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Supplemental Climate Information for Point Pelee National Park

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Contents

Preface

This is a supplement to the "Let's Talks about Climate Change: Great Lakes Region" (Parker, 2017) report and is intended to support climate change discussions at Point Pelee National Park.

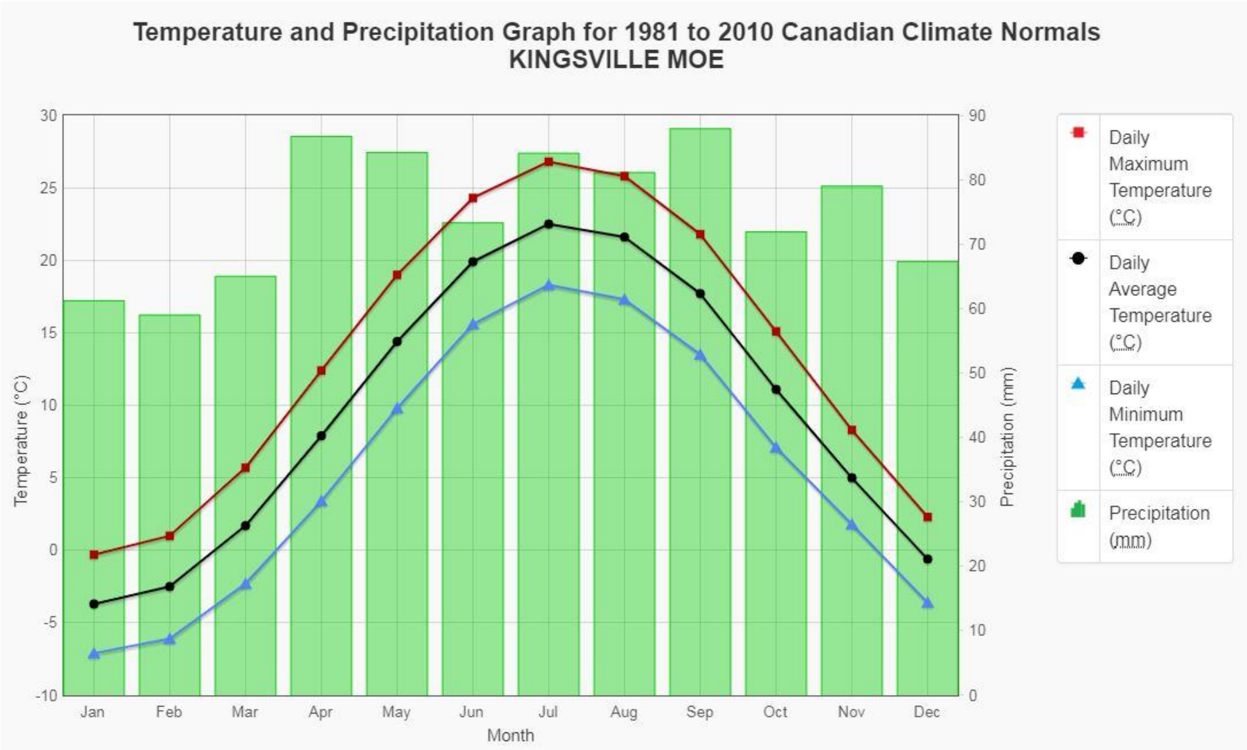
Future climate projections are modelled with several different greenhouse gas concentration trajectories called **Representative Concentration Pathways (RCP)** (Vuuren *et al.*, 2011). They describe possible climate futures and are named after respective radiative forcing values in the year 2100 relative to pre-industrial values (i.e., +2.6, +4.5 and +8.5 watts/m^2). **RCP 2.6** assumes we take action and greenhouse gas emissions peak in 2010-2020 and decline thereafter. **RCP 4.5** assumes emissions peak around 2040 and then decline. **RCP 8.5** assumes we take no action and emissions continue to rise "status quo" throughout the 21^{st} century. We are currently tracking RCP 8.5.

This is a site focussed document and to understand the larger climate change context please consult Canada's changing climate assessment reports (e.g., Bush and Lemmen, 2019; Warren and Lemmen, 2014) and the Intergovernmental Panel on Climate Change assessment reports (e.g., IPCC, 2014). With respect to adaptation and mitigation options, please review Gross *et al.* (2016), Parker *et al.* (2018) or Rockman *et al.* (2016).

<u>Disclaimer</u>

Views, statements, findings and conclusions are solely those of the author and do not necessarily reflect the views and policies of Parks Canada. Although the author has made every effort to ensure that the information is accurate, complete and correct, neither Parks Canada nor the author can guarantee its integrity. Readers are encouraged to verify with original sources.

1. Historic Climate



Climate "normals" (1981-2010) for Kingsville Meteorological Station. Figure source: Environment and Climate Change Canada (http://climate.weather.gc.ca/climate_normals/).

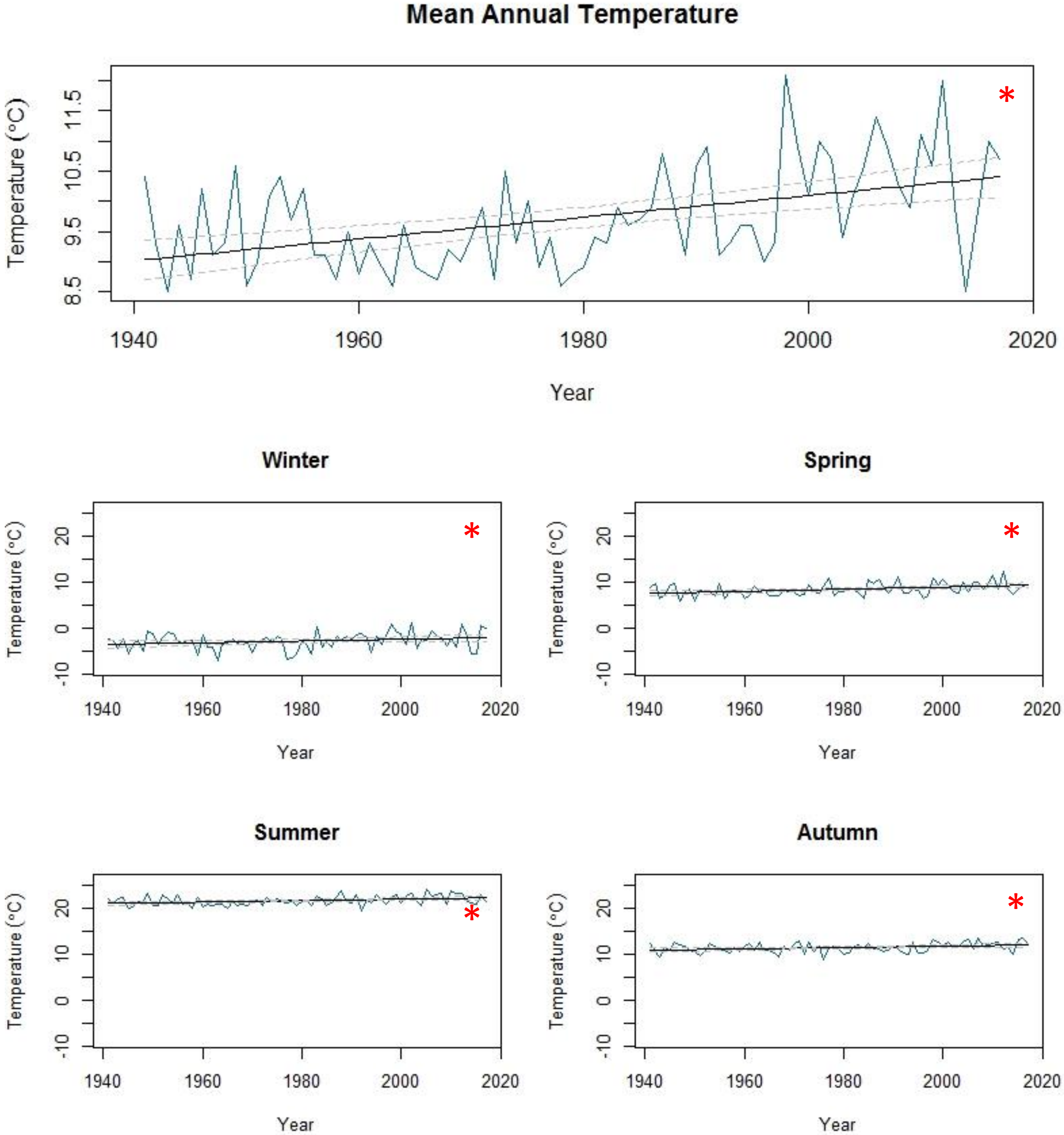
There are 25 meteorological stations found within a 50 km radius of Point Pelee National Park (PPNP). Historical data is available from Environment and Climate Change Canada, http://climate.weather.gc.ca/historical_data/search_historic_data_e.html. The Adjusted and Homogenized Canadian Climate Database (ECCC, 2017) is generally used for longer term trend analysis since it corrects for small shifts in station locations or equipment changes.

Regional meteorological stations

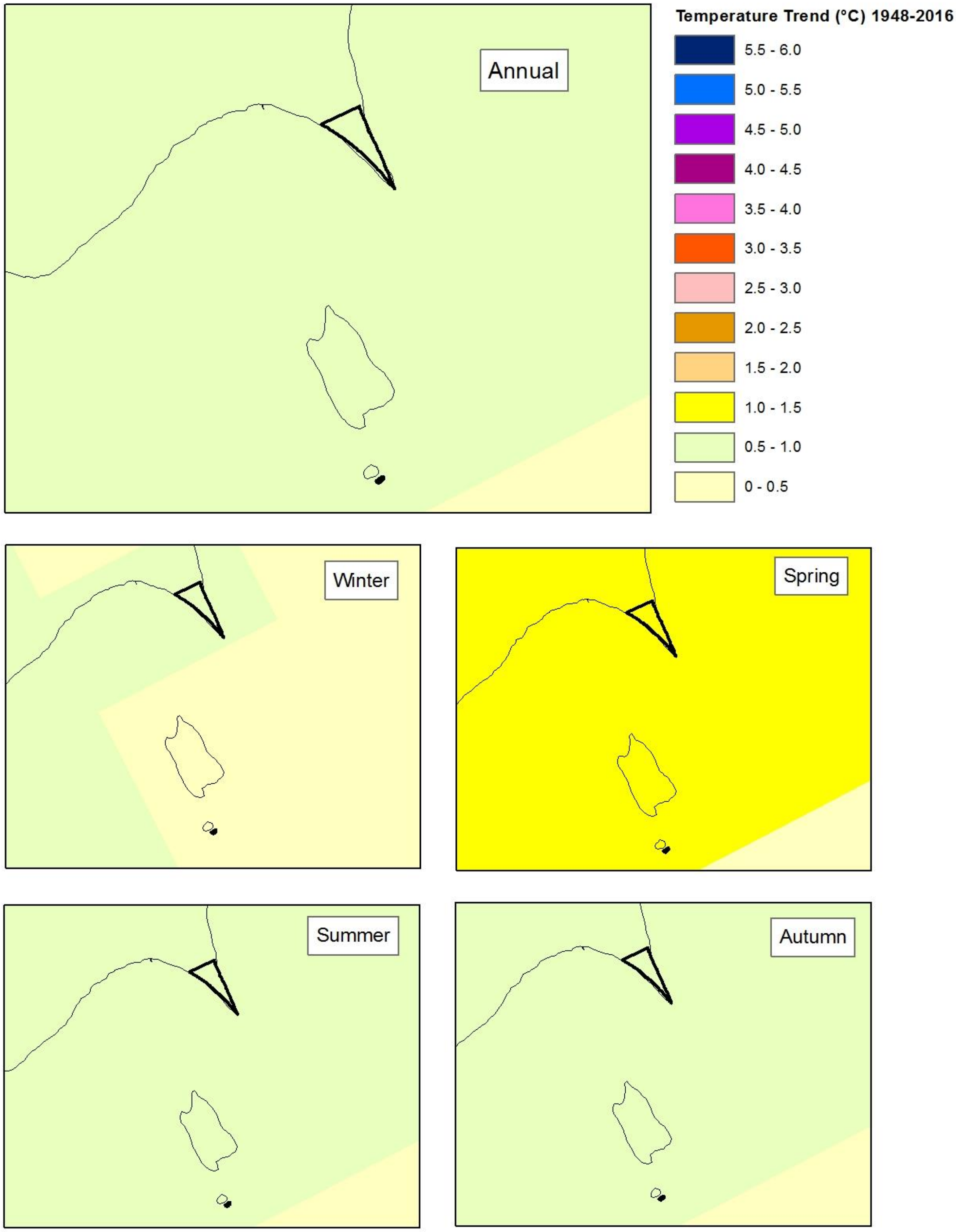
Station	ID#	Data Interval	Start Year	Last Year
Point Pelee	613FN58	Daily	1974	1997
Point Pelee CS	613P001	Hourly	2001	2019
Leamington	6134390	Daily	1916	1978
Kingsville MOE	6134190	Daily	1960	2019
Harrow CDA Auto	6133362	Hourly	2000	2019
Harrow CDA	6133360	Daily	1917	1993
Amherstburg	6130257	Daily	1988	2019
Windsor A	6139525	Hourly	1953	2014
Windsor A	6139527	Hourly	2014	2018
Windsor A	6139530	Hourly	2018	2019

1.1 Temperature

Windsor (6139527) is the closest meteorological station with long term temperature data (ECCC, 2017). Trends from 1941 to 2017 determined using a generalized linear model (R Core Team, 2017) including 95% confidence intervals. "*" = statistically significant trend (P<0.05).



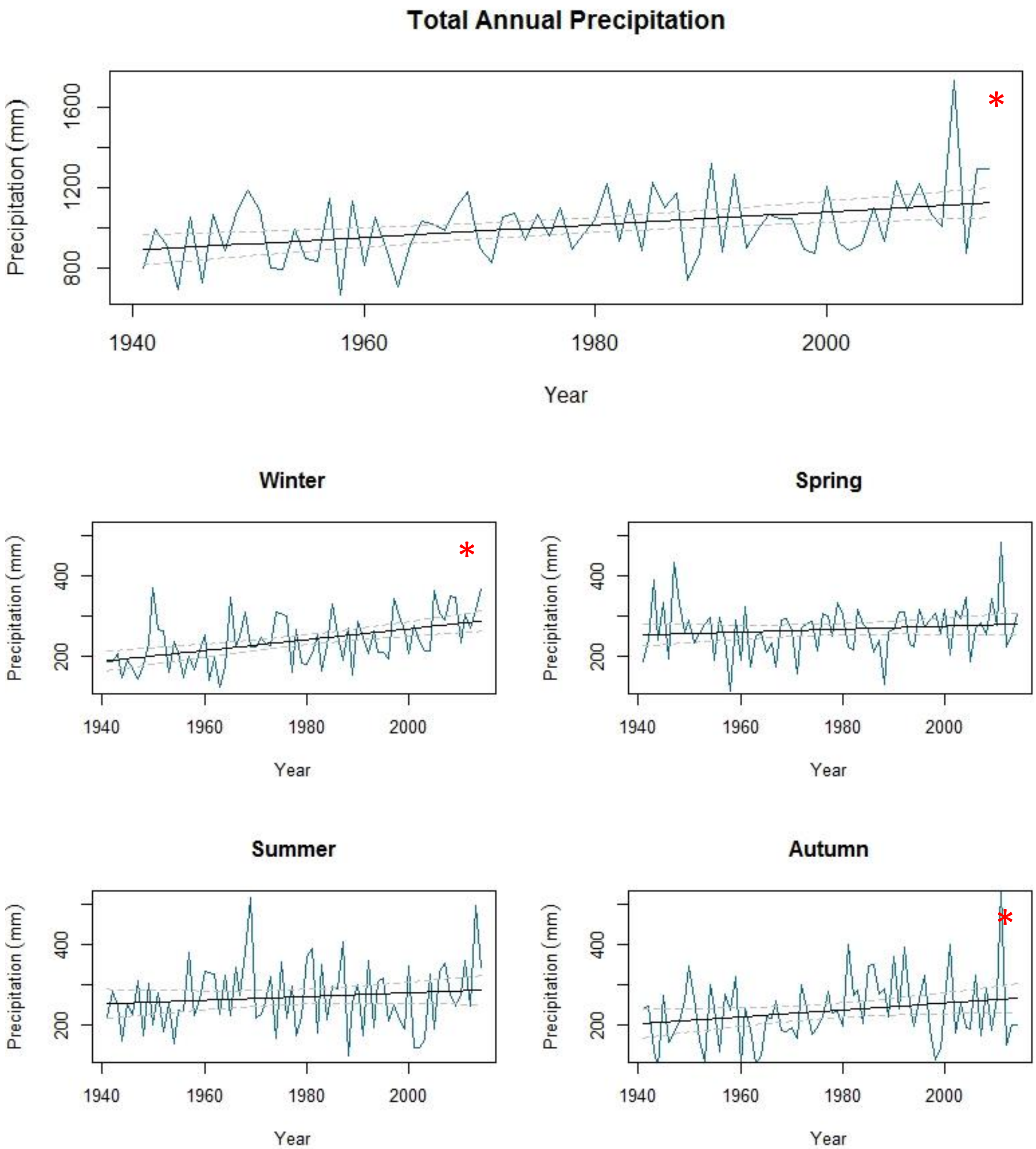
Windsor mean annual and seasonal temperature. A statistically significant (P<0.05) increase observed in mean annual and seasonal temperatures. Mean annual temperature has increased by 1.4°C since 1941. Of all the seasons, spring (Mar, Apr, May) temperature has increased the greatest, 1.8°C since 1941.



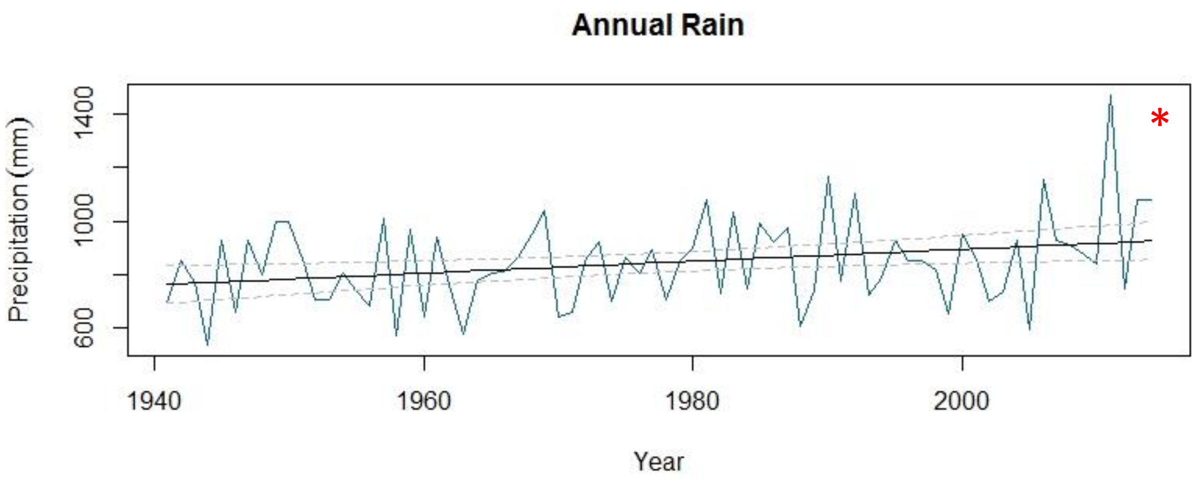
Mean annual and seasonal temperature trends (˚C) for Point Pelee NP for 1948-2016. Based on Canadian gridded data (CANGRD) it represents the change in temperature over the period of record (1950-2016). Data source: https://climate-change.canada.ca/climate-data/#/historical-gridded-data.

1.2 Precipitation

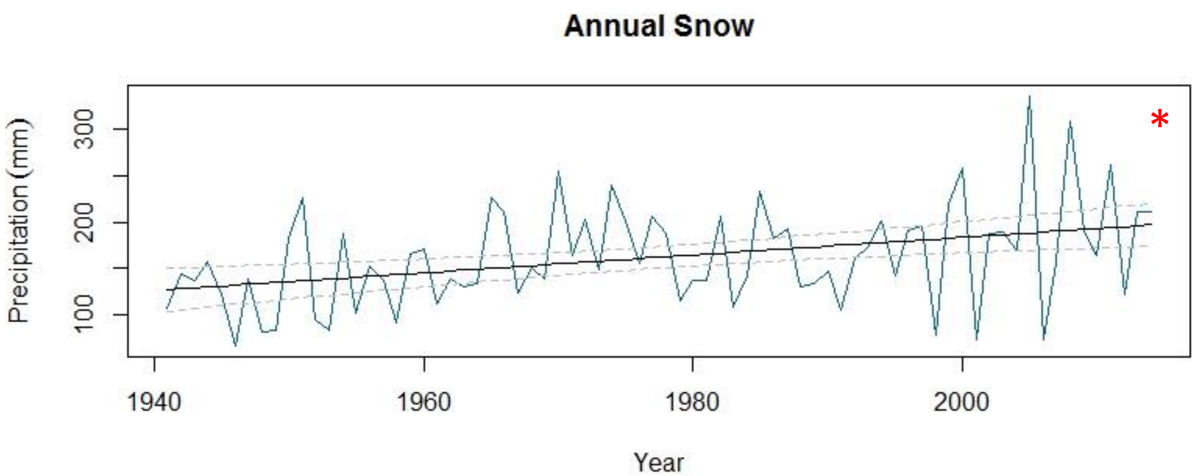
Windsor (6139525) is the closest meteorological station with long term precipitation data (ECCC, 2017). Trends from 1941 to 2014 determined using a generalized linear model (R Core Team, 2017) including 95% confidence intervals. "*" = statistically significant trend (P<0.05).



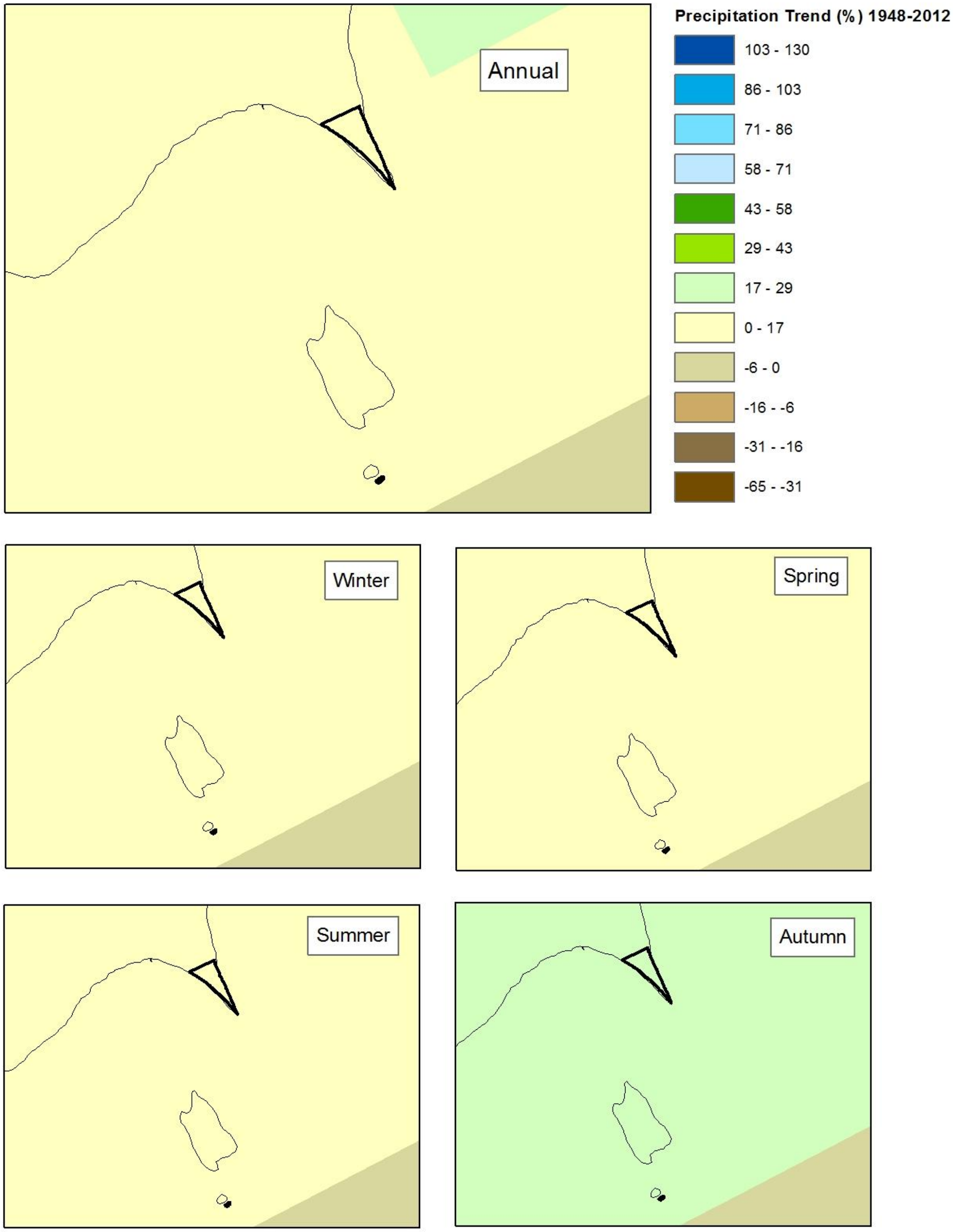
Windsor total annual and seasonal precipitation. Total annual precipitation demonstrated a statistically significant increase (P<0.05), +233 mm (26%) from 1941 to 2014. Winter (Dec, Jan, Feb) and autumn (Sep, Oct, Nov) both demonstrated a statistically significant (P<0.05) increase, the greatest being observed for winter, +99mm (53%).



Windsor total annual rain demonstrated a statistically significant (P<0.05) increase from 1941 to 2014, +163 mm (21%).



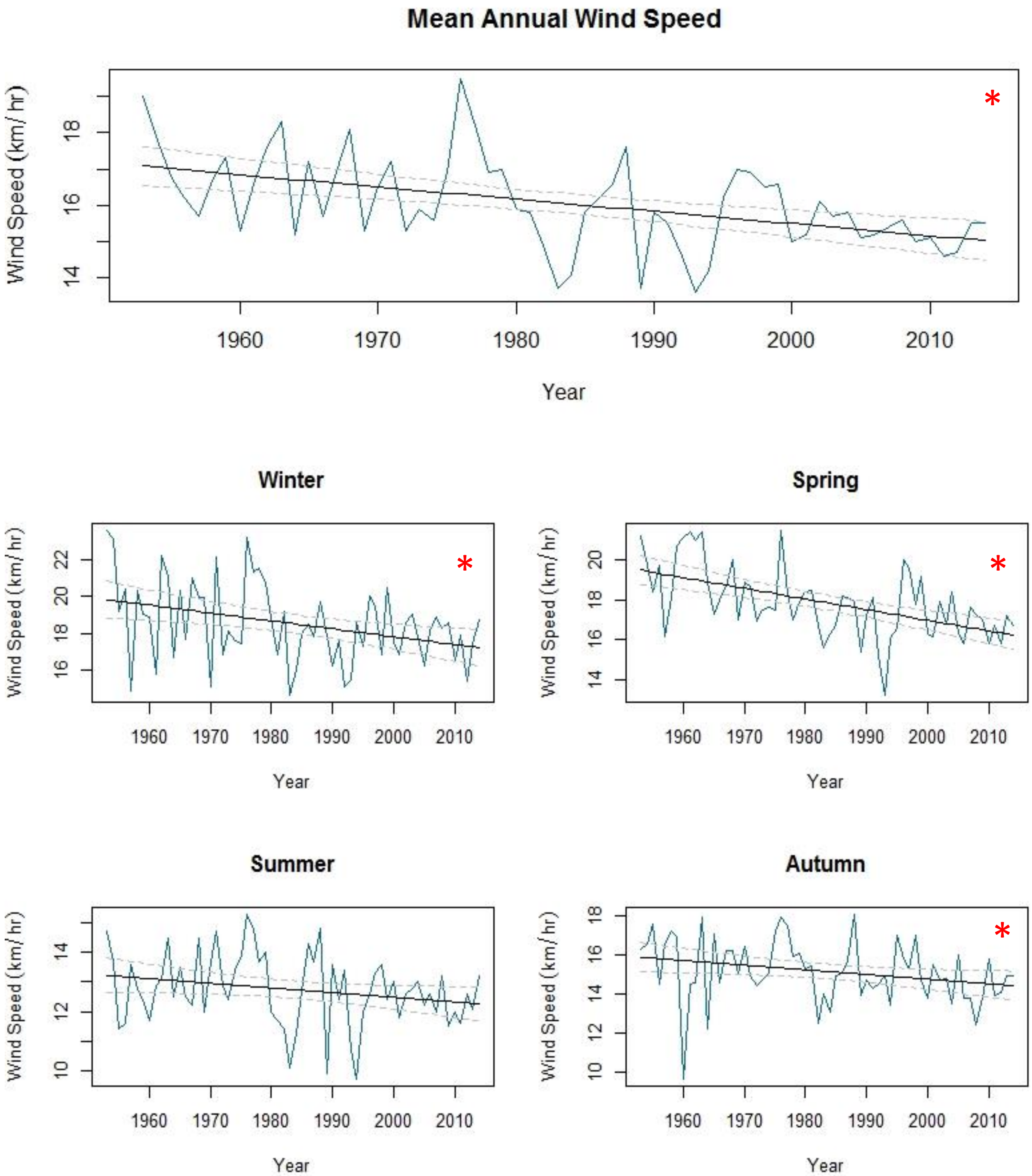
Windsor annual snow demonstrated a statistically significant (P<0.05) increase from 1941 to 2014, +69 mm (55%).



Total annual and seasonal precipitation trends (%) for Point Pelee NP for 1948-2012. Based on Canadian gridded data (CANGRD) the relative trends reflect the percent change in total precipitation over the period of record (1948-2012). Data source: https://climate-change.canada.ca/climate-data/#/historical-gridded-data.

1.3 Surface Wind Speed

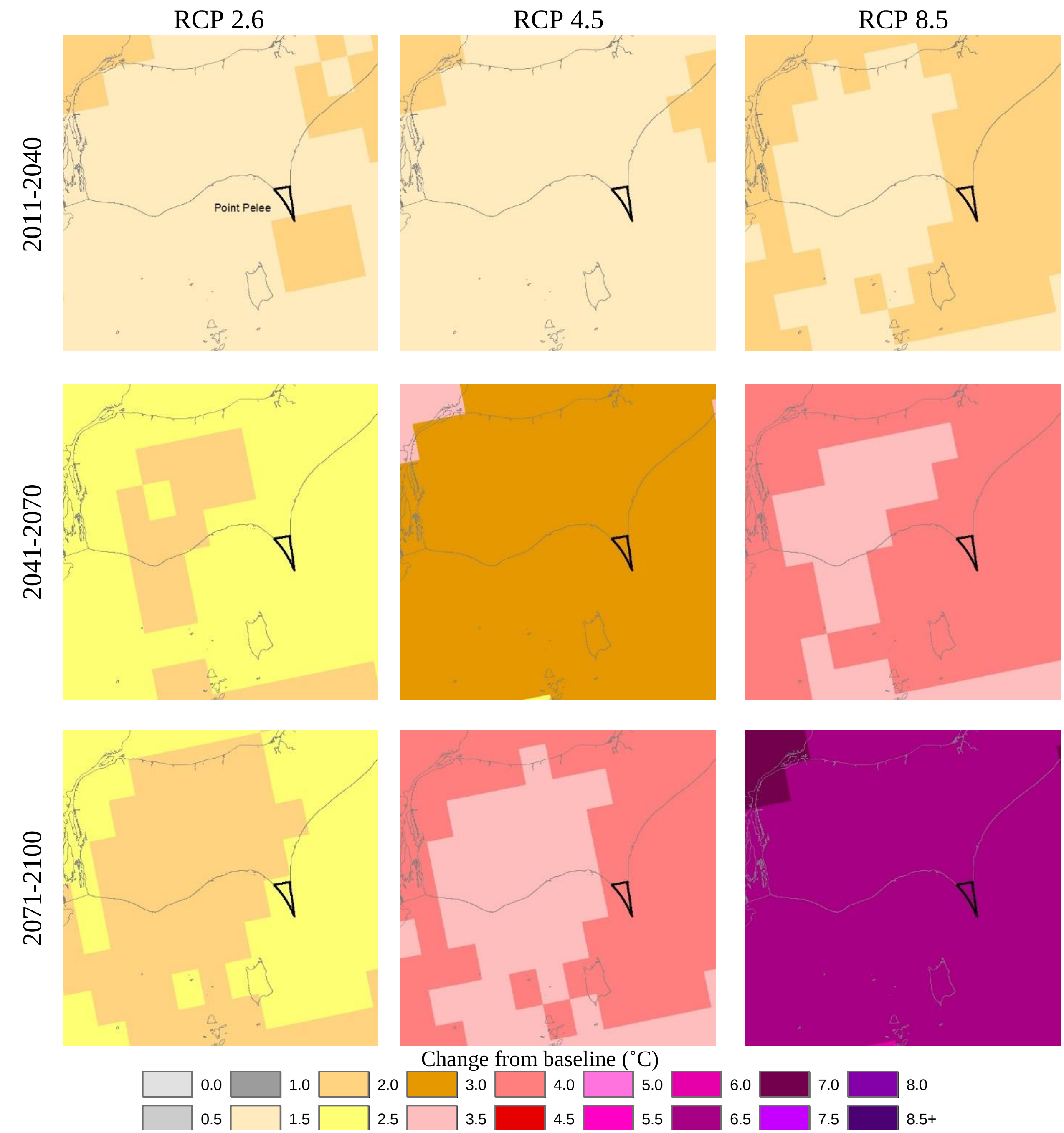
Windsor (6139525) is the closest meteorological station with long term wind data (ECCC, 2017). Trends from 1953 to 2014 determined using a generalized linear model (R Core Team, 2017) including 95% confidence intervals. "*" = statistically significant trend ($P<0.05$).



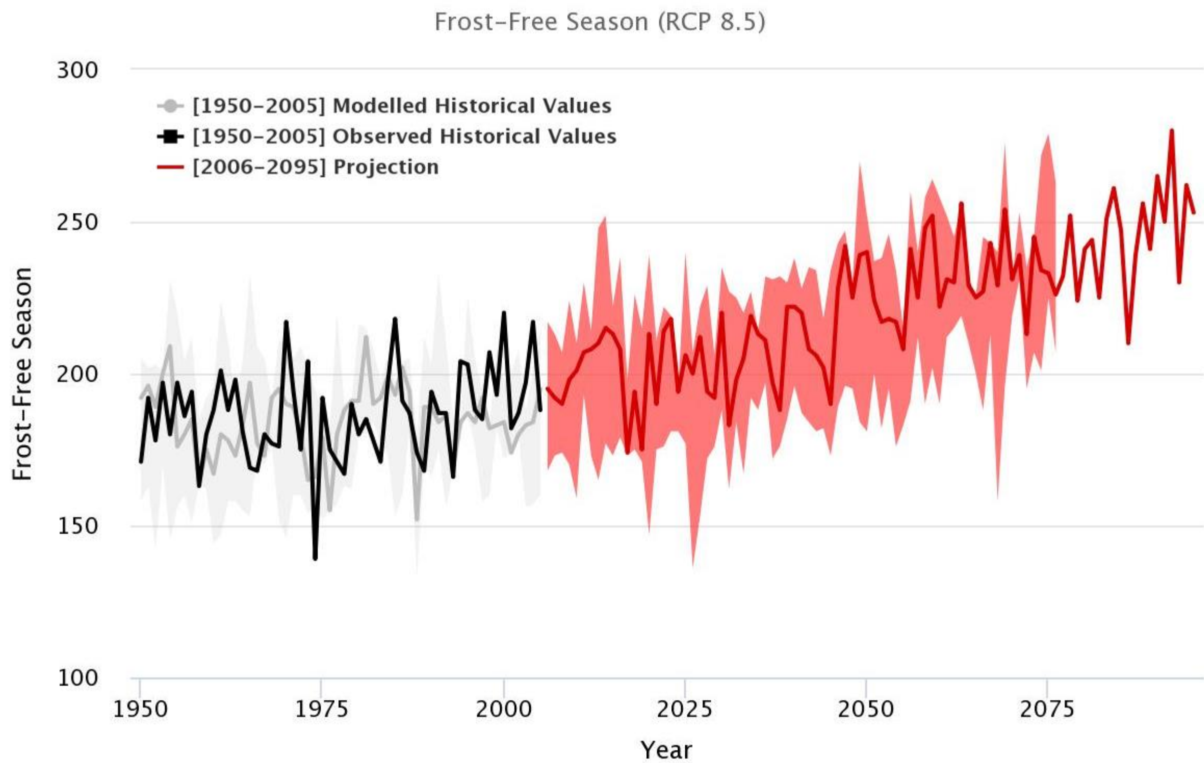
Windsor mean annual and seasonal wind speeds. Mean annual wind speeds have demonstrated a statistically significant ($P<0.05$) decrease, -2.5 km/hr (-14%) from 1953 to 2014. All seasons, except summer (Jun, Jul, Aug) demonstrated a statistically significant ($P<0.05$) decrease, the greatest being observed for spring, -3.9 km/hr (-19%) from 1953 to 2014.

2. Projected Climate Trends

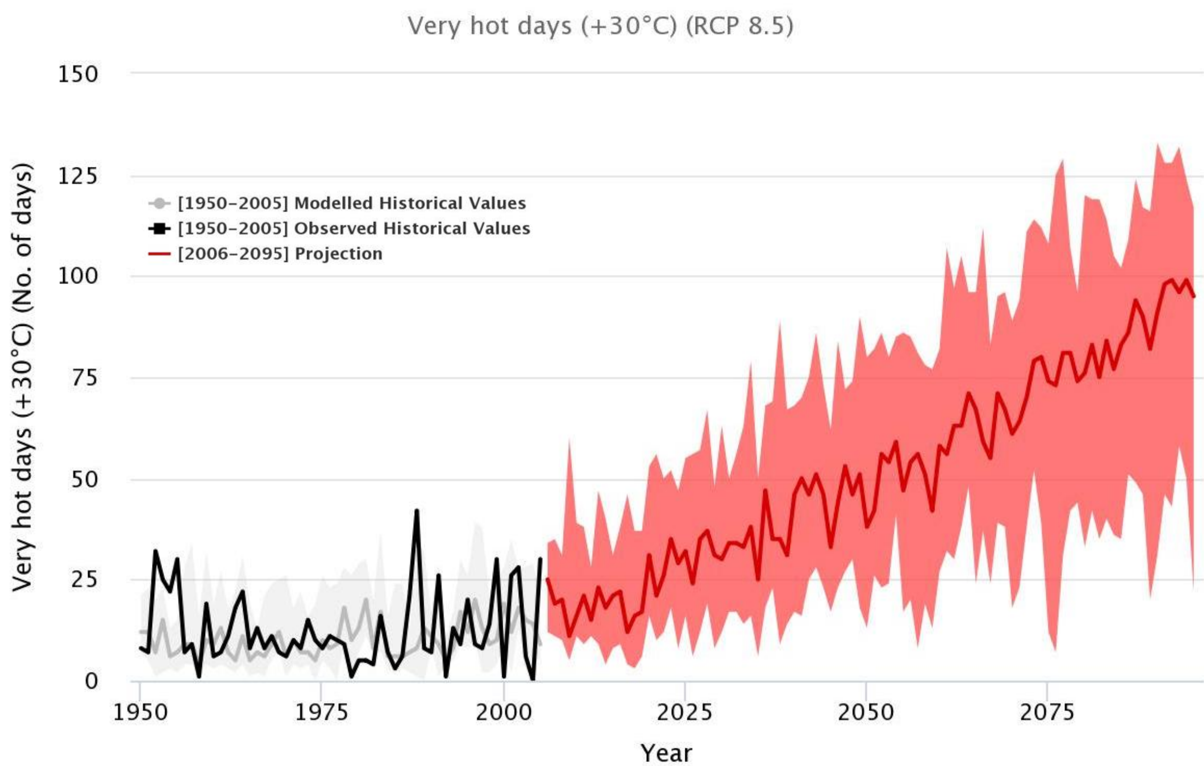
2.1 Temperature



Projected mean annual temperature increase for Point Pelee NP from a 1980-2010 baseline. Composite projection of CanESM2, CESM1CAM5, HADGEM2ES and MIROCESM. Data source: Natural Resources Canada, Canadian Forest Service, http://cfs.nrcan.gc.ca/projects/3 (Price *et al.*, 2011). Depending on the RCP scenario, mean annual temperatures are projected to increase 2.5 to 7°C by 2071-2100.

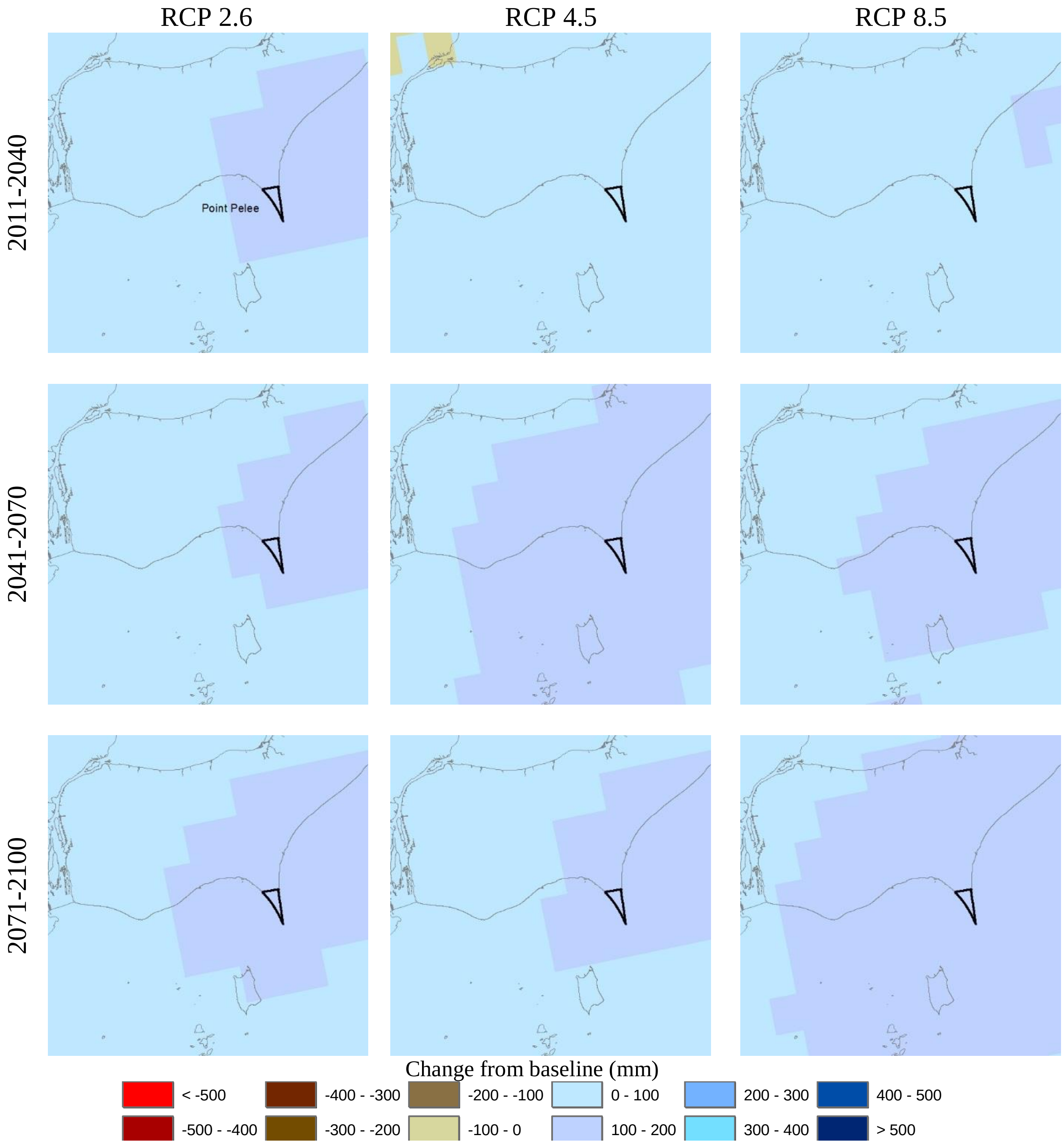


The frost-free season (days) for Leamington is projected to increase by 46.6 days from the 1976-2005 baseline by 2051-2080 (https://climateatlas.ca/). Frost-free season approximates the length of growing season (i.e., no freezing temperatures to kill or damage plants).



Very hot days (+30˚C) for Leamington are projected to increase from 11.7 days/year from the 1976-2005 baseline to 63.5 days/year by 2051-2080 (https://climateatlas.ca/).

2.2 Precipitation



Projected total annual precipitation change for Point Pelee NP from a 1980-2010 baseline. Composite projection of four spatially interpolated downscaled Global Circulation Models: CanESM2, CESM1CAM5, HADGEM2ES and MIROCESM. Data source Natural Resources Canada, Canadian Forest Service, http://cfs.nrcan.gc.ca/projects/3 (Price *et al.*, 2011). Depending on the RCP scenario, total annual precipitation is projected to increase 114 to 147 mm by 2071-2100.

Seasonal differences in precipitation patterns are expected. Increases in winter and spring are projected, while summer and autumn will be more variable with a trend towards drier summer conditions (https://climateatlas.ca/; Basile *et al.*, 2017; Byun and Hamlet, 2018), see Appendix 1.

Rainfall Intensity, Duration and Frequency (IDF)

These rainfall IDF values are calculated with IDF_CC Tool 3.0 (http://www.idf-cc-uwo.ca/) using Generalized Extreme Values (Simonovic *et al.*, 2017).

Baseline total precipitation amounts (mm) for Point Pelee NP from 1975-2004.

T (years)	2	5	10	25	50	100
5 min	9.75	12.62	14.45	16.67	18.26	19.79
10 min	14.31	18.17	20.33	22.67	24.18	25.50
15 min	16.85	21.63	24.64	28.27	30.85	33.31
30 min	20.46	27.72	33.93	43.83	53.02	64.06
1 h	25.45	36.81	46.21	60.78	73.92	89.35
2 h	30.98	45.11	56.46	73.53	88.54	105.73
6 h	39.81	57.33	71.73	93.89	113.77	136.97
12 h	45.93	64.78	80.78	106.15	129.00	149.40
24 h	52.65	72.93	88.36	110.47	129.00	149.40

Projected (2050-2100) precipitation (mm) for Point Pelee NP using an ensemble of models and **RCP 4.5**.

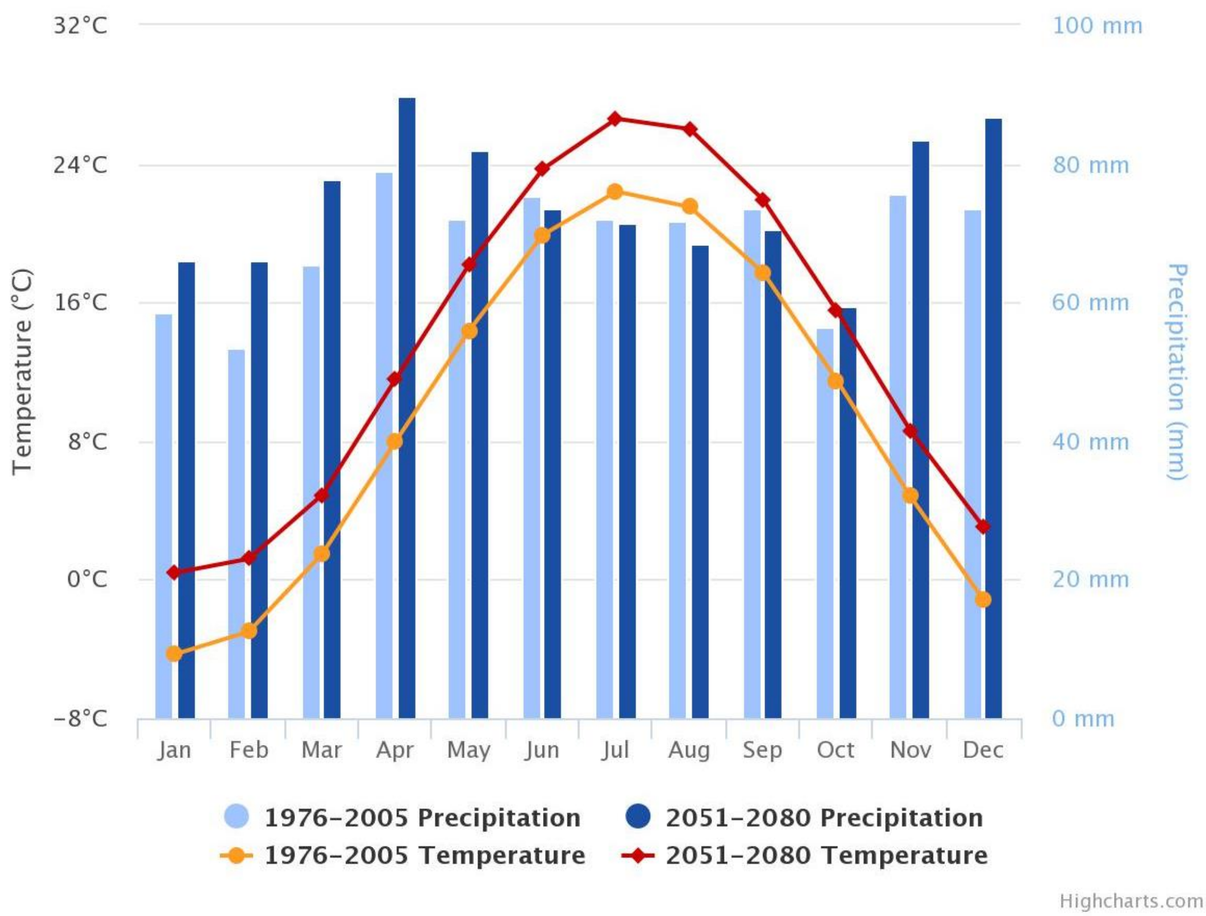
T (years)	2	5	10	25	50	100
5 min	12.64	17.11	19.26	23.03	25.88	28.76
10 min	18.50	24.53	27.16	31.42	34.38	37.16
15 min	21.82	29.33	32.86	39.07	43.74	48.42
30 min	26.63	37.71	44.75	59.17	72.74	83.37
1 h	33.26	49.91	60.87	82.20	101.81	118.31
2 h	40.43	61.16	74.51	99.83	122.61	142.32
6 h	52.00	77.76	94.55	127.11	156.90	182.00
12 h	59.94	87.91	106.27	143.18	177.70	205.82
24 h	68.57	99.12	117.10	150.98	180.20	206.04

Projected (2050-2100) precipitation (mm) for Point Pelee NP using an ensemble of models and **RCP 8.5**.

T (years)	2	5	10	25	50	100
5 min	13.44	18.04	20.88	24.95	27.21	29.32
10 min	19.73	25.93	29.36	34.16	36.45	38.44
15 min	23.22	30.91	35.60	42.34	46.00	49.39
30 min	28.16	39.93	49.50	63.68	74.96	89.32
1 h	35.10	52.81	67.02	88.40	105.07	125.70
2 h	42.73	64.63	81.78	107.41	126.83	149.96
6 h	54.90	82.25	104.04	136.73	162.00	193.02
12 h	63.28	93.12	117.44	154.01	183.17	214.05
24 h	72.58	104.54	128.21	162.72	187.04	214.05

Point Pelee NP IDF observations and projections. Observe that today's "one in 100 year" rainfall event (i.e., 89.35 mm/hr) is projected to be closer to a "one in 25 year" event by 2050-2100 and the future "one in 100 year" rainfall event is projected to increase in intensity (i.e., 118.31 – 125.70 mm/hr). In addition, the Climate Atlas of Canada (https://climateatlas.ca/) projects that the number of heavy precipitation days (>20mm) will increase from the 1976-2005 baseline of 7.4 to 8.7 days by 2051-2080.

2.3 Summary Climograph



Climograph for Leamington (RCP 8.5). Modelled monthly mean temperature and total precipitation for the 1976-2005 baseline and 2051-2080 future projection. Figure source: Climate Atlas of Canada (https://climateatlas.ca/).

3. Climate Change Impacts

3.1 Lake Erie

- The surface waters of the western Lake Erie are slowly warming (0.04 °C/yr) (Mason *et al.*, 2016).
- The length of the summer thermal stratification period in Lake Erie is increasing (Xiao *et al.*, 2018; Zhong *et al.*, 2016). For instance, the number of days with a surface water temperature greater than 4°C is projected to increase by 42-61 days by 2071-2100 relative to a 1971-2000 baseline (Dove-Thompson *et al.*, 2011; Trumpickas *et al.*, 2008).
- Wang *et al.* (2012) report that the spatial extent of ice coverage on Lake Erie declined by 50% from 1973 to 2010 and Mason *et al.* (2016) report a decline in ice cover duration of -0.59 days/year for Lake Erie. A decline in ice cover is projected to continue (Notaro *et al.*, 2015).

- Detailed analysis of historical changes to hydrology can be assessed using the North American Great Lakes hydrometeorological database (Hunter *et al.*, 2015; Smith *et al.*, 2016) and changes to ice cover using the Great Lakes Ice Atlas (https://www.glerl.noaa.gov/data/ice/atlas/).
- Lake level data is available for the Kingsville Hydrographic Station (02GH010) from 1962 to present day (https://wateroffice.ec.gc.ca/report/historical_e.html?stn=02GH010). Although no analysis was undertaken for this report, the data does highlight the variability in lake levels across times scales from hours to decades, with a recorded minimum/maximum difference of 2.3 m at this station. Also of note, although the marsh is periodically breached, it is generally a closed system with water levels slightly higher (~10cm) than the lake.
- Higher precipitation appears to have driven an increase in lake levels in 2017 (Gronewold and Rood, 2019).
- It is believed that earlier lake level models tended to overestimate the effect of evapotranspiration (ELPC, 2019). More recent methods generally project a modest decline in lake levels within historic range of variability (Lofgren and Rouhana, 2016; MacKay and Seglenieks, 2013; Notaro *et al.*, 2015).
- A decrease in protective winter ice is projected to increase vulnerability to coastal erosion (BaMasoud, 2013; BaMasoud and Byrne, 2011; 2012).
- Phosphorus loading into the lake is expected to be higher in spring due to increased precipitation and runoff from agricultural fields and decrease in summer (Collingsworth *et al.*, 2017; ECCC and OMECC, 2018).
- Maximum spring runoff is occurring earlier and with a lower amplitude, flooding from more extreme precipitation events is expected to increase (Adamowski *et al.*, 2013; Cheng *et al.*, 2012b; Cunderlik and Ouarda, 2009; Jones *et al.*, 2015; Karl *et al.*, 2009).
- Chu (2015) indicates (Figure 3) that the wetlands in Point Pelee have a high vulnerability to drying due to changes in air temperature and precipitation by the 2080s.
- Harmful algal blooms are increasing in frequency and severity and are directly influenced by climate change, e.g., increase runoff in heavy precipitation events, warmer water temperatures and stratification (Watson *et al.*, 2016).

3.2 Species

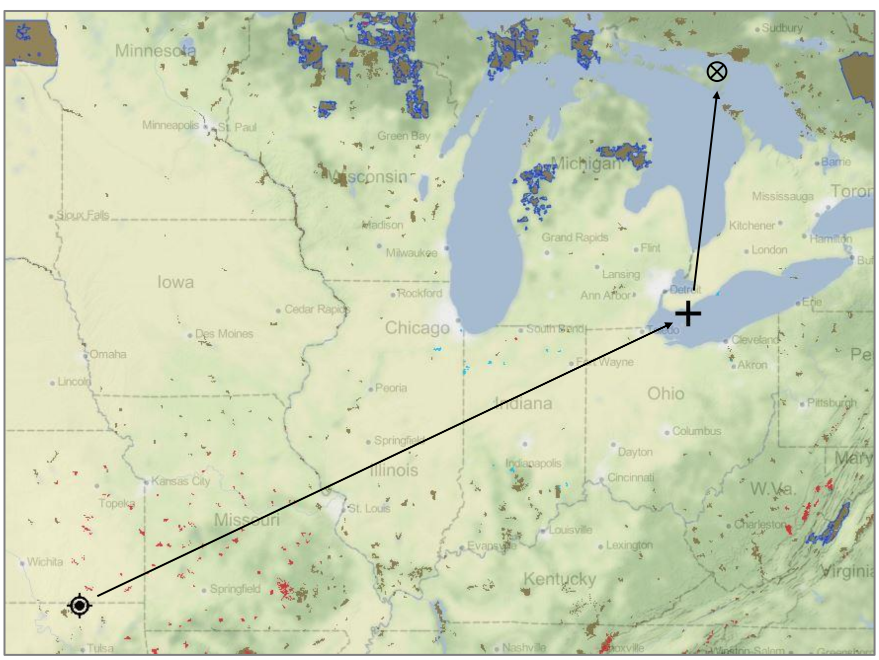
Biodiversity is the variety of genes, species and ecosystems and is essential to our social, economic and ecological well-being. The effects of climate change on biodiversity include: shifts in species distribution; changes in phenology; decoupling of interactions (plant-pollinator); reductions in population size; species extinction and extirpation; habitat loss; increased disease and spread of invasive species; competitive exclusion; and, change to ecosystem services (Nantel *et al.*, 2014; Nituch and Bowman, 2013; Pecl *et al.*, 2017).

- Brinker *et al*. (2018) determined that Fowler's Toad (*Anaxyrus fowleri*), Louisiana Waterthrush (*Parkesia motacilla*), Spoon-leaved Moss (*Bryoandersonia illecebra*), Northern Brook Lamprey (*Ichthyomyzon fossor*), Spotted Gar (*Lepisosteus oculatus*) and Common Five-lined Skink (*Plestiodon fasciatus*) are highly vulnerable to climate change in the park region.

- The Lake Erie Biodiversity Conservation Strategy includes an overview of climate trends and implications for biodiversity (Pearsall *et al.*, 2012).
- An increase in coastal erosion (i.e., decrease in protective ice) may directly impact coastal species (e.g., Nayak, 2018).
- Plant Hardiness is associated with probabilities of plant survival in relation to average, broad scale climatic conditions. Natural Resources Canada maintains a database that includes future projections of plant hardiness (http://www.planthardiness.gc.ca/). See Appendix 2 for potential changes in tree species distribution (e.g., 49% of assessed trees species are projected to be outside of their climatic range by 2071-2100).
- While warmer conditions may benefit the parks Prickly Pear Cactus (*Opuntia humifusa*) population, Drezner (2017) introduced the negative impacts from increased competition and successional change, and Lundy (2009) highlighted potential impacts from coastal erosion (i.e., decreased winter ice) and increased visitation.
- Evidence suggests that tree species are moving northward at 10-15 km/decade (Fei *et al.*, 2017; Woodall *et al.*, 2009).
- Utilizing the National Audubon Society birds and climate change data (e.g., http://climate.audubon.org/; Wu *et al.*, 2018) a preliminary assessment for PPNP, suggests a potential turnover for the park species between the present and 2050 is 35% in summer residents and 29% in winter residents.
- Browne and Hecnar (2007) discuss change in turtle population and community in PPNP and suggest that temperature-dependent sex determination was not a factor at that time.
- Although not explicitly based on future climate scenarios, Vis *et al.*, (2014) state-and-transition models for PPNP describes potential future conditions of the marsh based on lake levels and management interventions.

Climate Velocity

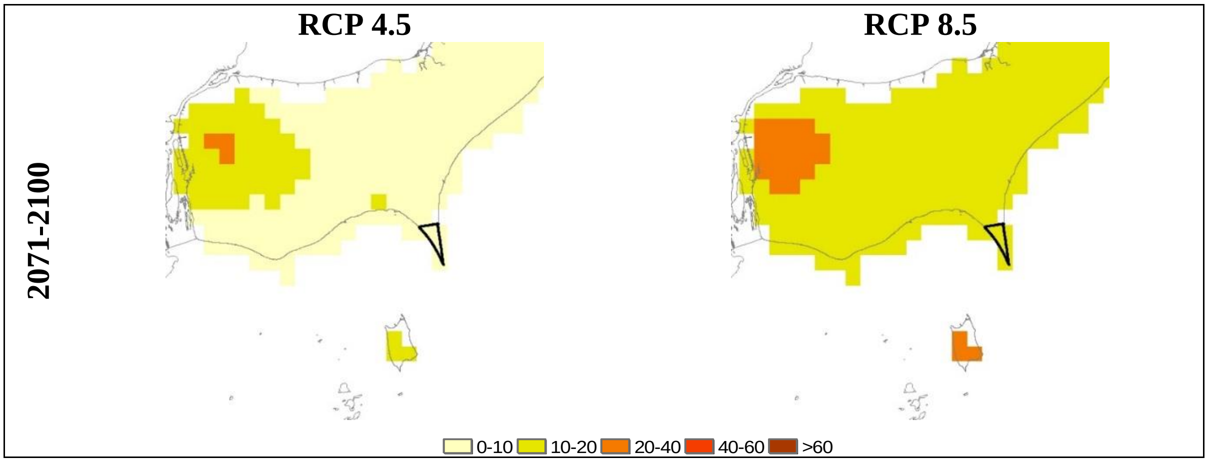
AdaptWest (https://adaptwest.databasin.org/) provides integrative tools that can inform conservation planning, including analysis on climate velocity.



Origin and destination of the future climate type for Point Pelee NP (2080's, RCP 8.5) determined using AdaptWest's Climate Displacement Tool. The forward or outgoing velocity is estimated to be **5.3 km/yr**, while the backward or incoming velocity is estimated to be **13.6 km/yr**.

3.3 Wildfire

Due to positive trends in drying and potential escalation of fire severity and intensity, a moderate increase in wildfire risk is projected for this area (Whitman *et al.*, 2015).



Projected increase in wildfire season for Point Pelee. Increased length in days from baseline (1981-2010) under RCP 4.5 and RCP 8.5 scenarios. Depending on the RCP scenario, an increase of 6 to 12 days is projected by 2071-2100. Data source: Natural Resources Canada, http://cfs.nrcan.gc.ca/fc-data-catalogue.

3.4 Visitor Experience and Operations

Visitor Experience

Visitation Patterns

Although visitation patterns are monitored during the operational season, assessing and predicting the influence of climate change on total visitation or park specific activities has not been explicitly studied. However, it is expected that visitation will increase due to an earlier spring and warmer summer and autumn conditions. Naturally, knowledge from other studies may help to inform management actions in this regard, for example:

- Visitation is projected to increase in Ontario's provincial parks by the 2020s (11–27%) due to a warmer climate, and this increase may be even higher (23-41%) when combined with demographic changes (Jones and Scott, 2006b).
- Maximum and minimum temperature were determined to be most influential climate variable for predicting visitation in 15 national parks (these parks accounted for 86% of Parks Canada's visitation at the time) (Jones and Scott, 2006a).
- At Pinery Provincial Park critical temperature thresholds for visitation were revealed as being less than 11˚C and above 29˚C during the shoulder season and above 33˚C during the peak season. Modelled projections resulted in a 3.1% increase in annual visitation for every degree of warming (+1 to +5˚C), despite increases in precipitation. Shoulder season visitation, particularly the autumn, is expected to increase (Hewer *et al.*, 2016; Hewer *et al.*, 2015; Hewer *et al.*, 2017a; 2017b).
- The US National Park Service examined visitation response across their network and found that it generally increased as mean monthly temperatures increased, but decreased strongly as temperatures exceeded 25˚C. Future climate/visitation projections suggest that

there is a complex and cascading effect and a need to develop park and neighbouring community adaptation strategies (Fisichelli *et al.*, 2015).

Recreational Opportunities

- Hewer and Gough (2018) reviewed 30 years of climate change impacts on outdoor recreation in Canada, including increased risks to cold-weather activities and opportunities for warm weather activities.
- Beaches / swimming areas may face closures due to poor recreational water quality from warmer waters and increased nutrient and bacteria loads (e.g., stormwater runoff). Harmful algal blooms and filamentous algae growth will increase under such conditions as well (Barton *et al.*, 2013; Reavie *et al.*, 2014).
- Decreased snowpack will negatively impact winter recreational activities such as snowshoeing, skiing, ice fishing, ice travel and snowmobiling.
- A longer and more intense fire season will affect visitor safety and experience (e.g., area closures).

Human Health

- Lyme disease (tick carrying the borrelia pathogen) is already present in PPNP and was formerly restricted to localized areas by temperature and relative humidity (Eisen *et al.*, 2016; Ogden *et al.*, 2006). Other pathogens associated with black legged ticks include arboviruses (encephalitis), Anaplasma, Ehrlichia, Babesia, Rickettsia and Bartonella (Nelder *et al.*, 2016). Companion animals are also at risk to Lyme and other tick-borne diseases (e.g., Public Health Ontario, 2017).
- Increasing incidences of West Nile Virus (mosquito vector) have been linked to climate change, including the temperature for mosquito development (14-35˚C) and the extrinsic incubation period (Chen *et al.*, 2013; Soverow *et al.*, 2009).
- The literature suggests that climate change will increase the northward expansion of mosquito's and associated pathogens (Wudel and Shadabi, 2016). The range of *Aedes albopictus* which is a vector for Zika virus, Dengue virus, Yellow fever and other diseases, is projected to expand into parts of Ontario by 2041-2070 (Ogden *et al.*, 2014).
- Changing weather and increased temperature can affect the rate of photochemical smog formation (e.g., ozone).
- Extreme weather events are the top risk globally in terms of likelihood and the second highest risk in terms of impact (after weapons of mass destruction) (World Economic Forum, 2018). Intense rainfall, lightning storms, hail, extreme winds and wildfire events are all potential hazards whose risks are projected to increase (e.g., Brimelow *et al.*, 2017; Cheng *et al.*, 2012a; IPCC, 2012). Besides a potential role in emergency preparedness and response, protected areas are increasingly being recognized as a "natural solution" in terms of disaster risk reduction (e.g., flood control, protection from storm surge, etc…) (e.g., Dudley *et al.*, 2015; Lo, 2016; Murti and Buyck, 2014).

Interpretation and Communication

Climate change is a theme in Parks Canada's communication and interpretation programs (e.g., https://www.pc.gc.ca/en/nature/science/climat-climate). By engaging and inspiring the public, Parks Canada is able to build support for its mandate and adaptation actions. A place for "natural solutions" is a concept used to frame and present Parks Canada's response to climate change mitigation and adaptation, as it highlights the importance and effectiveness of ecosystem-based approaches (e.g., CPC, 2013; NAWPA, 2012)

"The changing climate surrounds us, compelling us to tell the story" (US NPS). Of related interest, is the US National Park Service climate change interpretation and education strategy (US NPS, 2016) and climate change interpreter training (http://idp.eppley.org/training/specialist/interpreting-climate-change). Parks Canada staff have found this training to be very helpful.

Assets and Infrastructure

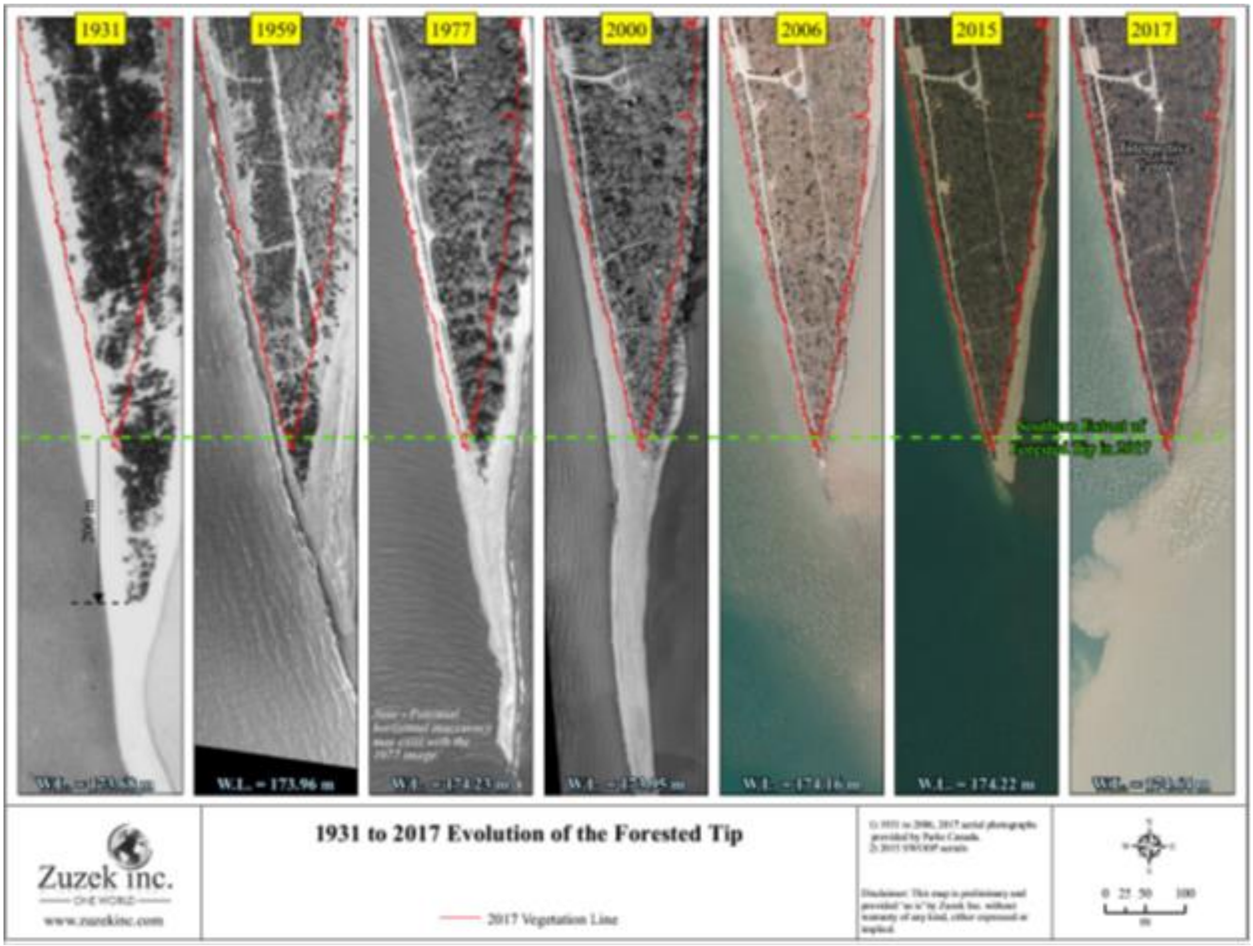
The impacts to Canada's assets and infrastructure from climate change are well documented (e.g., Boyle *et al.*, 2013; Canada, 2017; Palko and Lemmen, 2017; Warren and Lemmen, 2014) and are explicitly mentioned as a concern in Parks Canada's Departmental Plan (Parks Canada, 2017). Although an assessment of vulnerabilities and risks to infrastructure has not been completed at Point Pelee, in light of the information in this report, expected concerns could include:

- Localized flooding from intense rainfall and winter rain events.
- Freezing rain or hail damage to buildings and power/communication lines.
- Longer wildfire season and more intense burns.
- Increased lake storm intensity and less ice cover increases risk of coastal flooding and erosion
- Longer seasonal use of trails.
- Increased temperatures could lead to premature weathering. Similarly, increased spring rains could lead to premature weathering and deterioration (e.g., building foundations, corrosion, and mold).
- Summer drought increases water demands and may exceed system capacity.
- The energy demands for cooling buildings will increase.

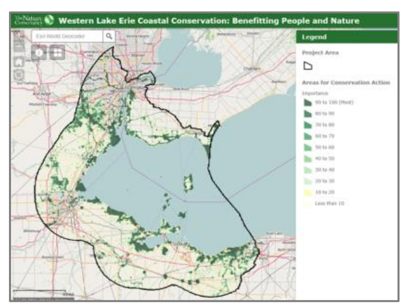
An assessment of greenhouse gas (GHG) emissions was not in the scope of this report. However, it is important to observe that throughout the document different RCP scenarios were presented and if we meet (and celebrate) RCP 2.6 or continue to track (and mourn) RCP 8.5, depends entirely on our actions to address and reduce GHG emissions today. Federally the government is committing to reducing GHG emissions by 80% below 2005 levels by 2050 (https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html). Also see Parks Canada's 2015 Master Plan to reduce GHG emissions (Parks Canada, 2015).

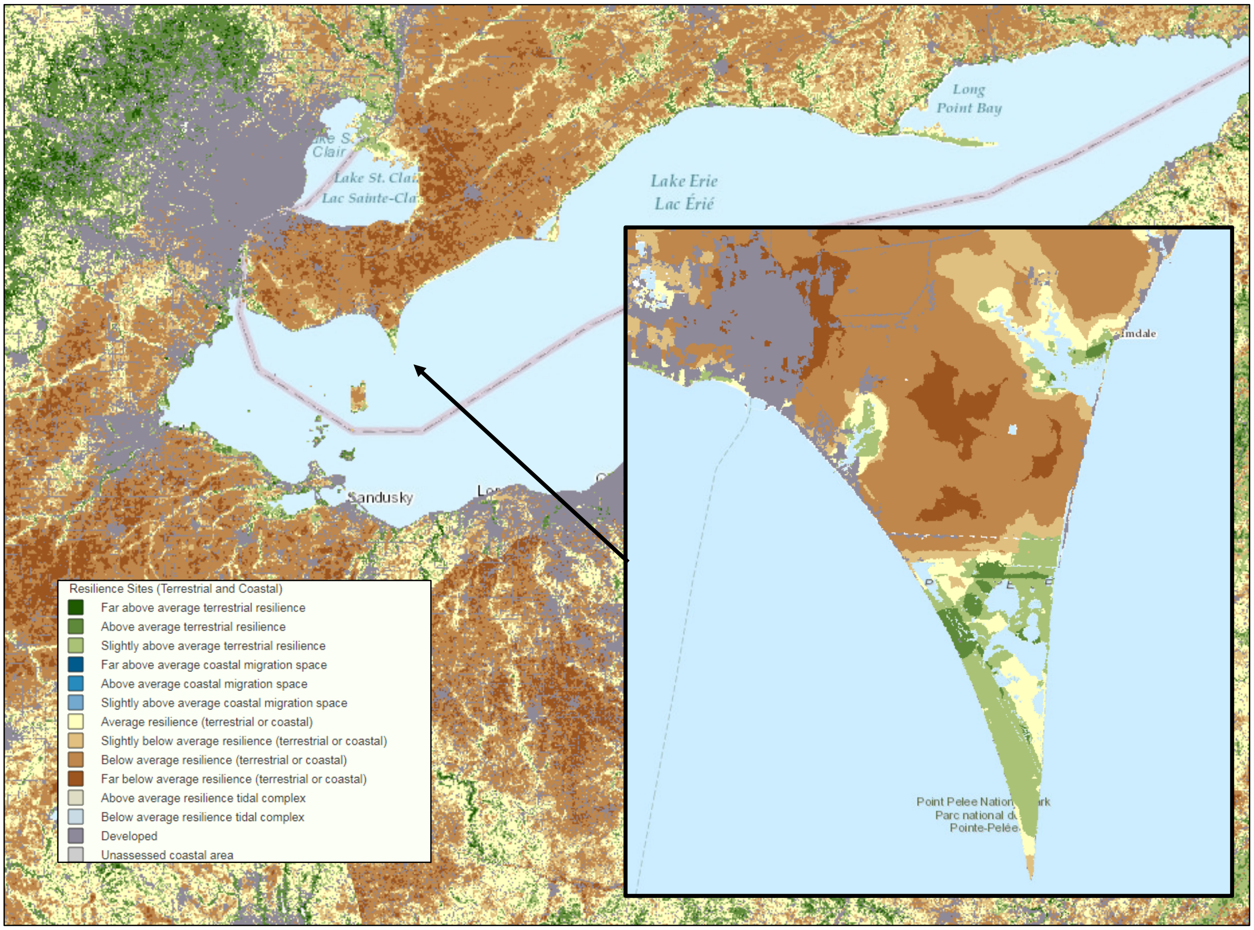
3.5 Related Information

Peter Zuzek (2018) prepared a "Synopsis of Point Pelee National Park Erosion and Mitigation Approaches", including a detailed summary of historical changes to the shoreline and a future projection.



The Nature Conservancy's (TNC) "Western Lake Erie Coastal Conservation" project includes maps of conservation opportunities for people and nature (https://conservationgateway.org/). In addition, the TNC's "Resilient Land Mapping Tool" highlights areas with sufficient variability and microclimate options to enable species and ecosystems to persist in the face of climate change (http://maps.tnc.org/resilientland/).





The Nature Conservancy's Resilient Land Mapping Tool (Anderson *et al.*, 2016).

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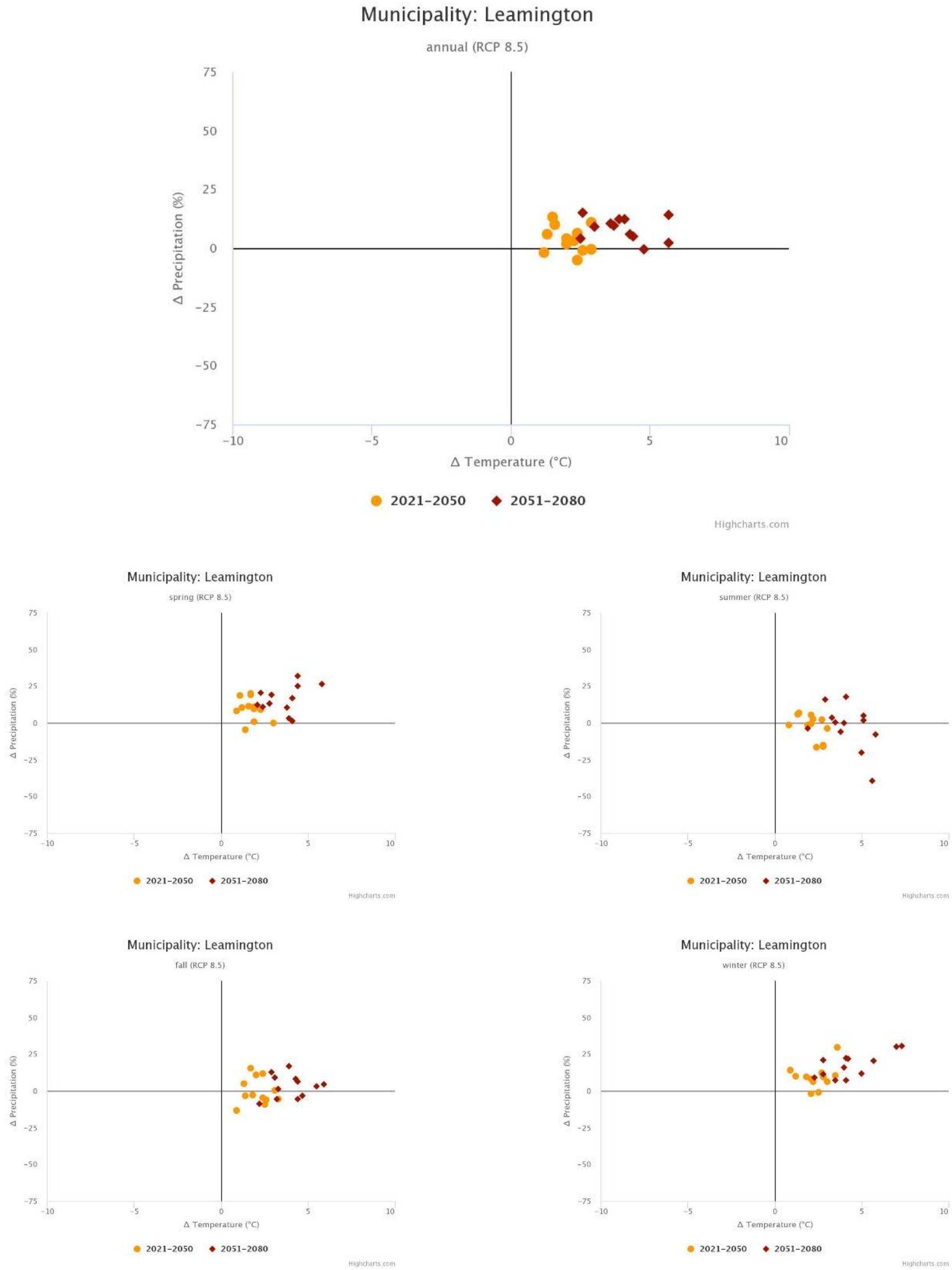
Appendix 1. Temperature and Precipitation Scatterplots

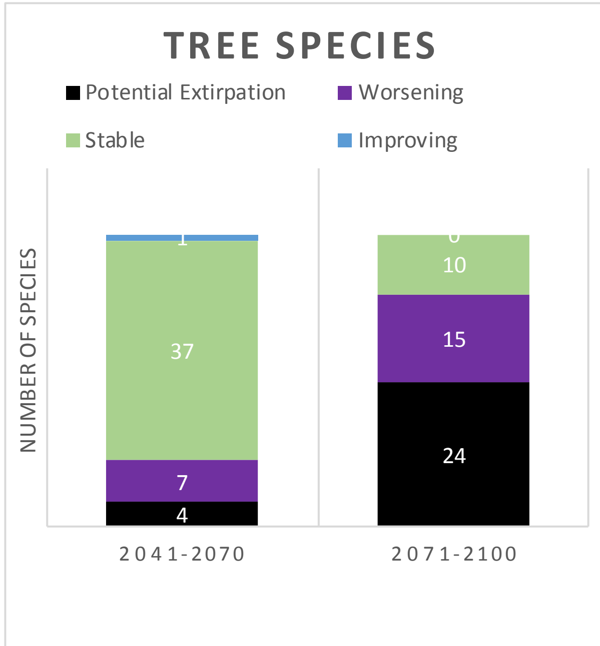


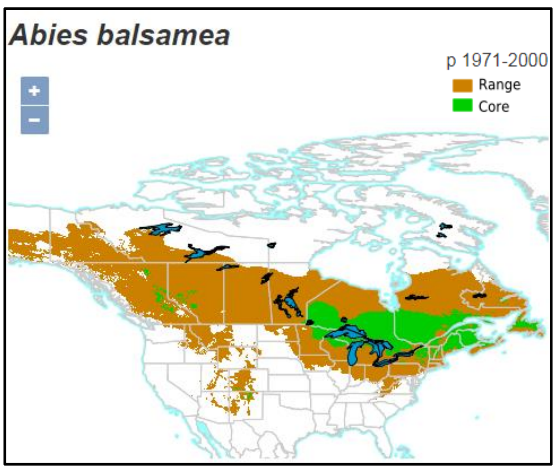
Climate models for Leamington. Each point represents a single model-simulated temperature/precipitation response to the RCP 8.5 scenario. Statistically downscaled data (Bias Corrected Spatial Disaggregation; BCSD) derived from 12 CMIP5 global climate models: ACCESS1.0, CanESM2, CCSM4, CNRM-CM5, CSIRO-Mk3-6.0, GFDL-ESM2G, HadGEM2-CC, HadGEM2-LR, INM-CM4, MPI-ESM-LR, MRI-CGCM3, MIROC5 (PCIC, 2014). All the models project warmer conditions and most project wetter conditions.

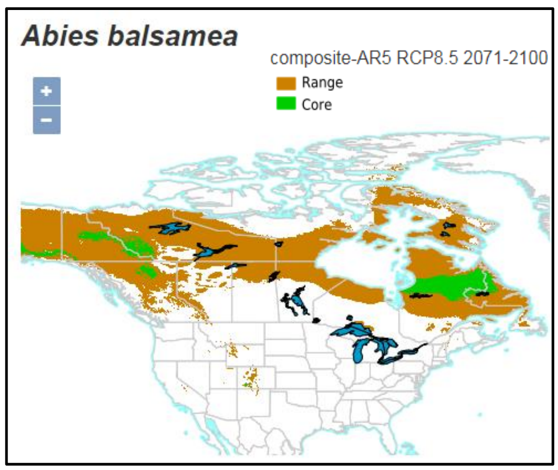
Appendix 2. Trees and Climate Change

Georgian Bay Islands National Park

- **Plant Hardiness** is associated with probabilities of plant survival in relation to average, broad scale climatic conditions. As the climate changes, habitat suitability for plant species also changes (McKenney *et al.*, 2001; McKenney *et al.*, 2014; McKenney *et al.*, 2011).
- Species climatic distribution based on the Current and ANUCLIM Composite-AR5, RCP8.5 maps and models within the Plant Hardiness of Canada database, http://planthardiness.gc.ca/.
- Some species are identified as being within their current climatic range, but may not actually be present in the area.
- Potential colonizers were not assessed (e.g., currently absent and may be within future range or core).







			2041-2070		2071-2100	
Common_Name	**Scientific_Name**	**Current**	**Range**	**Trend**	**Range**	**Trend**
Alternate-Leaf Dogwood	Cornus alternifolia	Range	Range	Stable	Absent	Potential Extirpation
American Beech	Fagus grandifolia	Core	Core	Stable	Absent	Potential Extirpation
American Chestnut	Castanea dentata	Range	Range	Stable	Absent	Potential Extirpation
American Elm	Ulmus americana	Core	Core	Stable	Range	Worsening
Balsam Poplar	Populus balsamifera	Range	Range	Stable	Absent	Potential Extirpation
Basswood	Tilia americana	Core	Range	Worsening	Range	Worsening
Bitternut Hickory	Carya cordiformis	Core	Core	Stable	Range	Worsening
Black Ash	Fraxinus nigra	Range	Range	Stable	Absent	Potential Extirpation
Black Cherry	Prunus serotina	Core	Core	Stable	Range	Worsening
Black Gum	Nyssa sylvatica	Range	Range	Stable	Range	Stable
Black Oak	Quercus velutina	Range	Range	Stable	Range	Stable
Black Walnut	Juglans nigra	Range	Range	Stable	Range	Stable
Black Willow	Salix nigra	Core	Core	Stable	Range	Worsening
Blue Ash	Fraxinus quadrangulata	Range	Range	Stable	Absent	Potential Extirpation
Blue-Beech	Carpinus caroliniana	Core	Core	Stable	Range	Worsening
Bur Oak	Quercus macrocarpa	Core	Range	Worsening	Range	Worsening
Butternut	Juglans cinerea	Core	Core	Stable	Absent	Potential Extirpation
Chokecherry	Prunus virginiana	Core	Range	Worsening	Absent	Potential Extirpation
Common Hoptree	Ptelea trifoliata	Range	Range	Stable	Absent	Potential Extirpation
Eastern Redcedar	Juniperus virginiana	Core	Core	Stable	Range	Worsening
Eastern White Cedar	Thuja occidentalis	Range	Absent	Potential Extirpation	Absent	Potential Extirpation
Eastern White Pine	Pinus strobus	Core	Range	Worsening	Range	Worsening
Green/Red Ash	Fraxinus pennsylvanica	Core	Core	Stable	Range	Worsening
Ironwood	Ostrya virginiana	Core	Core	Stable	Range	Worsening
Kentucky Coffeetree	Gymnocladus dioicus	Range	Range	Stable	Absent	Potential Extirpation
Largetooth Aspen	Populus grandidentata	Core	Absent	Potential Extirpation	Absent	Potential Extirpation
Manitoba Maple	Acer negundo	Core	Core	Stable	Range	Worsening
Northern Hackberry	Celtis occidentalis	Range	Range	Stable	Range	Stable
Ohio Buckeye	Aesculus glabra	Range	Range	Stable	Absent	Potential Extirpation
Pawpaw	Asimina triloba	Range	Range	Stable	Absent	Potential Extirpation
Peachleaf Willow	Salix amygdaloides	Core	Range	Worsening	Range	Worsening
Pin Cherry	Prunus pensylvanica	Range	Range	Stable	Absent	Potential Extirpation
Pin Oak	Quercus palustris	Range	Range	Stable	Absent	Potential Extirpation
Red Maple	Acer rubrum	Core	Core	Stable	Range	Worsening
Red Mulberry	Morus rubra	Range	Core	Improving	Range	Stable
Red Oak	Quercus rubra	Core	Core	Stable	Absent	Potential Extirpation
Sassafras	Sassafras albidum	Range	Range	Stable	Range	Stable
Shagbark Hickory	Carya ovata	Range	Range	Stable	Range	Stable
Shumard Oak	Quercus shumardii	Range	Range	Stable	Range	Stable
Silver Maple	Acer saccharinum	Core	Range	Worsening	Absent	Potential Extirpation
Sugar Maple	Acer saccharum	Core	Range	Worsening	Absent	Potential Extirpation
Swamp White Oak	Quercus bicolor	Range	Range	Stable	Absent	Potential Extirpation
Sycamore	Platanus occidentalis	Range	Range	Stable	Range	Stable
Tamarack	Larix laricina	Range	Absent	Potential Extirpation	Absent	Potential Extirpation
Trembling Aspen	Populus tremuloides	Range	Absent	Potential Extirpation	Absent	Potential Extirpation
Tulip Tree	Liriodendron tulipifera	Range	Range	Stable	Absent	Potential Extirpation
White Ash	Fraxinus americana	Core	Core	Stable	Range	Worsening
White Oak	Quercus alba	Range	Range	Stable	Range	Stable
Yellow Birch	Betula alleghaniensis	Range	Range	Stable	Absent	Potential Extirpation