Climate Change and the Kawarthas

Context, Issues and Response

KLSA

Kawartha Lake
Stewards Association
2020

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Introduction

Kawartha Lake Stewards Association (KLSA) members have identified climate change as an area of interest and concern. Federal and provincial government scientists have undertaken a number of studies and models to try to understand what the implications of a changing climate will be on the lands and lakes located in the Great Lakes Basin and the Lake Ontario watershed and in some cases the Kawartha Lakes region. Our interest is the Kawartha Region of the Trent-Severn Waterway.[1] The Kawartha Lakes region is shown in Figure 1 (Spence 2016). KLSA defines the Kawartha Lakes as the lakes within the Trent-Severn Waterway whereby Balsam Lake is the most upstream lake and Katchewanooka Lake is the furthest downstream lake (White 2006).[2] In KLSA's 2018 Annual Lake Water Quality Report we summarized climate change related to projected annual air temperatures and precipitation rates for two modeling scenarios which extend to the end of this century (Napier 2019a).

Figure 1. Watersheds of the Trent-Severn Waterway showing the central location of the Kawartha Lakes.

In this report, we describe the effects of climate changes on the environment and paint a scenario of what may be in store for us.

Canadian and US scientists have assessed climate change projections for the Great Lakes Basin and evaluated the degree of evidence and the consensus of agreement on various climate change impact indicators (McDermid 2015a).

Physical Environment

Table 1 summarizes projected climate change impacts upon the physical environment. The strength of evidence and degree of agreement by the scientists were ranked as "high", "medium" and "low". Some of the key physical attributes found by these researchers are described below.

[1] The Trent Severn Waterway comprises of the Severn Region, Simcoe Region, Kawartha Region and Trent Region. See: http://www.thewaterway.ca/maps.html#sthash.pbUrH6Hn.dpbs.

[2] See the KLSA 2018 Annual Lake Water Quality report for a map of the lakes where water quality is tested.

Table 1: Climate Change-Projected Impacts: Great Lakes Basin - Physical Effects[3]

Evidence \ Agreement	Low	Medium	High
High	↑ Lake water temperature ↑ Ice free days (42 to 90 days) ↑ lake stratification Variable: water levels effects	↑ Precipitation (20%) ↑ Rain ↓ snow ↑ Extreme rain events ↓ Ice cover, thickness, extent ↑ Mid winter thaws	↑ Air temperature ↑ Frost free days
Medium		↑ Flood severity and frequency ↑ Number and extent of fires	
Low	↑ Ice storms ↑ Wind gusts ↑ Temperature wetlands Variable: Lake chemical effects		↑ Drought periods Variable: river temperatures

Air Temperature

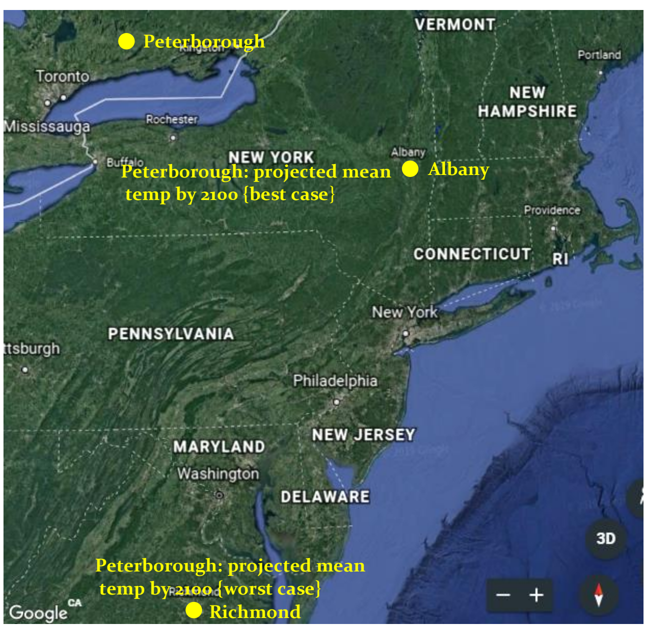

Figure 2: Scenario Based Air Temperature

As previously reported there is a high degree of certainty surrounding the projections on air temperatures (Napier 2019a). Over the last 63 years Ontario's average annual air temperature has increased by 1.6°C. Annual average temperatures are projected to increase by 3.0°C to 7.6°C above the baseline period (1971 to 2000) by the year 2100 (McDermid 2015b). Figure 2 provides a context of where geographically equivalent annual average temperatures are expected to be by the end of the 21st Century. Based on the low emission (i.e. best case) scenario, the average annual temperature for the Peterborough area will be similar to the present day average annual temperature at Albany NY. Assuming the high emission (i.e. worst case) scenario the average annual temperature for our area will be what is now occurring at Richmond VA. The warming temperatures in the Great Lakes Basin have already extended growing seasons by 1-1.5 days per decade during the past 50 years, which has a direct impact for plants, aquatic primary productivity and fish, whose life cycles are all highly dependent on temperature. With the increase in temperatures there will be the cascading effect of less

[3] See McDermid 2015b and Fausto, undated for the information contained in Tables 1 and 2.

snowfall, more rain and more mid-winter thaw events (McDermid undated). Researchers are beginning to suspect that the worst case scenario, which was estimated to have a 3% chance of happening is unlikely to occur. “Under this scenario, a 500% increase in the use of coal was estimated which is now considered unlikely” (McGrath 2020).

Lake Temperature

Lake water temperatures are a by-product of climate change (i.e. ‘the warmer the air, the warmer the water’). In the last century, surface water temperatures of the Great Lakes have increased by as much as 3.5°C. In the coming century, surface water temperatures are projected to increase by a further 2.9°C to 6°C depending on the climate change scenario and location within the Great Lakes Basin. Changes in air temperature and corresponding surface water temperature influence the extent and duration of lake ice cover. Over the past century, there has been a strong trend toward later freeze-up and earlier break-up of lake ice.

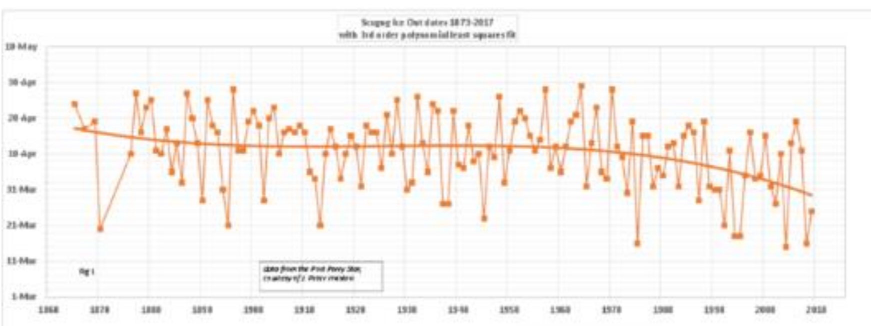

Figure 3: Lake Scugog ice cover – Historic trends

The shortened ice period is derived not only from anecdotal evidence of grandparents lamenting the fact that the duration of ice rinks on the lakes has been shortened but also from historical data. As reported in the Port Perry Star, Figure 3 shows the “ice out” days from Lake Scugog.[4] Today, the ice cover is off Lake Scugog approximately three weeks earlier than in the middle of the 19th Century. Similarly, Figure 4 shows the number of ice-free days (pink squares as shown on the right hand axis) compared with the number of ice-cover days (blue diamonds as shown on the left hand axis) on Harp Lake from 1975 until 2009.[5] Harp Lake is one of the long-term monitoring sites maintained by the Dorset Environmental Science Centre. The change in the lake’s thermal dynamics will affect the lake’s ecosystem.

A consequence of fewer ice-cover days on both Georgian Bay and Lake Ontario could alter the lake effect snowfall for both the reservoir lakes and the lower Trent Lake system respectively. The longer open water period will increase evaporation from Georgian Bay and Lake Huron well into the winter months, providing greater quantities of moisture delivered along the snow-belt (e.g. reservoir lakes).

[4] Courtesy of J.P. Hvisten, Port Perry Star. This graph can be found at the Chandossier website which also contains several environmental data sources: https://chandossier.com/.

[5] Figure 4 - courtesy of Dorset Environmental Science Centre.

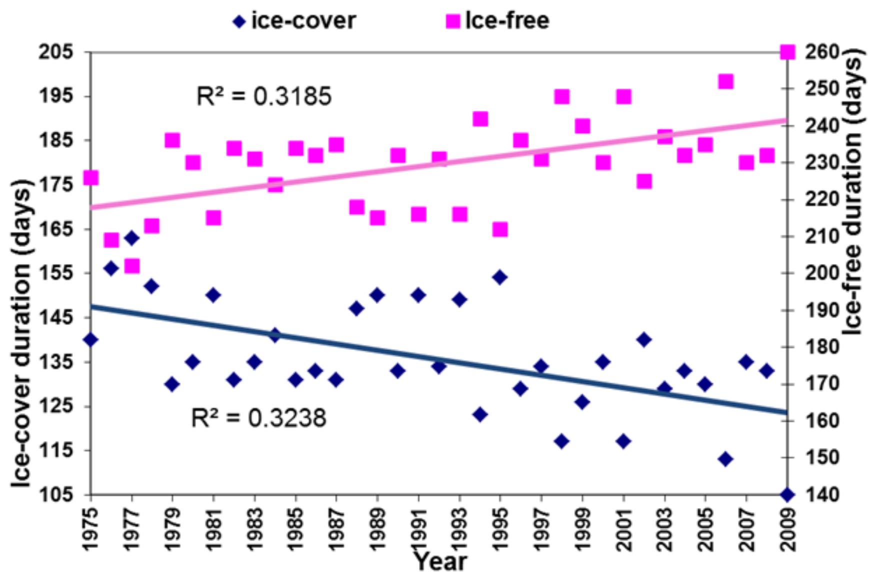

Figure 4: Harp Lake: Changes in Ice Cover

Not only will ice cover be affected, the type of ice on lakes will also change (Buttle 2019). Alterations to the nutrient cycles, reduction in dissolved oxygen concentrations and changes in aquatic habitats may occur. Lake mixing regime responses to climate change are complex and may not be associated closely with change in any one climatic variable. Climatic factors that may contribute to the lake heat budget are air temperature, solar and thermal radiation, cloud cover, wind speed, and humidity (Woolway 2019). The timing of breakup, freeze dates and open water days are projected for Ontario's fishery management zones including the Kawartha Lakes. By the end of the century Kawartha Lakes open water duration is projected to be 13 to 43 days longer that what occurred between 1971 and 2000 (Minns 2014).

Increased water temperatures and the corresponding increase in the duration of the lake stratification period result in decreased oxygen levels in bottom waters.[6] Warmer water enhances productivity, which could increase the number and growth of undesirable species and cause algal blooms. As temperatures increase, warm water holds less oxygen than cold water. Oxygen levels in the lower levels of the lake can be further reduced by the decomposition of organic matter as it drifts down from the surface which, in turn, may lead to depleted oxygen conditions (anoxia) which is compounded by longer periods of lake stratification (Dove Thompson 2011). Dissolved oxygen levels of 5 mg/l or greater are preferred by most fish of interest to anglers, while concentrations below 2 to 3 mg/l are considered hypoxic.[7]

Warmer waters can contribute to increases in algal blooms (Rex 2013). Each year, KLSA summarizes Total Phosphorus (TP) concentrations within the Kawartha Lakes and also reports on TP loadings from municipal sewage treatment plants and interprets historical phosphorus trends

[6] For a description of lake stratification see totsaltot2015a Box 2: Thermal stratification in lakes.

[7] Hypoxic water conditions are where dissolved oxygen concentrations are less than 2 mg/L, making life difficult for aerobic organisms.

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or anomalies (Dolbey 2016).[8] KLSA has undertaken a review of Total Phosphorus trends for a 10 year period (Dolbey 2015) and has identified how TP concentrations have changed in the past 250 years and the implications for the lakes' trophic status (Laird 2018, Napier 2019b). Phosphorus release rates from lake sediments can be affected by dissolved oxygen concentrations and a variety of other environmental factors (Orihel 2017). The release of phosphorus from sediments is partially temperature dependent; therefore, warmer water temperatures may increase phosphorus levels in the water column. "If lake sediments become warmer and more hypoxic in response to climate change, the contribution of phosphorus from lake sediments may increase" (Gibbons 2013). Because of increased frequency and intensity of rainfall events, surface runoff may cause additional TP loadings to local waterbodies. Moreover warmer water will promote the growth of both aquatic plants and algae biomass as well as causing species shifts.

Precipitation

Table 1 shows there is high evidence (x axis) and medium concurrence (y axis) to the impacts on both timing and the amount of precipitation resulting from climate change. As noted in the KLSA 2018 annual report,[9] annual precipitation in the Kawarthas is projected to increase under all climate projections across the watershed by 7% to 10% by the end of the 21st century.

However, seasonal precipitation rates may vary. Mean summer precipitation is projected to decrease under most scenarios, while winter precipitation amounts are projected to increase across all scenarios. The winter precipitation event will see more rain and freezing rain and less snowfall. The largest snowfall losses in North America are projected for the Great Lakes Basin with declines of up to 48% by the late 21st Century. The increase in precipitation rates and expected changes in the pattern of seasonal rainfall could cause a number of other effects such as an increase in flood frequency and timing, an increase in severe storms and fluctuating river and lake hydrological regimes. The Coalition for Equitable Water Flow assessed potential changes in the Trent-Severn Waterway. [10] During the summer months of 2016, there was a rainfall deficit in the Peterborough, Trenton and Haliburton districts from the 'normal' period when compared to the 'actual' precipitation levels.[11] We have already seen increased drought periods in the Kawartha and Haliburton areas during the summer season coupled with extreme spring rainfall events. For example, in 2013, 2016, 2017 and 2019 precipitation events were 130% to 235% above the average amount for rainfall (Spence 2019a).

Parks Canada has developed a strategy for managing water levels along the Trent-Severn Waterway (TSW) and this strategy is considered a mitigating feature to address climate change.[12]

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[8] See https://klsa.wordpress.com/published-material/ for all KLSA Annual Lake Water Quality Reports.
[9] See Napier 2019a.
[10] See Spence 2016.
[11] See Spence 2016 slide 30.
[12] See: https://www.pc.gc.ca/en/lhn-nhs/on/trentsevern/info/infonet/gestion-eau-water-management.

In recent years, TSW has added real-time snow gauges to augment snow surveys, installed automatic level recorders on all the key reservoir lakes, reports daily on precipitation events and undertakes inflow/outflow water balances to evaluate lake storage capacities. The collection of these data and modeling analysis allows TSW to respond to real-time conditions (Spence 2019b). The likely result is that the Kawartha Lakes will maintain its summer water levels by additional scrutiny and management attention by TSW throughout the year especially during the shoulder seasons.

Biological Environment

Table 2 shows the projections of the biological component for the Great Lakes Basin. Biological environmental attributes are harder to predict and project because of the number of variables that could influence biotic change. Climate is only one factor, albeit an important one!

Table 2: Climate Change-Projected Impacts: Great Lakes Basin - Biological Effects

Evidence \ Agreement	Low	Medium	High
High			
Medium		↓ Range for coldwater fish, turtles ↑ Range for cool/warmwater fish ↑ Range oak/birch forest, sugar maples, hickory, plant productivity ↓ Boreal species Variable: wetland vegetation requiring little water such as sedges, grasses, will replace emergent and submergent species	
Low	Variable: Phenology (amphibians) Variable: Aquatic species genetics ↑ Wildlife Pathogens and parasites range and prevalence.		↑ Non-native species ↑ Range for invasive species ↑ Aquatic vegetation, trees, plant pathogens and parasites range and prevalence.

Forests

It is difficult to predict the potential effects of climate change for the terrestrial environment in the Kawartha region. We are blessed to live in a richly diverse terrestrial environment where climate plays an important but not exclusive role in dictating the land cover. Ontario is divided into three ecozones, based primarily on geological features and then is divided into 14 ecoregions based on climate, physiographic differences, vegetation type and geology. “The climate within an ecoregion has a profound influence on the vegetation types, substrate formation, and other ecosystem processes, and associated biota that live there” (Crins 2009). The Kawartha region

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straddles ecoregions 5E and 6E and is comprised of six ecodistricts[13] and dozens of ecosites – therefore predicting effects to one changing, albeit vital parameter, lends itself to uncertainty (ESTR Secretariat 2016).[14] A report prepared by Federal and Ontario scientists projected the changes to Ontario's ecoregions (McKenney 2010) by assessing the current climate and comparing predicted climate scenarios. Their analysis indicates that by the end of the century the ecoregions 5E and 6E will shift northwards and almost disappear in the Kawartha area and of note the ecoregion conditions will become more fragmented than at present.[15] The Report states that observing the climate conditions shift doesn't necessarily mean that forest ecosystems will shift within the same timeframe. *"First, we do not suggest that tree populations will actually follow the projected shifts in climate. We simply identify where the climatic conditions in which a tree species currently grows are projected to move to; the extent to which tree species will actually shift with climate, through natural and/or assisted migration, is highly uncertain"*.

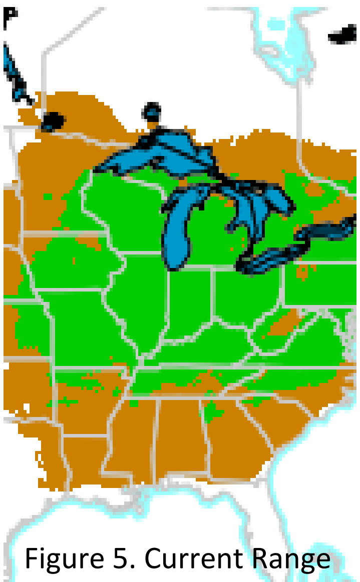
Figure 5. Current Range of Red Oak

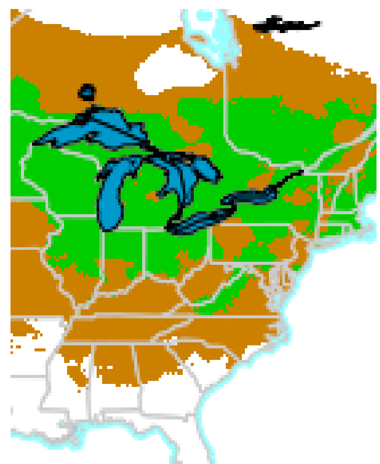
Figure 6. Red Oak Range by end of Century

Without question, a changing climate will affect forests. Trees on one hand are long living and have evolved to live through periods of stress. On the other hand, the rapid change experienced by climate change could cause changes to the types of trees that constitute the Kawartha forest cover and more importantly shift other vegetation species found in the understory that in turn alters land ecosystems. Also many of the dominant tree species in the Kawartha area have large ranges: Eastern white pine can be found anywhere from southern Canada to the Appalachian Mountains".[16] Figures 5 and 6 show the extent of red oak currently and the expected range at the end of this century.[17] As the province warms, southern deciduous species (e.g., tulip, poplar, black walnut, and shagbark hickory) are projected to have more areas with suitable climate in Ontario's protected areas.

[13] There are 16 ecodistricts in ecozone 6E and 11 ecodistricts in ecozone 5E. Ecodistricts are divided into a finer scale categorized as ecosections, ecosites and ecoelements. These categories are used to assess various habitat types. *Ecosites of Ontario*. 2009. Operation Draft. http://www.cnfer.on.ca/SEP/PELC/PDFs/OntarioEcositesKey.pdf.
[14] For a description on anticipated changes to ecoregions see: https://biodivcanada.chm-cbd.net/ecosystem-status-trends-2010/mixedwood-plains-summary#_fig02.
[15] For an interactive map showing the location of Ontario's ecozones and the projected changes in the ecoregions see: https://www.ontario.ca/environment-and-energy/climate-change-ecoregions.
[16] For an explanation of tree species ranges see: https://projects.ncsu.edu/project/dendrology/index/plantae/vascular/seedplants/gymnosperms/conifers/pine/pinus/strobi/easternwhite/habitat.html.
[17] For projections on trees and plants see http://planthardiness.gc.ca/index.pl?lang=en&m=7&speciesid=1000963.

Figure 5 shows the current range of red oak. The green and brown areas represent respectively the core and the extent of its range. Figure 6 show the projected range of red oak by end of the century. Not all tree species found in the Kawartha region will experience range expansion. As time marches on, boreal species such as black spruce, white spruce, balsam fir and trembling aspen are likely to become absent from the area. In fact, black spruce is projected to be found only in the northern reaches of the Province.

The change in black spruce range is more startling as shown in Figures 7 and 8. At present black spruce is found along the north shore of the Great Lakes. Black spruce almost disappears in the Kawartha Region.

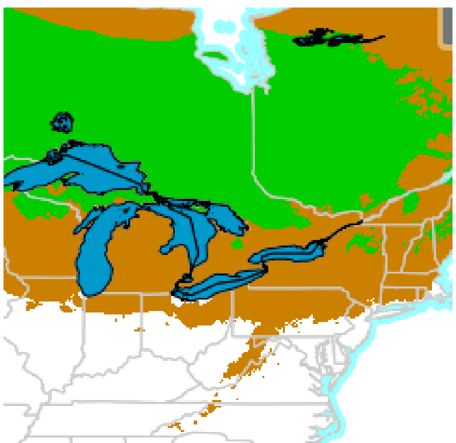

Figure 7. Current Range of Black Spruce

The generally dryer conditions during the growing season could increase the risk of fire. During the early stage of ecosystem succession, pioneer species will change as will the forest floor understory as species from the Carolinian forests find their way into our neighbourhood.

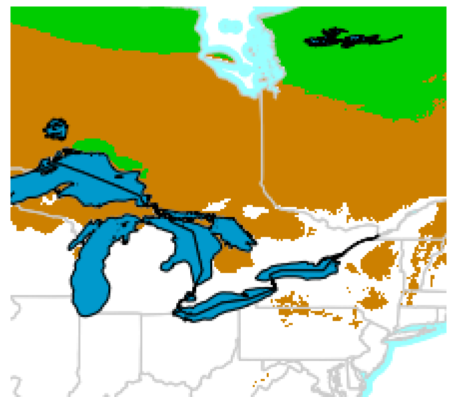

Figure 8. Black Spruce Range by end of Century

Wetlands

The potential effect on wetlands (see Table 2) has been classified with medium evidence and medium agreement. Wetlands constitute 14% of the area managed by the Kawartha Region Conservation Authority.[18] Wetlands are an important constituent of the water resources found within the Kawartha Lakes. "Extensive wetlands were once associated with the rivers and lakes of the region and many of these still exist, both treed swamps and marshes" (Berry 2011). While there haven't been many climate change assessments, higher wetland water temperatures in shorter, warmer winters and longer summers will result in increased evapotranspiration and evaporation leading to decreased water levels in wetlands (McDermid 2015a). Wetlands, such as bogs, that depend on precipitation and surface runoff rather than groundwater are particularly sensitive to drying and peatlands are likely to dry due to increased evapotranspiration. The drying will promote the growth of sedges, grasses and trees that will eventually replace the emergent and submergent species.

[18] See: https://kawarthaconservation.com/wetlands.

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Fisheries

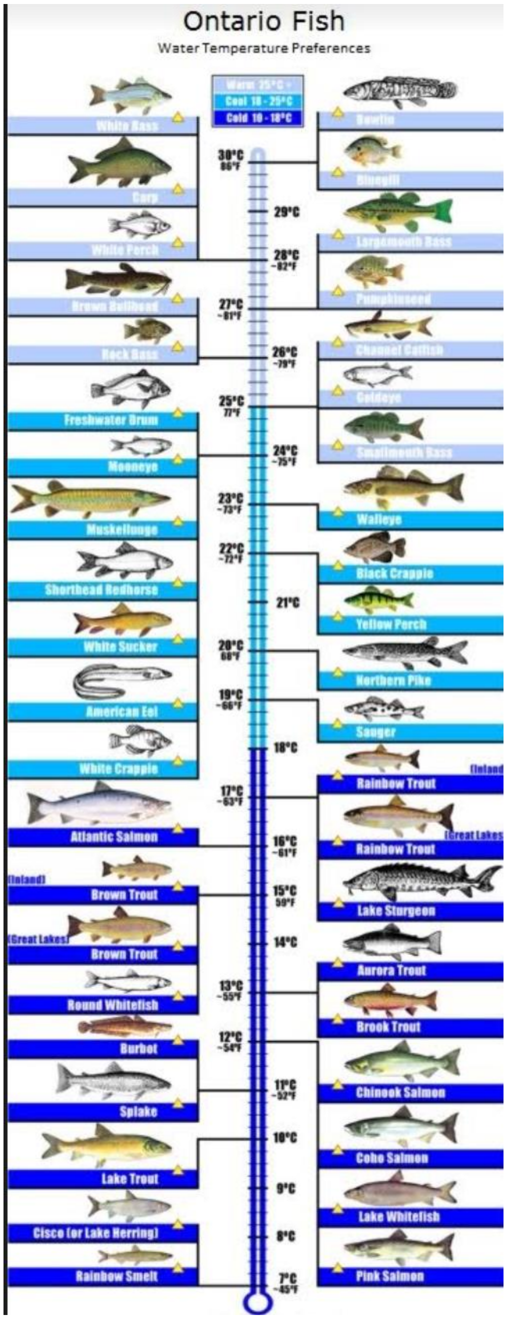

Figure 9. Preferred temperature range for Ontario fish species

There is a link between water temperature and the productivity of some fish species. A change in lake water temperature could affect not only habitat suitability (distribution) but reproduction, survival, growth and food habits. Some fish species thrive in warmer water while others prefer cooler temperatures. Fish body temperatures are regulated by their environment, i.e. the water temperature. Each fish species has a temperature range which is considered to be optimal. The thermal guild is the group of species that share a common preferred temperature range. The three main thermal guilds relevant to us are the cold water guild, the cool water guild and warm water guild. The cold water guild includes lake trout with an optimal temperature range of 10 to 18°C; the cool water guild includes walleye with an optimal temperature range of 18 to 25°C; and the warm water guild includes smallmouth bass with temperatures greater than 25°C. Figure 9 provides the preferred temperature range for common Ontario fish species.[19] Increasing lake temperatures have already resulted in a change in fish populations. Over the past 30 years some fish species have moved northward at a rate of 12 to 17 km per decade in Ontario (Alofs 2014). Efforts to model the fisheries gains and fisheries losses have been undertaken by researchers (Van Zuiden 2016 and Edwards 2016). Scientists project that overall fisheries production in the Great Lakes will expand as the upper and middle layers of the lake strata increase creating more warm water fish habitat while not limiting the habitat for those fish that enjoy cooler or cold water (McDermid 2015).

However, in shallow lakes such as those found in the Kawartha Lakes, cold water habitat will be severely restricted. Cool water fish such as walleye could come under stress in the Kawartha Lakes system. Warm water

[19] For optimal lake temperature for certain species see: http://www.fishing.info/water_temp.html.

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fish, such as bass, are projected to benefit from elevated water temperatures. Researchers project that a water temperature increase of 4.5°C to 5°C would increase fish species richness from 12 to 60 fish species in Ontario's 137 tertiary watersheds (Dove-Thompson 2011).

Ecosystems

The vulnerability of species in the Great Lakes Basin has been assessed by scientists (Brinker 2018) using an established methodology to rank species' vulnerability. Two-hundred and eighty species were assessed over 10 major taxonomic groups: amphibians, birds, bryophytes (mosses and liverworts), fish, insects and spiders, lichens, mammals, molluscs, reptiles, and vascular plants (see Figure 10).[20]

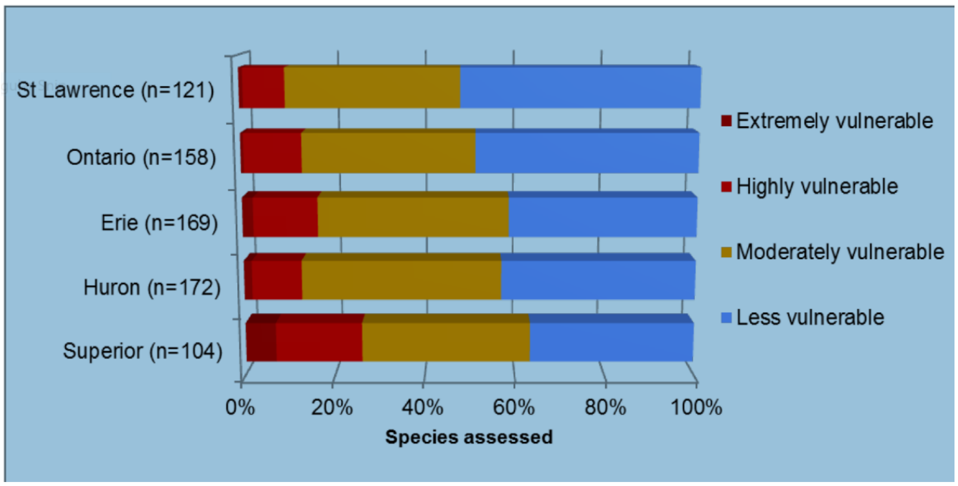

Figure 10. Percentage of species found to be vulnerable to climate change

The Report states that with the advance of climate change, populations have two survival options: (i) they can remain in situ and tolerate/adapt /evolve to the new conditions; or (ii) they can move to track their climatic niches. Thus we can expect shifting distributions of species as some species will expand their ranges north, in some cases vacating their current locations. Other species with constricted habitats and niches may find it difficult to adjust.

Vulnerable species are molluscs, fish, amphibians, and lichens. Species with a restricted ecological niche are more vulnerable. Mammals and birds are less vulnerable because of their ability to disperse. The Lake Superior watershed has the most species in the extreme and highly vulnerable categories. This is in part because the species found in this region are located at the southern boundary of their habitat range and other species have local specialized niches which will be altered with a warmer climate. In the Lake Ontario watershed approximately 78 species are considered to be vulnerable to climate change. Figure 11 shows the 19 most vulnerable

[20] See Table 2 in Brinker 2018.

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species. The redside dace was found to be extremely vulnerable.[21] Eighteen other species were assigned a highly vulnerable score. Taxa found to be highly vulnerable included 2 amphibians, 2 birds, 5 fish, 2 bryophytes, 1 reptile, and 6 vascular plants. Another 59 species (not listed in Figure 11)[22] were considered moderately vulnerable. Within the Kawartha region there are no areas where there are concentrations of extremely or highly vulnerable species.[23]

Taxonomic group	Scientific name	Common name	Score*
Amphibian	*Desmognathus fuscus*	Northern dusky salamander	HV
Amphibian	*Desmognathus ochrophaeus*	Allegheny mountain dusky salamander	HV
Bird	*Charadrius melodus*	Piping plover	HV
Bird	*Parkesia motacilla*	Louisiana waterthrush	HV
Bryophyte	*Bryoandersonia illecebra*	Spoon-leaved moss	HV
Bryophyte	*Tortula porteri*	Porter's screw moss	HV
Fish	*Acipenser fulvescens* pop. 3	Lake sturgeon (Great Lakes -Upper St. Lawrence River pop.)	HV
Fish	*Clinostomus elongatus*	Redside dace	EV
Fish	*Ichthyomyzon fossor*	Northern brook lamprey	HV
Fish	*Lepisosteus oculatus*	Spotted gar	HV
Fish	*Moxostoma duquesnei*	Black redhorse	HV
Fish	*Percina copelandi*	Channel darter	HV
Reptile	*Plestiodon fasciatus* pop. 1	Common five-lined skink (Carolinian pop.)	HV
Vascular plant	*Asplenium scolopendrium* var. *americanum*	American hart's-tongue fern	HV
Vascular plant	*Conioselinum chinense*	Chinese hemlock-parsley	HV
Vascular plant	*Cypripedium candidum*	Small white lady's-slipper	HV
Vascular plant	*Gratiola quartermaniae*	Limestone hedge-hyssop	HV
Vascular plant	*Platanthera leucophaea*	Eastern prairie fringed orchid	HV
Vascular plant	*Woodsia alpina*	Alpine woodsia	HV

Figure 11: Lake Ontario Basin species found to be extremely or highly vulnerable species resulting in an increased incidence of hybridization

In our sister watershed to the west, (Lake Simcoe), another wildlife vulnerability study assessing climate change was undertaken (Walpole 2011). This study observed an increase in bird and mammal species richness and accelerated reproduction in spring-breeding anurans (frogs and toads). There will be a shift in bird and mammal composition as some species expand into the area while others recede out of the watershed.

A National Audubon Society study attributes a 30% loss in bird numbers since 1970 to a number of non-related climate change effects but states that climate change will compound declining bird populations. The Society has projected the amount of habitat loss and habitat gained (usually less habitat) for hundreds of bird species as a result of climate change (see: https://www.3billionbirds.org/).

[21] Redside dace is classified as a threatened species, primarily because of urban sprawl resulting in habitat loss along the GTA and western section of Lake Ontario, see: https://www.ontario.ca/page/guidance-development-activities-redside-dace-protected-habitat.
[22] See Table 3 in Brinker 2018.
[23] That is an area with greater than 4 extremely or highly vulnerable species. See Figure 40 in Brinker 2018.

While the opossum has been around Southern Ontario since 1970, Figure 12 shows its projected range expansion as a result of climate change[24]. Several authors have pointed out that the influx of subspecies will lead to hybridization of various mammals and plants. For example, the rapid northward expansion of some species may lead to new or renewed contact and interbreeding and hybridization of distinct populations of species (Morand undated). Examples of hybridization that is expected to occur is among different species/populations of flying squirrels and chickadees (Varrin 2007, Garroway 2010). While hybridization can result in a decrease in diversity and fitness there can also be positive outcomes in terms of genetic variation (McDermid 2015a).

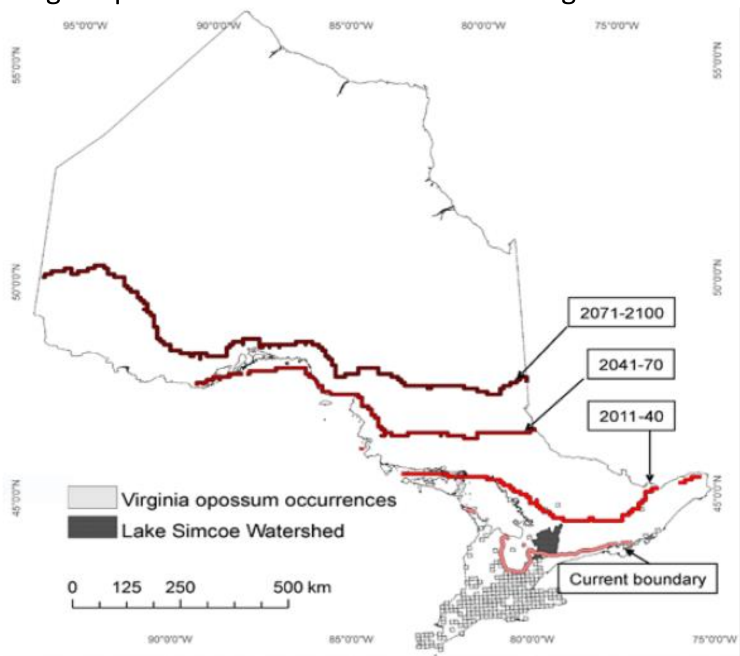

Figure 12: Welcome the Virginia Opossum

Data Interpretation – caveats

Tables 1 and 2 showing the projections for flora and fauna changes are hinged with model uncertainty.[25]

There is relatively high confidence and agreement for model projections of air temperature (Table 1). Projection for elements that require a number of factors to consider and which are dependent on other projections become less certain. This explains in part why biological projections fall within the medium confidence and medium agreement category.

All models have limits to the precision of projections and occasionally the results of models portraying the same ecological component offer conflicting conclusions. For example, some models project groundwater recharge rates will increase by 3% to 4%, others have projected a 19% decrease in recharge: both using recognized climate models. The uncertainty of climate change projections at the regional level is greater than with Canada-wide or world-wide analyses, therefore attributing anthropogenic climate change at a local scale is more difficult to determine (Bush 2019).

[24] See Figure 4 in Walpole 2011.

[25] Note the evaluation of climate change effects referenced in McDermid 2015a was published before the Dinker 2018 article. Therefore, it is unknown if the rankings shown in Table 2 would be altered as a result of this new information and interpretation.

The next revision to the model scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) is expected in 2021. The IPCC will release the Sixth Assessment Report, AR6. Based on their projections, we can expect another round of projections and proposed recommendations.

Summary, projections and what the future may hold.

So, what does all this mean for the Kawartha region?

- While there will still be warm years and cold ones, wet ones and dry ones, the typical year at mid-century is likely to be 2°C to 3°C and by the end of the century 3°C to 7°C warmer and possibly about 10% wetter.
- A dramatic 'weather change' will be the intensity of storms that we will need to adjust to.
- Lake ice conditions will become variable as slushing conditions prevail; ice will be off the lakes sooner and arrive later on our lakes.
- Fishing for lake trout and walleye will become more difficult but bass, catfish, pumpkin seed and maybe even pike may become more plentiful.[26]
- We will be on the telephone to the Trent-Severn Waterway asking them to raise or lower lake elevations as water levels fluctuate with more intense rain events and dry periods.
- There will still be forests but there will be a variety of different species found in all regions.
- The boreal trees that are located in the northern border of the Kawartha region are at their current southern range and will become stressed under warmer climate conditions.
- The generally dryer conditions during the growing season could increase the risk of fire, and some of our forests may well be reshaped by new fire regimes.[27]
- During the early stage of ecosystem succession, pioneer species will change as will the forest floor understory as species from the Carolinian forests find their way into our neighbourhood.
- Similarly, some new bird species will become present and some of our current friends will find the Temiskaming Lakes area more to their liking.
- The warmer climate and increased atmospheric carbon dioxide levels should facilitate plant growth and farmland should become more productive given ample water.

Some economists see an economic advantage, on a macro scale, for an area that will have an annual increase in average air temperatures (Burke 2015). With the extended season, it is anticipated certain Kawartha businesses will benefit. It is expected there will be an increase in tourism because of an earlier spring and warmer summer and autumn conditions. For Ontario's provincial parks, visitation is projected to increase by the 2020s (11–27%) due to a warmer climate, and this increase could even be greater (23-41%) when combined with demographic

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[26] For a description of the potential effects of climate change on fish species, see Dove Thompson 2011, section 6 "*The Effects of Climate Change on Selected Fish Species*".

[27] Droughts are predicted to increase in frequency and extent, while rain events will become more sporadic and extreme see McDermid 2015a.

changes (Parks Canada 2017). In response to projected climate change, the weather-visitation models suggest that for each additional degree of warming experienced, despite the negative effects of increasing precipitation and more frequent heat extremes, annual park visitation could increase by 3.1%, annually. The projected increase in park visitation as a result of rising temperatures was mainly associated with shoulder season visitation, with only minor increases in peak season visitation (Hewer 2016).

What can be done?

Individual action, or as some believe, Canada's action is insufficient to prevent the ongoing effects of a changing climate. Canada contributes about 1.6% of the world's greenhouse gas (GHG) emissions.[28] Canada's emissions reduction commitment under the Paris Agreement is that GHG should be 30% below 2005 levels by 2030. Currently sitting at a 2% reduction since 2005, we have a long way to go (Environment and Climate Change Canada 2019). The strategy in the Paris agreement consists of countries reducing their own emissions and for developed countries to offset high emission by transferring funds to developing countries. This transfer of wealth has made some countries and pundits critical of the Paris Agreement (Roman 2019).[29] Notwithstanding the ineffectiveness of international agreements, the climate change issue is imminent, real and occurring. Therefore, simply doing nothing is not an option for the planet. Addressing climate change is not only a necessity but a responsibility of every government and citizen.[30] It is necessary to both adapt to the changes that are taking place and to take action to reduce the cause of these changes, our CO_2 emissions.

"You can't manage what you can't measure"

KLSA, as a citizen science organization, believes that by quantifying issues, by measuring and monitoring, we can provide the necessary information to take prudent and effective actions. The breadth and complexity of a changing environment can be overwhelming. KLSA proposes a two-pronged approach that is tangible, realistic and within the capability of each of us to deliver. We have distilled the two actions to make a positive change and support the credo of "thinking globally and acting locally".

Action #1 - Individual metrics

While it is incumbent on governments to show leadership in GHG emission reduction, it is also incumbent on individuals to take actions by assessing if, where, when and how to reduce our

[28] These data are for 2017, the most recent annual publicly available dataset and referenced Environment and Climate Change Canada 2019.
[29] In 2015, Canada committed $2.65 billion in climate finance over five years to support climate change action in developing countries.
[30] Climate change adaptation is the means of mitigating the potential adverse effects of climate change. See: https://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/municipalities/10081

own GHG emissions. Canada's per capita emissions have dropped 14% since 2005. In 2005 Canada's total emissions from all sources were about 22.7 tonnes CO_2 eq/capita; by 2017 they were 19.5 tonnes CO_2 eq/capita. [31] However, a per capita value doesn't equate to a household or an individual's GHG production rate. Permanent and seasonal Kawartha residents are constrained by some measure in the means to reduce GHG emission. Outside the urban areas in the Kawartha region, options to substitute energy use or take advantage of alternative transportation are limited. By virtue of lifestyle, necessity and opportunities to enjoy the recreational experience offered in the Kawarthas, we are in many ways tied to the use of fossil fuels. Some of you may recall the Federal government's initiative to have each Canadian reduce their emissions by one tonne. Comedian Rick Mercer led the charge with a series of commercials. At that time, 2004, the average Canadian produced about 5 tonnes of GHG emissions per year – about ¼ of Canada's total emissions.[32] While the ad campaign that was initiated was ineffective,[33] the idea of each of us taking responsibility for our own emissions resonates with most Canadians.

The *Deep Decarbonization Pathways Project* determined that in order to hold the global temperature rise to 2˚C or less, everyone on Earth will need to average an annual carbon footprint of 1.7 tonnes by 2050.[34] There are a number of publicly available tools that can be used to calculate one's carbon footprint. Once an individual's or household GHG use is known, measures can be employed to manage our carbon footprint.[35] There is no shortage of those who suggest ways to reduce individual carbon footprints – some are reasonable.[36]

Action #2 Environmental monitoring, measurement and program assessment

Virtually every publication cited in this article calls for monitoring key environmental variables. Monitoring can serve the purpose of validating model results and assessing trends to determine what actions are required. Shoreline communities and lake managers need the most up-to-date and locally relevant information in order to be in the best position to anticipate and adapt to changes. Furthermore, shoreline residents are more likely to take action on their own properties if they are engaged in collecting data, and if they are well-informed with local and current climate-related information and adaptation/resilience options.

KLSA and its partners propose undertaking a multi-year project to collect information on lake temperatures and dissolved oxygen measurements. This program will need to be long term to assess climate changes.

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[31] Assuming on average each tree absorbs 0.063 tonne of CO_2/a, each Canadian would need to plant 309 trees.
[32] https://danielquinn.org/blog/take-the-one-tonne-challenge/
[33] https://www.theglobeandmail.com/news/national/the-challenge-no-one-understands/article18240876/
[34] https://blogs.ei.columbia.edu/2018/12/27/35-ways-reduce-carbon-footprint/
[35] Two of the tools are: http://www.carbonzero.ca/calculate and https://treecanada.ca/reforestation-carbon-offsetting/carbon-offsetting/carbon-calculator/
[36] For some suggestions, see http://www.globalstewards.org/reduce-carbon-footprint.htm

Upon consultation with our scientific advisors, it was suggested that one of the most direct effects of climate change will be on lake temperatures. As noted above, dissolved oxygen is important for aquatic species and is essential to prevent internal loading of nutrients from the sediments into the lake. Low levels of dissolved oxygen have been observed in some of the Kawartha Lakes (Hill 2018). The Environmental Council for Clear, Ston(e)y and White Lakes recognized the importance of dissolved oxygen measurements and has initiated an annual summer sampling program (Baxter 2020).[37,38]

The results of the study will be used to determine if mitigating strategies for variables such as phosphorus loadings need to be implemented or enhanced, as well as being used to determine the effectiveness of programs developed to "remove/mitigate watershed and in-stream features that contribute to stream warming, and install/maintain features that contribute to stream *cooling*" (Kawartha Conservation 2016). Lastly, the results will provide residents, business communities, and municipal governments information on the state of the lakes' physical properties and anticipated ecological changes.

Conclusion

Natural ecosystems have evolved over a number of successional events and change is inherent to all aspects of the Earth's biosphere.[39] The "world we are entering is not an impossible one in which to live" (Sale 2016) and with the onslaught of anthropogenic climate change we too, need to plan, prepare, reduce and adapt. As stated in the Muskoka Climate Change Report[40] which can equally apply to the Kawartha region:

"Climatic changes likely to come to Muskoka by mid-century are manageable if we plan ahead and take adaptive action. Our experience will be better, and the expense we will incur in adapting to the new climate will be less, if we begin that planning and those actions now".

Let's make it so.

[37] http://www.environmentcouncil.ca/dissolved-oxygen-key-indicator-of-aquatic-health/.
[38] For an overview on some factors that affect dissolved oxygen levels in one of the Kawartha Lakes see: https://www.youtube.com/watch?v=eM08-j0v45Q and https://www.youtube.com/watch?v=vbXSllV6fWg.
[39]Currently, the world's forests store more carbon than is in the entire atmosphere. Yet, deforestation contributes 11 percent of global greenhouse gas emissions — more than all passenger cars combined.
[40] See Sale 2016.

References

Alofs, K.M., D.A. Jackson and N.P. Lester. *Ontario freshwater fishes demonstrate differing range-boundary shifts in a warming climate*. Divers. 2014.

Baxter S., V. Castro. 2020. *Temperature and Dissolved Oxygen in Clear and Stony Lakes*. Climate Change and Citizen Science in the Kawarthas**.** KLSA 2019 Lake Water Quality Report. https://klsa.wordpress.com/.

Berry G. et al. 2011, Peterborough Field Naturalists. *Nature in the Kawarthas*. Chapter 2, Regional Ecosystems.

Brinker, S.R., M. Garvey and C.D. Jones. 2018. *Climate change vulnerability assessment of species in the Ontario Great Lakes Basin*. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, ON. Climate Change Research Report CCRR-48. 85 p. + append.

Burke M. *et. al*. 2015. *Global non-linear effect of temperature on economic production*. Nature**.**

Bush, E. and Lemmen, D.S., editors. 2019.: *Canada's Changing Climate Report*. Government of Canada. 444 p. see Box 8.1.

Buttle J. 2019*. Lake ice dynamics and the Kawarthas: Climate change at your dock*. Kawartha Lake Steward Association Spring meeting.

Crins, W. J., Paul A. Gray, Peter W.C. Uhlig, and Monique C. Wester. 2009. *The Ecosystems of Ontario, Part I: Ecozones and Ecoregions*. Ontario Ministry of Natural Resources, Peterborough Ontario, Inventory, Monitoring and Assessment, SIB TER IMA TR- 01, 71pp.

Dolbey M. 2015. *Analysis of Ontario Lake Partner Program: Total Phosphorus Data for the Kawartha Lakes*. The Nature of our Lakes. KLSA 2014 Lake Water Quality Report. https://klsa.wordpress.com/.

Dolbey M. 2016. *Investigation of apparent increase in Total Phosphorus between Cameron Lake and Sturgeon Lake*. Protecting the Natural Beauty Around Us. KLSA 2015 Annual Lake Water Quality Report. https://klsa.wordpress.com/.

Dove-Thompson, D., C. Lewis, P.A. Gray, C. Chu and W.I. Dunlop. 2011. *A summary of the effects of climate change on Ontario's aquatic ecosystems*. Ont. Min. Nat. Resources., Appl. Res. Develop. Br., Sault Ste. Marie, ON. Clim. Change Res. Rep. CCRR-11. 68p.

Edwards B. A. et al. 2016. *Using Climate and a Minimum Set of Local Characteristics to Predict the Future Distributions of Freshwater Fish in Ontario, Canada, at the Lake-Scale*. Global Ecology and Conservation. https://reader.elsevier.com/reader/sd/pii/S2351989416300026?token=4CE567215008CDFB38FED569C81DDA3BA90B51456DD8ADFBDB54B92810C1EF0FC630CD5964539A2925BC0E896618214B.

Environment and Climate Change Canada. 2019. National Inventory Report 1990–2017: *Greenhouse Gas Sources and Sinks in Canada: Executive Summary*. Issued by the Pollutant Inventories and Reporting Division.

ESTR Secretariat. 2016. *Mixed wood Plains Ecozone evidence for key finding summary. Canadian biodiversity: ecosystem status and trends 2010, Evidence for Key Findings.* Summary Report No. 7. Canadian Councils of Resource Ministers. Ottawa, ON. x + 145 p.

Fausto E. Undated. *State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects*. Ontario Climate Change Consortium.

Garroway C.J. et al. 2010. *Climate change induced hybridization in flying squirrels*. Global Change Biology 16: 113–121.

Gibbons K.J. 2016. *Effect of Temperature on Phosphorus Release from Anoxic Western Lake Erie Sediments*. MSc Thesis. University of Toledo.

Hewer M., Daniel Scott & Adam Fenech. 2016. *Seasonal weather sensitivity, temperature thresholds, and climate change impacts for park visitation*, Tourism Geographies, 18:3, 297-321, DOI: 10.1080/14616688.2016.1172662.

Hill C., C. Houston, M. Van Meer, C. Vieau. 2018. *Report on the Status of Dissolved Oxygen Levels in Pigeon, Lovesick and Stony Lakes*. Fleming College. https://klsa.wordpress.com/.

Kawartha Conservation. 2016. *Climate Change Strategy*. 277 Kenrei Road, Lindsay ON. KawarthaConservation.com.

Laird K.R., B. Cumming. 2018. *Assessment of Algal And Elemental Changes in Three Kawartha Lakes: A Paleolimnological Assessmen*t. Queen's University, Kingston. Paleoecological Environmental Assessment and Research Laboratory (PEARL). https://klsa.wordpress.com/.

McDermid, J., S. Fera, and A. Hogg. Undated. *Climate Change Projections for the Lake Ontario watershed: An updated synthesis for policymakers and planners*. Ontario Ministry of Natural Resources and Forestry.

McDermid, J.L., S.K Dickin, C.L. Winsborough, H. Switzman, S. Barr, J.A. Gleeson, G. Krantzberg, P.A. Gray. 2015a. *State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrological and Ecological Effects*. Prepared jointly by the Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry to advise Annex 9 - Climate Change Impacts under the Great Lakes Water Quality Agreement, October 2015.

McDermid, J.L., S. Fera and A. Hogg. 2015b. Climate change projections for Ontario: An updated synthesis for policymakers and planners. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, Ontario. Climate Change Research Report CCRR-44.

McGrath. M. 2020. *Climate change: Worst emissions scenario 'misleading'*, British Broadcasting Correspondent.

McKenney, D.W. 2010. *Current and Projected Future Climatic Conditions for Ecoregions and Selected Natural Heritage Areas in Ontario*. Climate Change Research Report CCRR-16.

Minns C.K. B.J. Shuter and S.R. Fung. 2014. Regional Projections of Climate Change Effects on Ice Cover and Open-Water Duration for Ontario Lakes Using Updated Ice-Date Models. Climate Change Research Report CCRR-40.

MIRARCO. Undated. *Climate Impacts and Adaptation Resources*. Poster. Laurentian University, Sudbury, Ontario, Canada

Morand A., A. Douglas. Undated. *Biodiversity In a Changing Climate: Impacts and adaptation in Ontario*. Ontario Centre for Climate Impacts and Adaptation Resources, Mirarco.

Napier W.A. 2019a. *The Impact of Climate Change on the Kawarthas*. Our Kawartha Lakes: Past, Present, Future. KLSA 2018 Annual Lake Water Quality Report. https://klsa.wordpress.com/

Napier W.A. 2019b. *Part 2 Historical Lake Productivity Levels*. Our Kawartha Lakes: Past, Present, Future. KLSA 2018 Annual Lake Water Quality Report. https://klsa.wordpress.com/

Parks Canada. 2017. Office of the chief ecosystem scientist. *Let's Talk about Climate Change: Great Lakes Region.*

Rex E. 2013. *Harmful Algal Blooms Increase as Lake Water Warms - Increasing temperatures as a result of climate change have aided blooms of algae*. Scientific American. https://www.scientificamerican.com/article/harmful-algal-blooms-increase-as-lake-water-warms/.

Robinne R.N., et al. 2018. *A spatial evaluation of global wildfire-water risks to human and natural system*. Science of the Total Environment.

Roman A. November 19, 2019. *We need to stop pretending the Paris Agreement will fix the 'climate crisis'* Opinion: *Are we really willing to suffer painfully high taxes to fund new energy infrastructure while China and others massively increase their emissions?* Financial Post.

Sale P., Richard Lammers, Norman Yan, Neil Hutchinson, Kevin Trimble, Paul Dinner, Piret Hurrell, Jan McDonnell, and Scott Young, 2016. *Planning for Climate Change in Muskoka. A Report from the Muskoka Watershed Council.* Muskoka Watershed Council, Muskoka, Canada, 52 pages.

Spence T. 2016. *Climate Change, the Trent-Severn Waterway and the Reservoir Lakes*. Coalition for Equitable Water Flow. Presentation to Environment Haliburton Enviro-Café.

Spence T. 2019a. *A CEWF Perspective on the Context for 2019 Water Management in the TSW Reservoirs Lots of snow and extreme spring rain followed by drought in 2019!* Coalition for Equitable Water Flow.

Spence T. 2019b. *Overview of the Coalition for Equitable Water Flow and the TSW* and *Review of Water Management Across the TSW Reservoirs with Focus on Soyers Lake Area*. Soyers Lake Meeting –July 6, 2019. Coalition for Equitable Water Flow.

Van Zuiden T. M. et al. 2016. *Projected impacts of climate change on three freshwater fishes and potential novel competitive interactions.* Biodiversity and Distributions. https://onlinelibrary.wiley.com/doi/full/10.1111/ddi.12422.

Varrin, R., J. Bowman and P.A. Gray. 2007. *The known and potential effects of climate change on biodiversity in Ontario's terrestrial ecosystems: Case studies and recommendations for adaptation*. Ont. Min. Nat. Resour., Appl. Res. Develop. Br., Sault Ste. Marie, ON. Clim. Change Res. Rep. CCRR-09. 47p.

Walpole A. A., Bowman J. 2011. *Wildlife Vulnerability to Climate Change: An assessment for the Lake Simcoe Watershed*. Wildlife Research and Development Section, Ontario Ministry of Natural Resources.

White M. 2006. *Phosphorus and the Kawartha Lakes (Land use, Lake Morphology and Phosphorus Loading)*. Kawartha Lake Stewards Association. https://klsa.wordpress.com/

Woolway R., C.J. Merchant. 2019. *Worldwide alteration of lake mixing regimes in response to climate* change. Nature Geoscience. VOL 12.