THE CANADA COUNTRY STUDY:

Climate Impacts and Adaptation

ONTARIO REGION EXECUTIVE SUMMARY

Environment Canada

Canada

Ecozones
of
Ontario
MANITOBA
HUDSON PLAINS
BOREAL SHIELD
MIXEDWOOD PLAINS
QUÉBEC
Kenora
Thunder Bay
Timmins
Lake Superior
MINNESOTA
Sudbury
Sault Ste. Marie
N
St. Lawrence River
Georgian Bay
Ottawa
WISCONSIN
Lake Huron
Kingston
MICHIGAN
Toronto
Lake Ontario
Hamilton
London
0 100 200
kilometres
Lake Michigan
Windsor
Lake Erie
NEW YORK

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THE CANADA COUNTRY STUDY

Ontario Region Executive Summary

As the likelihood of climate change resulting from human activities increases, there is a growing need to estimate the magnitude of these changes, determine their impacts on the environment, our society and our economy, and identify the most effective strategies for adapting to the anticipated changes. This report summarizes the most recent literature describing the impacts of current climate and the potential effects of anticipated climate change on the environment and on those social and economic sectors in Ontario most likely to undergo significant changes.

Current Climate of Ontario

Ontario's climate varies widely from season to season and from one part of the province to another. In Northern Ontario, the climate is primarily continental, with cold winters and mild summers. Most precipitation falls in the form of summer showers and thunderstorms; winter snowfall amounts can be impressive, but usually contain less water. Precipitation amounts increase as one moves from northwest to southeast - a reflection of the increasing influence of moisture transported from the Great Lakes and the Gulf of Mexico. In Southern Ontario, the climate is highly modified by the influence of the Great Lakes. The addition of moisture from the Great Lakes in autumn and winter increases precipitation amounts, while the heat of the Great Lakes protects the region from the worst of winter’s cold. In the spring and summer, the cooler waters of the Great Lakes act to moderate the oppressive heat of tropical air, which regularly approaches the area. The combination of uniform precipitation amounts year-round, delayed spring and autumn, and moderated temperatures in winter and summer makes Southern Ontario’s climate one of the most suitable in Canada for both agriculture and human settlement.

Ontario experiences a variety of extreme weather events. In winter, Northern Ontario can have prolonged periods of extreme cold. Farther south, very heavy snow is a regular feature in the snowbelts to the lee of Lakes Superior and Huron, and Georgian Bay; major storms lash most parts of Ontario at least once or twice per year, with high winds and a mix of rain, freezing rain and snow. In spring, rapid snowmelt or ice jamming can lead to flooding of Ontario's rivers. Spring also marks the beginning of the tornado season in Southern Ontario, which has the highest frequency of tornadoes in Canada. In summer, thunderstorms can produce heavy downpours, hail, damaging winds and occasional tornadoes. Stagnant tropical air masses can bring poor air quality, heat waves and drought. In autumn, an early frost can damage crops, and remnants of hurricanes occasionally produce high winds and excessive rainfalls.

Impacts of Climate

Ontario's environment, society and economy are all affected by climate. The environment is well adapted to the current climate. Our economy and society have also adjusted, but as our knowledge of climate expands and our awareness of its impacts increases, further improvement is possible. The social and economic sectors most affected by climate include water resources, human health, the built environment, energy, transportation, tourism and recreation, forestry, agriculture, construction and finance. Some of the most significant impacts are listed below.

• The major climate-dependent regional air issues are: smog, fine particulates, acid rain, and hazardous air pollutants (HAPs). Local pollutant concentrations depend on: weather patterns, local and regional emission rates, and weather-dependent air chemistry. Concentrations of smog and particulates continue to exceed ambient air quality objectives on some days. Interannual climate variability affects the frequency of such weather-related extremes.

• Climate affects health directly, especially in summer through heat stress. Severe weather poses a hazard in all seasons. In addition, climate affects health indirectly by interacting with other atmospheric stressors.

• Variability in temperature and precipitation causes variations in lake levels and river flows, which affect hydroelectric power generation. Thunderstorms, freezing rain, high winds, freeze-thaw cycles and frozen ground affect the infrastructure of the energy distribution system. Wind patterns and cloud cover play a significant role in determining the feasibility of wind and solar energy. Daily and year-to-year fluctuations in energy demand are driven largely by temperature.

• The composition of terrestrial ecosystems is generally determined by temperature, water availability and soils. Aquatic ecosystems are affected by water temperature, the distribution of freshwater, and the hydrologic cycle. Past temperature changes of one degree have caused substantial changes in the home ranges of species.

• The boreal forest covers 82 percent of the total forested area in Ontario. Climate has direct (fire conditions and strong winds) and indirect (insects and disease) impacts on the health of existing stands and on restocking efforts. The forest industry is vulnerable to changes beyond the adaptive capability of trees, which are able to withstand most natural climate variability.

• Mean climate conditions and soils determine which agricultural products will be viable in a particular area. Year-to-year changes in productivity are governed largely by the interannual variability of climate.

• Up to four percent of building costs in Toronto are attributed to adaptation to current climate. Snow loading is a key determinant of structural strength. Temperature determines heating and cooling requirements. Precipitation amounts affect the design of dams, sewers, and other water management infrastructure. Freeze-thaw cycles, ultraviolet (UV) radiation and acid rain weather exterior surfaces. Severe weather events can damage or destroy structures. Snow and excessive rainfall affect operations on construction sites. Variations in temperature can cause building materials to expand and contract.

• The estimated total cost of damages (in 1989 dollars) for the major flood events recorded in Ontario between 1837 and 1989 is between $566 million and $1.5 billion.

• Extreme low lake levels can restrict the maximum cargo capacity of vessels, and can increase operating costs of ports and shipping channels. Temperatures and wind patterns affect ice conditions, which determine the operating season of the St. Lawrence Seaway. Colder winter temperatures require changes in fuels and lubricants and increase maintenance costs for aircraft and airports. Traction can be impaired by rain, snow and freezing precipitation. Snow removal and anti-icing costs comprise a large portion of road and airport operating budgets; some of the chemicals that are used damage vehicles, structures and ecosystems. Weather conditions have a major impact on flight operations, with consequences for profitability. Road and railway infrastructure can be damaged or rendered impassable by major winter storms, flooding and objects felled by wind. High winds are hazardous to shipping, and can prevent stacking of containers on trains.

- Each outdoor recreational activity has a set of climatic requirements and a level of sensitivity to fluctuations in climatic conditions; key climate variables are temperature, precipitation, sunshine and wind.

Future Climate of Ontario

For Ontario, results from some of the latest Global Circulation Model (GCM) simulations of climate, with an atmosphere containing twice the current amount of greenhouse gases, suggest an average annual warming of some 2° to 5°C by the latter part of the 21st century. Even if greenhouse gas amounts stabilize at that point, temperatures would continue to increase thereafter, with overall warming of 3° to 8°C possible. Increases will probably be greater in the winter than in the summer. These changes would significantly decrease the duration of the annual snow season and lengthen the growing season. They could increase the frequency and severity of extreme heat events in summer. It must be remembered, however, that even the most sophisticated GCMs do not incorporate the effects of important local climate controls, such as the Great Lakes. For this and other reasons, considerable uncertainty still exists about the application of GCM results on a regional scale.

Anticipated Impacts of Future Climate

While the greatest confidence is attached to projections of changes in temperatures, the most significant impacts are expected to result from the changes in other climatic conditions. These include changes in precipitation patterns, in soil moisture, and possibly in the frequency and intensity of severe weather events. Some of the key impacts of a changing climate are listed here.

- Changes in weather patterns may affect the frequency and intensity of pollution episodes. Air-water partitioning of HAPs may be affected by increased temperatures, and reduced frequency of lake turnover. Increased summertime temperatures could increase the volatilization of organic compounds, and the rates of chemical reactions, which could enhance the formation of ground-level ozone. However, these increases might be modulated by changes in cloud cover and precipitation frequency.

- Increased heat stress, and possible increases in the number or severity of episodes of poor air quality and extreme weather events could all have a negative effect on human health. A warmer climate may facilitate migration of disease-carrying organisms from other regions.

- Average water levels of the Great Lakes could decline to record low levels during the latter part of the 21st century. Water supply from both surface and groundwater sources is expected to decrease in Southern Ontario; the effect on water supply in Northern Ontario is unknown. Water demand is expected to increase during the summer months.

- Changes in the hydrologic cycle may result in more variability in water supply for hydroelectric power production. Energy demand is expected to increase in the summer and decrease in the winter.

- In the Great Lakes, the warming of waters in the summer is expected to cause fish species to shift northward. Many of the nearshore parts of the Great Lakes and stream waters will become too warm for salmonids in the summer, but will become optimal earlier in the spring and later in the autumn. Changes in wetlands and littoral areas may alter their efficacy as spawning and nursery areas. Some wetlands could shrink or disappear, others could move or expand, and new wetlands could be created. Increases in water temperature in the Great Lakes could reduce the frequency of overturning, which would seriously affect aquatic ecosystems.

- The cool temperate, moderate temperate and grassland regions are expected to expand northwards as the boreal forest retreats. Additional damage to forest ecosystems by pests and diseases, and increased frequency and intensity of fires may occur. Some moose and caribou habitat could be destroyed, leading to a decrease in the numbers of these animals. Species currently threatened with extinction face the greatest risk of extinction in a changing climate, while opportunities for successful establishment of exotic species will be enhanced. Forest industry operating costs may increase because of a shorter winter harvesting season.

- Warmer temperatures and a longer growing season may increase opportunities for crop selection. Productivity in some areas may be limited by moisture rather than by temperature. Should climate variability increase, it would increase variability in productivity. Increased concentrations of carbon dioxide (CO_2) may improve yields and water utilization for some crop types.

- Decreased snow load may result in reduced cost of buildings and infrastructure. More frequent freeze-thaw cycles could increase weathering. The need for heating will be reduced, while demand for cooling will increase. Warmer winters will lengthen the construction season. In far Northern Ontario, degradation of permafrost may affect the stability of existing structures and the conditions for future construction.

- Changes in the frequency or intensity of extreme events would have consequences for the property insurance industry and possibly for disaster-relief agencies. Changes in human health could affect the health and life insurance and pension industries.

- Reduced ice on the Great Lakes is expected to increase the length of the shipping season. Dramatically lower lake levels would reduce the maximum capacity of vessels and could increase operating costs for ports and shipping channels. Changes in shipping conditions on the Great Lakes could affect demand for bulk shipment by rail. Changes in production of climate-sensitive commodities, such as agricultural products, could affect demand for rail and marine transport. The need for snow removal and aircraft de-icing could be reduced in Southern Ontario. Shorter seasons are anticipated for winter maintenance in Northern Ontario.

- Snow conditions are expected to be less reliable for outdoor winter recreation. Increased use of beaches and parks is possible as the annual period of favourable temperatures lengthens; this may be limited by beach aesthetics and water quality.

Adaptation to Climate Variability and Change

As we have seen, many aspects of Ontario's environment, economy and society are sensitive to climate variability and anticipated changes in climate conditions. One way Ontario could lessen the impacts of a changing climate is to reduce known vulnerabilities to current climate variability. In some cases, a changing climate could necessitate additional adaptive actions. Some adaptive strategies for climate sensitive sectors are suggested here.

- Increased use of energy-efficient cooling technologies and practices would reduce heat stress on humans. Adjustments in the health care system may be necessary to cope with new diseases.

- Water demand can be reduced through increased efficiencies of its delivery and utilization. Adjustment of shoreline ecosystems and facilities may be necessary to compensate for lower water levels.

- Energy conservation and efficiency measures should be encouraged. Water storage could be increased to reduce the variability of water supply for electricity production.

- Efforts to restore degraded habitats and preserve existing ecosystems should allow for expected changes in climate and their effects on optimum ranges of species. Where the establishment of exotic species is inevitable, it may be possible to select species that would be most beneficial to other components of the ecosystem.

- Preservation of existing tree stocks could be enhanced by increased public education and fire suppression, and improved pest and disease management. When replanting, new strains or species more tolerant of expected conditions could be introduced. Practices may have to be tuned to optimize use of these resources.

• Crop types could be adjusted and new agricultural areas developed as climate changes. Crop insurance programs could be adjusted to encourage adaptation.

• Water control structures may need to be redesigned to handle greater variability of precipitation, including a possible increase in the intensity of extreme events. Building codes and land-use planning regulations may need to be revised.

• Improved knowledge regarding spatial patterns of, and trends in extreme weather events is necessary to improve estimates of future risk. The insurance industry could have more input into land-use planning to reduce exposure to future risks.

• Road weather information systems could be used more widely to optimize winter maintenance operations. Cleaner energy technologies would reduce emissions of pollutants. Increased use of communications technology could reduce the need for travel. More convenient public transit could encourage reductions in automobile usage. Shipping channels and ports may require increased dredging when lake levels are low.

• Operations at recreational facilities could be diversified to improve resilience to climate variability.

• Reducing emissions remains the best way to address air issues.

Areas Requiring Further Research

Information regarding climate change impacts, especially on regional scales, is still somewhat inexact. Although much more is known about the impacts of current climate variability, there remain gaps in our knowledge in this area, too. In order to better assess the relative magnitudes of climate impacts, and devise effective adaptation strategies, more research is required in all areas. Some of the key areas for future study are:

• climate and impacts modelling—increasingly accurate simulations of climate on regional and smaller scales, and better simulations of the hydrologic cycle, to improve our ability to quantify impacts of future climate;

• integrated air issues—the interaction of the various air issues with climate and with each other, as well as our understanding of their synergistic impacts on human and ecosystem health, and on economic sectors sensitive to atmospheric stresses;

• the impact of climate on water resources—on groundwater across Ontario, and also on surface waters in Northern Ontario;

• the climatology of severe weather and climate events—this should continue to be refined as more data becomes available, so that sectors sensitive to extreme events are better able to quantify risks;

• response strategy development—continued development will be possible as the scientific foundation continues to improve.

Accessible, high-quality environmental and socio-economic data is a requisite in order to detect climate change, to understand climate impacts, and to formulate and execute effective adaptation strategies.

Concluding Remarks

Adapting most effectively to a changing climate requires a knowledge of how climate will change and how the changes will affect the environment, society and the economy. However, changes in other key variables, such as technology, personal preferences and social values, will probably influence both the rate of climate change and our ability to adapt to it. For this reason, the unforeseeable future, the most prudent strategies to adopt today are so-called "no regrets" strategies. That is, regardless of what changes occur, these strategies will provide a net benefit to the environment, society and the economy. Examples of no-regrets strategies include more efficient use of energy and materials, and improving adaptation to current climate.

For Ontario, a changing climate will present challenges for some sectors, and opportunities for others. The present technology of climate prediction and our knowledge of climate impacts do not allow us to make confident estimates of losses and benefits. However, most expert opinion suggests that climate will continue to change, and that the costs of the impacts are likely to exceed the benefits from a warmer climate. Therefore, a sensible approach would be to: minimize anthropogenic forcing of climate change to the extent possible, without unduly disrupting the very environmental, social and economic systems we seek to preserve; and to improve our adaptation to current climate conditions in ways that will increase our ability to adjust to future changes.

The responsibility for action is broadly based: the scientific community must provide advice and information; governments must identify and eliminate barriers and disincentives to adaptation; and those in affected sectors must educate themselves about the risks and opportunities of a changing climate and act accordingly.