VULNERABILITY ASSESSMENT SUMMARY

Natural Systems in Peel Region

Prepared for:

Region of Peel
working with you

Prepared by:

Toronto and Region Conservation
for The Living City

ONTARIO CLIMATE CONSORTIUM

Action on Climate Change in the Region of Peel

Addressing climate change is nothing new in the Region of Peel. The two regional Conservation Authorities, Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC), have been actively involved in climate change adaptation and mitigation initiatives for the past decade and considerably longer from the perspective of managing natural areas and hazards, a recognized component of adaptation. The Region recognizes the importance of working together to build resilience and adaptive capacity to climate change at a local scale. In 2011, it partnered with the TRCA and CVC, as well as lower tier municipalities (Brampton, Mississauga and Caledon), to develop the Peel Climate Change Strategy.

The Strategy serves as a roadmap for addressing climate change impacts in Peel Region through the following:

- proactive and responsive planning and leadership
- actions to reduce greenhouse gas emissions
- targeted and proactive adaptation actions
- shifting to a green economy
- increasing awareness of, and engagement in, climate issues in Peel
- ongoing research and adaptive risk management

Peel commissioned the development of vulnerability assessments to investigate the impacts of climate change on a variety of systems. The information gained in these assessments will help identify opportunities for adaptation to climate change and reduction of its negative effects.

In 2017, this vulnerability assessment was completed, which studies the impacts of climate change on natural systems in the Region. The following summary of that assessment was prepared by Hutchinson Environmental Ltd. and Shared Value Solutions Ltd., in collaboration with the Toronto and Region Conservation Authority, the Ontario Climate Consortium and the Region of Peel.

The full technical report for this and other assessments is available at climateconnections.ca.

Note: Please refer to the full technical report for all source material used in the assessment and this summary.

Suggested citation for the full technical report:

Tu, C., Milner, G., Lawrie, D., Shrestha, N., Hazen, S. 2017. **Natural Systems Vulnerability to Climate Change in Peel Region.** Technical Report. Toronto, Ontario: Toronto and Region Conservation Authority and Ontario Climate Consortium Secretariat.

Preparing for the Future

Climate change is one of the greatest challenges humans face in the 21st century. As the planet warms, we are witnessing more extreme and variable climate patterns, which are leading to unprecedented impacts for society and natural environments worldwide. The warming trend is no longer reversible, which means that even if we drastically curb greenhouse gas emissions today, we will still continue to experience devastating climate change effects for decades to come. Adaptation is needed at all levels, from local to global, to adjust to the new reality under our changing climate.

Calls to Action

The results of this vulnerability assessment, summarized over the following pages, make it clear that we must act now:

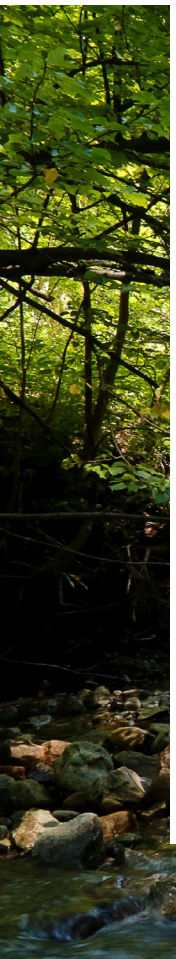
- ✓ Enhance the urban tree canopy and supporting efforts made through the Peel Climate Change Partnership on Heat Resiliency, especially in areas with little or no ability to effectively regulate summer land and water temperatures, including areas of acute thermal stress to fish.
- ✓ Start or continue adaptation and natural heritage planning, incorporating the implementation of new policies contained within the four amended plans[1] that take into account climate change, while leveraging this and other existing community assessments and system datasets.
- ✓ Increase the enhancement and protection of existing wetlands and tablelands and creating new wetland features where possible to build resilience and deliver numerous ecosystem services, including increased flood regulation.
- ✓ Protect, enhance and restore regional species diversity by increasing connectivity of natural areas through existing restoration programs, particularly in high priority areas.
- ✓ Incorporate climate change into watershed planning more directly, including identifying and protecting important local connections between shallow groundwater and surface features.
- ✓ Promote effective collaboration and information sharing between Conservation Authorities, and with adjacent and upstream municipalities through active participation in the renewed Peel Community Climate Change Partnership.

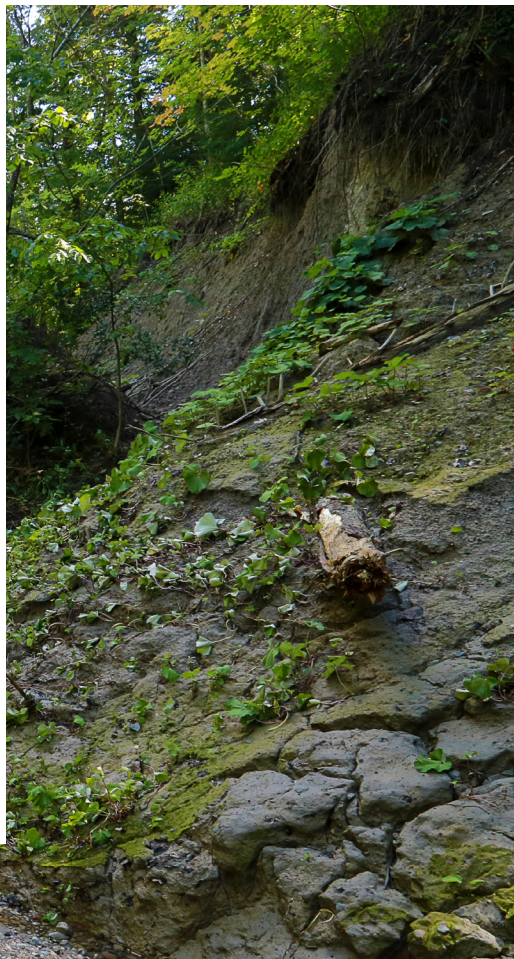
FOCUS OF THE NATURAL SYSTEMS VULNERABILITY ASSESSMENT

Peel's vulnerability assessment of the impacts of climate change on natural systems in the Region focuses on three types of systems:

- Groundwater systems: recharge areas, aquifers and discharge areas
- Aquatic systems: rivers, streams, lakes and wetlands
- Terrestrial systems: natural and urban forests, grasslands, wetlands, bluffs

[1] See the updated policies of the Growth Plan for the Greater Golden Horseshoe, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, and the Niagara Escarpment Plan at www.mah.gov.on.ca/Page10882.aspx





There is a growing recognition that ecosystem services are not really free, and that we need to make a concerted effort to protect and enhance them.

How Does Climate Change Affect Natural Systems?

Impacts on Ecosystem Services

Natural systems provide a wide range of goods and services that benefit humans, such as food, timber, drinkable water, pollination, flood regulation, and clean air. These ecosystem services support us in many ways, by enriching our health and well-being, offering recreational, aesthetic and spiritual opportunities, and strengthening our economy. Ecosystem services also help us address climate change (for example through forest and wetland carbon sinks, and the provision of renewable energy sources).

There is a growing recognition that the benefits provided by ecosystem services are not really free, and that we need to make a concerted effort to protect and enhance them, especially in the face of climate change. This means protecting the natural systems that support and produce ecosystem services, including forests, wetlands, rivers, lakes and urban green spaces. Climate change is considered a major threat to biodiversity, which is the foundation of healthy and resilient natural systems. The increased frequency and severity of extreme weather projected under climate change will adversely affect biodiversity, and thus compromise ecosystem services we rely on.

The future of natural systems under climate change ultimately affects our future. We must act now to increase the protection of natural systems so that ecosystem services are continually delivered, sustainable over the long-term and resilient to climate change.

DEFINING VULNERABILITY TO CLIMATE CHANGE

Many definitions of vulnerability to climate change exist. For the purposes of this assessment, the definition from the Intergovernmental Panel on Climate Change was used:

"Vulnerability encompasses ... sensitivity or susceptibility to harm and lack of capacity to cope and adapt."

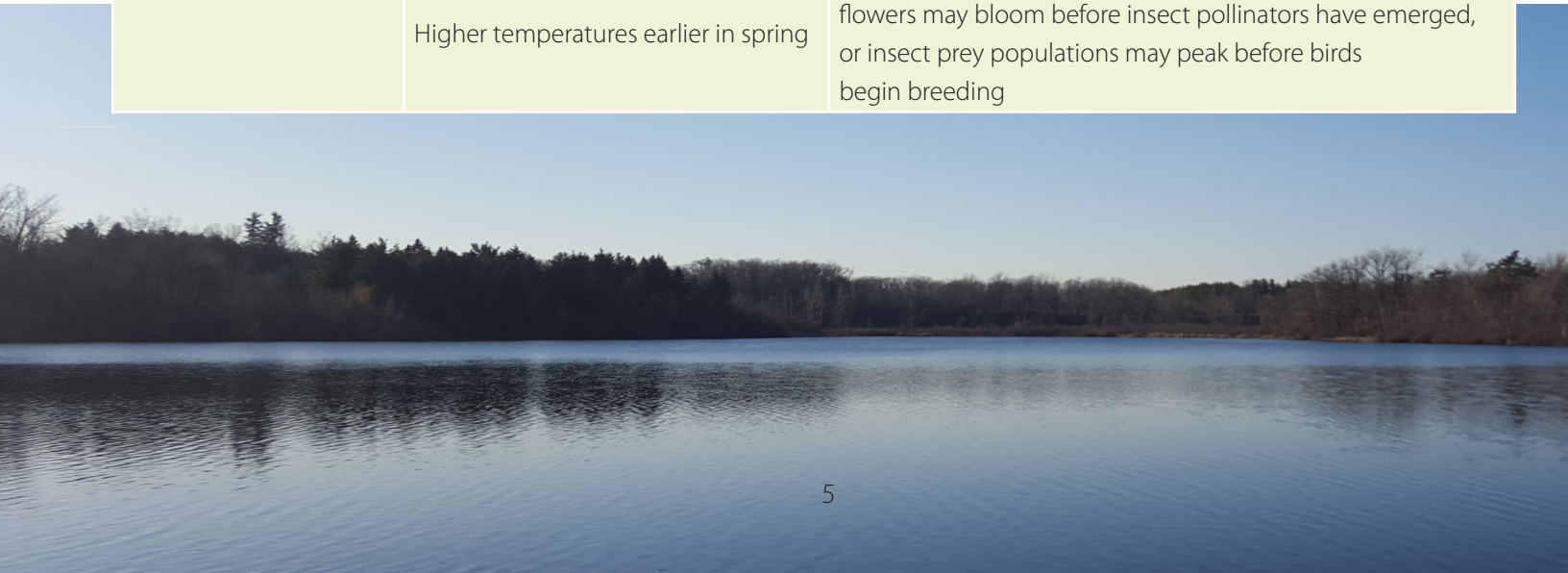
ECOSYSTEM SERVICES

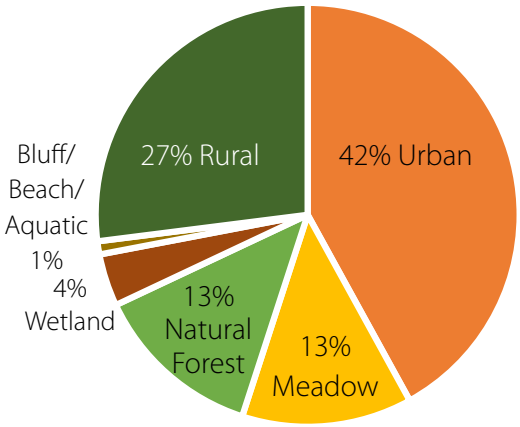
Humans derive countless benefits, or "ecosystem services," from natural systems. These services fall into four categories:

- Regulating Services, such as water and air quality
- Supporting Services, such as habitat diversity
- Provisioning Services, such as food and timber
- Cultural & Socio-Economic Services, such as recreational opportunities

Examples of Climate Change Impacts on Natural Systems

Natural System	Climate Driver	Potential Impacts to Natural Systems
Groundwater	Higher temperatures and more frequent extreme heat events	May cause higher evaporation rates, especially during the summer, reducing the amount of water soaking into the ground
	Increased winter rainfall	May extend the window for aquifer recharge (in temperate zones this currently occurs in early spring and late fall), potentially providing more opportunity for groundwater supplies to be replenished
	Short bursts of extreme rainfall	May be too brief for water to soak into ground and recharge aquifers
	More frequent and intense rainfall	May increase runoff in urban areas where recharge areas have been paved over, or where capacity for recharge is limited because of a high water table
Aquatic	Increased precipitation overall, as well as more frequent and intense	May increase runoff to rivers, wetlands and lakes, affecting flows and increasing delivery of nutrients and sediment
	Higher air temperatures and more frequent and intense drought	May cause low flow conditions and greater evaporation, which would reduce and degrade aquatic habitat
	Higher water temperatures	May affect what plant and animal species can live in aquatic systems, could threaten the survival of sensitive species
Terrestrial	Higher temperatures and more frequent and intense drought	May stress native plants and animals, making them more susceptible to disease and invasive species; could cause species to move further north to find suitable environmental conditions
	Higher temperatures earlier in spring	May disrupt synchrony in biological systems. For example, flowers may bloom before insect pollinators have emerged, or insect prey populations may peak before birds begin breeding





LAND COVER IN PEEL REGION

Natural Systems in Peel Region

Peel Region is situated in the "mixedwoods plains ecozone," which has one of the mildest climates in Canada, characterized by cool winters and long hot and humid summers. There are four major watersheds in the Region: Credit River, Humber River, Etobicoke Creek and Mimico Creek. All forests in the Region are fragmented, and most of the original wetlands have been lost.

Peel is one of the most densely populated areas in Canada, and all of its watersheds are under pressure from human activity, particularly urbanization. Other potential threats include aggregate extraction, agriculture and increases in recreational activity. Specific impacts on natural systems in the Region include the following:

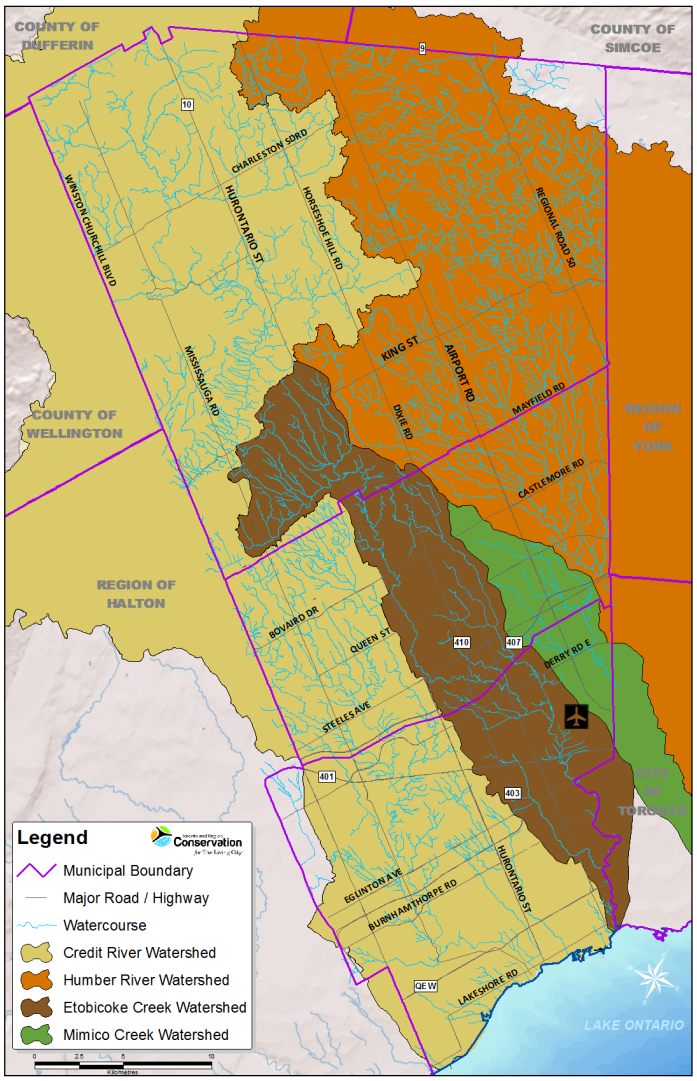
- Forest fragmentation
- Pollution of streams by stormwater, fertilizers, pesticides, and livestock
- Lowering of the water table due to water taking
- Air pollution
- Wetland loss and degradation
- Spread of invasive species such as Emerald Ash Borer, Gypsy Moth, Butternut Canker, and Dutch Elm Disease

DEFINING RESILIENCE AND ADAPTIVE CAPACITY TO CLIMATE CHANGE

The vulnerability of natural systems to climate change will depend in large part on their resilience and adaptive capacity.

Resilience refers to a system's ability to cope with and recover from disturbance.

Resilience is closely tied with the concept of **adaptive capacity,** which is the ability to adjust and respond to changes.



Major Watersheds in Peel Region

Possible Futures Under Climate Change

Climate Trends in Peel Region

In general, temperature and precipitation patterns follow a north-south gradient in Peel Region, influenced by topography, elevation and land use activities. Temperatures tend to be higher in the southern portion, where the effects of Lake Ontario and highly urbanized areas trap heat. To the north, the higher elevation of the Niagara Escarpment and Oak Ridges Moraine combines with a less urbanized landscape comprised of farmland, natural forests and some grasslands, to produce cooler temperatures. Similarly, the southern portion of Peel is drier than the north, driven by geography and differences in regional storm tracks.

Predicting future climate is not an exact science, but trends can be forecasted based on a range of future greenhouse gas emission scenarios. Under business as usual, Peel Region is expected to be hotter at all times of year, with changes to seasonal precipitation patterns, more rainstorms and more heat waves. Winter, spring and fall will likely be wetter, while summer will be drier on average, but punctuated by heavy storms. Over the next few decades, northern Peel is expected to warm faster than southern Peel, while the north-south gradient in precipitation patterns will likely intensify.

Natural System Vulnerabilities to Climate Change

Urbanization is the principal stress on natural systems in Peel, although aggregate extraction and agriculture are also important. Climate change will interact with these stressors to amplify and exacerbate impacts on natural systems.

The groundwater, aquatic and terrestrial systems examined in this assessment are tightly linked, and climate change will have complex and overlapping effects on them. Because many aspects of Peel's natural systems display a more or less north-south gradient in condition, climate change will have uneven effects throughout the Region.

FUTURE CLIMATE TRENDS IN PEEL REGION

A study of predicted climate trends for Peel Region found that

By 2050

- Annual mean temperature will rise by 2°C
- The number of extreme heat days (over 30°C) will more than double
- The intensity of extreme storms will increase by 28-51%
- The growing season will be 20% longer than today

By 2080

- Annual mean temperature will rise as much as 5°C from current levels
- There will be up to five times more extreme heat days
- The intensity of extreme storms will increase by 46-90%
- The growing season will be 30% longer than today

Peel Region will be hotter at all times of year, with changes to seasonal precipitation patterns and more heat waves and rainstorms.

Groundwater plays a vital role in maintaining watershed health and resiliency by providing a constant, cold and clean source of water to the surface, supporting natural habitats, native biodiversity and residents of Peel Region.

Peel's Groundwater System

Groundwater plays a vital role in maintaining watershed health and resiliency by providing a constant, cold and clean source of water to the surface, supporting natural habitats, native biodiversity and residents of Peel Region. Groundwater generally flows from north to south in the Region, from the Niagara Escarpment and Oak Ridges Moraine down to Lake Ontario. The groundwater system is comprised of a mix of shallow and deep aquifers, which respond differently to climate change. Deeper systems are relatively protected from present day stressors (such as pollution or climate) because of the long time it takes water to filter down from the surface, recharge deep aquifers and then discharge to the surface again (on the order of 10, 000 years). Shallow aquifers, meanwhile, are more sensitive to environmental changes.

Groundwater and associated surface waters already under stress from urbanization will face further threats from climate change, such as the following:

- Reduced groundwater levels in shallow systems
- Reduced volume of water discharging to surface waters (such as streams and rivers)
- Increased risk of shallow aquifers drying out in summer
- Loss of stream habitat
- Warming of surface waters

These impacts, in turn, will affect a variety of ecosystem services in Peel, such as regulation of water quality and quantity. Groundwater delivery to surface waters is projected to be more variable and intermittent, especially during summer months. While this is not expected to be a problem for potable water supply due to the Region's proximity to Lake Ontario, it may adversely affect non-potable water use, particularly in local areas already under stress, like Fletcher's Creek, and the West Humber and Etobicoke Headwaters.

POTENTIAL IMPACTS OF CLIMATE CHANGE TO NATURAL SYSTEMS


Shallow aquifers may dry out


Warming surface waters


Erosion


Algal blooms


Invasive species


Heat stress to plants

Peel's Aquatic System

Peel's aquatic system delivers numerous ecosystem services, including a clean and stable water supply, control of flooding and erosion, and many recreational opportunities. Most watercourses are fed by groundwater in Peel. Streams south of the escarpment tend to have more intermittent

headwaters and gather groundwater as they flow downstream, while streams above the escarpment and in the Oak Ridges Moraine are typically fed by groundwater-dominated headwaters.

Peel's aquatic system is experiencing a number of impacts associated with urbanization and resource use (recreational and sport fishing):

- Elevated stream temperatures
- Elevated levels of nutrients (such as phosphorus)
- Localized flooding
- Habitat fragmentation due to in-stream structures (such as dams and weirs) and ponds

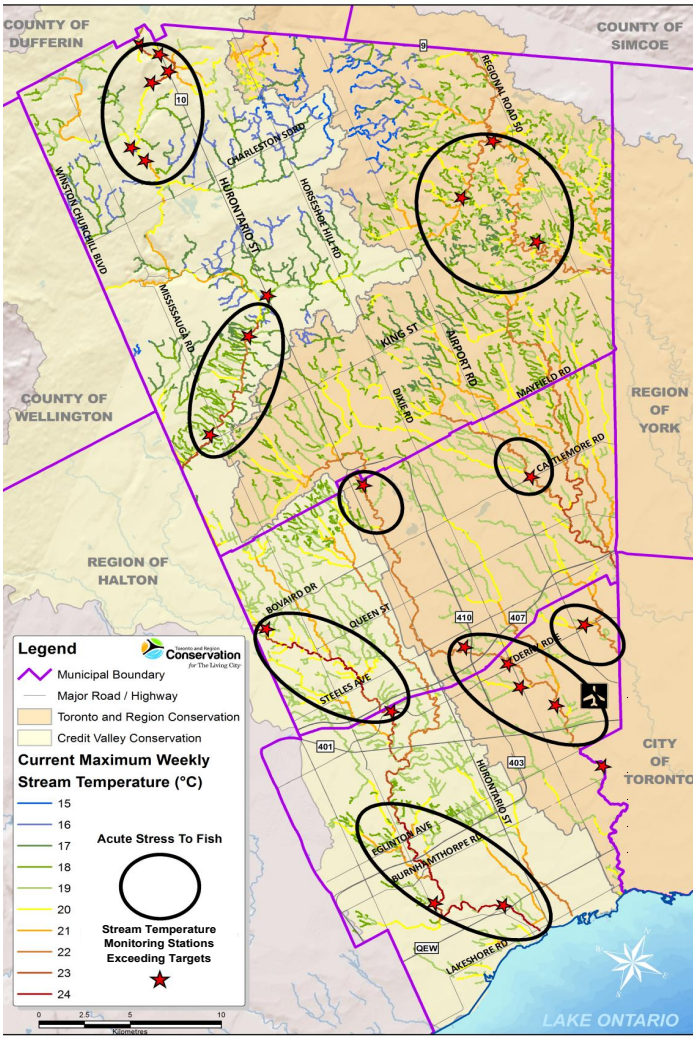
Some parts of the aquatic system are in good ecological condition and support an abundance and diversity of aquatic plants and animals. Other parts of the system, however, are not faring so well, especially in the highly urbanized lower portion of Peel. These areas will be particularly hard hit by climate change.

Nine highly vulnerable stream reaches have been identified in the Region due to their current low flows and elevated stream temperatures in summer. Under climate change, these hotspots may no longer be able to support sensitive fish species, such as Brook Trout and Redside Dace. Three aquatic species at risk are found in the Humber and Credit River watersheds (two endangered fish, Redside Dace and American Eel, and one endangered dragonfly, Rapid Clubtail).

Climate change may further degrade Peel's aquatic system:

- Warming summer stream temperatures by as much as 2°C, making them unsuitable for many fish species
- Lowering seasonal water levels and summer flows, compromising fish movement and survival
- Increasing stream erosion and urban flooding due to more frequent and intense storms
- Increasing the spread of invasive species, as well as levels of pollutants and nutrients, through changes to flooding patterns
- Promoting favourable conditions for algal blooms, making them more common and intense
- Altering winter ecology because of warmer and wetter winter conditions, influencing survival of fish and fish eggs, and fish spawning in spring

Nine highly vulnerable stream reaches have been identified in the Region due to their current low flows and elevated stream temperatures in summer.



Location of Nine Highly Vulnerable Stream Reaches Based on Stream Flow and Water Temperature

Peel's Terrestrial System

Land cover in Peel follows a distinct geographic pattern, with northern (or Upper) Peel mainly consisting of rural and natural habitats, compared with mostly urban or urbanizing areas in Middle and Lower Peel.

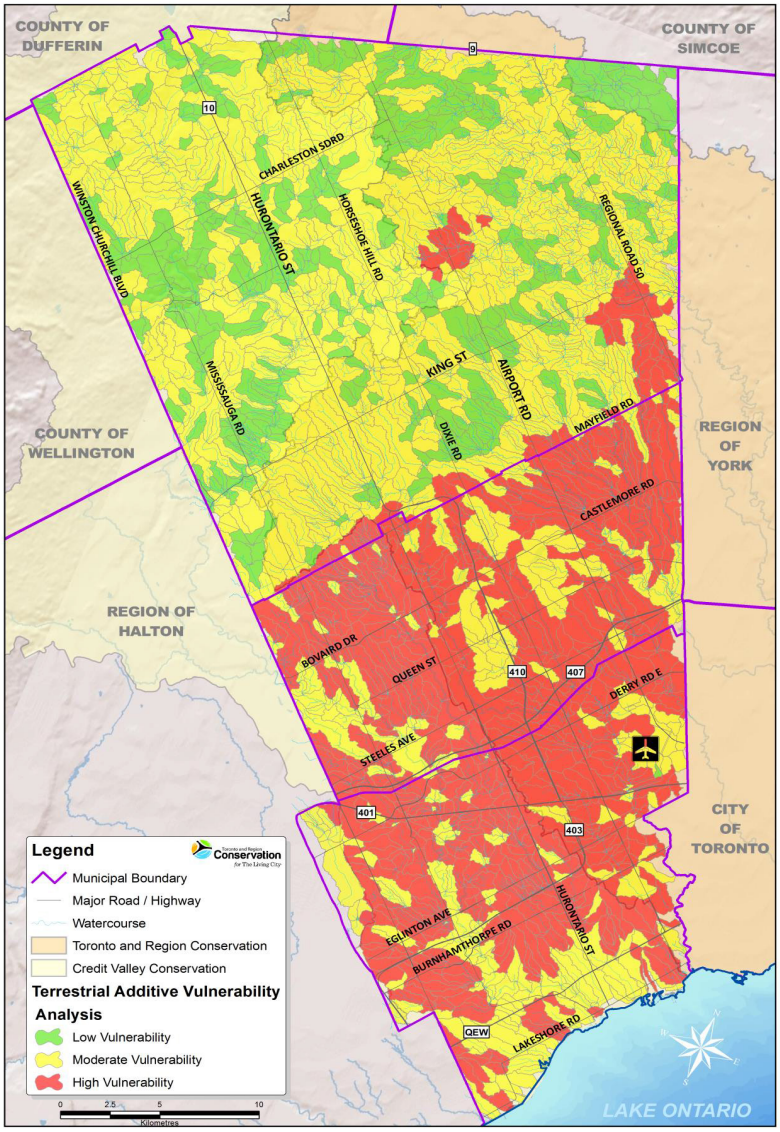
Climate change will amplify the effects of urbanization on the terrestrial system. Currently, 55% of the terrestrial system is considered highly vulnerable to increasing air temperatures and longer summer dry periods Most of these vulnerable areas are small isolated patches of natural habitat located close to urbanization, where they already face the following pressures:

- A shift from natural cover (which is 'pervious', allowing water to soak into soil and minimize flooding) to paved cover (which is 'impervious', preventing water from reaching soil)
- Loss of habitat connectivity (which reduces species movement and gene flow)
- Increased habitat fragmentation (which makes habitat patches more vulnerable to invasive species and disease)
- Reduced forest canopy (which reduces shading and cooling effects of vegetation)

In comparison, natural areas in northern Peel tend to be more widespread and well-connected. Although northern natural areas are currently in good ecological condition, they may experience drastic declines and shifts in species in the future, because they contain many climate sensitive plant communities, such as those found in swamps, marshes and fens far from watercourses.

Some of the potential impacts of climate change on Peel's terrestrial system include the following:

- Drying of wetlands (swamps far from watercourses and bogs are believed to be most vulnerable)



Terrestrial System Vulnerability

- Reduced snow cover, reducing beneficial insulation of plants and animals in winter
- More water flowing overland, leading to increased flooding especially in urban areas
- Increased heat stress for plants
- Increased spread of invasive species and frequency of pest outbreaks
- Shift in tree species from northern to southern species
- Intensified heat island effect in urban areas

Currently, 55% of the terrestrial system is considered highly vulnerable to increasing air temperatures and longer summer dry periods.

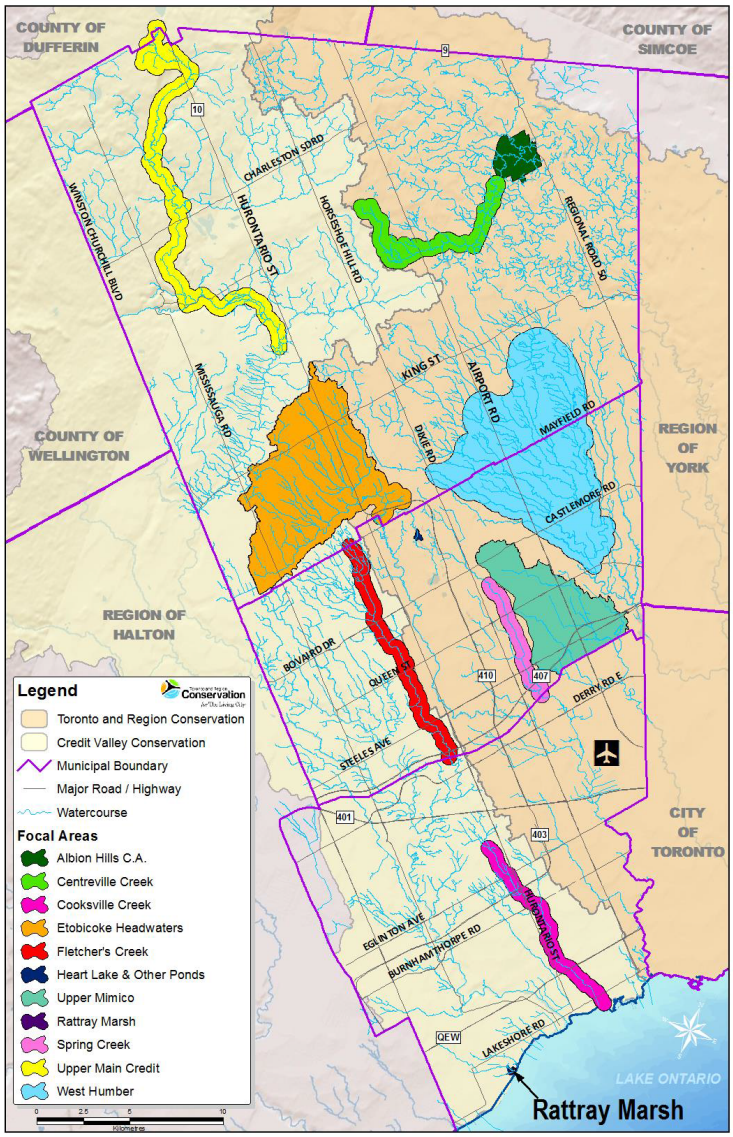
What the Storylines Tell Us

The natural systems assessment presented a series of 11 focal area storylines to provide more in-depth detail on climate change vulnerabilities across the Region. The storylines were selected based on areas that had sufficient information for identifying vulnerabilities, and are not uniformly distributed throughout Peel. They do not necessarily reflect priority areas of concern, but do represent case studies of how natural systems may respond to climate change within Peel Region.

Storylines were grouped into three categories covering conservation areas, subwatersheds and watercourse examples. One storyline from each category is summarized below.

- **Conservation Area Storyline: Rattray Marsh Conservation Area**
- **Subwatershed Storyline: Etobicoke Creek Headwaters**
- **Watercourse Storyline: Upper Main Credit**

Locations of Focal Area Storylines



Rattray Marsh supports a diversity of plant and animal species and has been designated an Environmentally Significant Area, Provincially Significant Wetland, and an Area of Natural and Scientific Interest.

Conservation Area Storyline: Rattray Marsh Conservation Area

Rattray Marsh Conservation Area is located in south Mississauga, within the Sheridan Creek watershed. It comprises 38 hectares of lakeshore, marsh, field and woodland habitats along the Lake Ontario shoreline. The marsh itself is one of the last baymouth bar coastal wetlands in western Lake Ontario, and one of the few remaining coastal wetlands in the Greater Toronto Area. Rattray Marsh supports a diversity of plant and animal species and has been designated an Environmentally Significant Area, Provincially Significant Wetland, and an Area of Natural and Scientific Interest. The Area provides important habitat for migrating birds, many aesthetic and recreational opportunities for local residents, and a cooling effect on surrounding built-up areas during summer.

The Conservation Area is surrounded by urban landscape, and over time has experienced substantial ecological degradation, including sediment build-up in Sheridan Creek, poor water quality, and spread of invasive species. Native species diversity in Rattray Marsh is considered degraded compared with wetlands in northern Peel Region.

Influence of Climate Change

Climate change is anticipated to influence the Conservation Area primarily through warmer and drier summer conditions. By the 2050s it is projected that Rattray Marsh may experience the following:

- Loss of forest habitat, replaced by shrubland and meadows
- Proliferation of existing invasive species, which are more tolerant than native species of a changing climate
- Loss of habitat connectivity for wetland species such as Spring Peeper and Wood Frog
- Degradation in habitat for migratory birds
- Increased occurrence of algal blooms
- Reduction in the cooling effect on surrounding urban areas during the hot summer

Management efforts are already underway in Rattray Marsh to strengthen its climate resilience. For example, dredging to remove sediment is helping to restore deep water habitat, while limiting access for the invasive Common Carp is increasing habitat diversity in the wetland.

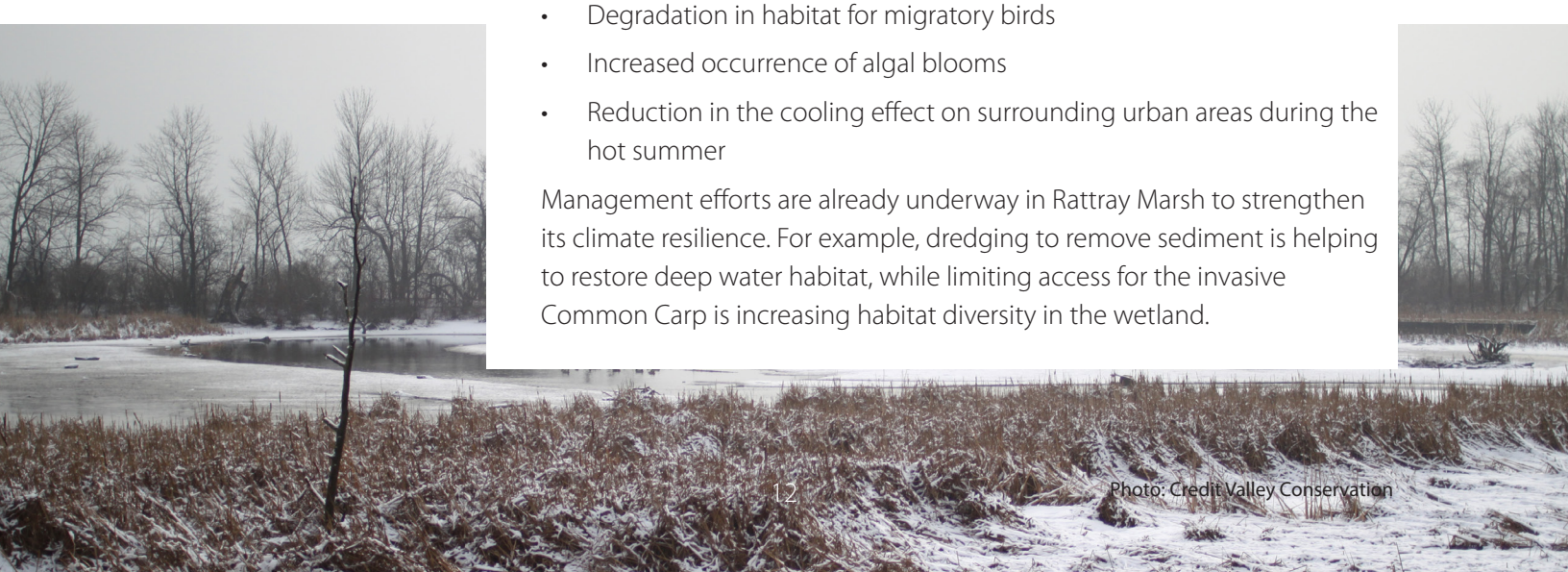


Photo: Credit Valley Conservation

Subwatershed Storyline: Etobicoke Creek Headwaters

The Etobicoke Creek Headwaters is situated in the northern portion of the Etobicoke watershed, in lower Caledon. Compared with the rest of the watershed, this area is in relatively good shape ecologically, with limited urban development (mainly in the south) and mostly natural or agricultural land cover (mainly in the north).

The groundwater system in the subwatershed is characterized by shallow aquifers, with among the lowest recharge levels in all of Peel, which makes this system particularly vulnerable to climate change. Some headwater tributaries commonly dry up during summer, limiting fish habitat and aquatic connectivity. Water quality is generally higher here than in downstream areas.

Natural forest cover is low and fragmented throughout the Etobicoke watershed, and most occurs within the Headwaters subwatershed. The area contains numerous climate sensitive vegetation communities (such as swamps and marshes) and species (such as beech and hemlock).

The vulnerability of the Headwaters subwatershed to climate change will be largely influenced by future development in the area. Although the Headwaters subwatershed currently has relatively good ecosystem function, if urbanization continues at the same pace, climate change impacts will be amplified and exacerbated.

Influence of Climate Change

Climate change is anticipated to influence the Etobicoke Creek Headwaters primarily through warmer and drier summer conditions, punctuated by heavy rainfall events. By the 2050s, the area may experience the following:

- Reduced water reaching the groundwater system
- Limited water availability in the aquatic system, especially in summer
- Increased overland flow, contributing to flooding downstream (e.g., in Brampton and Mississauga)
- Watercourses becoming wider and shallower, and drying up or having more frequent low flow conditions
- Higher surface water temperatures, adversely affecting aquatic life and recreational fishing
- Increased turbidity to surface waters; degraded water quality
- Declines in climate sensitive vegetation and replacement by more tolerant southern or shrubby species

STAKEHOLDER ENGAGEMENT

Because natural systems support us all in a variety of ways, it was important to gain input from as wide a cross-section of the Peel community as possible for this assessment process. Stakeholders were consulted through project meetings, interviews, and focus group workshops. Participants included representatives from Peel Region, TRCA, CVC, the Ontario Climate Consortium, the Ontario Centre for Climate Impacts and Adaptation Resources, the Ontario Ministry of Natural Resources and Forestry, as well as 19 subject matter experts from academic, government and non-government organizations.

Stakeholder participation was key to defining the project scope and conducting the vulnerability analysis. Participants identified what components of natural systems to consider in the assessment and which ecosystem services were most valued by them.

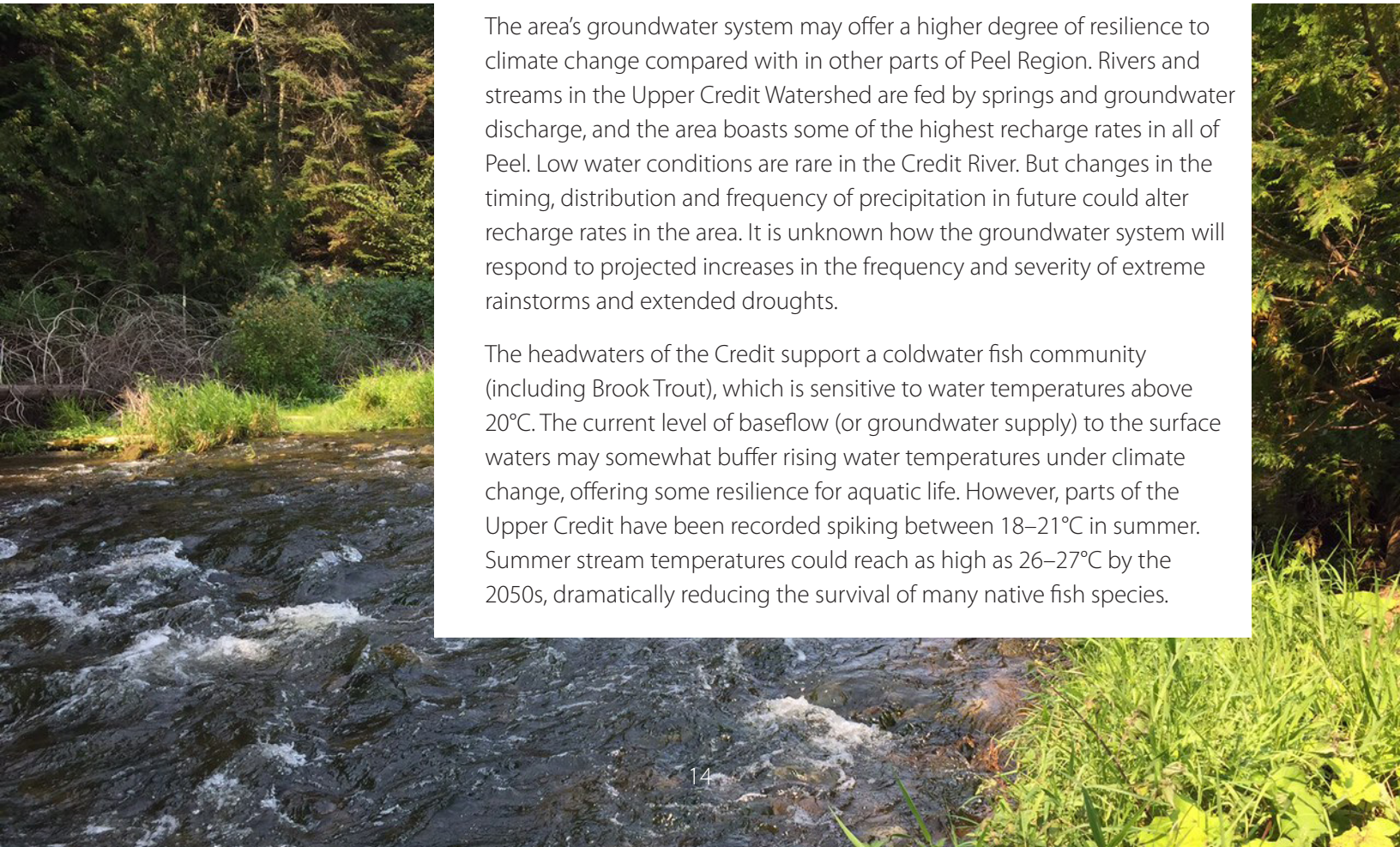
The ecosystem services provided by the Upper Credit Watershed are highly important for maintaining the ecological integrity of Peel's entire natural system.

Watercourse Storyline: Upper Main Credit

The Credit River begins north of Orangeville and flows into the northwest part of Peel Region above the Niagara Escarpment. This storyline focuses on the Upper Credit Watershed, covering the main branch of the Credit River from Melville to Cheltenham.

Most of the Credit River watershed is in good ecological health, despite historic and ongoing land use changes. The area is heavily forested, with only about 12% of the land cover under urban use. Compared with parts of the lower watershed, the Upper Credit retains high levels of pervious cover, forest and wetland habitat, natural habitat connectivity, and native species diversity. Its natural beauty is enjoyed by thousands of people throughout the year, including hikers, birdwatchers, and anglers.

Sections of the Upper Credit do face localized pressures and are areas of concern in the face of future climate change. For example, aggregate extraction, urban development and agricultural activity are creating water quality issues in the Shaw's Creek subwatershed, which flows into the Credit. Similar pressures affect the watercourse downstream, in Melville to the Forks of the Credit subwatershed.



The area's groundwater system may offer a higher degree of resilience to climate change compared with in other parts of Peel Region. Rivers and streams in the Upper Credit Watershed are fed by springs and groundwater discharge, and the area boasts some of the highest recharge rates in all of Peel. Low water conditions are rare in the Credit River. But changes in the timing, distribution and frequency of precipitation in future could alter recharge rates in the area. It is unknown how the groundwater system will respond to projected increases in the frequency and severity of extreme rainstorms and extended droughts.

The headwaters of the Credit support a coldwater fish community (including Brook Trout), which is sensitive to water temperatures above 20°C. The current level of baseflow (or groundwater supply) to the surface waters may somewhat buffer rising water temperatures under climate change, offering some resilience for aquatic life. However, parts of the Upper Credit have been recorded spiking between 18–21°C in summer. Summer stream temperatures could reach as high as 26–27°C by the 2050s, dramatically reducing the survival of many native fish species.

Influence of Climate Change

Climate change could affect the Upper Credit River in the following ways in future:

- Increased warming of surface waters could degrade water quality (which would be further worsened by urban expansion and associated increases in human activity).
- There could be an influx of coolwater fish species, and possibly invasive species expanding their ranges northward (which could change angling opportunities).
- Some or all Brook Trout populations could be lost in the area (especially from watercourses not buffered by groundwater).

The ecosystem services provided by the Upper Credit Watershed are important for maintaining ecological integrity within Peel Region. The Upper Credit is still in relatively good ecological condition, with large amounts of natural cover and a groundwater system supported by deep aquifers. These natural features mean that the Upper Credit has some buffering capacity against future climate change, which could help bolster the resilience of other downstream systems in Peel as well. But this adaptive capacity will not be possible under a "business as usual" approach in future. If human pressures continue to intensify in the area, the Upper Credit will not be able to withstand the added impacts of climate change.

Where Do We Go From Here?

This assessment is intended as a tool for identifying and prioritizing action to minimize vulnerability and maximize resiliency of natural systems in Peel under climate change. Current provincial land use policies, such as the Growth Plan, Greenbelt Act, Oak Ridges Moraine Act, and the Niagara Escarpment Act, represent steps in the right direction. This report offers a way to link these larger scale approaches to watershed and regional levels. Coordinating efforts at all these scales will contribute toward building a resilient Region with a high functioning natural landscape that delivers a full suite of ecosystem services to its residents.

The vulnerability assessment identified strengths and weaknesses in Peel's natural system that need to be factored into a coherent and effective plan to adapt to, and mitigate the effects of, future climate change. The following section outlines specific action Conservation Authorities and other stakeholders in Peel Region could take to build resilience in the natural systems.

The collective impact of a coordinated effort could be a resilient Region with a high functioning natural landscape that delivers a full suite of ecosystem services to its residents.

Habitat connectivity is recognized as one of the most important and effective ways to bolster species diversity under climate change.

Priorities for Action

1. Increase Connectivity

Protect, enhance or restore regional species diversity by increasing connectivity of natural areas, including forests, meadows, wetlands and watercourses. The focus should be on enhancing or expanding areas that currently function well and have low to moderate vulnerability to climate change. In Peel Region these areas include the northern portions of watersheds and/or headwater areas, which are strongholds for community diversity and high quality habitat.

Rationale:

- Biological diversity is the foundation of a resilient landscape.
- Habitat connectivity is recognized as one of the most important and effective ways to promote species diversity under climate change.
- This action will contribute to the overall resiliency of the entire landscape by protecting areas that act as sources of diversity.

2. Protect & Restore Natural Features

Protect existing and restore or create new natural features such as forests, meadows and wetlands across Peel. The immediate priority should be to protect, restore or create wetlands (especially swamps), which provide numerous protective mechanisms against climate change, but are also vulnerable to climate impacts.

Rationale:

- Drier summers punctuated with bursts of extreme rainfall will increase the risk and magnitude of flooding.
- Natural features minimize the adverse effects of flooding by blocking, storing and slowing surface runoff.
- Wetlands are among the most effective natural features at providing flood protection, but swamps fed by rainfall are particularly sensitive to climate change.

3. Enhance Urban Forest Canopy

Support municipalities to maintain and enhance the urban forest canopy. The initial focus should be on areas that currently have little or no ability to effectively regulate summer land surface temperatures. Intensive forest

Photo: Laura Taylor

management activities, such as introducing more southern tree species or planting more resilient native varieties may be warranted. New, innovative management approaches should be carefully monitored to ensure there are no undesired effects and that the expected outcomes are achieved.

Rationale:

- Heat stress in urban areas is expected to worsen with climate change, affecting not only humans, but also fish, wildlife and sensitive vegetation.
- Shading by the urban forest canopy can dramatically reduce the urban heat island effect.

4. Lower Maximum Water Temperatures

Increase efforts to lower summer maximum stream water temperatures. The priority should be on protecting coldwater habitats, as well as warmwater habitats that currently have elevated summer temperatures. Management initiatives should be coordinated across Conservation Authorities and integrated into existing restoration, retrofit and stewardship programs (through riparian planting for shade and infiltration of runoff, for example).

Rationale:

- Coldwater habitat is projected to significantly decline or disappear due to climate change.
- Temperature increases in warmwater habitat may exceed the tolerance level of native warmwater fish.

5. Protect and Improve Stream Baseflow

Protect and improve stream baseflow to minimize vulnerability to aquatic systems. The immediate focus should be on protecting coldwater networks (reaches, watercourses and subwatersheds). Action to protect baseflow may include operation of dams designed to augment baseflow (such as Island Lake Dam), as well as public awareness campaigns on water conservation.

Rationale

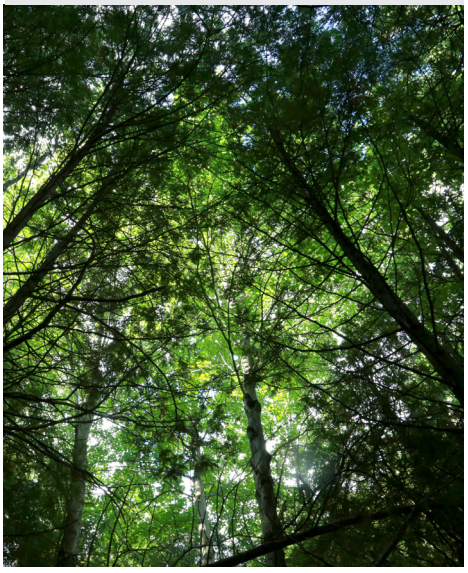
- Coldwater networks rely heavily on baseflow to support ecological function and are at greatest risk of habitat decline or loss under climate change.
- The maintenance of baseflow in coldwater networks will contribute to reducing vulnerabilities downstream.

THE HEAT ISLAND EFFECT

Urban areas are generally hotter than rural or natural areas because of the heat island effect. Vegetation is reduced in urban areas, and replaced with pavement and buildings, which leads to less shade and moisture to cool surroundings, especially in summer. The heat island effect has many negative consequences for urban dwellers, including increases in

- peak energy demand
- air conditioning costs
- air pollution
- greenhouse gas emissions
- heat-related illness and mortality

Some urban areas in Peel already experience a marked heat island effect in summer. In downtown Brampton, for example, daytime surface temperatures as high as 45°C have been recorded. Climate change will further intensify this effect.



WHAT THIS VULNERABILITY ASSESSMENT IS

- Part of the research phase of the adaptive management process Peel is conducting to respond to climate change
- Technical assessment to understand how natural systems in Peel respond to climate change
- Describes current climate vulnerability and how this might change in the future under climate change
- Provides evidence and information needed to inform adaptation
- Precursor to developing an adaptation strategy for protecting natural systems
- Provides background information that could be used in future risk assessments
- Developed through widespread consultation with local stakeholders

WHAT THIS VULNERABILITY ASSESSMENT IS *NOT*

- Not a prescriptive plan for addressing vulnerabilities and impacts
- Does not rank the relative significance of different climate change effects on natural systems
- Does not evaluate resources or programs available in Peel Region to support adaptation planning and implementation

6. Reduce Surface Water Pollution

Focus on reducing surface water pollution. Areas with degraded water quality and/or algal blooms should be targeted for management. Conservation Authorities should consider innovative approaches, such as promoting low impact development, establishing pollution offsetting, restoring wetlands and removing dams. In addition, Conservation Authorities should advocate for the best available technology for new and proposed wastewater treatment plants, including those draining into Peel.

Rationale

- Climate change is expected to worsen existing water quality issues in the Region.
- More frequent, intense and/or chronic algal blooms could destabilize aquatic food webs, foul public areas, and damage drinking water filtration infrastructure.

7. Protect Shallow Water Flow Paths

Identify and protect important local connections (or flow paths) between shallow groundwater and surface features, such as streams and wetlands.

Rationale:

- Groundwater supply from shallow aquifers is highly vulnerable to climate change and other stressors.
- While the provincial Sourcewater Protection Program has helped to identify priority groundwater areas and drinking water wells across southern Ontario, knowledge of critical connections at the local scale in Peel Region is lacking.

8. Review Natural System Monitoring Programs

Review current natural system monitoring programs carried out by Conservation Authorities and municipalities to ensure they include a focus on climate change impacts. If necessary, revise programs so that they effectively track vulnerabilities, and establish an evaluation system to measure the success of adaptation efforts in achieving watershed resiliency.

Rationale:

- Conservation Authorities are leaders in natural system monitoring, but some programs were designed before climate change was a major concern.
- A review of current programs and evaluation of adaptation action would help ensure a coordinated and consistent regional approach to climate change.

9. Implement & Update Conservation Policies

Continue to implement policies and programs related to sustainability and natural system protection and continue to update these guidance documents with new science, evidence and approaches for reducing natural systems vulnerability, starting with the information provided in this and other vulnerability assessments.

Rationale:

- Many existing policies contain management recommendations that contribute to climate change adaptation.
- However, many technical and guidance documents for Peel Region were developed before climate change was a major concern and thus lack focus on this issue.

10. Collaboration

Promote effective collaboration, cooperation and streamlined information sharing amongst regional Conservation Authorities, municipalities, and the Peel Community Climate Change Partnership, as well as with landowners, developers, businesses, non-governmental organizations, adjacent or upstream municipalities and the provincial and federal governments.

Rationale:

- Climate change affects everyone, and no single group has all the answers, resources, capacity or responsibility to manage natural systems and transform them into resilient ecosystems.
- A unified approach is the best way to promote widespread adaptation planning and implementation.
- The Region of Peel is a leader in conducting vulnerability assessments and in watershed protection, and its knowledge and experience should be shared to increase mutual benefits.

The future of natural systems under climate change affects our future. We must act now to protect natural systems so that ecosystem services are continually delivered, sustainable over the long-term and resilient to climate change.