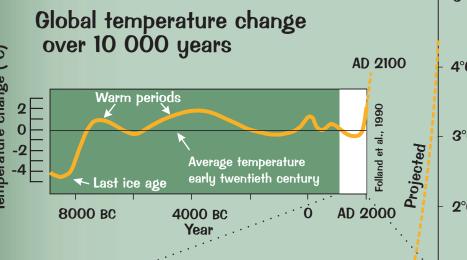
## The climate system — a balancing act

#### What is climate? The main elements of the climate system include the Sun (source of heat energy), atmosphere (providing a protective blanket), oceans (helping to distribute heat through its currents), water (as rain, snow, or ice), and land (reflecting or absorbing energy from the Sun). Changes to any of these

elements affect the balance of the entire system. Earth's climate is naturally variable. Warming and cooling trends are part of

#### Climate has always changed normal climatic cycles. Climatic conditions vary within a single year, from one year to the next, and over decades, centuries, and millennia. Historically, there have been frequent changes in climate, with repeated fluctuations between colder and warmer conditions.



Varm → ← Little Ice Age — 1998 → Past changes in climate have been

the last Ice Age (about 20 000 years ago), what is now Toronto was buried under about 900 metres of ice! Mann, M.E., Bradley, R.C., and Hughes, M.K., 1999: Northern hemisphere temperature during

century will not be the same as it has been in recent history.

Atmospheric CO<sub>2</sub> concentrations

Although a number of uncertainties about the rate and timing of change remain

Where we live, work, and play, how and what we build,

and how we travel are all affected by weather events and climate. Many

decisions we make routinely every day are affected by the weather: what we

wear, how we travel, and how we use our recreational time. Many things we

depend on in our day-to-day lives are affected by climate: the design capacity

freeze-thaw cycles could speed up the weathering process on our buildings and

Francis, D. and Hengeveld, H., 1998: Extreme weather and climate change; Climate Change

of our sewer systems, the energy efficiency of our houses, and the delineation

Canada, the average temperature has increased by 0.9°C since 1948.

Environmental Indicator Series; State of the Environment Bulletin

of hazardous areas such as flood plains, for example.

Shorter winters will likely mean

lower maintenance and snow-

removal costs for our roads

and railways, a shorter winter

recreation season, and a

transmission and road and

the fact is that Earth is experiencing a warming trend. The average global

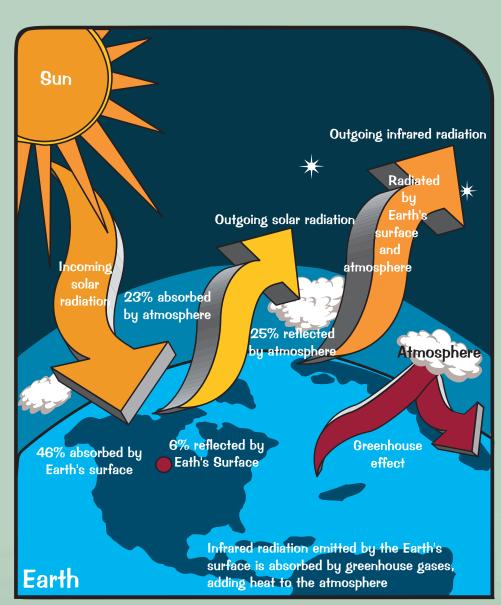
temperature has increased by approximately 0.5°C over the past 100 years. In

global ecosystems, with significant

impacts on natural habitat and human development. At the peak of Ice-age glacier 900 m thick

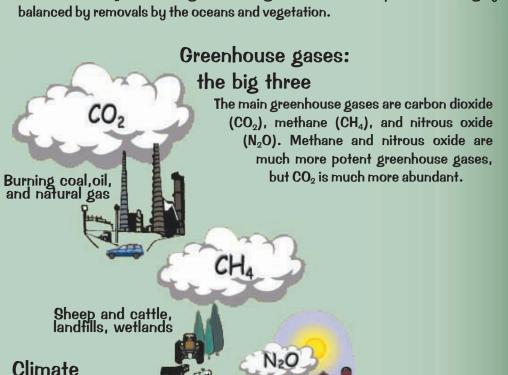
Of the total amount of radiation received from the Sun, roughly one third is reflected back into space by clouds and the Earth's surface. The remainder is absorbed by the Earth and its atmosphere. Some of this heat is radiated back into space, but most of it is trapped by our atmosphere, which acts like a large insulating blanket. The 'greenhouse effect' refers to the heat-trapping quality of the atmosphere created by gases known as 'greenhouse gases'.

Without this insulation, Earth would be about 33°C colder than it is now, making it inhospitable to life. When the amounts of these gases change, the capacity of the atmosphere to trap heat also changes.



Government of Canada, 1999: Canada's Perspective on Climate Change: Science, Impacts and n (online; http://www.ec.gc.ca/cc/CoP5/SIA/english/index.htm). Folland, C.K., Karl, T.R., and Vinnikov, K., 1990: Observed climate variations and change; in Climate Change: the IPCC (Intergovernmental Panel on Climate Change) Scientific Assessment,

Carbon is naturally present in the atmosphere (as  $CO_2$ ) and in the oceans. Huge amounts of carbon are also stored within the Earth in fossil fuels and sedimentary rocks, and in vegetation and soils. Before the Industrial Revolution, additions of CO<sub>2</sub> and other greenhouse gases to the atmosphere were largely



describes the day-to-day and hour-byhour changes in atmospheric conditions at a given location. 'Climate' describes the synthesis of these day-to-day variations into a set of average or expected conditions. Traditionally, it has been assumed that the climate we have experienced in recent history will be the climate we will experience in the future.

Many of the decisions we make as a society depend on this assumption.

Did you know? Although instrumental temperature records only date back about 150 years scientists can establish temperatures back tens of thousands of years by analyzing the gases found in ice cores from the Arctic and Antarctic.

Environment Canada, 1993: A matter of degrees: a primer on global warming: The Environmental

The current scientific consensus is that Earth's climate in the twenty-first

Primarily as a result of our use of fossil fuels, human activities over the last 100 years have increased the amount of greenhouse gases in the atmosphere.

This 'enhanced' greenhouse effect has the potential to warm the planet at a rate never before experienced in human history.

Ontario's climate in the twenty-Scientists now estimate that Ontario will warm an average of 2°C to 5°C within the next 75 to 100 1975–1985 and 2040–2060 years. Temperature increases will be greater in the winter than in the summer and the frequency and severity of extreme weather events are likely

Venus has an atmosphere that is 98% CO2. Due to the extreme greenhouse effect, temperatures reach 430°C. Similar conditions would exist on Earth if all the carbon

stored in rocks and vegetation was released as CO<sub>2</sub>.

Powerful computer simulations called general circulation models or global climate models (GCMs) are the primary tools for estimating the future climate. These models are complex mathematical approximations of processes that underlie the global climate system. The complex elements of the climate system - such as oceans, land masses, the atmosphere, ice and snow, and many other influencing factors - are reproduced by the GCM. The model then allows scientists to estimate future conditions based on the manipulation of various elements of the climate system within the model.

Environment Canada, 1998: Climate change; National Hengeveld, H.G., 2000: Projections for Canada's climate future: a Smith, J.V., Lavender, B., Auld, H., Broadhurst, D., and Bullock T., 1998: Turner, R.J.W. and Clague, J.J., 1999: Temperature rising: climate Adapting to climate variability and change in Ontario; Volume IV of the Canada change in southwestern British Columbia; Geological Survey of discussion of recent simulations with the Canadian Global Climate

# Where we live

Ontario falls prey to a number of natural hazards: drought, heat waves, floods, rain, snow and ice storms, tornadoes, and hurricanes (although rare). Small changes in average climate conditions are expected to generate significant

fewer extremely cold days and more extremely hot days > more severe thunderstorms, which can cause injury and property damage; more frequent freezing rain events.

and Responses, (ed.)B. Mills and L. Craig; *in* Proceedings of a Workshop held May 27-28, 1998,

er year in Ontario, 1991-1999

Haley, D., 1999: Perspectives from the Toronto and Region Conservation Authority. Atmospheric

Change in the Toronto-Niagara region: Towards an Integrated Understanding of Science, Impacts

The ice storm of January 1998 deposited about twice the amount of freezing

rain than previous ice storms on record. Stretching from as far west as Kitchener, through eastern Ontario, western Quebec, and the Eastern Townships to the Fundy coasts of New Brun<mark>sw</mark>ick <mark>and</mark> Nova Scotia, the storm caused at least 25 deaths, many from hypothermia; ➤ about 100 000 households to lose power in Ontario, 900 000 in Quebec;

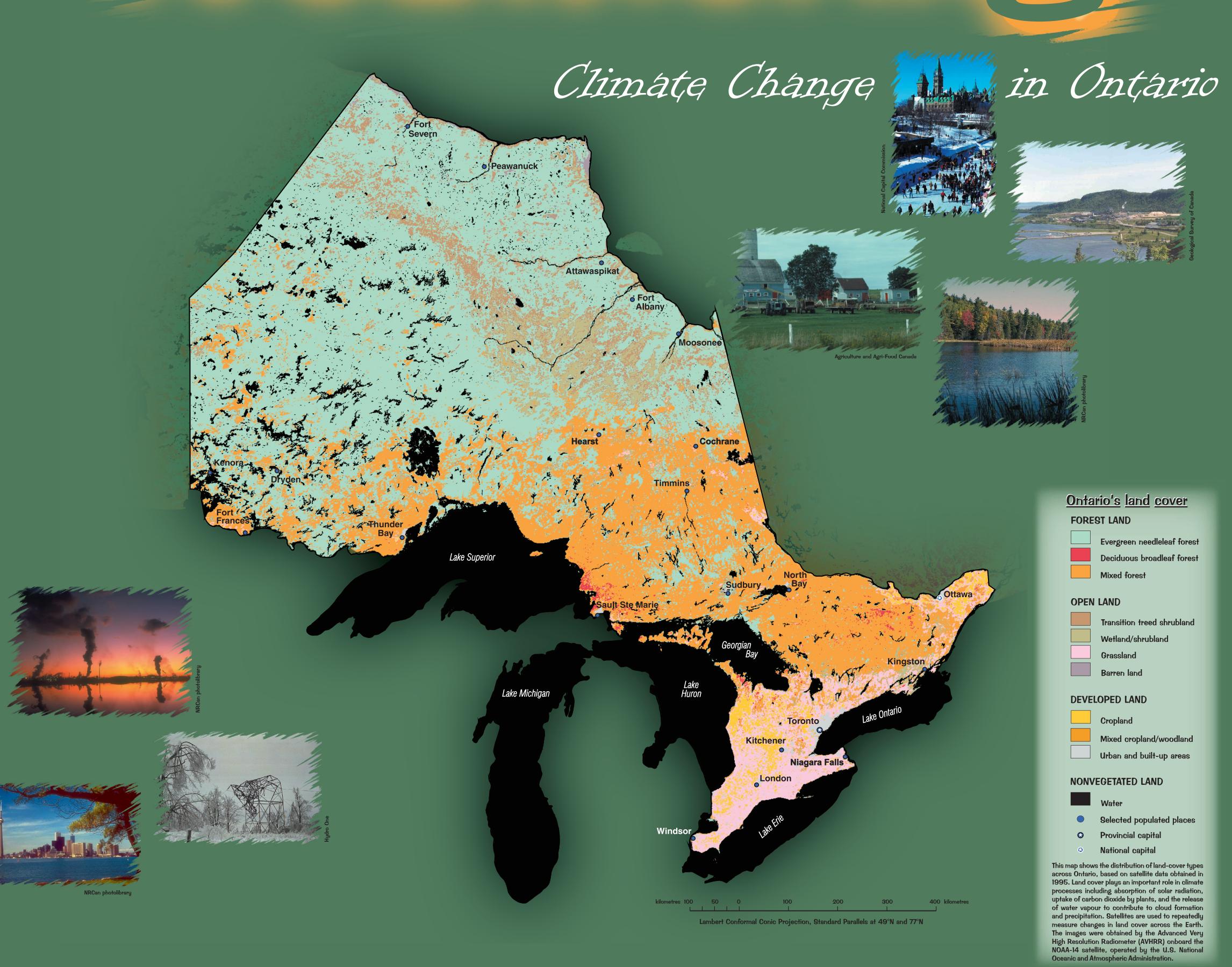
▶ 14 000 troops to be deployed to help with clean up, evacuation, and > the destruction of millions of trees, 120 000 km of power lines and telephone cables, 130 major transmission towers each worth \$100 000, and about 30 000 wooden utility poles each costing \$3000.

# per year that cause death or has increased significantly

Philips, D., 1998: The Worst Ice Storm in Canadian History?; Environment Canada (online: http://www.msc-smc.ec.gc.ca/cd/icestorm98/icestorm98\_the\_worst\_e.cfm).

shown in white.

# Et le changes



### Our forests



temperatures. The threats

decomposition may rise

is not a limiting factor, as the rate of litter

Existing forest species will have to decline and die before new species, better suited to the undergo a period of significant disruption. As a result, the way we manage these resources and the wildlife they support will need to be adjusted.

As with agriculture, the health and productivity of our forests are intricately linked to climate. Because trees have such long life cycles, forests are particularly vulnerable to long-term change. There will be both opportunities and threats for forests in different regions of the

Forests will also be subject to more frequent, extreme storms and wind damage, greater stress due to drought, and more frequent and severe fire and insect disturbances.

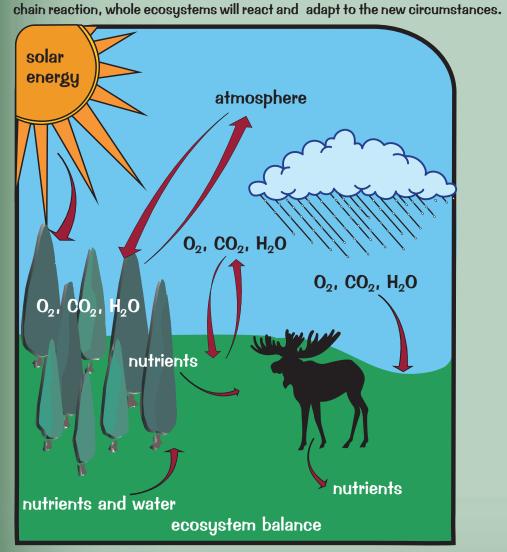


Every year in Ontario, about 1500 forest fires destroy over 290 000 hectares of forest.

Effects of climate change on forests and forestry

Our natural heritage

The relationships between climate and plant and wildlife species are complex. Each species and What's good for the goose... its habitat has a unique set of tolerances to climate. When the climate changes, each species will Snow goose numbers have increased 300% since White-tailed deer are expected to flourish in the southern parts of the province, whereas experts



Colder temperatures in northeast Hudson Bay have hunt seals, may suffer. summer in southwest Hudson Bay, instead of stopping briefly to feed in the spring on their way north. Thus, marshes of southwest Hudson Bay, that used to have the summer to recover from the spring

Fish in hot water? Warm-water fish, such as black bass, sunfish, white bass, and white perch, will thrive as the water warms. Cold-water species, such as lake trout and lake whitefish, may disappear from southern Ontario as their



react differently; some will thrive and some will diminish or migrate as habitats change. Like a the 1960s. Warmer central arctic temperatures have expect that the distribution of moose, easily stressed by heat, will shift northward. As the meant earlier springs and higher nesting success. season for nearshore sea ice is reduced, polar bears, who depend on this ice in spring and fall to

Colombo, S.J. and Buse, L.J. (ed.), 1998: The impacts of climate change on Ontario's forests; Ontario Forest Research Institute, Ontario Ministry of Natural Resources, Forest Research Information Paper Number 143.



he cold temperature of Lake Superior water creates favourable conditions for a number of arctic-alpine plant species, incl<mark>ud</mark>ing the common butterwort, which would not otherwise grow so far south. Warmer water temperatures could jeopardize this and several dozen other arcticalpine plant species and vegetation communities.

## How do we measure up?

Our challenge... Our climate dictates that we use a significant

Evergreen needleleaf forest

Transition treed shrubland

Urban and built-up areas

National capital

Less rainfall at different times could mean farmers would need more irrigation in

southwestern Ontario, particularly on drought-prone soils and for shallow-

rooted crops such as potatoes. Milder winters with less consistent snow cover

are likely to lead to an increase in injury damage to over-wintering crops in some

Did you know?

Adopting practices such as no-till farming, can reduce

amount of energy to heat and cool our houses, offices, and schools. We have a high standard of living, compared to many parts of the world, which means we have larger houses to heat and cool, larger and more cars, televisions, and computers, and we also travel more. All the things we buy and the trips we take consume energy. For these reasons, Canada is one of the largest per capita emitters of greenhouse gases

in the industrialized world. Did you know? In washing machines, 92% of the energy is used by the hot water heater to heat

water, and only 8% of the energy is actually used to run the machine. Using cold water to wash and rinse our clothes save up to 225 kg of

Each of us is responsible for the choices we make.

greenhouse gases where they are today, global  ${
m CO_2}$ 

emissions would have to be cut by 50 to 60%.

**Ontario** 

Tonnes per year Did you know?

> Every litre of gasoline you use in your car produces almost 2.5 kilograms of  $CO_2$ , as well as other pollutants.

> Fifteen seconds of idling a car engine uses more fuel than restarting it. ▶'Jackrabbit' starts consume about 50% more fuel than <mark>if</mark> you accelerate

regular light bulb with an energy efficient compact fluorescent bulb will save 225 kg of CO<sub>2</sub> per year.

Energy Information Administration, 1998: Annual Energy Review 1997, Department of Energy, Washington, D.C. (revised by Torrie Smith Associates, 1999)

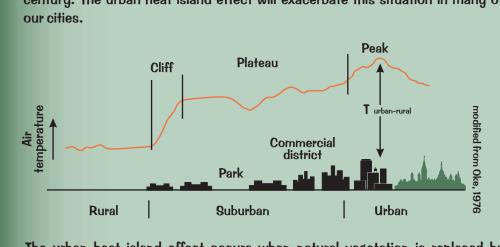
## Our health

and even atmospheric pressure can effect how we feel.

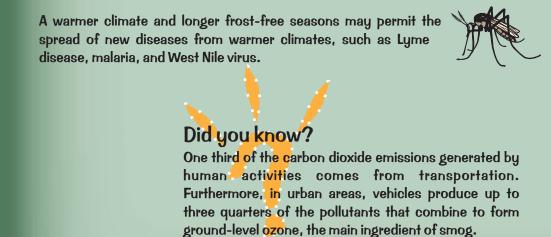
Global climate models suggest that over the next 50 years, southern Ontario is likely to experience more frequent, more intense, and longer heat waves. An increase in the number of hot days (over 35°C) could increase the risk of heatstress-related health problems, especially in the very old, the very young, and those with chronic lung diseases such as asthma.

Right now in southern Ontario, the average number of days over 35°C is 10 per

year. This may increase to as many as 46 per year by the middle of the next century. The urban heat island effect will exacerbate this situation in many of

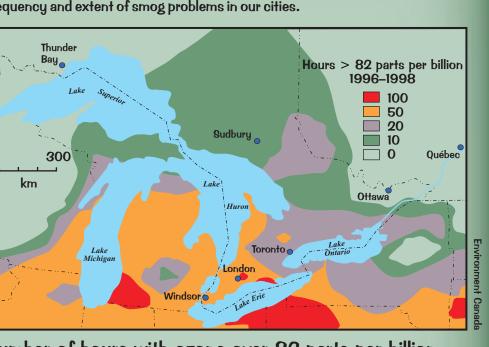


The urban heat island effect occurs when natural vegetation is replaced by surfaces that absorb heat, such as building roofs and walls, and pavement. This can make cities several degrees warmer than nearby rural areas.



Auld, H., MacIver, D., and Taylor, M., 1999: Climate change and the conservation challenge; Environment Oke, T.R., 1976: Inadvertent modification of the city atmosphere and the prospects for planned urb climates; in Proceedings, Symposium on Meteorology Related to Urban and Regional Land-Use Planning, Asheville, North Carolina; World Meteorological Organization, Geneva, Switzerland, p. 151-175.

As with all things, our health is influenced by climate; temperature, humidity, Since the creation of smog depends on a mix of urban pollutants, temperature, and solar radiation, warmer daytime temperatures will likely increase the frequency and extent of smog problems in our cities. Turning up the heat



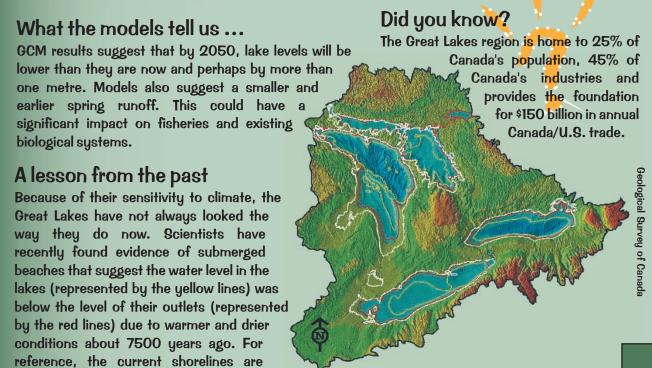
Number of hours with ozone over 82 parts per billion One of the highest concentrations of smog in Canada is in the Windsor to Québec corridor. Permanent lung damage can occur in healthy adults who spend four hours in air with ozone levels of 82 ppb (parts per billion).

Did you know? Winter and summer temperature extremes are responsible for more deaths than are more violent weather events such as tornadoes, blizzards, or floods.



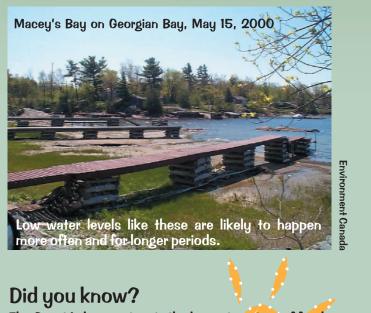
#### The Great Lakes

The Great Lakes play a vital role in the social and economic well being of Ontario. Climate affects both the quantity and quality of water in the Great Lakes. At the same time, the Great Lakes have a significant influence on Ontario's climate. As a result of their influence, instead of having a climate similar to that of the Prairies, Ontario's climate has less extremes in temperatures and greater precipitation.

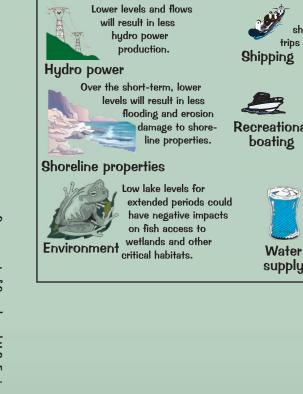


As the climate changes so too does the balance of these element The Great Lakes

## Our water



The Great Lakes system is the largest <mark>system</mark> of fresh, surface water on Earth. Only 1% of the Great Lakes volume is renewed on an annual basis. In other words, using more than 1% of the volume in a year will reduce the lake levels beyond natural renewal.



Government of Canada and U.S. Environmental Protection Agency, Smith, J.V., Lavender, B., Auld, H., Broadhurst, D., and Bullock, T., 1998: Turner, R.J.W. and Clague, J.J., 1999: Temperature rising: climate

1995: The Great Lakes: an environment atlas and resource book; Adapting to climate variability and change in Ontario; in Volume IV of the Canada change in southwestern British Columbia; Geological Survey of

Country Study: Climate Impacts and Adaptation; Environment Canada, 117 p. Canada, Miscellaneous Report 67.

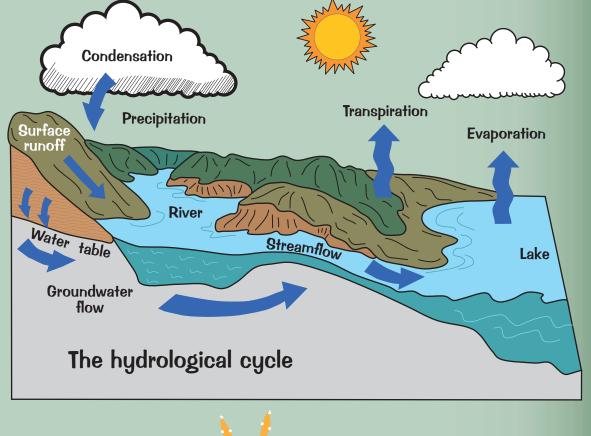
## Inland lakes, rivers, and streams



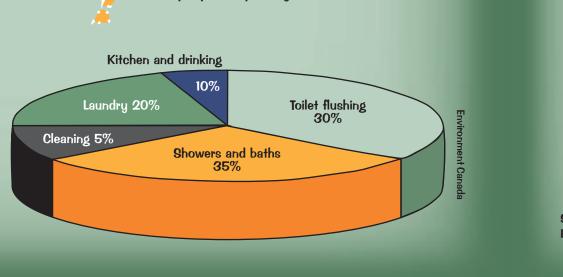


#### Water is an intricate and vital part of the climate system. Water is also critical to every aspect of our lives including our health, energy production, industry, and transportation. Change the air temperature and the rate of evaporation and precipitation changes, altering the balance of the entire system and everything that depends on it.

As the climate gets warmer and drier, demand for water used for irrigation of farms and watering household lawns and gardens will increase. This, combined with greater levels of evaporation, will reduce the amount of water in streams and lower the water table, leaving less and warmer water for us to use. Warmer water may be great for swimming, but will likely lead to problems with water quality - microbes and algal blooms like warmer water too.



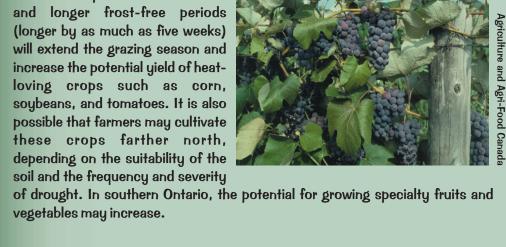
Canada's per capita water use is the second highest in the world. In 1996, nouseholds in Ontario used 270 lit<mark>res</mark> of water per person per day. Kitchen and drinkin in the home



## Our farms

Agriculture is perhaps the sector where the effects of climate on productivity and operations are most obviously felt. Quite often we get seasons with too much or too little rain, too much or too little heat, a spring thaw that arrives too late or a frost that arrives too early.

Warmer year-round temperatures and greater variability and predictability of precipitation, particularly in the winter months, will present farmers with new opportunities and new challenges. The opportunities Warmer temperatures and earlier



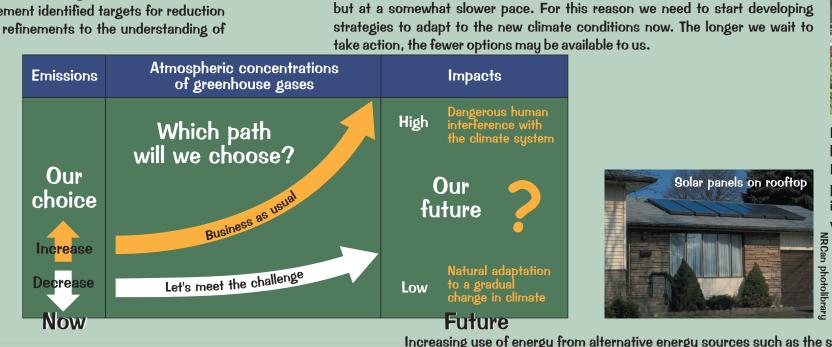
fuel and labour requirements, soil erosion from both Impacts of climate change on agriculture wind and water, and investment in capital while at the same time increasing long-term productivity. expands northward More crop damage Decreased winter cold injury to orchards, likely increased winter injury to alfalfa, summers 💉 summers increase

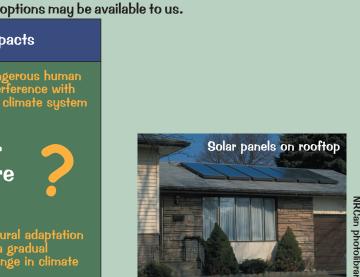
Reduced winter heating Introduction of new requirement for irrigation; crops suited to longer where water supply is limited warmer growing season Water well Smith, J.V., Lavender, B., Auld, H., Broadhurst, D., and Bullock, T., 1998: Adapting to climate variability and change in Ontario; in Volume IV of the Canada Country Study, Climate Impacts and Adaptation;

# Where do we go from here? It's up to us

Think globally Climate change is a global issue requiring international action and co-operation. In 1997, as part Reducing GHG emissions will be a significant challenge for Canada. The fact is that even with a 20 to 25% reduction in emissions, the climate will still change, of an international initiative to address climate change, 160 nations negotiated an international climate change agreement, the Kyoto Protocol. This agreement identified targets for reduction of GHG emissions. It also requires that countries pursue refinements to the understanding of climate change and development of strategies to adapt.

Opportunity knocking? Responding to climate change is presenting us with many opportunities for economic growth, jobs, increased trade and technological advancement, reduced levels of pollution, and a cleaner, healthier environment for many Canadians. Did you know? In order to stabilize atmospheric concentrations of





Bus programs, where groups o instead of driving — a walking version of the car pool!

garden technologies can

help to reduce GHG

emissions from heating

and cooling by shading

buildings, improving

insulation, and reducing

Increasing use of energy from alternative energy sources such as the solar panels on this house have helped to increase our total energy efficiency. Although our emissions have increased over the past years, they have not increased at the same rate as our economic growth. This means we are improving Turner, R.J.W. and Clague, J.J., 1999: Temperature rising: climate change in southwestern British Columbia; Geological Survey of Canada, Miscellaneous Report 67.

Weathering the changes - Climate change in Ontario Geological Survey of Canada, Miscellaneous Report 73, 2001

the efficiency of our energy use.

Carleton University

Environment Canada

Health Canada

Hydro One Inc.

Greenest City

Emergency Preparedness Canada

Fisheries and Oceans Canada

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