Climate Change Adaptation
‘Stories’ of Ontario

A collection of five adaptation initiatives from across Ontario

2017

OCCAR
Ontario Centre for Climate Impacts and Adaptation Resources
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To learn more, please visit: www.ClimateOntario.ca

For more information, please contact:

Suzanne Perdeaux
Climate Change Researcher
Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR)
MIRARCO/Laurentian University

705-675-1151 ext. 5121
sperdeaux@mirarco.org

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About OCCIAR

The Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is a university-based resource hub that promotes, supports, and advances climate change adaptation in Ontario through education, communication, and stakeholder engagement. Focused solely on climate change impacts and adaptation, OCCIAR’s experienced team of experts provide resources, information and facilitated support to a wide variety of stakeholders in Ontario and across Canada.

Since 2001, OCCIAR has completed more than 52 distinct climate change adaptation projects throughout Ontario and Canada, partnering with a range of stakeholders including municipal, provincial and federal governments, Conservation Authorities, First Nations, and a range of industries/sectors. OCCIAR has in-depth knowledge of climate change science, provincial, territorial and regional climate change impacts, adaptation planning frameworks and tools, and has extensive experience working with a broad range of communities (large-small, urban-rural, north-south) with diverse economies and a range of adaptation knowledge and needs.

You can visit OCCIAR’s website to learn more about the organization and to see a list of other past and on-going projects and activities:

www.ClimateOntario.ca
Introduction

Changes in Ontario’s climate have been observed over the past several decades. Between 1948 and 2012, the average annual temperature in Ontario increased by 1.5°C – a rate of warming that is faster than the global average (see Figure 1). Ontario’s spring and winter trends are also similar, with the most significant and dramatic increases in the northwest and the south. Weather stations across Ontario have shown a trend towards increases in rainfall in all seasons, with the most pronounced increases seen in the northwestern parts of the province during spring (see Figure 2). Moreover, increases in the number and/or intensity of extreme weather events such as heat waves, droughts, extreme rainfall events and ice storms have been observed province-wide.

Current changes in Ontario’s climate have serious and significant impacts that are felt differently throughout the province and across all sectors of the economy and society. Warmer winters have increased the length of the ice-free period on lakes in Ontario, reducing the length of the winter ice road season which is important for some remote northern communities, as well as for forestry and mining operations that rely on ice roads for access to northern locations. Record high temperatures have led to more frequent and prolonged heat waves, impacting agriculture yields, creating changes in the structure and function of ecosystems and prompting health concerns throughout the province.

Increasing mean annual temperatures are also leading to the northward expansion of some plant and animal species. Some rapidly migrating animal and plant species have the potential to alter the ecosystems they invade by outcompeting native species, spreading disease and altering natural patterns of biodiversity. For example, the winter range of the black-legged tick responsible for the spread of Lyme disease has expanded from southern
Ontario and the northeastern USA into central Ontario and is projected to reach northern Ontario by the 2080s\textsuperscript{iii}.

Furthermore, extreme weather events such as heavy precipitation are having devastating impacts on municipalities across Ontario. For example, in 2002 the City of Peterborough experienced widespread flooding from a 1 in 100 year rainfall event, followed by another 1 in 250 year rainfall event in 2004\textsuperscript{xiv}, which resulted in $95 million in insured losses\textsuperscript{xv}. Similarly, on July 8 2013, the City of Toronto received its total monthly average precipitation amount in just a few hours\textsuperscript{xvi}. The storm caused extensive flooding that damaged roads, inundated homes, caused power outages and shut down the city’s subway system\textsuperscript{xvii}. Events such as these can no longer be explained as part of normal weather variability, but are now part of a significant change in climate that is influencing the frequency and severity of extreme weather\textsuperscript{xviii/xix}.

These changes in climate and weather illustrate the potential future effects of increasing global greenhouse gas emissions (GHGs) on many aspects of life for Ontarians, including dramatic social, agricultural, economic, and ecological consequences. Studies agree that Ontario will continue to gradually get warmer and wetter\textsuperscript{xx}. If GHG emissions continue unabated, annual surface temperature is projected to rise 3-4°C by mid-century and annual precipitation may rise by as much as 20% in some parts of the province (see Figure 3).

These projected changes in future temperature and precipitation demonstrate the importance of understanding the impacts of climate change and adapting to them. Here, climate change adaptation refers to taking proactive action to minimize the risks of climate change, taking advantage of any opportunities that climate change presents, and ultimately increasing the resilience of Ontario’s economy and communities to withstand changes in climate conditions and weather events.

In this report, you will read about the exceptional measures that stakeholders in Ontario’s forestry, infrastructure, and municipal planning sectors are undertaking in order to reduce their vulnerability to the impacts of climate change. Collectively, these five ‘adaptation stories’ demonstrate that governments, corporations, businesses, organizations and individual citizens alike are concerned about climate change and believe that it should be considered in all current and future decision-making. Each ‘story’ describes ways in which climate change is affecting the individual communities, organizations and sectors, as well as the steps being taken to plan and prepare for the risks of climate change.

While climate change poses many risks, it can also present opportunities and benefits such as longer growing seasons, greater agricultural yields and increased recreational opportunities. Thus, in addition to the steps being taken to reduce the negative impacts of climate change, these adaptation stories highlight efforts to take advantage of the benefits that are presented by climate change.

Figure 3 – Projected annual temperature and precipitation change for RCP8.5 for 2046-2065 relative to a 1986-2005 baseline using the 50\textsuperscript{th} percentile of the distribution of the CMIP5 ensemble\textsuperscript{xvi}.
End Notes


vii Ibid.


xii Colombo, S. J., P. A. Gray, P. J. Partington and D. Pearson. 2015. Beyond 450 parts per million: Climate change hazards in a 4°C warmer world and how Ontario can help avoid them. Ontario Centre for Climate Impacts and Adaptation Resources, Sudbury, ON. Ontario Ministry of Natural Resources and Forestry, Peterborough, ON. Available at: http://www.academia.edu/21191364/Beyond_450_parts_per_million_Climate_change_hazards_in_a_4_C_warmer_world_and_how_Ontario_can_help_avoid_them


Story One – Preparing a ‘Forest City’ for Climate Change

ReForest London

Introduction

The City of London has long been known as the ‘Forest City’ – a city built around a forest. Located in southern Ontario, London’s urban area contains an extensive forest of more than four million healthy trees that would cost more than $1.5 billion to replace.

The community of London appreciates its forests for their vast benefits that go beyond aesthetic appeal. London’s forests provide clean air by filtering contaminants; fight climate change by sequestering and storing carbon; save money by shading buildings and reducing energy consumption; and help Londoners stay healthy by creating space for recreational activities. Together, London’s trees are estimated to deliver over $17 million in ecosystem goods and services every year.

Today, human-induced climate change has implications for the composition, structure, and function of local forest ecosystems, including drought stress, storm damage, disease, and invasive species. As a result of warmer winter temperatures, pests are able to spread into areas that were previously unsuitable, such as the Emerald Ash Borer – an invasive insect that infects and eventually kills ash trees (see Figure 2). The City of London will spend an estimated $14.3 million over a 15 year period on the treatment, removal, replanting, and monitoring of ash trees.

Figure 2 – The Emerald Ash Borer is an invasive wood-boring beetle that has spread from Michigan into southern Ontario due to warmer winter temperatures. The insect attacks all native species of ash trees, typically killing them within 2 to 3 years.

Warmer temperatures and altered precipitation patterns are shifting tree climate envelopes northwards – on average almost 60km between 1981-2010 compared to a 1931-1960 baseline. However, tree species are unable to shift north at the same pace.
as their climate envelopes. The effects of this lag are shown in a trend of earlier spring budbreak, which is increasing the occurrence of damages due to late spring frosts\textsuperscript{x}. Warmer winter temperatures are also causing more precipitation to fall as rain instead of snow\textsuperscript{x}. The reduced snowpack eliminates an important source of soil moisture for trees during the growing season and increases the risk of forest fires\textsuperscript{xii}. Further, more frequent and intense extreme weather events, such as heavy rainfall and ice storms, have caused devastating tree loss and damage, placing an economic burden on cities to remove and replace lost trees, which reduces their ecosystem benefits\textsuperscript{xii}.

The City of London has identified climate change as a key threat to its urban forest\textsuperscript{xiii} and is responding by taking proactive action to protect the ‘Forest City’. London’s Urban Forest Strategy contains goals and actions specific to improving tree care, tree management, and encouraging the inclusion of adaptive management into standards and best management practices\textsuperscript{xiv}. Through these actions, the City expects an improvement in the overall health of its forests, which will provide resilience to future climate change impacts\textsuperscript{xv}.

Managing for the impacts of climate change in London’s forests is also a focus of many local organizations. Born out of a growing concern for tree loss in the Forest City, ReForest London is taking proactive action to tackle the effects of climate change.

**Signs of Change by ReForest London**

ReForest London is a non-profit organization focused on enhancing environmental and human health in the Forest City through tree planting. Their programs are designed to increase the distribution and diversity of forests through initiatives that range from seed collection and harvesting to community-wide education programs that inspire residents to plant and care for trees in their neighborhoods\textsuperscript{xvi}. For ReForest London, the evidence of climate change in local forests is abundantly clear.

In recent years, the most prominent environmental change observed by ReForest London are changes in precipitation. Tree planting comprises the largest proportion of ReForest London’s initiatives, and changes in precipitation have impacted their entire organization. For example, staff have observed an increase in the frequency and severity of prolonged droughts, which has reduced the overall survival rate of their trees and made it more difficult for newly planted trees and shrubs to become established. Despite increasing the number of staff and volunteer hours dedicated to planting aftercare, the organization is often unable to meet the watering demand brought on by dry conditions.

Droughts are also impacting the ability of local trees to produce fruits and nuts, which affects the natural regeneration of forests. Because forest regeneration is dependent upon seedling production, the quantity and diversity of species are reduced during times of drought. This loss threatens the diversity of trees planted by ReForest London as any gap in seed collection for a
given species may reduce the availability of the species, and be consequently left out of the reforestation projects that year. ReForest London also collects their own seed for seedling growing with school groups and volunteers. The trees from these programs supplement ReForest London’s seedling giveaway program to the community and are used in infill planting – a practice that involves returning to tree planting sites and filling in the space between trees.

New and encroaching insects are also a growing concern. Since its discovery in London in 2006, the Emerald Ash Borer has caused significant damage to London’s ash trees and continues to threaten about 20,000 trees on public and private property. While the City of London is actively working to control the spread and damage caused by the Emerald Ash Borer, ReForest London had to redirect its tree planting efforts from expanding the city’s forest cover to refilling gaps in the forest community due to lost ash trees. The Emerald Ash Borer is expected to cost London about 10% of its ash trees, and other pests could cause an even more dramatic impact. For example, the Asian Longhorn Beatle is another invasive species that could damage multiple tree species, including maple, willow, and poplar.

Prepared the Forest City

Climate change has led ReForest London to redirect valuable time and resources to managing the impacts of climate change. The organization is working to protect and plan for future changes in climate through the ongoing development of a climate change adaptation plan, anticipated for release by the end of 2017. The plan is expected to highlight the importance of developing adaptive strategies in order to minimize the risks and maximize the benefits brought by a changing climate.

Anticipated changes in Ontario’s climate will reduce the degree to which local populations of tree species are adapted to the climate where they occur today. Many species, following their ideal ‘climate envelope’, are already being driven northward by shifting temperature regimes. The team at ReForest London is using publicly available climate change data and species hardiness models to anticipate changes in the range of tree species currently found in southern Ontario by the end of the century. The results of the modeling is helping to inform current species selection for individual planting sites, ensuring that the chosen tree species will survive in the future climate conditions expected for the area. For example, by 2071-2100, the natural southern range of spruce trees is estimated to be north of London; thus, ReForest London is considering halting any future planting of the species.

ReForest London staff are also considering ways to enhance the survival of tree species through the process of assisted migration. This would involve strategically moving the genetic material of trees (e.g. seeds and seedlings) to more climatically suitable habitats. To inform a program on assisted migration, ReForest London staff are researching the origins of Ontario’s invasive plant species, including their historical rate of movement and factors that led to their establishment in new areas. Through this research, ReForest London staff have decided to move forward with a “continentally native” framework, which would recognize that some species that are considered not native now may soon find their “natural” range occurring in their area, while non-continental species would still be considered unsuitable for London (since it would be impossible for them to naturally occur there). Their assisted migration program would also include consideration of the unique site requirements of each species and the range expansions projected by climate change models. In addition, ReForest London is contemplating the risks that are associated with implementing assisted migration. These might include: the impact of introduced species on the host environment; a species becoming invasive; and mortality or loss of investment if the species is not well adapted to local conditions.
However, according to ReForest London’s Director of Programs, Amber Cantell, doing nothing is not an approach that their organization is willing to take:

“We are simply running out of time. Climate change is coming up fast. Assisted migration comes with serious risk, especially considering the possibility of introducing new pests or diseases. However, trees simply aren’t able to adapt at a rate fast enough to keep pace with the amount of climate change humans are causing. As a result, we expect a massive disconnect between the habitat needs of trees and where they happen to be growing. Now we’re stuck between a rock and a hard place: we’re afraid of the risks, but doing nothing looks likely to come with an even greater cost”.

– Amber Cantell, Director of Programs, ReForest London

With this in mind, ReForest London is focusing its efforts on maintaining the ability of their trees to reproduce naturally. The best tree planters, they point out, are trees themselves. The organization is also a firm believer in combining the natural ability of nature with human efforts to combat the impacts of climate change.

Conclusion

While there is much uncertainty about Ontario’s future climate, including how forests will respond to climate change, ReForest London is taking proactive steps to ensure healthy forests that are resilient to change. They are formulating a response to the threat of climate change by increasing their understanding of the potential effects of climate change on city forests and incorporating new information into their long-term strategic planning. By adapting to the realities of climate change, ReForest London will ensure the sustainability of its operations and will continue fulfilling its mission to enhance the quality of environmental and human health in London’s Forest City.

To learn more about ReForest London, please visit: www.ReForestLondon.ca
End Notes

i City of London. 2016. Founding of the Forest City. Available at: www.london.ca/About-London/london-history/Pages/Overview.aspx


iii Ibid.

iv Ibid.


ix Ibid.

x Colombo, S. J., P. A. Gray, P. J. Partington and D. Pearson. 2015. Beyond 450 parts per million: Climate change hazards in a 4°C warmer world and how Ontario can help avoid them. Ontario Centre for Climate Impacts and Adaptation Resources, Sudbury, ON. Ontario Ministry of Natural Resources and Forestry, Peterborough, ON. Available at: www.academia.edu/21191364/Beyond_450_parts_per_million_Climate_change_hazards_in_a_4_C_warmer_world_and_how_Ontario_can_help_avoid_them


xii Ibid.


xiv Ibid.

xv Ibid.

xvi ReForest London. 2011. Our Programs. Available at: www.reforestlondon.ca/programs


xviii Personal Communication with Amber Cantell, Director of Programs, ReForest London (June 8, 2017).

xix Ibid.


xxi ReForest London accesses information on species hardiness and climate change from Natural Resources Canada. Available at: www.planthardiness.gc.ca
Story Two – The Home Flood Protection Program: Working with Homeowners to Reduce Flood Risk

*Intact Centre on Climate Adaptation*

**Introduction**

Urban flooding has become one of the most substantial threats to property and health safety in Canadian municipalities. The seriousness of the problem was recently exemplified in the southeastern Ontario city of Burlington. On August 4, 2014 the city experienced a rainstorm that delivered 192mm of rainfall within a period of several hours – an amount equivalent to nearly two-months of rainfall the city would regularly experience in the summer. The intense storm generated a significant volume of water that entered into homes through sump pits, plumbing fixtures and drains (sewer backup) and through openings and cracks in windows and foundations above grade (overland flow). Approximately 6,000 properties were reported to have experienced flooding, roughly 3,500 of which reported basement flooding.

It is estimated that the storm caused over $90 million in insured damages. While some received full coverage, many homeowners and property owners whose buildings were affected by overland flooding received only partial coverage, and in some cases, no coverage at all. Insurance protection for overland flooding only became available for Canadians in 2015, leaving many uninsured residents to pay out of pocket for replacing their valuables and repairing damages. In addition, while sewer backup coverage is available to most homeowners in Canada, many opt to not purchase it, as multiple insurance claims for damages from past sewer backups can result in increased premiums or reduced payout limits for future claims.

**Box 1: Overland Flooding**

Overland flooding is a type of urban flooding that occurs when water flows overland and seeps into buildings above the surface of the ground through windows, doors, cracks and openings in the foundation such as vent holes. It is one of the most frequent and costly natural hazards in Canada.

*Figure 1 – A homeowner in Burlington pumps out flood water from the basement entrance of his home after the August 2014 record storm.*
Extreme rainfall events, like the one experienced in Burlington in 2014, are becoming increasingly common due to climate change. Outdated and aging municipal infrastructure, and a lack of household level preventative maintenance are also contributing to increases in basement flood damage across Canada\textsuperscript{ix}. As a result, flood damage now surpasses fire as the primary cause of home insurance losses in Canada\textsuperscript{v}.

Following the August 2014 storm, the City of Burlington commissioned a ‘Flood Vulnerability, Prioritization and Mitigation Study’ to analyze the storm and its impact on the city’s stormwater system. The findings led City Council to approve an additional $20.4 million in funds for stormwater infrastructure improvements, such as larger creek culverts and creek channel improvements\textsuperscript{xii}. Halton Region, which comprises the city of Burlington, also increased financial support for households who have experienced flooding due to sanitary sewer backups, including a Sewer Backup Flooding Grant and a Basement Flooding Prevention Subsidy Program\textsuperscript{xii}.

Now, with the combined support of the City of Burlington, the Intact Centre on Climate Adaptation, and the Government of Ontario, Burlington residents have the opportunity to participate in a program that will help them take practical action to reduce flood risk and the risk of damage in the event of a flood.

**Home Flood Protection Program**

Since 2016, the Intact Centre on Climate Adaptation (Intact Centre) at the University of Waterloo has been developing a comprehensive, community-based, basement flood-risk reduction program called the Home Flood Protection Program. The educational program works with the insurance industry, government, and community volunteers to develop simple and consistent messaging and free resources to help address knowledge gaps that limit homeowner action to protect their homes from flooding.

The Home Flood Protection Program provides a list of online resources customized for a particular community that helps homeowners tackle a variety of ‘do-it-yourself’ flood protection projects around the home\textsuperscript{xiii}. These resources help communities increase their knowledge on flood protection measures and build their capacity to prepare for, and adapt to, the risks of basement flooding.

**Box 2: Web Resources Available to Homeowners**

- Risk-prevention checklists
- How-to videos
- Seasonal maintenance reminders accessible through the quarterly Home Flood Protection Program newsletter
- Tips for finding qualified contractors
- Questions to ask insurance providers
- Information about local subsidies for home flood prevention measures

Photo courtesy of the Intact Centre on Climate Adaptation
The Home Flood Protection Program also offers custom support to individual households through a flood-risk evaluation, known as the ‘Home Flood Protection Assessment’\textsuperscript{xiv}. Together, with a University of Waterloo trained Home Flood Protection Assessor, homeowners rank the performance of 50 physical features inside and outside their home.

The preventative maintenance routine carried out by the homeowner is also ranked and provided with a score. The results are compared against a nationally developed set of criteria after which a report is generated identifying the top physical upgrades and preventative maintenance practices to:

- Reduce sewer backup, groundwater seepage and overland flood risks;
- Reduce moisture levels that cause mould and mildew growth;
- Reduce damage risks to contents and valuables;
- Wisely manage water onsite; and
- Understand risks as they relate to insurance coverage.

A follow-up with the Assessor, a customer service help-line and seasonal maintenance reminders provide additional support to homeowners as they work to protect their properties from future flooding events.

**Program Rollout in Burlington**

With funding support from the Ontario Ministry of the Environment and Climate Change and the City of Burlington, the Intact Centre on Climate Adaptation is piloting the Home Flood Protection Program in Burlington in 2017. The high number of basement floods experienced by homeowners after the August 2014 storm provides a unique opportunity to test the effectiveness of the flood-risk reduction education program in the community\textsuperscript{xv}.

![Figure 2 – Blair Feltmate from the Intact Centre on Climate Adaptation speaks at the announcement of the Home Flood Protection Program in Burlington in August 2016\textsuperscript{xvi}.

Between July and December 2017, a total of 4,000 flood adaptation assessments will be carried out in homes throughout Burlington. Homeowners that participate in the assessment will receive access to customized, one-on-one support for taking action to reduce their risk of basement flooding.

**Table 1: Program Goals**

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<td>1.</td>
<td>Assess the vulnerability of Burlington-area homes to flood damage</td>
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<td>2.</td>
<td>Identify top-ranked physical features and preventative maintenance practices that present flood risk at homes and provide access to user-friendly resources to help people take action to reduce flood risk</td>
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<tr>
<td>3.</td>
<td>Collect the data needed to inform potential expansion of the program across Ontario and Canada</td>
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All single family homes in Burlington will have access to the assessment service and four neighbourhoods will be targeted for intensive promotion that are representative of those found across Ontario based on their type of municipal infrastructure, lot size and past experience with basement flooding. Lessons learned from the pilot program in Burlington will inform a broader rollout of the program across the province.

To encourage neighborhood-level engagement, Home Flood Protection Program staff will work with members of target neighbourhoods and their Ward Councillor to create educational campaigns geared at building awareness of flooding and promoting actions homeowners can take to reduce their flood risk. Free online resources for homeowners will be linked to City websites, councilor newsletters, social media, printed on pamphlets and included in community presentations.

**Raising Awareness of Flood Risk**

Urban flooding presents a severe and growing problem for homeowners, municipalities and insurers in Canada. Recent events, including the 2014 event in Burlington, have exemplified the financial and social impact of severe urban flooding events.

Along with municipal infrastructure upgrades and improved planning approaches, actions at the homeowner or lot level can play a significant role in the reduction of urban flood risk. Hazard-vulnerable residents often lack knowledge of the risks of flooding and/or perceive investments in damage-reducing measures as not worthwhile. Due to the increasing intensity and frequency of extreme weather events, all homes are now vulnerable to flooding due to the sheer volume of water that some storms generate. As a result, there is a vital need for programs aimed at increasing public awareness of urban flood risk and encouraging the sustained adoption of mitigation measures.

The Intact Centre for Climate Adaptation’s Home Flood Protection Program represents a comprehensive approach that encourages private homeowners to implement flood-mitigation adjustments and increases awareness of flood risk through customized educational campaigns. A challenge with any type of awareness building program is maintaining long-term momentum and results. The Home Flood Protection Program is unique in that it is working directly with insurers, local governments, realtors and retailers to develop consistent messaging for a seasonal awareness-raising and preventative maintenance campaign that can be sustained in the long-term in each community.

Homeowner flood risk awareness is a critical beginning. Taking action to reduce flood risk is the next step. Ongoing awareness and preventative maintenance represents the long-term journey that will help address the growing problem of basement flooding across Canada.

To learn more about the Home Flood Protection Program, please visit: [www.homefloodprotect.ca](http://www.homefloodprotect.ca)
End Notes

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v Ibid.


xii More information on the Halton Region sanitary sewer flooding support program is available at: www.burlington.ca/en/services-for-you/Flood-Prevention-Home-Checkup.asp

xiii Intact Centre on Climate Adaptation. n.d. Programs. Available at: www.intactcentreclimateadaptation.ca/programs/


Story Three – Automated Rain Barrels: A ‘Smart’ Stormwater Solution

RiverSides

Introduction

Located on the shores of Lake Ontario, the City of Toronto is highly vulnerable to climate change due to its high-density population, rapid urbanization and networks of interdependent infrastructure. Over the past two decades, Toronto has observed increasing temperatures, changing precipitation patterns, and a record number of extreme weather events that have affected the city’s water resources in different ways.

During the summer of 2016, historically low precipitation led to a severe drought across the city with some areas recording deficits of more than 120mm by summers end. The city was subjected to reduced water availability and residents were asked to curtail their water consumption by 10%.

Alternating patterns between drought conditions and flooding has also occurred. On July 8 2013, the equivalent of one month’s worth of rain (126mm) fell within hours across Toronto. The heavy rainfall exceeded the capacity of the city’s stormwater sewers and flooded the Don River, which flows into Lake Ontario. The water poured from sewers and surfaces into subway stations and basements, stranded commuters, and left many residents without power. The storm had an economic impact of almost $1 billion in damages – the most expensive natural disaster to date in Ontario.

Figure 1 – Lawns and gardens throughout the city were left to dry during a severe drought in the summer of 2016.

Figure 2 – The equivalent of one month’s worth of rain fell within hours during a July 2013 storm event in Toronto.
In the future, climate change is expected to create different weather patterns across the city. By mid-century, average annual temperatures are projected to rise by as much as 4.4°Cxi and the number of days reaching temperatures above 30°C are expected to increase from 20 to 66 days per decade (based on the 2000-2009 baseline)xiii. Changes in precipitation are also expected to occur across the city, including less snow and more rainfall in the winter, and less rainfall in the summer but more intense storms that produce greater amounts of rainfall in shorter periods of timexiv. For example, the maximum amount of precipitation experienced in one day could increase from 66mm (from the 2000-2009 baseline) to 166mm in the 2040 to 2049 timeframe xv.

These changes in temperature and precipitation have implications for the management of Toronto’s stormwater through changes in the amount, timing and intensity of rainfall events. Water resource decision-makers will need to consider new and enhanced ways for managing stormwater that accounts for climate change and climate change related events, such as heavier downpours and oscillating drought-flood conditionsxvi.

**Responding to Climate Change**

The City of Toronto is responding to the risks associated with climate change by implementing a number of strategies and initiatives for its stormwater system. Examples include: a by-law requiring new commercial developments of a certain square footage to have green roofs; a mandatory downspout disconnection program; and expanding storm sewer capacity in areas susceptible to flooding xvii.

Toronto residents are also taking action to prepare for water-related impacts of climate change. In the summer of 2016, the Toronto neighbourhood of Riverdale became the pilot site for the world’s first automated rain barrel system. Environmental organization RiverSides tested the effectiveness of the technology in helping alleviate stormwater stress in the city. The success of the pilot program, highlighted here, shows the potential for individual homeowners and the broader community to protect their property and city stormwater infrastructure from the impacts of climate change.

**Box 1: Rain Barrels**

Rain barrels work by capturing rain where it falls and storing it for future use. Rain barrels are often used in Low Impact Development (LID), or green infrastructure, an approach to managing stormwater by imitating the natural movement of water. Along with other LID technology (e.g. rain gardens, green roofs) rain barrels reduce the pressure of stormwater on municipal infrastructure and prevents the amount of untreated rainfall from discharging into water bodiesxix.

**Stormwater Solutions at RiverSides**

RiverSides was founded in 2002 in response to many stormwater infrastructure failures that occurred across Toronto. The organization began advocating for the residential management of urban stormwater through the use of large, sturdy rain barrels to simply and effectively divert stormwater xviii. After a decade of installing and maintaining the rain barrel systems, RiverSides identified many key limitations (e.g. rain barrels are manually operated and their effectiveness is dependent upon property owner intervention). In search of a solution, Founder and then Manager of RiverSides, Kevin Mercer, developed automated controllers for the barrels, a technology he called RainGridxix. The
technology allows owners to monitor and automatically manage the rain barrel’s water level\textsuperscript{xx}. RiverSides continues to use the RainGrid technology, as well as support the open-source development of what they now describe as automated rain barrels.

**How Does the System Work?**

Automated rain barrels (ARBs) are stand-alone residential stormwater systems that capture up to 90% of annual rainfall runoff from roofs and redirects it away from the foundation of the home, reducing the risk of flooding\textsuperscript{xxi}. Each rain barrel is equipped with automated sensors that monitor the barrel’s water level, predicts anticipated rainfall events, and automatically drains the stored water at least 24 hours prior to a storm\textsuperscript{xxii}. The barrels are connected to the internet, allowing homeowners, municipalities or Conservation Authorities to control rain barrels from smart phones or computer dashboards.

![Figure 3 – The controller box provides communication between the rain barrel and a computer. Each rain barrel is equipped with a small solar panel that provides back-up energy for the controller’s battery\textsuperscript{xxiii}.]

The stormwater system helps prevent basement flooding by reducing discharge to municipal sewers and safely storing, capturing and redirecting stormwater on the property. The system works by reducing the amount of rainfall during a storm that could lead to flooding and creates a stock of accessible water that can be used in periods of drought. The barrels also provide municipalities and Conservation Authorities with measurable data that they can use to monitor the effectiveness of their stormwater resiliency measures.

**Testing the Technology in Riverdale, Toronto**

In the summer of 2016, RiverSides launched the first-of-its-kind community pilot to test and demonstrate the automated rain barrel technology. After extensive community consultation, RiverSides fitted 15 homes in the Toronto neighbourhood of Riverdale with one 500L automated rain barrel. Despite an exceptionally dry summer, each rain barrel diverted between 1,000 to 2,000 L of rainwater a month from Toronto city sewers, the Don River and Lake Ontario\textsuperscript{xxiv}. The results show that each well-installed prototype diverted 10,000 L to 20,0000 L of water annually — or collectively over 50,000 L in the five-month data collection period\textsuperscript{xxv}. The automated rain barrels when working, had a high degree of satisfaction among participants\textsuperscript{xxvi}; the unique internal sensor gave homeowners the option to by-pass drainage and use the water around their property – a popular option during the drought of 2016.

Results of the pilot study show that residents used 80% or more of the total water collected on their property for gardening and other uses\textsuperscript{xxvii}. This shows the value of the rain barrel system in providing a stock of accessible water to residents in times of drought and thus alleviating pressure on municipal water resources.
Figure 4 – Homeowners were able to access information about their rain barrel through a dashboard, including the water capacity of their rain barrel, a five-day weather forecast, and data on the amount of diverted rainwater to date.xxviii

Conclusion

Recent extreme weather events in the City of Toronto show the escalating threat of climate change on stormwater and city infrastructure. However, the results of the 2016 pilot program revealed that automated rain barrels directly prevent residential flood risk and can be easily integrated into a broader municipal system. When the system is working properly, each barrel can capture between 10,000 and 20,000 litres over a 10 month collection season. When scaled up, a system of 15 thousand rain barrels can divert up to 3 billion litres of water over 10 yearsxxix, proving to be an effective adaptation option at the community-level.

The automated rain barrel system is a highly valuable tool in adapting to unpredictable and extreme weather events as it not only collects water during heavy rainfall events, but also provides water during times of drought. Together, RiverSides and one Toronto community have demonstrated that cities can increase the resilience of municipal stormwater infrastructure to increasing extreme weather events, one automated rain barrel system and one household at a time.

Table 1: Projections over time in thousands (K), millions (M) and billions (B)xxx

<table>
<thead>
<tr>
<th>Number of automated rain barrels</th>
<th>Min-max volume (L) 3 years</th>
<th>Min-max volume (L) 5 years</th>
<th>Min-max volume (L) 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30-60K</td>
<td>50-100K</td>
<td>100-200K</td>
</tr>
<tr>
<td>50</td>
<td>1.5-3M</td>
<td>2.5-5M</td>
<td>5-10M</td>
</tr>
<tr>
<td>500</td>
<td>15-30M</td>
<td>25-50M</td>
<td>50-100M</td>
</tr>
<tr>
<td>1,000</td>
<td>30-60M</td>
<td>50-100M</td>
<td>100-200M</td>
</tr>
<tr>
<td>5,000</td>
<td>150-300M</td>
<td>250-500M</td>
<td>500M-1B</td>
</tr>
<tr>
<td>15,000</td>
<td>450-900M</td>
<td>750M-1.5B</td>
<td>1.5-3B</td>
</tr>
</tbody>
</table>

To learn more about RiverSides or RainGrid, please visit: www.RiverSides.org www.RainGrid.com
End Notes


iv Ibid.


vi Ibid.


viii Ibid.

ix Ibid.

x Capital Region District. 2013. Green Infrastructure. Available at: www.crd.bc.ca/education/low-impact-development

xi Image of rain barrel: Capital Region District. n.d. Rain Barrels. Available at: www.capitolregionwd.org/residents/rain-barrels


xiii Ibid.

xiv Ibid.

xv Ibid.


xix RainGrid incorporated and separated from RiverSides in 2014.


Ibid.


Ibid.


Ibid.
Story Four – Urban Forests in a Changing Climate

Urban Forest Associates Inc.

Introduction

Urban forests are a vital component of any healthy city. Trees, both on public and private property, provide a multitude of benefits that improve the quality of life in the urban environment. Urban forests can support a variety of environmental functions, provide a range of economic benefits, and make significant contributions to human health and community well-being.

A healthy urban forest is also critical to a city’s defense against the impacts of climate change. Forests are responsible for:

- Absorbing vast amounts of carbon dioxide and other pollutants from the air;
- Preventing flooding by absorbing rainfall;
- Cooling communities in extreme heat;
- Protecting against strong wind during storms; and
- Providing habitat for resident and migratory birds.

The City of Toronto has long recognized the importance of the urban forest, the benefits it provides, and its role in reducing climate change impacts in its urban environment.

Over the past decade, the City of Toronto has improved tree-related policies, by-laws and guidelines to better support the protection and enhancement of its urban forest. In 2013, Toronto City Council approved the city’s first-ever Strategic Forest Management Plan with the goal of increasing forest canopy cover to 40%.

Table 1: Toronto’s Urban Forest - by the Numbers

<table>
<thead>
<tr>
<th>Number of trees in Toronto</th>
<th>Approximately 10.2 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy cover</td>
<td>26.6 to 28%</td>
</tr>
<tr>
<td>Canopy cover target</td>
<td>40%</td>
</tr>
<tr>
<td>Structural value</td>
<td>Approximately $7.1 billion</td>
</tr>
<tr>
<td>Ecological services provided</td>
<td>Valued at $28.2 million annually</td>
</tr>
<tr>
<td>Carbon storage</td>
<td>Valued at $25 million</td>
</tr>
</tbody>
</table>

The City of Toronto is committed to increasing its urban forest canopy cover to 40% by 2025. The City has set a goal of planting 100,000 trees per year to achieve this target. The City has also established a tree planting program that provides free trees to residents and businesses.

Figure 1 – Map of the City of Toronto’s greenspace.

Planting trees and expanding forest canopy cover are considered key strategies for reducing climate change impacts in urban areas. However, Toronto’s urban trees and forests
are vulnerable to climate change through shifts in tree habitat suitability, changes in pests and diseases, temperature fluctuations, and more frequent and severe extreme weather events\textsuperscript{vii}. The risks of climate change are particularly high for trees located in cities as they are often already under stress from urbanization\textsuperscript{viii}.

In contrast, climate change can bring a range of ecological and economic benefits to forests and the forest industry. For example, warmer temperatures can increase the growth rate of some tree species, thus expanding the habitat for wildlife and lengthening the timber harvest season\textsuperscript{ix}. Nevertheless, climate change poses new challenges, opportunities, and constraints to forest management. Scientific evidence indicates that the climate is changing and forest managers will need to consider these changes in daily and long-term planning\textsuperscript{x}.

A small number of Canadian forest companies are explicitly addressing climate vulnerability and change through adjustments to their operations and management\textsuperscript{xii}. One such example is Urban Forest Associates Inc., a Toronto-based private urban forestry company that is taking action to reduce the negative impacts of climate change while taking advantage of beneficial opportunities.

**Climate Change at Urban Forest Associates Inc.**

Urban Forest Associates Inc. (or UFORA) is a small urban forestry consulting and contracting firm. Their work involves designing, installing and maintaining urban forest habitats. The firm offers expertise on all aspects of urban tree care on both public and private properties, especially ravine forests. Through their services, UFORA helps individual homeowners, municipalities, professionals and community organizations improve the urban forest and natural habitat in the Toronto area as well as throughout southern Ontario\textsuperscript{xii}.

Working directly to improve urban forests, UFORA has observed first-hand the impacts of climate change on Toronto’s trees and on the company’s ability to manage and maintain the health of Toronto’s forests.

Over the past 10 years, staff at UFORA have observed changes in climate variability and weather conditions across all seasons. Their observations include:

- Warmer winters;
- Winter precipitation falling as rain instead of snow;
- Reduced precipitation in the winter and spring leading to drier soils;
- Frosts and ground freezing occurring later in the fall season;
- Shallower ground freezing;
- Changes in the distribution of rainfall; and
- Less predictable weather conditions, making project planning and budgeting more challenging.

![Figure 2 – UFORA supports the regeneration of urban forests in Toronto neighborhoods through organizing community tree planting projects\textsuperscript{xiii}.](image-url)
UFORA witnesses first-hand how warmer temperatures and changes in precipitation patterns are having a direct impact on the distribution, survival rate and sustainability of Toronto’s trees. For example, the team at UFORA have observed changes in the ability of certain tree species to thrive. White spruce is a well-known species that is tolerant to a wide range of weather conditions; however, UFORA is now seeing a slower growth rate than in the past, with some trees dying on sites that are exposed to extreme drought conditions.

Changes in the distribution of certain tree species have also been observed. For example, black walnut was a relatively rare species in the Toronto area prior to the 1990’s, but UFORA is now seeing it more frequently on landscapes. As well, prior to the year 2000 oak trees produced heavy crops of acorns every 3-5 years, but UFORA is now seeing abundant seed crops less often, and not on a predictable timeline.

Changes in the frequency and intensity of extreme storm events is also negatively impacting UFORA’s business operations and the viability of its tree planting events. On July 8, 2013 an intense rainstorm hit the City of Toronto, bringing 123mm of rainfall within a few hours. The record-breaking storm caused three of UFORA’s projects to undergo severe slope failures and caused minor damage to four other projects; resulting in over $1 million in repair costs, and further disturbances to our forests.

Higher risks of more frequent slope failure has led UFORA to consider the effects of water flow and vegetation cover on slopes more cautiously. The company now installs full grass cover on sites that are at higher risk of erosion during heavy rainstorms, and implements water infiltration measures only on sites that are not steeply sloped. Although grass cover competes with planted stock, it provides necessary protection from slope erosion and failure.

Managing Toronto’s Urban Forest for Climate Change

Figure 3 – Heavy rainfall during a July 2013 storm led to catastrophic slope erosion on a residential property in Toronto. The storm washed out a retaining wall and all vegetation and soil. The cost to rebuild the slope was in the range of several hundred thousand dollars⁶⁶. As a result, a more engineered approach was used to rebuild the slope than originally planned in order to protect against future slope wash-outs.

For UFORA, the risks of climate change on the integrity of its service offerings are apparent. In response, the company is taking action by implementing a variety of adjustments to its forest management practices and business operations that aim to increase resilience to climate change.
UFORA accepts that the climate will be different in the future when compared to historical conditions, leading the company to manage Toronto’s forests in a different way. To plan for changes in climate, UFORA has adopted an adaptive management approach to inform its project planning and management decisions. This approach, known as ‘learning while doing’, is a process whereby decision-makers make adjustments in their management of resources based on observations and new information, even in the face of uncertainty\textsuperscript{xv}. Learning from experience and iteratively incorporating information into future plans is considered an important approach to adapting forests and ecosystems to current and future climate change\textsuperscript{xvi}.

Learning through first-hand observations is important for UFORA. Staff monitor sites after planting to measure their rate of survival, ability to thrive, and overall health status and then incorporate these observations into new site designs. For example, greater incidences of flooding have led UFORA to incorporate strategies that enhance the water retention ability of vegetation to match increases in heavy rainfall. Specifically, the company has increased the amount of biomass on their sites by adding more woody and deciduous leaf material. This application enhances the natural absorption rate of water, adds organic matter to the soil, and supports habitat for terrestrial species. UFORA has also adjusted its financial budgets to allow for the preparation and maintenance of more unpredictable and extreme rainfall events that can lead to erosion and damage to its sites. As an example, the costs of more frequent site inspections, maintenance and communication among staff and clients are now incorporated into project budgets.

At the strategic planning level, UFORA applies a toolbox approach to project planning and management from which various treatments and practices are selected or combined to fit current or anticipated weather conditions. The company no longer pre-schedules their annual work; instead, they apply very general timelines with room to prepare and adapt to unexpected changes in weather conditions. In the past, the company would repeat work on certain projects or services at the same time every year. Now, they form a ‘rolling’ list of work that is scheduled according to upcoming weather conditions.

Using information on long-term climate projections\textsuperscript{xvii}, UFORA compares its list of plant and tree species to future climate conditions expected in the region. Their research indicates that most species native to the area today will continue to thrive in the future. As a result, UFORA is maintaining the amount of native species that they currently plant, but monitoring health

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**Figure 4** – Adaptive management is a decision-based process that promotes flexible decision-making that can be adjusted as outcomes from management actions and other events become better understood\textsuperscript{xvii}. 

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and growth rates while considering the use of selected species and planted sources from more southern areas and reducing the number of northern species where warranted. They are cautious about the introduction of new species as they have observed that some southern species, such as the Kentucky coffee-tree and hackberry, are reproducing aggressively and could themselves become a threat to biodiversity. They have also observed the spread of new invasive species, and/or increases in the rate of reproduction.

In the past, UFORA has witnessed devastating loss and damage to trees from extreme weather events. As the frequency and intensity of storms is expected to increase into the future, UFORA performs property site checks after wind events that reach 70km/hr or greater. Staff assess tree damage and carry out clean-up as necessary. During individual storm events of over 60mm in rainfall, staff check sites that have steep slopes for erosion and respond accordingly.

**Realizing Economic Opportunities**

Not only does UFORA’s adjustments in forest management work to protect their business operations from the impacts of current and future climate change, but it helps to take advantage of the economic opportunities that arise from shifting climate regimes. For example, the company has shifted the start of their spring season by 10 to 15 days earlier and the end of their fall season later in the winter, often by an additional month. This provides the opportunity to hire more staff, extend the working season for existing staff, and increase revenue for the company by staying in operation longer. Earlier spring melt also make it easier for the company to undertake certain types of work that were limited by weather conditions in the past, such as spring tree planting events. However, many nurseries have not adjusted their delivery schedules to suit the longer seasons; therefore, the company is somewhat constrained by the supply of plant stock for their planting initiatives.

In addition to the adjustments in forest management, UFORA collaborates with other members and organizations within the industry to increase awareness on the threat of climate change and the urgent need to adapt. Stephen Smith, an ISA Certified Arborist and Urban Forester at UFORA, is a board member at the Forest Gene Conservation Association – a non-profit organization that supports research and dissemination of information to forest managers on climate change impacts and adaptation. Staff at UFORA also participate in conferences and workshops aimed at providing information to the public and industry members on adapting urban forest management practices to climate change.

**Conclusion**

UFORA is a forestry firm that is showing the importance of urban tree management in increasing resilience to climate change. By embracing flexibility in its management approach, UFORA can continue to maintain its business operations and enhance the health of Toronto’s urban forest, all in the face of climate change. With a healthy forest, trees throughout Toronto’s neighborhoods can continue to play a role in fighting climate change and helping the urban community adapt to its effects.

*To learn more about Urban Forest Associates Inc., please visit:* [www.ufora.ca](http://www.ufora.ca)
End Notes


11 Ibid.

12 Urban Forest Associates Inc. Available at: www.ufora.ca

13 Photo courtesy of Urban Forest Associates Inc.

14 Photos courtesy of Stephen Smith, ISA Certified Arborist, Urban Forester at Urban Forest Associates Inc.


18 Sourced from Forest Gene Conservation Association. Available at: www.fgca.net

19 Forest Gene Conservation Association. 2017. Available at: www.fgca.net/about
Story Five – Ontario’s Headwaters and a Changing Climate

Ontario Headwaters Institute

Introduction

Headwaters and their catchments play significant roles in Ontario’s natural heritage, watersheds, and ecological integrity. As a result, climate change impacts on headwaters are an important area of research, education, and evolution of best practices.

Headwaters and their catchments are often found at the outer edges of watersheds and include: small streams; surface and groundwater collection areas; areas of groundwater discharge and upwelling; vernal pools; spring-fed ponds; and wetlands. Headwaters can emerge from forested wetlands, beaver impoundments, or elevated areas as varied as the sand and gravel of the Oak Ridges Moraine (see Figure 2) or the rocky outcrops of the Niagara Escarpment. Headwater streams are also influenced by the topography and geology of the surrounding landscape and have significant contributions to downstream characteristics.

Headwaters also help to regulate water flow and temperature as well as sediment and nutrient loads, which can influence the health of downstream rivers and lakes. As well, headwater catchments offer a higher convergence of forest and stream habitat than larger watercourses downstream, providing an abundance of both terrestrial and aquatic insects that act as important food sources for wildlife. Moreover, headwaters provide niche habitats that are important for wildlife breeding and rearing young, and act as important travel corridors for migrating wildlife, such as moose and forest-dwelling bats.

Figure 1 – Various types of headwater streams exist, such as those cascading through forests or meandering through wetlands.

Figure 2 – The Oak Ridges Moraine is one of Ontario’s most extensive areas of contiguous upland headwater catchments. The Moraine forms the watershed divide between Lake Ontario and Lake Simcoe and provides headwater to more than 30 rivers.
Due to the density and scale of their biodiversity, headwaters are vulnerable to the impacts of human activities such as agriculture, forestry, mining, urbanization, pollution, and population growth. Unfortunately, these activities may act synergistically with climate change to alter Ontario’s aquatic and terrestrial ecosystems. Increases in air and water temperature, decreases in ice and snowpack, and alterations in the timing and amount of precipitation can impact ecosystems in a variety of ways. These include, but are not limited to: habitat availability; changes to phenology, species distribution and productivity; increased deposition of air pollutants; and altered soil and water chemistry. For example, warmer water temperatures are expected to shift aquatic species ranges to the north, and many terrestrial species could be displaced or go extinct due to limits in drainage flows and barriers due to habitat fragmentation.

Climate change will impact both terrestrial and aquatic ecosystems in the Great Lakes and St. Lawrence River Basin, where more than 90% of Ontario residents live and work. As a result, there may be significant ecological, cultural, social and economic implications to those living, working and benefiting from agriculture, forestry, mining, recreation and other sectors in the Great Lakes Basin. In addition, more frequent and intense weather events, such as flooding and prolonged drought, could affect the health of natural heritage areas (see Box 1) and the ecological goods and services available to society.

Changes in climate will also affect natural heritage management. For example, current monitoring programs may need to be re-examined to ensure they include climate sensitive indicators relevant to expected changes in climate. In response to these challenges, the Ontario government is pursuing several initiatives, including:

- Science and research reports on the vulnerability of aquatic ecosystems to climate change;
- Implementing the new wetland strategy;
- A review of the Conservation Authorities Act;
- The implementation of the Great Lakes Protection Act; and
- The implementation of the Co-ordinated Land Use Planning Review for the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Plan, the Greenbelt Plan, and the Growth Plan, including the development of a watershed planning guidance document.

Initiatives to protect Ontario’s headwaters in a changing climate are also occurring at other levels. The Ontario Headwaters Institute, for example, identifies climate change as a significant yet relatively un-examined challenge to headwaters, which harbor much of Ontario’s biodiversity, watersheds and receiving waters, such as the Great Lakes.

**Tackling Climate Change: A Three-Pronged Approach**

The Ontario Headwaters Institute (OHI) was founded in 2003 following the water crisis in Walkerton, Ontario. The Institute grew out of an interest in addressing safe drinking water through a watershed approach, including headwater areas upstream of municipal water intakes. Today, OHI programs are centered on research, education and best practices, with the latter focused primarily on provincial policy related to natural heritage, watershed management and land use planning in Ontario. Recent successful policy submissions (particularly those associated with the Co-ordinated Land Use Planning Review) position the Institute as the leading not-for-profit organization in Ontario working on both headwater protection and improvements to the provincial framework for watershed management.

While urban and rural development continue to present direct challenges to Ontario’s headwaters, the OHI expects that climate change will have more systemic and far-reaching impacts to small streams, the natural heritage in their catchments, and their downstream ecosystems. The OHI is already seeing the effects
of changes in temperature, the chemical composition of precipitation and altered weather norms on aquatic and terrestrial habitats.

Observations and trends of concern include:
- Increased temperatures in cold, cool, and warm-water streams;
- Degraded coastal wetlands through reduced water levels and increased water temperatures in the Great Lakes;
- Altered stream flows resulting in erosion from flooding events and reduced water availability for local species and human use during low water events;
- Increased potential for forest fires and resulting changes to stream and groundwater flow;
- Changes to Ontario’s ecological integrity through altered biodiversity from migrating flora and fauna;
- Impacts on plants due to changes in the chemical composition of precipitation, such as higher pH levels; and
- Increased levels of harmful toxins caused by algae in streams and lakes due to warmer water temperatures.

Figure 3 – Changes in temperature and water levels in the Great Lakes are contributing to the production of blue-green algae, prompting health warnings to residents and touristsxx.

The OHI is addressing the threat of climate change in each of their three program areas: research, education and best practices.

Box 1: What is Natural Heritage?
The Province of Ontario defines a natural heritage system as: “A system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions and working landscapes that enable ecological functions to continuexx.”

Research
The OHI’s research efforts focus on science, policy and performance related to natural heritage, headwaters and watershed health, with biodiversity and climate change as common threads. In a 2016 paper called Protecting Ontario’s Headwatersxxi, the OHI provided an overview of headwaters in Ontario, how climate change is threatening their integrity, and the need to protect headwaters from development and climate change, particularly in Contiguous Upland Headwater Catchments (see Box 2).

Education
To help Ontarians understand and better appreciate the role of headwaters and the threat presented by climate change, the OHI has developed three programs: OHMapping, Headwater Hikes, and its own YouTube channel.

OHMapping: The Institute calls this program “superficially meaningful”, in other words, a simple yet powerful visualization of headwater conditions.
OHMapping is an online tool that provides a series of maps that depict local watersheds (see Figure 4). By colour-coding stream orders and labeling boundaries of first- and second-order streams, OHMapping provides readers with a simple portrayal of the state of the natural heritage and the extent of human impact upon headwaters in five watersheds throughout south-central Ontario.

**Headwater Hikes:** This program comprises eleven self-guided hikes spanning St. Catharines in the Niagara Region, Caledon in the Greater Toronto Area, and across the Oak Ridges Moraine and into Lindsay. Headwater Hikes are designed to encourage public awareness of the role of headwaters in local biodiversity and water resource protection. Each hike contains maps and information on the landscape, natural history and watershed features that users can print and use at their own convenience.

**Box 2: Contiguous Upland Headwater Catchments (CUHC)**

Most watersheds contain large portions of their headwaters in areas that the OHI has termed Contiguous Upland Headwater Catchments or CUHCs (pronounced ‘kooks’). CUHCs, represented by the blue circle in the image below, constitute the drainage areas of first- and second-order streams that connect in the upstream areas of any watershed.

The Institute believes CUHCs represent the best opportunity to protect the regional natural heritage and ecological integrity in both headwaters and throughout a watershed.

**Stream definitions:**

- First-order streams (1) contain no tributaries.
- Second-order streams (2) begin where two first-order streams converge.
- Third-order streams (3) start where two second-order streams meet (third-order streams are not included in the OHI concept of CUHCs).

**OHI YouTube Channel:** The newest OHI initiative is a channel on the video-sharing website, YouTube. The OHI’s YouTube channel features a series of educational pieces, including:

- Five educational PowerPoint presentations;
- A time-lapse video of the four seasons of a watershed;
- Two 90-second vignettes, one on the convergence of three small streams and one on the importance of the spring freshet to headwaters; and
- A video on climate change that is currently in production.

![Figure 4 – Watercourses in the OHMapping tool are colour-coded by stream order and depict the boundaries of CUHCs, which help readers visualize headwater conditions.](image-url)
**Best Practices**

At the OHI, ‘best practices’ focuses on efforts to enhance natural heritage protection and watershed management through improved policies and programs. For example, while Ontario has demonstrated leadership in protecting watersheds (e.g. establishment of Conservation Authorities), the OHI has identified a number of policy gaps and areas where new policies are needed. A few examples include:

- Setting targets for natural heritage protection on a watershed basis across Ontario through, for example, a reinforced Ontario Natural Heritage Reference Manual;
- Standardizing key aspects of both the Ontario Natural Heritage Reference Manual and Conservation Authority guidelines required under Ontario Regulation 97/04 (i.e. Development, Interference with Wetlands and Alterations to Shorelines and Watercourses);
- Establishing triggers to require action based on exceedances to the Provincial Water Quality Objectives;
- Ensuring adequate resources for watershed planning, management, enforcement and monitoring with timely public access to data; and
- Developing protocols to protect CUHCs.

Areas in which past suggestions have been incorporated into provincial initiatives are outlined in Table 1.

**Table 1: OHI Suggestions in Policy**

<table>
<thead>
<tr>
<th>Strategic Policy Document</th>
<th>Measures advocated by the OHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Lakes Strategy</td>
<td>Ensuring the inclusion of watershed management in the policy vision.</td>
</tr>
<tr>
<td>Great Lakes Protection Act</td>
<td>Submitting targets for natural heritage protection based in part on a federal guideline titled ‘How Much Habitat is Enough?’ xxvi</td>
</tr>
<tr>
<td>Co-ordinated Land Use Planning Review</td>
<td>Securing targets that retain natural heritage in new development, as well as on the amount of impervious surface area allowed in these areas.</td>
</tr>
<tr>
<td></td>
<td>Obtaining commitments to:</td>
</tr>
<tr>
<td></td>
<td>• Require watershed and sub-watershed planning prior to land-use permitting; and</td>
</tr>
<tr>
<td></td>
<td>• Develop a watershed planning guidance document to establish consistency across agencies involved in watershed management.</td>
</tr>
<tr>
<td></td>
<td>Subsequently appointed member to a watershed guidance document advisory group.</td>
</tr>
</tbody>
</table>
Conclusion

By identifying, studying and addressing the impacts of climate change in Ontario’s headwaters, the OHI is working to both seek improved natural heritage protection and improved watershed management – not just for today, but for a future shaped by a changing climate.

While many climate change headlines focus on extreme weather, greenhouse gas reduction, green energy and complete communities, the Institute hopes more people will look upstream and appreciate the contribution of Ontario’s headwaters in protecting the region’s ecological integrity and the economic and social vitality they provide.

To learn more about the Ontario Headwaters Institute, please visit: www.ontarioheadwaters.ca
End Notes


ii Ibid.

iii University of New Hampshire. 2015. Natural Resources: Headwater Streams. Available at: www.extension.unh.edu/Headwater-Streams

iv Ibid.

v Ibid.

vi Oak Ridges Trail Association. n.d. The Oak Ridges Moraine. Available at: www.oakridgestrail.org/moraine


xvi In 2000, runoff from heavy rainfall containing harmful pollutants contaminated local drinking water in Walkerton, Ontario exposing residents to bacteria. More information is available at: www.theglobeandmail.com/news/national/the-walkerton-tragedy/article4164697/

xvii Ontario Headwaters Institute. n.d. About. Available at: www.ontarioheadwaters.ca/about

xviii Personal Communication with Andrew McCammon. February 9, 2017.

Photo courtesy of Dr. J. M. Reutter, Ohio Sea Grant and Stone Laboratory.


By scientific definition, headwaters include third-order streams. However, the OHI excludes third-order streams from both their OHMapping program and in recommendations for certain policy initiatives and focuses on first- and second-order streams which require a more sensitive policy approach.

Ontario Headwaters Institute. n.d. OHMapping. Available at: www.ontarioheadwaters.ca/mapping

OHI’s YouTube channel is accessible at: www.youtube.com/channel/UC--cVXQm2rF0iuivpy-2-Ug