



ONTARIO CLIMATE CHANGE AND HEALTH MODELLING STUDY

Report



Authors: William Gough, Vidya Anderson, Kris Herod

Acknowledgements: This publication was completed with financial support from the Ministry of the Environment and Climate Change. The authors would also like to thank Dr. Jinliang (John) Liu for his contributions to the report.

Ministry of Health and Long-Term Care
Public Health Policy and Programs Branch
393 University Avenue, 21st Floor
Toronto, ON M7A 2S1

Copies of this report can be obtained from
INFOnline: 1-866-532-3161
TTY 1-800-387-5559

ISBN 978-1-4606-7703-2 (PDF)

© Queen's Printer for Ontario, 2016. Printed in Ontario, Canada, 2016

TABLE OF CONTENTS

INTRODUCTION2

Background3

Health Implications of Climate Change.....3

Methods4

RESULTS5

Heat5

UV Exposure8

Air Pollution – Ozone 12

Vectorborne Disease – West Nile Virus (WNV) 17

Impacts Associated with Extreme Precipitation 19

MOVING FORWARD.....21

Evidence-informed Change21

Building Adaptive Capacity21

Reducing Public Health Vulnerability21

REFERENCES.....22

NOTES24





Photo Credit: Shutterstock

INTRODUCTION

The Environmental Health Climate Change Framework for Action has been developed by the Population and Public Health Division of the Ministry of Health and Long-Term Care to meet the public health challenges of a changing climate in Ontario. This framework is designed to support an adaptive and resilient public health system that anticipates, addresses and mitigates the emerging risks and impacts of climate change. This framework will improve the overall effectiveness and efficiency of the public health system and its ability to:

- › Reduce incidence of adverse health outcomes from the impacts of climate change
- › Reduce public exposure to health hazards related to a changing climate
- › Identify interventions that reduce exposure to climate change impacts
- › Enhance capacity to address the risk factors associated with climate change

As part of the Environmental Health Climate Change Framework for Action, a toolkit has been developed to assist public health units across Ontario. This toolkit includes the:

- › *Ontario Climate Change and Health Vulnerability and Adaptation Assessment Guidelines: Technical Document;*
- › *Ontario Climate Change and Health Vulnerability and Adaptation Assessment Guidelines: Workbook;* and
- › *Ontario Climate Change and Health Modelling Study: Report.*

These documents are designed to be used in concert to enable public health units to identify vulnerabilities within their communities; identify and implement local mitigation and adaptation strategies; raise awareness about the health hazards of climate change; and reduce public health vulnerability to climate change.

The *Ontario Climate Change and Health Modelling Study: Report* was developed in partnership with the Ministry of the Environment & Climate Change and the University of Toronto Climate Lab to:

- › Assess the potential impacts of climate change on human health and forecast key health risks across Ontario;
- › Generate projection scenarios for the 2050s and 2080s for each of the 36 public health unit areas; and
- › Provide graphical representation to illustrate the spatial distribution of potential health risks.

This *Report* summarizes the results of the modelling study and is intended to provide a foundation for public health units to undertake and complete a Climate Change and Health Vulnerability and Adaptation Assessment in each of their communities.



Background

Rainstorms and floods have always been a fact of life in Ontario. So have droughts and heat waves, winter storms, tornadoes and windstorms. These events used to happen infrequently. Now, these events have become more common – a clear sign of a shift in our weather patterns. This shift is called ‘climate change.’ It threatens our health and safety, our environment and our economy.

The Intergovernmental Panel on Climate Change’s Fifth Assessment report has confirmed the high likelihood that anthropogenic release of greenhouse gases has led to a warmer climate and the legacy greenhouse gases and new emissions commit the world to a warming climate for decades to come.

Between 1948 and 2008, the average annual temperature in Ontario has increased by approximately 1.5 degrees Celsius. In Ontario, we can expect average temperatures to rise by as much as 3 to 8 degrees Celsius over the next century. Warmer temperatures will result in milder winters, longer growing seasons and a higher frequency of severe weather events such as record-breaking storms, floods, droughts and heat waves. The expected changes in our climate will have a significant impact on all sectors of our province.

Health Implications of Climate Change

Across Ontario we have seen an increase in prolonged heat waves, torrential rain storms, windstorms, even drought. Extreme weather events are becoming more frequent and more intense. However, climate change is not merely an environmental phenomenon. Humans are directly exposed to climate change and its related health hazards through changes in weather patterns. Humans are also at risk of adverse health outcomes from the impacts of climate change including:

- Increased incidence of heat-related illness and respiratory and cardiovascular disorders due to rising temperatures and reduced air quality;
- Risk of diseases (e.g., Lyme disease, West Nile virus) transmitted by mosquitoes, ticks and other vectors will increase due to rising summer temperatures, shorter winters, ecological changes, increased human exposure, and faster maturation cycles for pathogens;
- Aggravation of allergy symptoms and respiratory conditions due to increased pollen and spore production as summer temperatures increase and the winters become shorter; and
- Increased risk of food and waterborne illnesses and the possibility of injury, illness or loss of life due to damage and weakening of infrastructure from extreme weather events such as flooding, ice and windstorms.

The impacts of climate change on human health occur through multiple interdependent mechanisms. Some health outcomes may be considered direct results of climate change, however, most will occur through indirect exposures. Health outcomes caused by direct exposures include injuries, illnesses and deaths sustained as a direct result of the weather, for example broken bones from falls on ice; illness due to extreme heat; and drowning during a flood. These outcomes may be expected to occur more frequently with an increase in climate variability including extreme weather events.

Indirect human exposures can occur through complex processes. Alterations to environmental conditions such as ecology, air, water and food quality can increase human exposure to pathogens and contaminants thereby increasing risk of illness. For example, warmer temperatures are favourable to the growth of micro-organisms and are associated with outbreaks of foodborne diseases. Similarly, the reproduction and survival of disease-carrying insects, ticks and rodents can be influenced by temperature.



Photo Credit: Shutterstock



Weather, climate variability, and other environmental factors are key determinants of health. Climate change can affect the economic and social factors that play an important role in human health. For example, impacts on transportation, including damage from extreme weather events and loss of access, have significant implications for access to food, goods, services and employment. Disruptions to economic activity have consequences for individuals and communities, and can result in changes in nutrition, housing conditions, sanitation, and social networks. In addition, health inequities will increase among Ontario residents who are older, chronically ill and socially disadvantaged and are more vulnerable to the health effects of climate change such as extreme heat.

Methods

Climate change manifests regionally and locally in a heterogeneous fashion. This modelling study examined the impacts of projected climate change on public health across the 36 public health units in Ontario.

Climate change has been clearly identified as a pressing environmental issue with widespread social implications. One such implication is human health. These potential health implications are summarized by the Intergovernmental Panel on Climate Change in the Working Group II report (IPCC, 2014). The IPCC summary referenced literature that has provided a foundation to assess the potential health impacts for the 36 public health units in Ontario. From this summary the following health exposure units were identified as potentially relevant for Ontario including: heat, ultra-violet (UV) exposure, air pollution, vector borne disease, and extreme precipitation events and associated impacts.

A climate change impact assessment framework was used to examine each of the identified exposure units. In this framework, two major steps were followed. Initially, a careful review of relevant scientific literature was undertaken to provide a clear link between the exposure units and relevant climate variables. Included in this first step, was an assessment of the baseline behaviour of the identified climate variables using historical climate data. The second step was to project the relevant climate variables for the rest of the century and relate these projections to the exposure units. Although a number of techniques are available to project climate, projections were generated from Global Climate Models (GCMs). An ensemble approach was used to produce projections, rather than an individual model – this provided an ensemble average of available models (30+). These projections are based on a range of scenarios that include a number of demographic, economic and technological assumptions producing a range of emission scenarios that directly determine projected greenhouse gas concentrations.

The analysis of these climate projections has been tailored to the 36 public health units in Ontario by providing projections based on the geographical location of each individual public health unit. The baseline climate assessment uses climate stations within the public health unit or stations closest to the area if no climate stations were located within the public health unit area itself.



RESULTS

Heat

Heat wave frequencies for the baseline (1971–2000) and the two future periods (2050s, 2080s) are presented in Figures 1, 2 and 3. Table 1 presents the same information on a per public health unit basis. A heat wave is defined in this study using criteria established by the Ontario Ministry of Labour, of at least three consecutive days exceeding 32°C. Throughout Ontario during the baseline period, heat waves occur less than once per year (the peak is 0.66 per year in the Windsor-Essex County Public Health Unit, Table 1). During the 2050s, 25 PHUs could exceed 1 per year and of these, 3 PHUs could exceed 2 per year. By the 2080s, all but two PHUs could exceed 1 per year and 28 exceed two per year. The peak value is 5.74 for the Windsor-Essex Public Health Unit, an almost 9 fold increase over the baseline period.

Figure 1 – Number of heat waves for the baseline period (1971–2000)

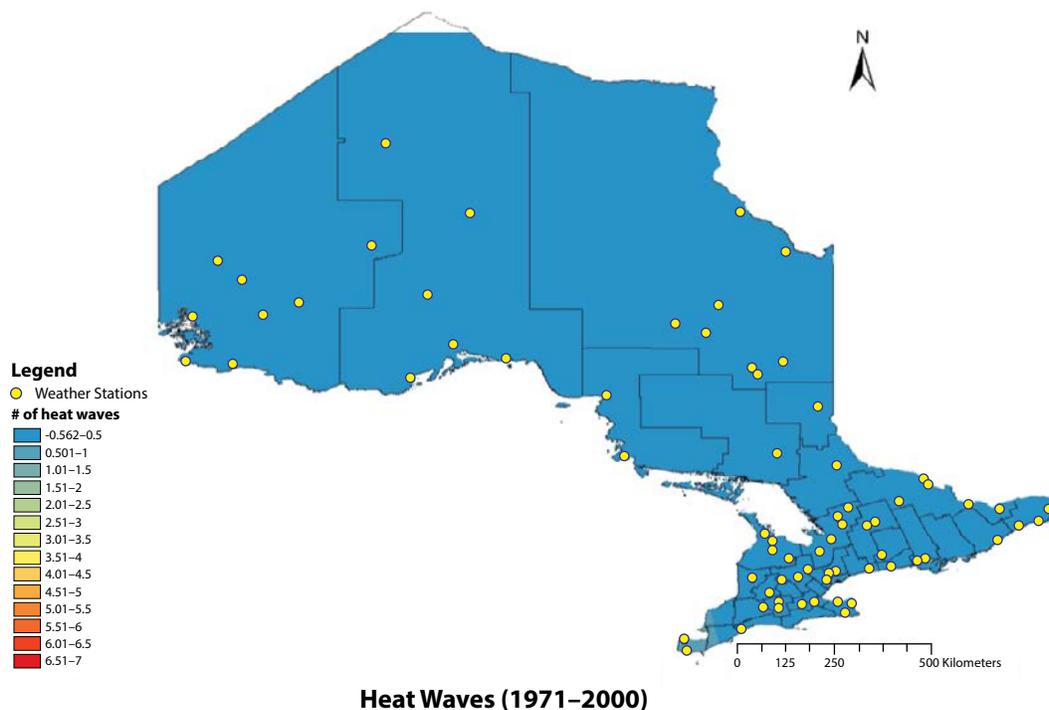


Figure 2 – Number of heat waves for the 2050s

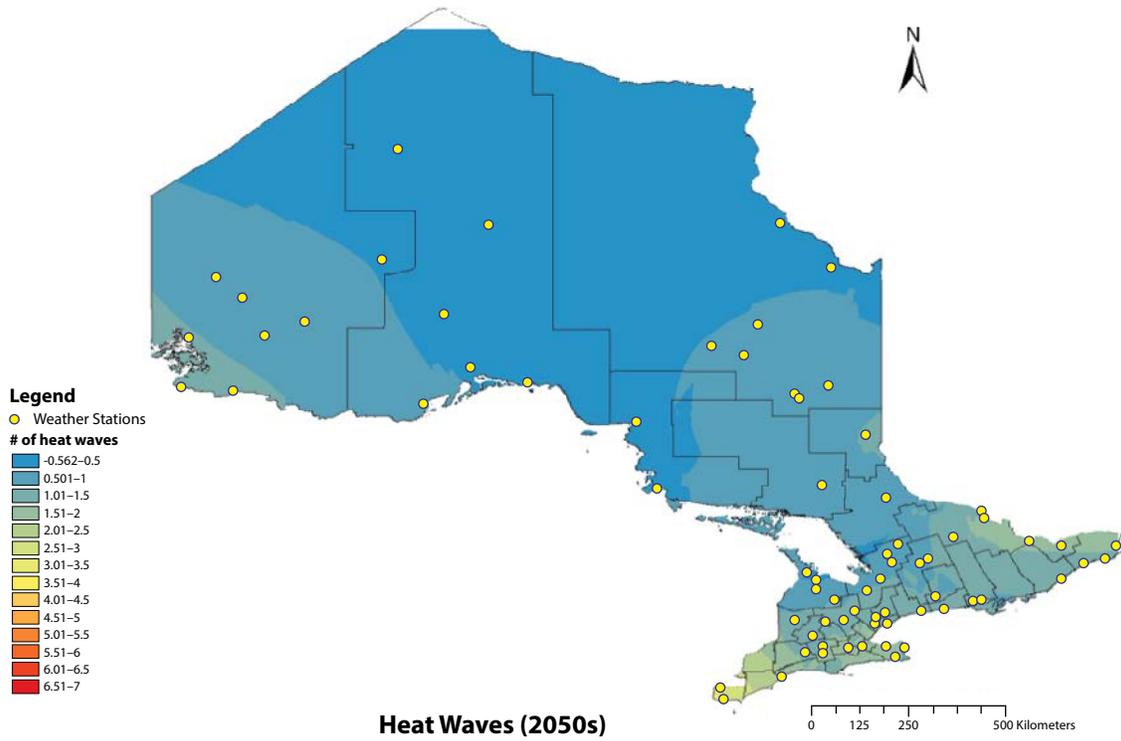


Figure 3 – Number of heat waves for the 2080s

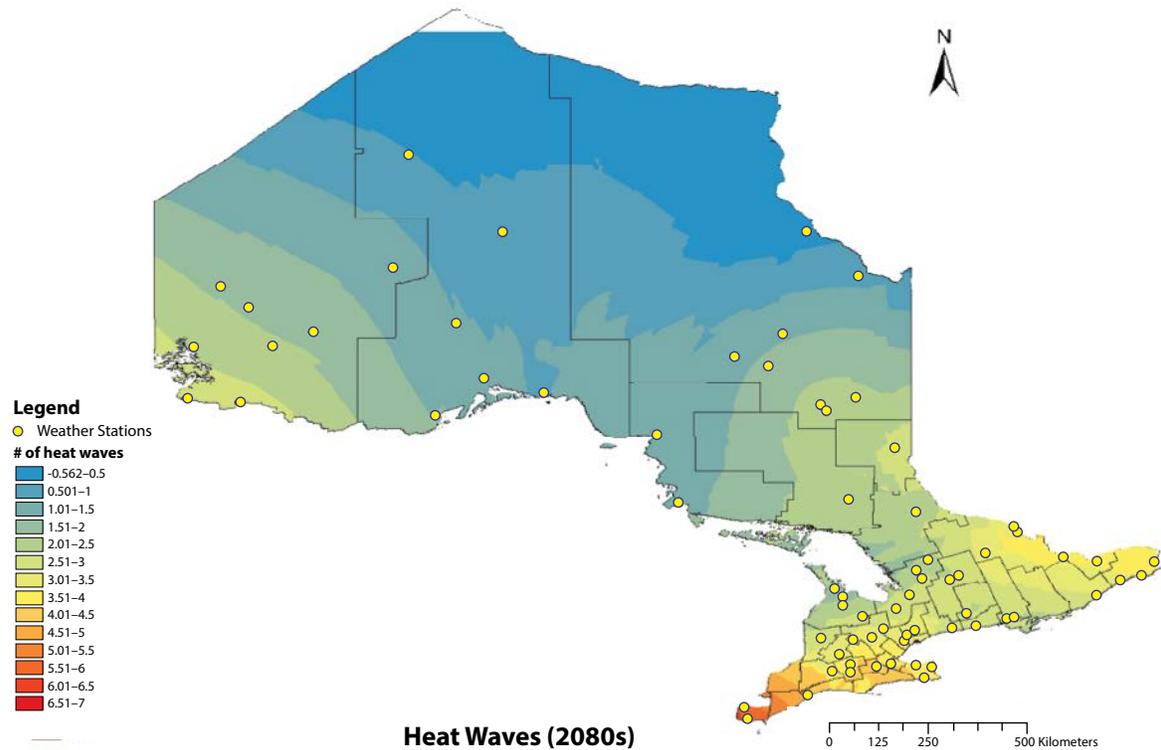


Table 1 – Number of heat waves per public health unit. A heat wave is defined in this study as at least three consecutive days exceeding 32°C. Frequency of heat waves exceeding one per year are highlighted in orange, those exceeding 2 per year are bolded in orange.

PUBLIC HEALTH UNITS	HEAT WAVES (1971–2000)	HEAT WAVES (2050s)	HEAT WAVES (2080s)
Algoma	0.05	0.50	1.40
Brant County	0.24	1.60	4.11
Chatham-Kent	0.48	2.32	4.99
Durham Region	0.22	1.22	2.93
Eastern Ontario	0.29	1.54	3.68
Elgin-St. Thomas	0.27	1.67	4.18
Grey Bruce	0.10	0.72	2.21
Haldimand-Norfolk	0.23	1.57	4.09
Haliburton, Kawartha, Pine Ridge District	0.18	1.02	2.72
Halton Region	0.26	1.55	3.68
Hamilton Public Health Services	0.25	1.58	3.91
Hastings & Prince Edward Counties	0.16	1.17	2.84
Huron County	0.12	1.14	2.87
Kingston, Frontenac and Lennox & Addington	0.17	1.19	2.89
Lambton Community Health Services	0.45	2.12	4.52
Leeds, Grenville & Lanark District	0.21	1.31	3.16
Middlesex-London	0.27	1.64	3.92
Niagara Region	0.25	1.57	3.78
North Bay – Parry Sound District	0.13	0.75	2.26
Northwestern	0.12	0.62	1.59
Ottawa	0.29	1.56	3.59
Oxford County	0.21	1.50	3.91
Peel Region	0.29	1.42	3.38
Perth District	0.15	1.23	3.25
Peterborough County	0.15	1.03	2.67
Porcupine	0.03	0.27	0.70
Renfrew County and District	0.24	1.29	3.20
Simcoe Muskoka District	0.19	0.85	2.50

continued on next page



PUBLIC HEALTH UNITS	HEAT WAVES (1971–2000)	HEAT WAVES (2050s)	HEAT WAVES (2080s)
Sudbury & District Health Unit	0.11	0.71	1.97
Thunder Bay District Health Unit	0.02	0.22	0.72
Timiskaming	0.17	0.93	2.46
Toronto Public Health	0.29	1.45	3.34
Waterloo Region Health	0.22	1.44	3.70
Wellington-Dufferin-Guelph Health	0.21	1.21	3.15
Windsor – Essex County	0.66	2.87	5.74
York Region	0.28	1.31	3.12

UV Exposure

Exposure to solar ultraviolet radiation has implications for public health. Many studies have demonstrated evidence of harm associated with overexposure to UV. Skin cancer and malignant melanoma are among the most severe health effects (WHO, 2006). There are three main types of skin cancer: basal cell carcinoma, squamous cell carcinoma, and melanoma. Squamous cell carcinoma occurs when there is uncontrolled growth in the squamous cells, in the upper layer of the skin. Basal cell carcinoma is uncontrolled growth in the basal cells, in the deepest layer of the skin. Since chlorofluorocarbons (CFCs) have been released into the atmosphere, the ozone levels in the stratosphere have dropped significantly resulting in higher levels of UV radiation. As such, the levels of basal and squamous cell carcinoma are projected to rise in the future. Ultraviolet-B-radiation (UV-B, 280-316 nm) is well known to cause non-melanoma skin cancer.

So far, the link between UV-B radiation and melanoma is less clear (Diffey, 2004). One study (van der Leun et al., 2008), showed that basal cell and squamous cell carcinoma increased by 2.9% and 5.5% respectively per °C increase in summer temperature. These results are derived from epidemiological studies and the relationship with temperature may have proxy elements. With this caveat, the study uses this relationship between cancer rate and temperature as the basis of the assessment of future risk. It is recognized that other factors such as the recovery of the ozone layer are also at play and may mitigate this risk.

The results for basal cell carcinoma change are presented in Figures 4 and 5 and Table 2. They are represented as a percentage increase over the baseline period (1971–2000) rather than absolute numbers. A north to south gradient of increased rates of basal cell cancer is a reflective of the gradient of temperature which also increases with latitude, reflective of amplification of warming associated with the disappearance of James Bay and Hudson Bay sea ice (Gagnon and Gough, 2005). For completeness the results for the squamous cell carcinoma have been included in Figures 6 and 7 and Table 2. These results essentially show the same pattern except with a higher magnitude due to the stronger relationship with temperature (5.5% increase per °C).



Figure 4 – Projected percentage increase in Basal Cell Carcinoma for the 2050s over the baseline (1971–2000)

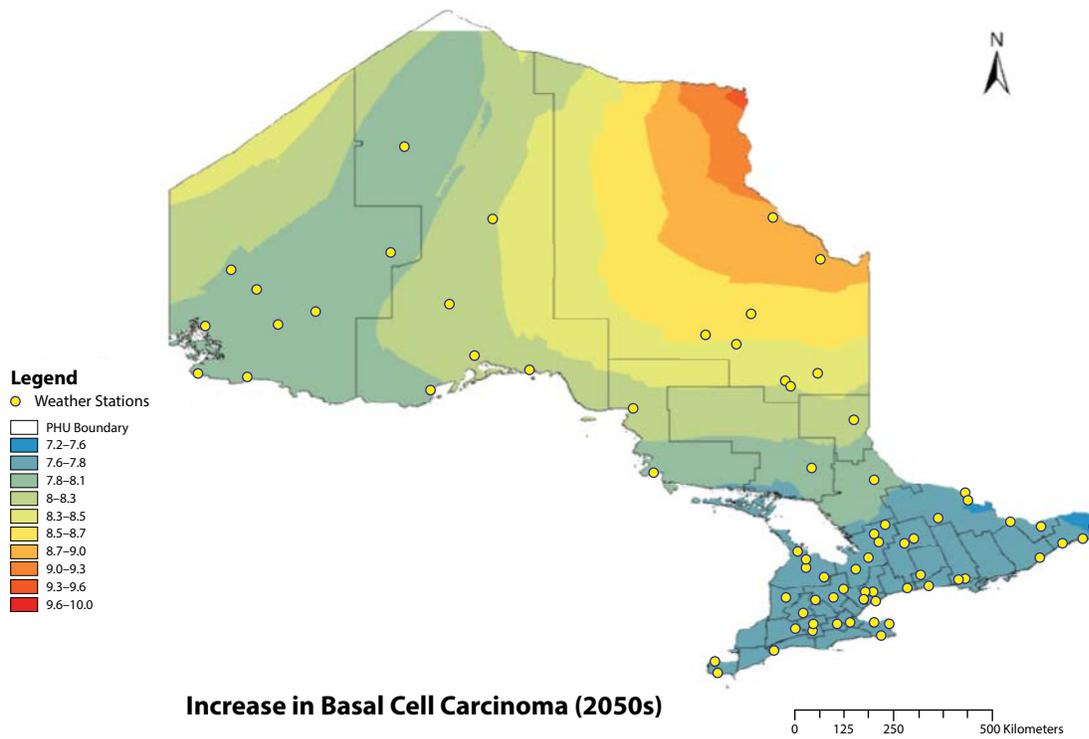


Figure 5 – Projected percentage increase in Basal Cell Carcinoma for the 2080s over the baseline (1971–2000)

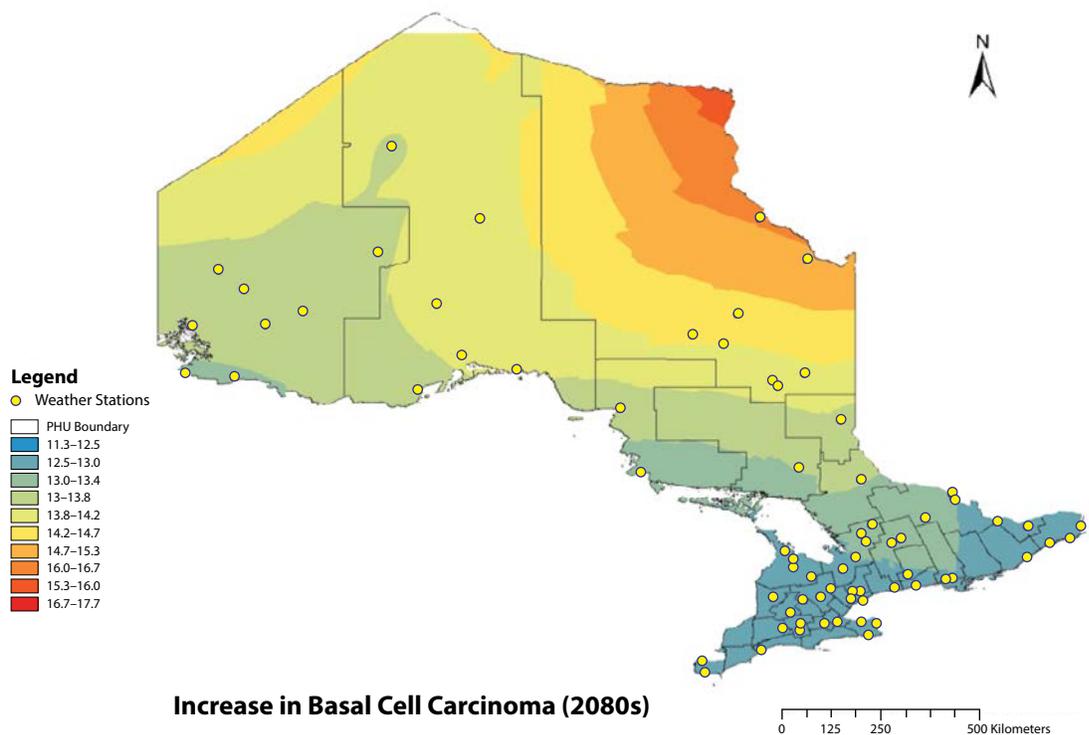


Figure 6 – Projected percentage increase in Squamous Cell Carcinoma for the 2050s over the baseline (1971–2000)

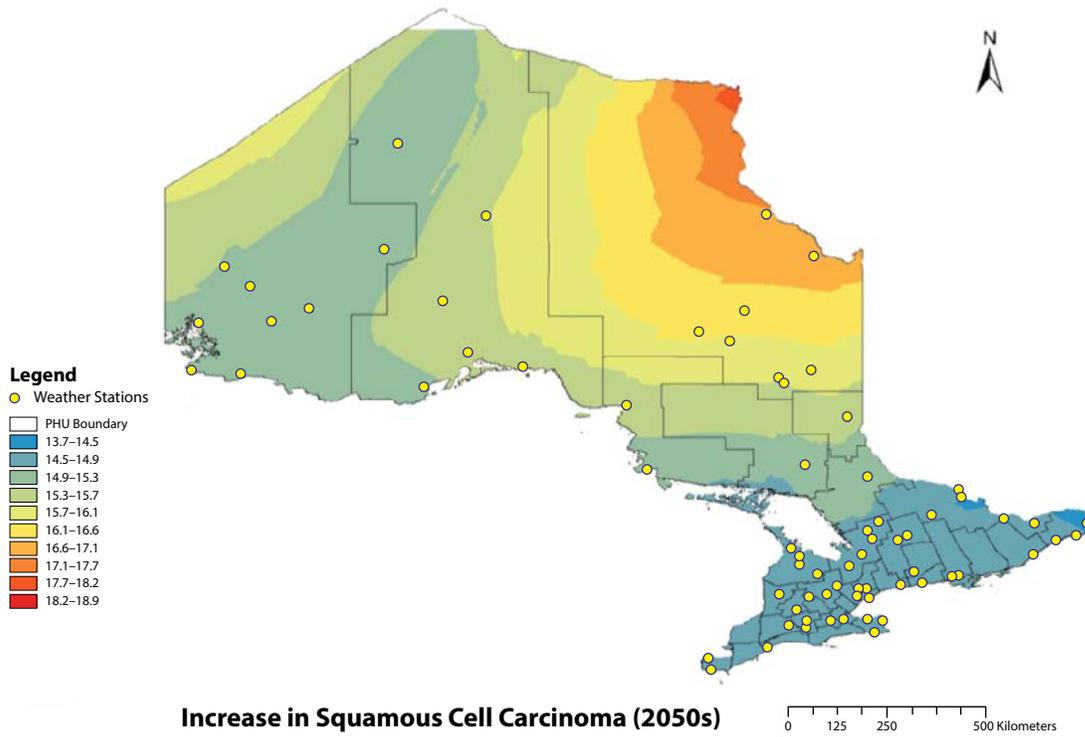


Figure 7 – Projected percentage increase in Squamous Cell Carcinoma for the 2080s over the baseline (1971–2000)

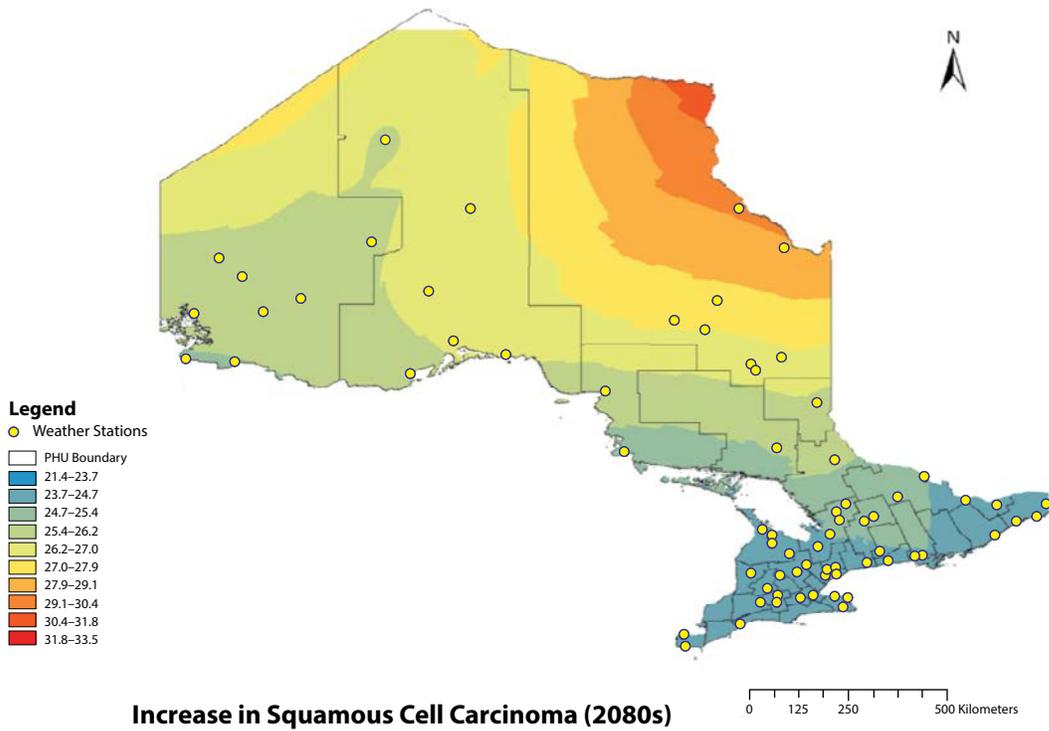


Table 2 – Projected percentage increase in basal cell and squamous cell carcinoma per public health unit for 2050s and 2080s over the baseline period (1971–2000)

PUBLIC HEALTH UNITS	% INCREASE IN BASAL CELL CARCINOMA (2050s)	% INCREASE IN BASAL CELL CARCINOMA (2080s)	% INCREASE IN SQUAMOUS CELL CARCINOMA (2050s)	% INCREASE IN SQUAMOUS CELL CARCINOMA (2080s)
Algoma	8.2	13.6	15.5	25.8
Brant County	7.7	12.8	14.6	24.4
Chatham-Kent	7.8	12.8	14.8	24.3
Durham Region	7.8	13	14.7	24.7
Eastern Ontario	7.7	12.9	14.5	24.5
Elgin-St. Thomas	7.7	12.8	14.7	24.4
Grey Bruce	7.7	13.0	14.7	24.6
Haldimand-Norfolk	7.8	12.8	14.7	24.3
Haliburton, Kawartha, Pine Ridge District	7.8	13.1	14.7	24.8
Halton Region	7.7	12.9	14.7	24.5
Hamilton Public Health Services	7.7	12.9	14.7	24.4
Hastings & Prince Edward Counties	7.8	13.0	14.7	24.7
Huron County	7.7	12.9	14.6	24.5
Kingston, Frontenac and Lennox & Addington	7.7	13.0	14.7	24.7
Lambton Community Health Services	7.8	12.8	14.7	24.4
Leeds, Grenville & Lanark District	7.7	13.0	14.6	24.6
Middlesex-London	7.7	12.9	14.6	24.4
Niagara Region	7.8	12.9	14.8	24.5
North Bay – Parry Sound District	8.0	13.4	15.1	25.4
Northwestern	8.1	13.8	15.4	26.2
Ottawa	7.7	13.0	14.6	24.6
Oxford County	7.7	12.9	14.6	24.4
Peel Region	7.7	13.0	14.7	24.6
Perth District	7.7	12.9	14.6	24.4

continued on next page



PUBLIC HEALTH UNITS	% INCREASE IN BASAL CELL CARCINOMA (2050s)	% INCREASE IN BASAL CELL CARCINOMA (2080s)	% INCREASE IN SQUAMOUS CELL CARCINOMA (2050s)	% INCREASE IN SQUAMOUS CELL CARCINOMA (2080s)
Peterborough County	7.8	13.0	14.7	24.7
Porcupine	8.7	14.8	16.5	28.0
Renfrew County and District	7.7	13.1	14.7	24.9
Simcoe Muskoka District	7.8	13.1	14.8	24.8
Sudbury & District	8.1	13.5	15.3	25.7
Thunder Bay District	8.2	14.0	15.5	26.5
Timiskaming	8.2	13.8	15.5	26.1
Toronto Public Health	7.8	13.0	14.7	24.6
Waterloo Region Health	7.7	12.9	14.6	24.4
Wellington-Dufferin-Guelph Health	7.7	12.9	14.6	24.5
Windsor – Essex County	7.8	12.8	14.8	24.3
York Region	7.8	13.0	14.7	24.7

Air Pollution – Ozone

Air pollution events are expected to rise in the future as a result of increases in average temperature. Air pollutants of particular concern are particulate matter and ground level ozone. Although these pollutants have antecedent processes that are independent of climate change, air pollution can be exacerbated by the changing climate. For example, extreme heat events can effect air pollution due to associated weather patterns and elevated temperatures can alter the rates of photochemical smog formation (Seguin and Berry, 2008). In addition, air pollutants, such as ozone, are greenhouse gases that can potentially effect rising temperatures (Beaney and Gough, 2002). It has been estimated that in the eastern United States, an increase of 0.34 parts per billion (ppb) in ozone could occur for every 1°C increase in temperature (Pfister et al., 2014). This demonstrates the impact of rising temperatures on ozone production, however, this does not account for ozone or ozone precursors that are transported from one region to another. Southern Ontario, in particular, is subject to substantial transborder transport of ozone and its precursors (Beaney and Gough, 2002; Huryn and Gough, 2014). For the purposes of this analysis, the focus is on the direct effect of increasing temperature on ozone production in southern Ontario as the occurrence of ozone exceedances (>80 ppb) is typically restricted to the southern Ontario region.

The average ozone concentration for the baseline period and the projection periods (2050s and 2080s) are presented in Figures 8 to 10 and Table 3. There is a modest increase by the 2050s and 2080s over the baseline period for ozone exceedance (>80 ppb) days. As noted above, these changes are a direct result of temperature change and do not reflect potential impacts of the transborder transport of ozone and ozone precursors that can have a much larger effect.



Figure 8 – Number of days with ozone exceedances (> 80 ppb) for the baseline period (1971–2000)

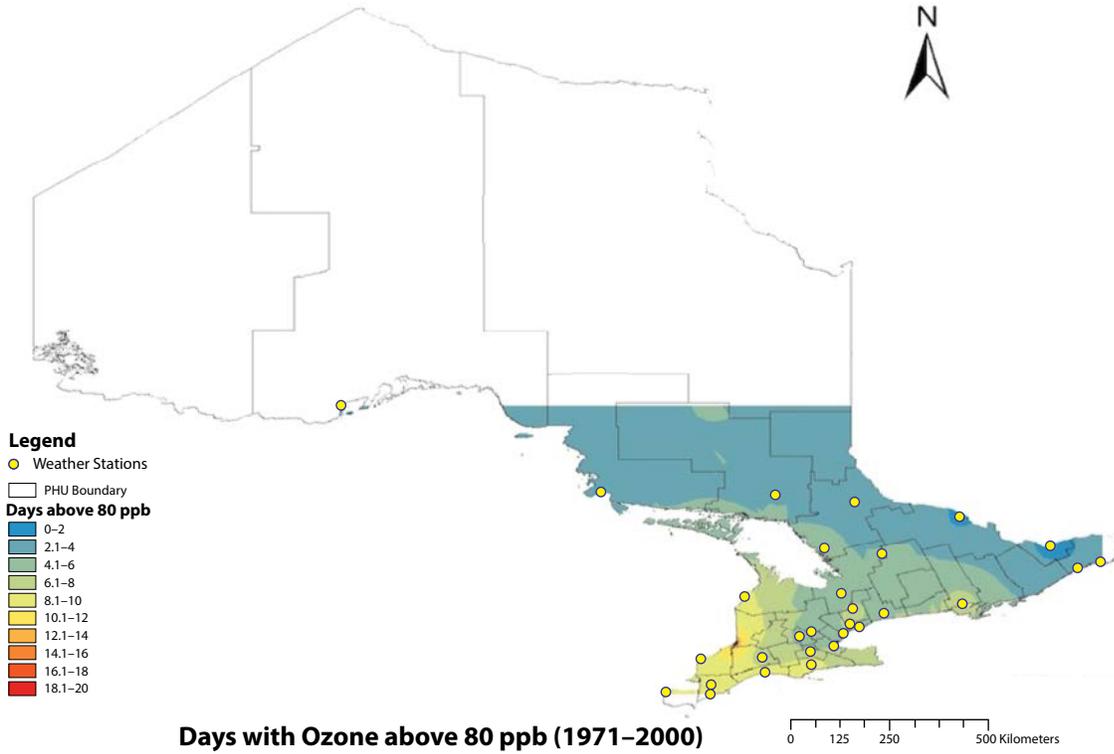


Figure 9 – Number of days with ozone exceedances (> 80 ppb) count for the 2050s

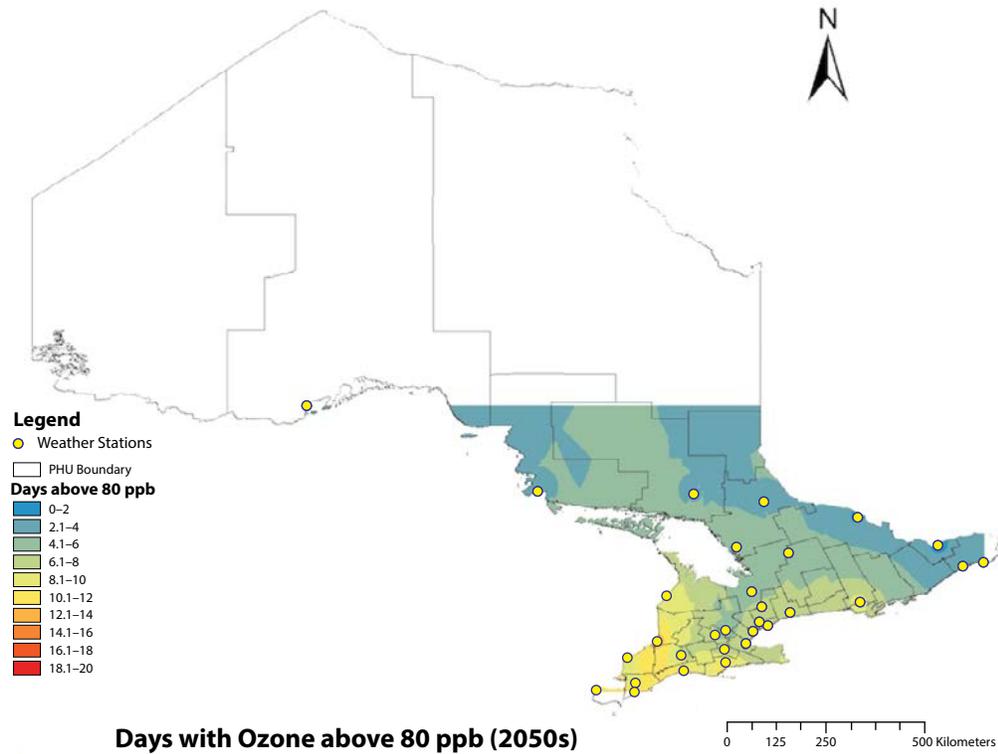


Figure 10 – Number of days with ozone exceedances (> 80 ppb) count for the 2080s

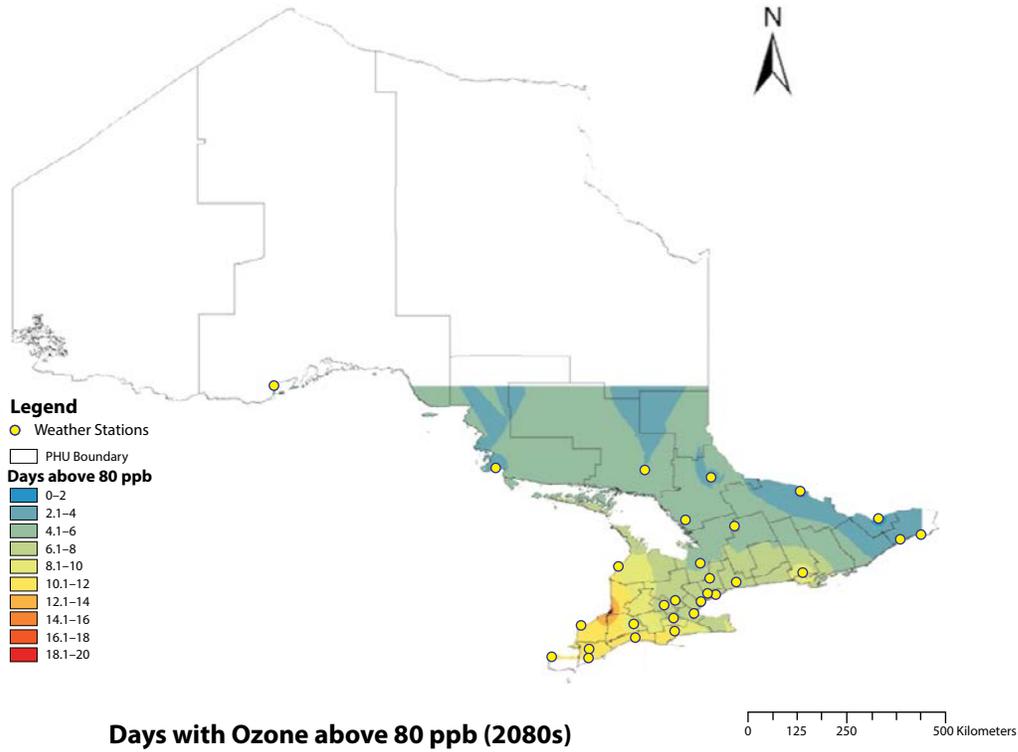


Photo Credit: Shutterstock



Table 3 – Changes in number of exceedances (> 80 ppb) count (days per year) by PHU in southern Ontario for the baseline period (1971-2000) and two projection periods (2050s) and (2080s)

PUBLIC HEALTH UNITS	DAYS ABOVE 80PPB (1971–2000)	DAYS ABOVE 80PPB (2050s)	DAYS ABOVE 80PPB (2080s)
Algoma	0	1	1
Brant County	4	5	6
Chatham-Kent*	Range 8–12, Average 10	Range 9–12, Average 10.5	Range 10–13, Average 11.5
Durham Region	5	6	6
Eastern Ontario*	2	Range 2–3, Average 2.5	Range 2–3, Average 2.5
Elgin-St. Thomas	12	14	15
Grey Bruce	9	9	10
Haldimand-Norfolk	14	14	14
Haliburton, Kawartha, Pine Ridge District	4	5	5
Halton Region	5	6	7
Hamilton Public Health Services	6	7	8
Hastings & Prince Edward Counties	10	12	13
Huron County	9	9	10
Kingston, Frontenac and Lennox & Addington	10	12	13
Lambton Community Health Services*	Range 7–17, Average 12	Range 8–17, Average 12.5	Range 9–19, Average 14
Leeds, Grenville & Lanark District	0	0	0
Middlesex-London	2	3	3
Niagara Region	6	7	8
North Bay – Parry Sound District*	Range 2–5, Average 3.5	Range 3–6, Average 4.5	Range 3–6, Average 4.5
Northwestern	—	—	—
Ottawa	0	0	0

continued on next page



PUBLIC HEALTH UNITS	DAYS ABOVE 80PPB (1971–2000)	DAYS ABOVE 80PPB (2050s)	DAYS ABOVE 80PPB (2080s)
Oxford County	2	3	3
Peel Region	5	5	5
Perth District	2	3	3
Peterborough County	4	5	5
Porcupine	—	—	—
Renfrew County and District	0	0	0
Simcoe Muskoka District	3	3	4
Sudbury & District Health Unit	2	2	3
Thunder Bay District	—	—	—
Timiskaming	2	2	3
Toronto Public Health*	Range 5–8, Average 6.5	Range 6–9, Average 7.5	Range 6–10, Average 8
Waterloo Region Health	4	5	6
Wellington-Dufferin-Guelph Health	4	5	5
Windsor – Essex County	10	11	12
York Region	8	8	9

*Specific projected changes in number of exceedance days are listed for most PHUs in Table 3, while ranges are provided for Chatham-Kent, Eastern, Lambton, North Bay-Parry Sound and Toronto PHUs in which additional information from multiple stations exists.



Vectorborne Disease – West Nile Virus (WNV)

West Nile Virus (WNV) was first recognized in Africa in the 1930s and primarily circulates between birds and bird-biting mosquitoes (PHO, 2014). WNV is transmitted to humans when particular species of mosquito obtain the virus from biting an infected bird, prior to biting a human. These species of mosquitoes that transfer the virus from birds to humans in Ontario are the *Culex pipiens/restuans* species which may be found in significant numbers in urban areas.

The climate linkage to the spread of WNV is connected to the nature of its carrier, the *Culex pipiens/restuans* mosquito. The minimum threshold temperature required for this mosquito to develop is 14°C, and the maximum temperature is 35°C (Chen et al., 2013). Another climate related consideration for WNV transmission is the extrinsic incubation period (EIP), the period of time between infection of the mosquito and its ability to transmit the infection. The climate projections show an expansion of the regions in Ontario that will be able to climatologically host mosquitoes that transmit WNV, to virtually all of Ontario by the 2080s. Actual occurrence of WNV and expansion into these new areas is also dependent on other factors including the nature of propagation and remediation efforts. Figures 11, 12 and 13 depict the favourable climatic conditions (degree days) for the spread of WNV. In addition, the statistics for the incidence rate of WNV from 2012–2013 (Public Health Ontario, 2014) were added to the baseline period map as a reference of the actual extent of reported WNV occurrence.

Figure 11 – WNV. Favourable climatic conditions for the baseline period (1971-2000) including incidence rate of WNV for 2012–2013

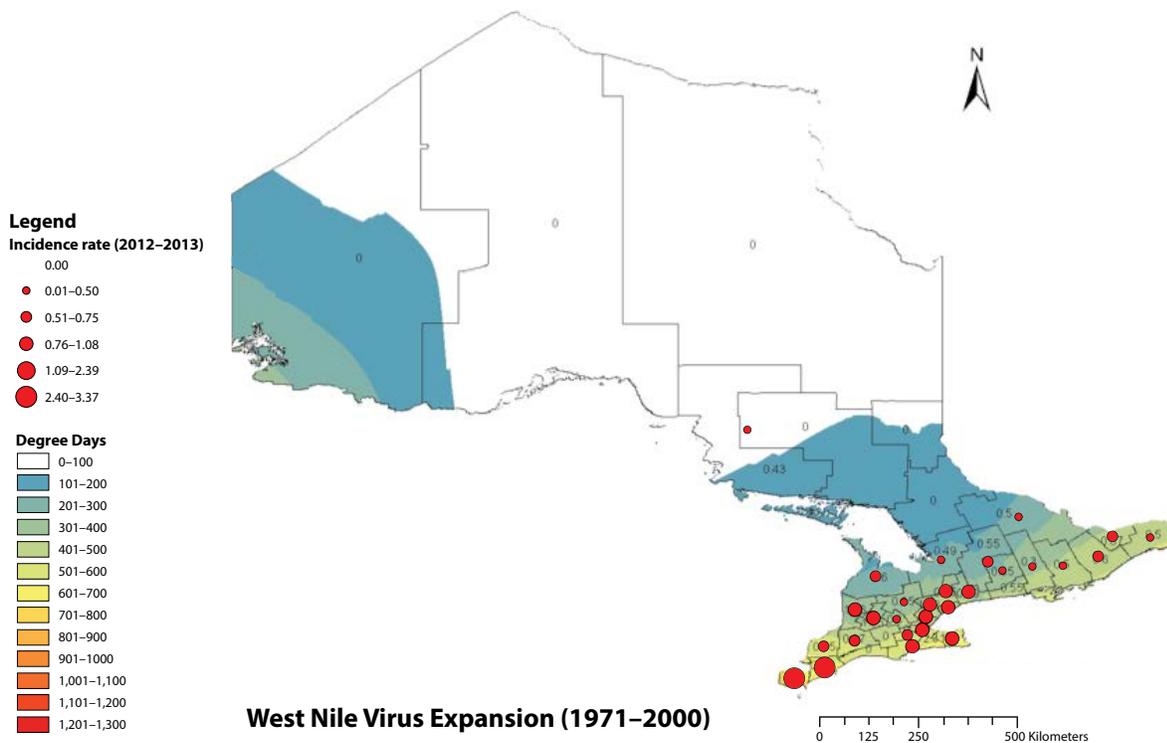


Figure 12 – WNV. Favourable climatic conditions for the 2050s

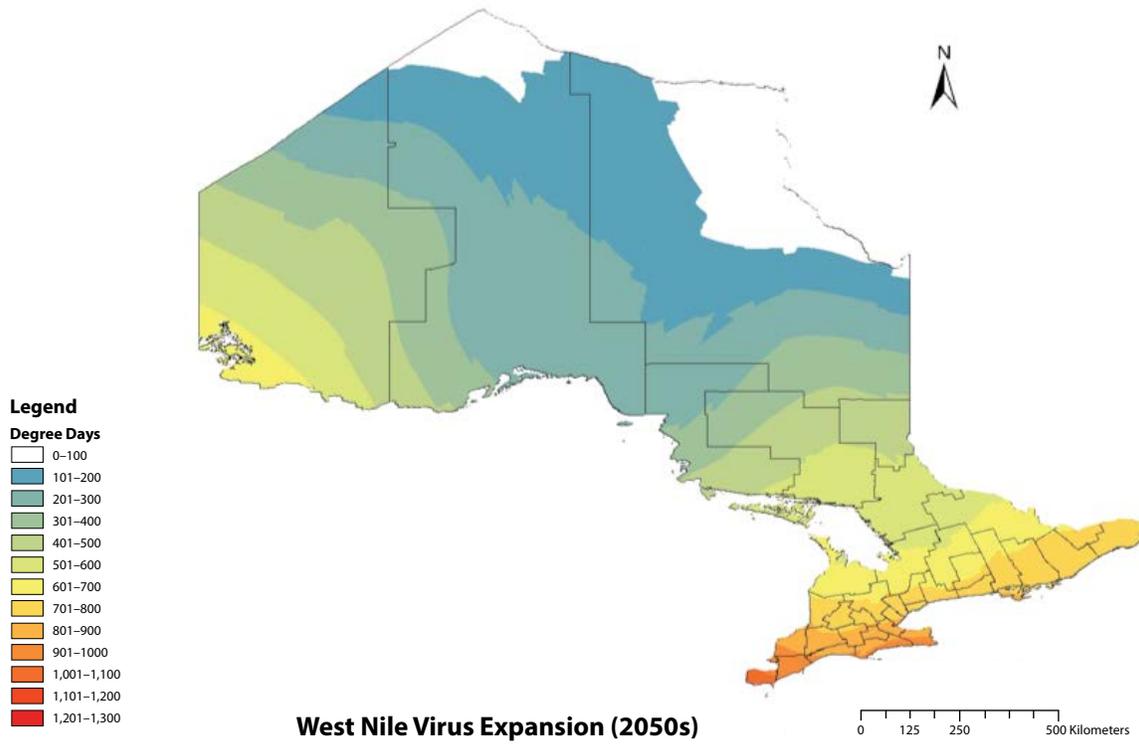
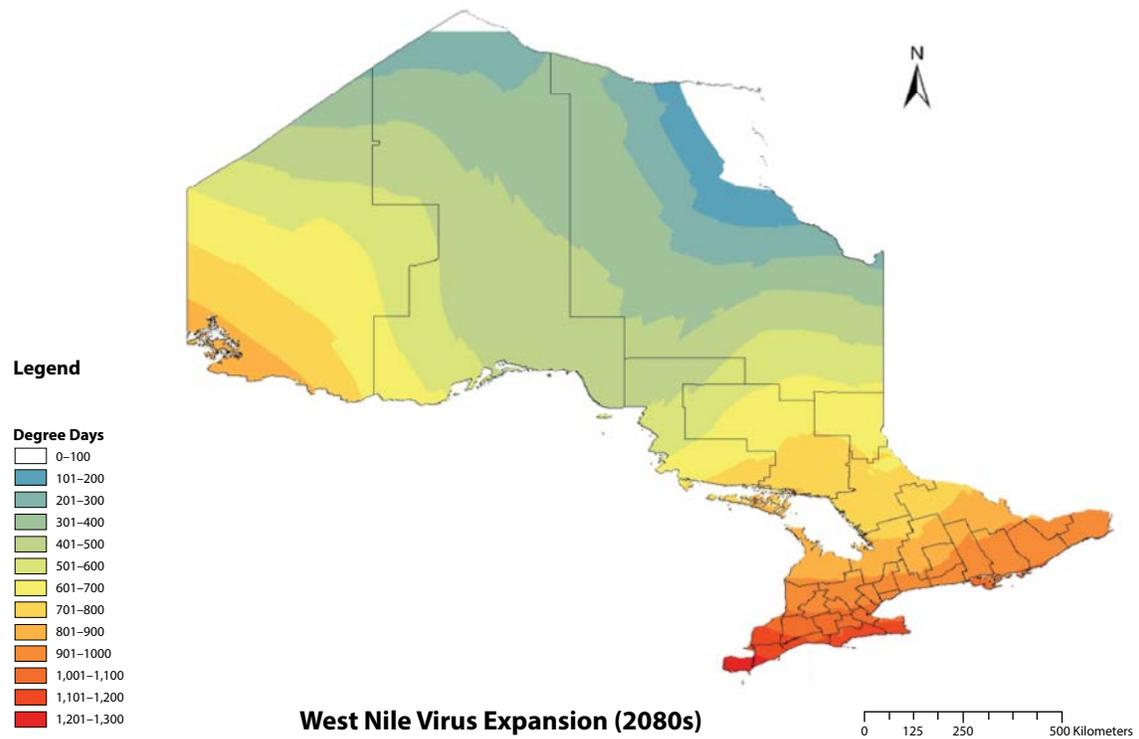


Figure 13 – WNV. Favourable climatic conditions for the 2080s



Impacts Associated with Extreme Precipitation

The occurrence of extreme precipitation events in general is increasing. The frequency and intensity of these extreme events are changing and infrastructure of all kinds is becoming subject to conditions for which it was not designed. This includes stormwater and wastewater infrastructure which may become overwhelmed, impacting water quality, water quantity and the ecosystem (MOECC, 2016). Beach contamination can occur as a result of extreme precipitation events, typically characterized by high bacteria counts linked to ear, nose and throat infections. These events often result in beach closures. For the Great Lakes region of the United States, contamination events typically occur when the daily rainfall amount exceeds a threshold of 5–6 cm (Patz et al., 2008). Since beach usage maximizes in the summer, for the purposes of this study, only summer anomalies and rain events were examined.

Figures 14, 15 and 16 depict the number of extreme rainfall events in the summer (i.e. June, July and August) for the baseline period, the 2050s, and 2080s. Over any of these 3 time periods, the number of days with more than 50 mm of rainfall is less than one per summer for most of Ontario, with a slight increasing trend in the future, especially over northern Ontario.

Figure 14 – Extreme precipitation events (>50 mm) per summer (June, July and August) for baseline period (1971–2000)

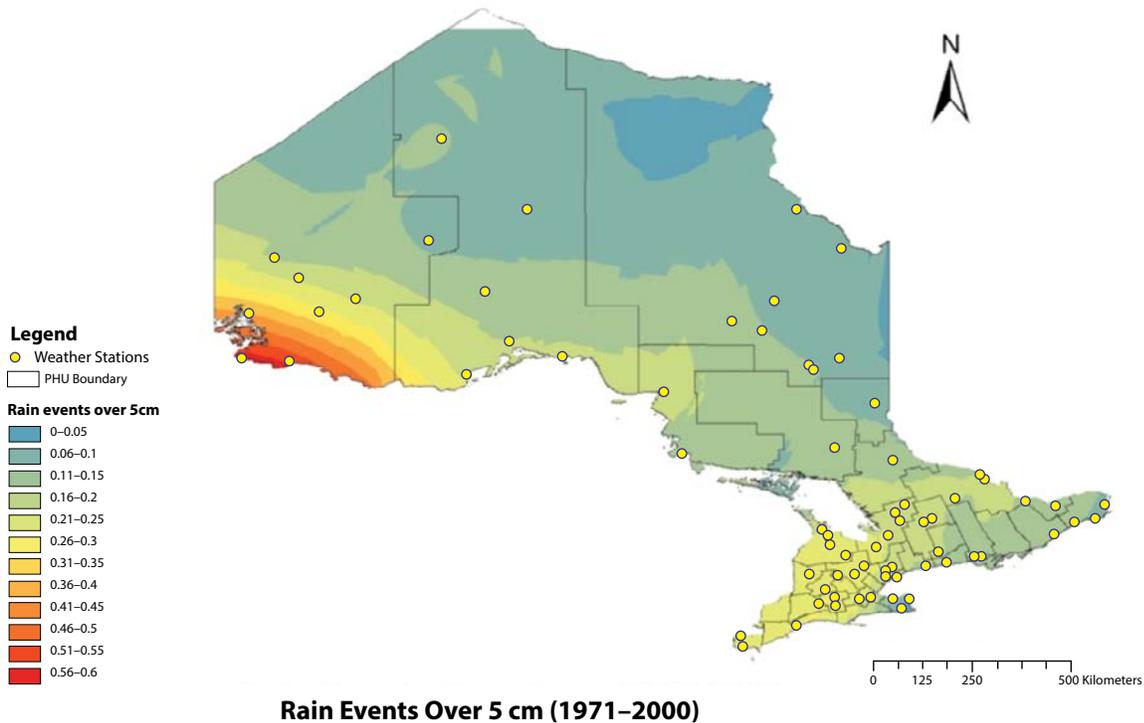


Figure 15 – Extreme precipitation events (>50 mm) per summer (June, July and August) for the 2050s

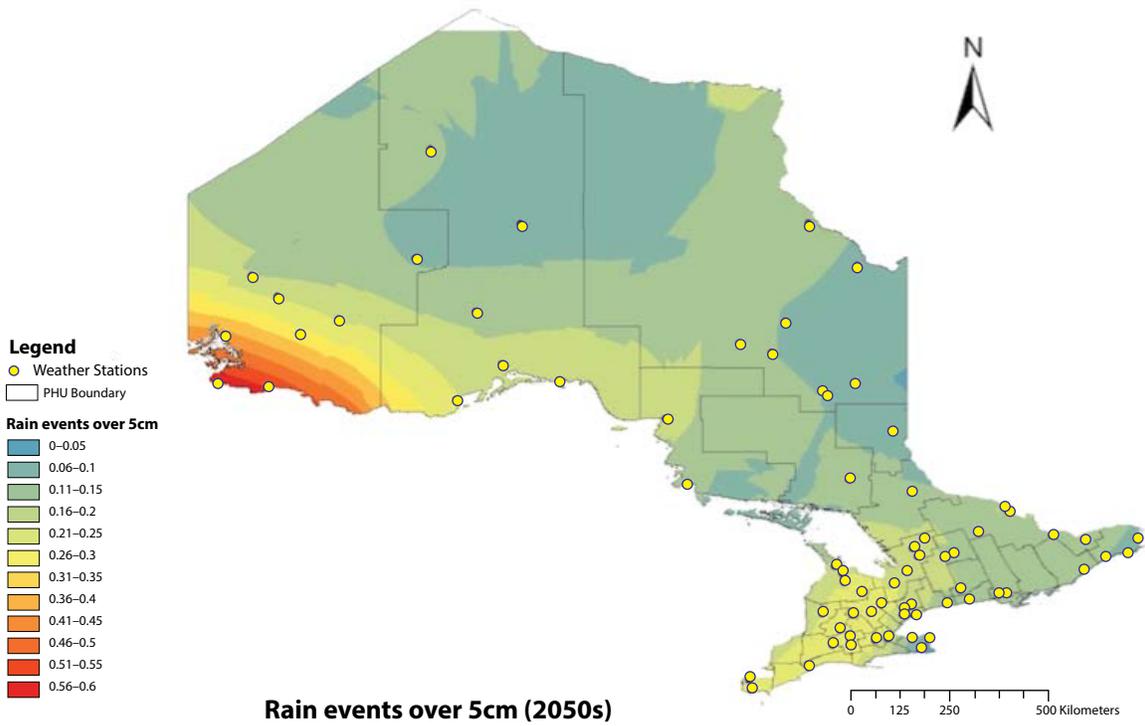
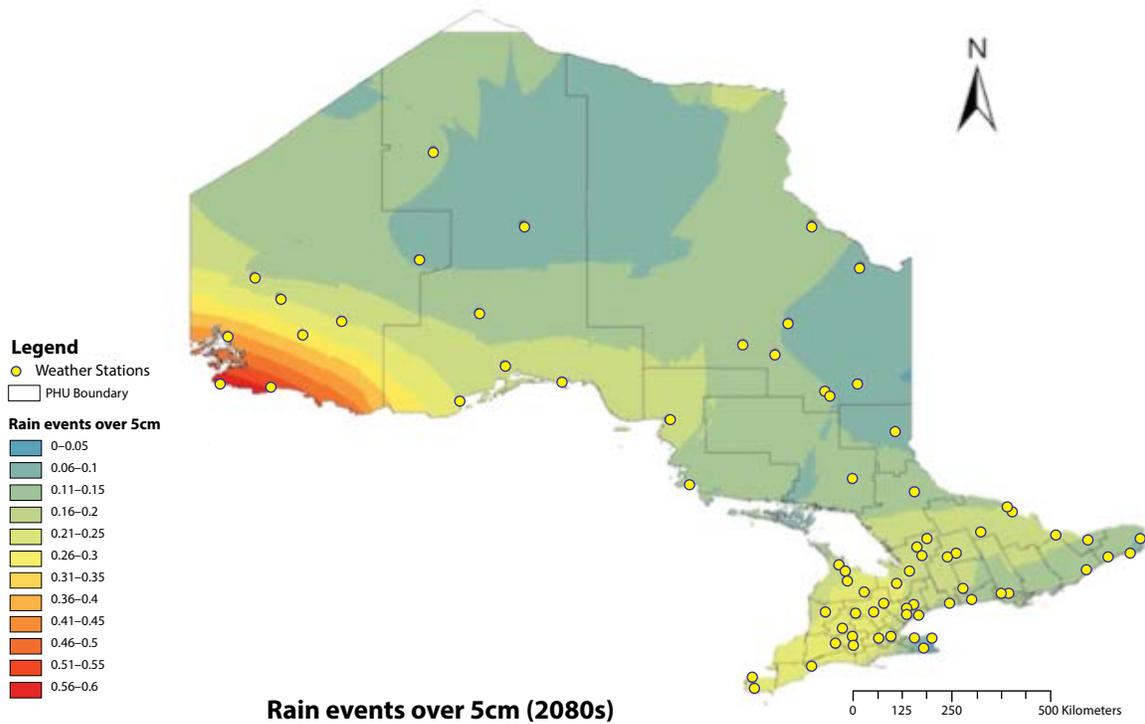


Figure 16 – Extreme precipitation events (>50 mm) per summer (June, July and August) for the 2080s



MOVING FORWARD

Evidence-informed Change

Climate change is already impacting human health as demonstrated by rising temperatures, reduced air quality and increased precipitation. Reducing public health vulnerability to climate change requires effective and informed adaptation strategies. Emerging evidence and information regarding climate change health risks, vulnerabilities and impacts is essential to this process. This research will support and enhance the foundation of knowledge necessary to target areas of vulnerability.

Building Adaptive Capacity

Adaptive capacity has been defined by the Intergovernmental Panel on Climate Change as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Barriers to successful adaptation include insufficient knowledge of health risks; disproportionate access to interventions; limited awareness of best management practices and adaptation measures to reduce health vulnerability; and limited ability and resources to enhance or create new health protection programs and services (Health Canada, 2008).

For the public health system, its ability to adapt and meet the climate change challenge will be determined by its ability to comprehend, assimilate, and utilize emerging knowledge and expertise; engage in agile and responsive problem resolution; and leverage partnerships and collaborative opportunities.

Reducing Public Health Vulnerability

Climate change is not simply an environmental problem – it poses a serious public health challenge. Bridging the divide between the human health and environmental impacts of climate change is the key to promoting healthy environments – both natural and built – improving health and reducing health and social costs. Public health units are uniquely positioned to bridge this divide and reduce public health vulnerability to climate change through risk assessment, preparation and public communication. To effectively address the climate change challenge, climate change information and adaptation considerations need to be integrated into operational processes.

Planning for climate change impacts requires the enhancement of capacity and comprehension to support adaptation activities at the local and community level. To this end, assessments of health risk and vulnerability at the local level are essential to understanding and reducing the incidence of adverse health outcomes from the impacts of climate change. Vulnerability assessments identify the health risks and impacts of climate change and facilitate identification and prioritization of prevention and response activities within communities. The findings from this modelling study provide a starting point for public health units to identify the projected health risks and impacts of climate change within each of their communities and to inform the completion of a local Climate Change and Health Vulnerability and Adaptation Assessment.





Photo Credit: Shutterstock

REFERENCES

- Beaney, G. & Gough, W.A. (2002). The influence of tropospheric ozone on the air temperature of the city of Toronto, Ontario, Canada. *Atmospheric Environment*, 36(2002), p 2319–2325.
- BC Centre for Disease Control. (2013). Growing Degree Days Mapping for West Nile Virus Surveillance in British Columbia. Retrieved from: <http://www.bccdc.ca/NR/rdonlyres/A70B5D89-BBED-4CA4-A3A7-2EA0DC5AAE3D/0/GrowingDegreeDaysMethodology2013.pdf>
- Canadian Centre for Occupational Health and Safety. (2011). Hot Environments – Control Measures. Retrieved from: http://www.ccohs.ca/oshanswers/phys_agents/heat_control.html.
- Cancer Care Ontario. (2013). Cancer Incidence, 2003–2009. Ontario Cancer Registry.
- Chen, S., Blanford, J.I. & Thomas, M.B. (2013). Estimating West Nile Virus Transmission Period in Pennsylvania Using an Optimized Degree-Day Model. *Vector Borne and Zoonotic Diseases*, 13(7): 489–497.
- Chen, C.C., Jenkins, E. & Soos, C. (2013). Climate Change and West Nile Virus in a Highly Endemic Region of North America. *Int J Environ Res Public Health*, 10(7):3052–3071.
- Diffey, B. (2004). Climate change, ozone depletion and the impact on ultraviolet exposure of human skin. *Physical Medical Biology* 49.
- Gagnon, A.S. and W.A. Gough (2005). Climate change scenarios for the Hudson Bay region: An intermodel comparison. *Climatic Change* 69: 269–297.



Gough, W.A., Tam, B.Y., Mohsin, T. & Allen, S.M.J. (2014). Extreme cold weather alerts in Toronto, Ontario, Canada and the impact of a changing climate. *Urban Climate*(2014).

Government of Canada. (2014). Climate. Retrieved from: <http://climate.weather.gc.ca>

Gray, J.S., Dautel, H., Estrada-Peña, A., Kahl, O. and E. Lindgren (2009). Effects of Climate Change on Ticks and Tick-Borne Diseases in Europe. *Interdisciplinary Perspectives on Infectious Diseases*, Article ID 593232.

Health Canada. (2005). Health Policy Research. *Health Policy Research Bulletin* – issue 11.

Huryn, S.M. and W.A. Gough (2014). Impact of urbanization on the ozone weekday/weekend effect in Southern Ontario, Canada. *Urban Climate*, 8:11–20.

IPCC. (2007). *Climate Change 2007 – Impacts, Adaptation and Vulnerability*. IPCC WGII AR 4

IPCC. (2014). Chapter 11. Human Health: Impacts, Adaptation, and Co-Benefits. IPCC WGII AR5 Chapter 11.

Karl, R.T. and Knight, R.W. (1998). Secular Trends of Precipitation Amount, Frequency, and Intensity in the United States. *Bull. Amer. Meteor. Soc.*, 79, 231–241.

Ontario Ministry of the Environment and Climate Change (2013). Air Pollution data. Retrieved from: <http://www.airqualityontario.com/history/>

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Vector-borne diseases 2013 summary report. Toronto, ON: Queen’s Printer for Ontario; 2014. Retrieved from: http://www.publichealthontario.ca/en/DataAndAnalytics/Documents/PHO_WNV_Weekly_Vector_Surveillance_Report_2014_Week_32.pdf

Ontario Ministry of Labour. (2014). Heat Stress. Retrieved from: http://www.labour.gov.on.ca/english/hs/pubs/gl_heat.php.

Patz, J.A., Vavrus, S.J., Uejio, C.K. & McLellan, S.L. (2008). Climate Change and Waterborne Disease Risk in the Great Lakes Region of the U.S. *American Journal of Preventive Medicine*, 35(5), 451–458.

Pfister, G.G., Walters, S., Lamarque J.F., Fast, J., Barth, M.C., Wong, J., Done, J., Holland, G. & Bruyere, C.L. (2014). Projections of Future Summertime Ozone over the U.S. *American Geophysical Union*. 10.1002/2013JD020932

Seguin, J. & Berry, P. (2008). Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity.

Skin Cancer Foundation. (2014). Squamous Cell Carcinoma (SCC). Retrieved from: <http://www.skincancer.org/skin-cancer-information/squamous-cell-carcinoma>

Skin Cancer Foundation. (2014). Basal Cell Carcinoma (SCC). Retrieved from: <http://www.skincancer.org/skin-cancer-information/squamous-cell-carcinoma>

van der Leun, J.C., Piacentini, R.D. & de Gruijl, F.R. (2008). Climate change and human skin cancer. *Photochemical Photobiological Science*, 7(6), 730–3.

World Health Organization. (2006). Solar ultraviolet radiation: Global burden of disease from solar ultraviolet radiation. *Environmental Burden of Disease Series*, No. 13



NOTES





978-1-4606-7703-2 (PDF)

© Queen's Printer for Ontario

