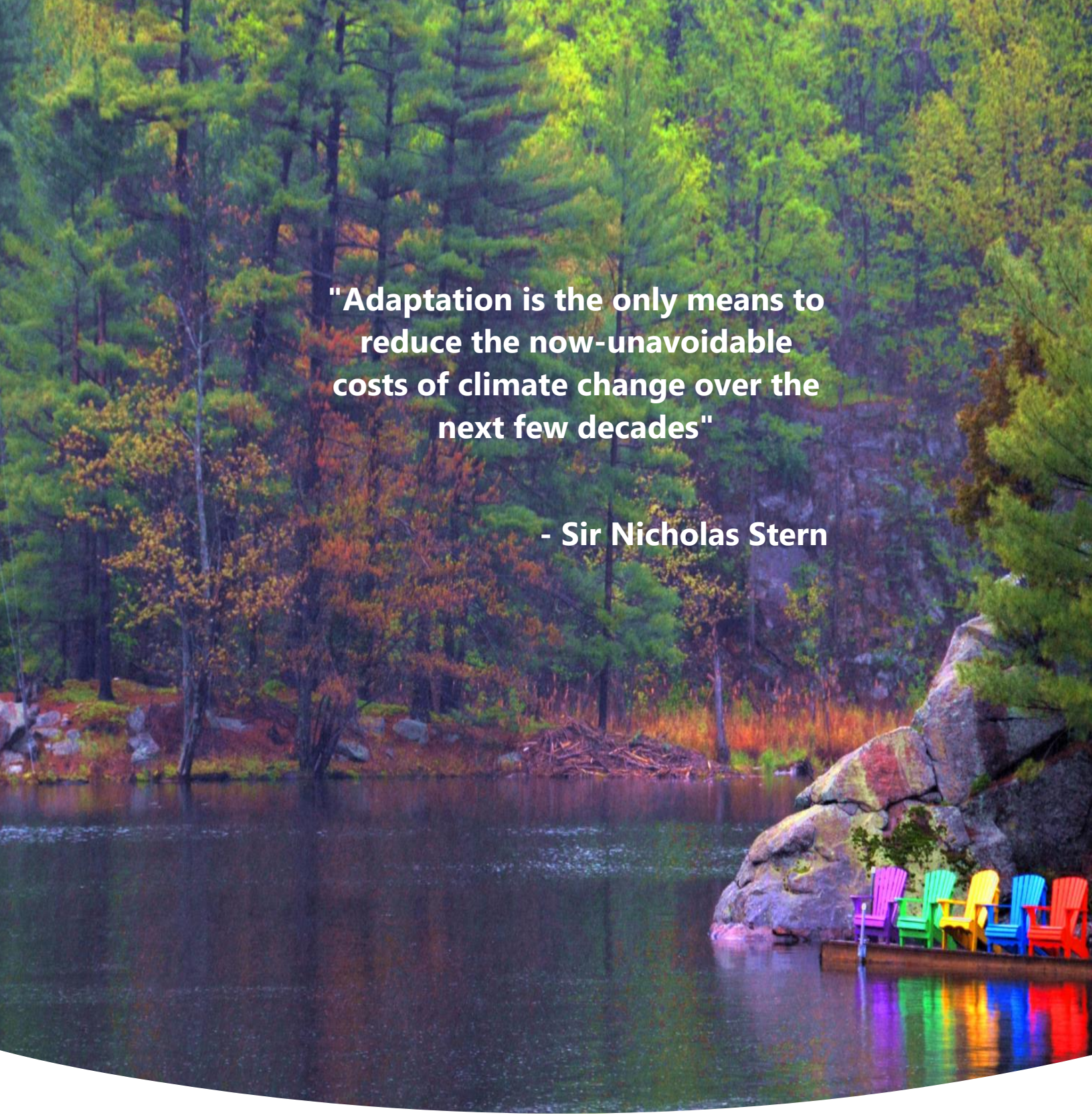
Government of Ontario

Emergency Management Ontario provides tools to support emergency planning efforts, information about current emergency-related events, training opportunities, resources for teachers and educators, and more: www.emergencymanagementontario.ca

Flood Forecasting and Warning Program prepares provincial and local authorities in the event of a flood: www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program

The Flood page includes hazard information, safety tips, and frequently asked questions in the event of a flood: www.ontario.ca/page/floods

The Climate Change page provides an overview of how Ontario is fighting climate change and helping to build a cleaner, more sustainable future for generations to come: www.ontario.ca/page/climate-change



OCCIAR
Ontario Centre for Climate Impacts and Adaptation Resources

Ontario
Ministry of Natural Resources and Forestry