A change in the wind

Climate change is more than just global warming.

However, global warming is part of climate change.

Climate change in Quebec

What is climate change ?

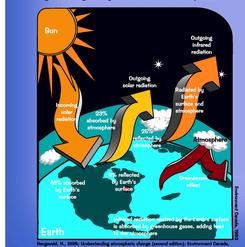
In recent years, climate change has become one of the most important issues on the planet. Climate change is a change in the 'average weather', affecting all the features we associate with weather, including temperature, wind patterns, precipitation, and storms.

Myth : A cool summer or colder than average winter means that global warming is not really a problem.

Greenhouse effect

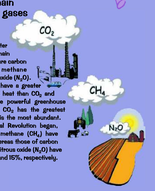
The average temperature at the Earth's surface is 15°C because of a natural phenomenon called the 'greenhouse effect'. If it were not for certain gases that function as a greenhouse to trap the sun's heat close to the Earth, the average temperature would drop to -18°C, and life as we know it could not exist.

Since the beginning of the Industrial Revolution, this natural effect has been enhanced by human activity (use of fossil fuels, agriculture, deforestation). This enhancement of the greenhouse effect contributes to global warming and may have various environmental repercussions.



Environment Canada, 1997. (Understanding climate change (second edition): Environment Canada, State of the Environment Report no. 96-2, p.26.

The three main greenhouse gases

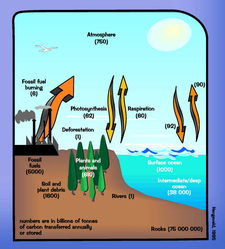


In addition to water vapour (H_2O), the main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Methane and N_2O have a greater capacity to absorb heat than CO_2 and are therefore more powerful greenhouse gases. However, CO_2 has the greatest impact because it is the most abundant. Since the Industrial Revolution began, concentrations of methane (CH_4) have risen by 145%, whereas those of carbon dioxide (CO_2) and nitrous oxide (N_2O) have increased by 90% and 15%, respectively.

How can we reduce the amount of carbon in the atmosphere?

Did you know? Even if emissions of greenhouse gases were to stop immediately, earlier emissions would continue to affect climate for centuries to come.

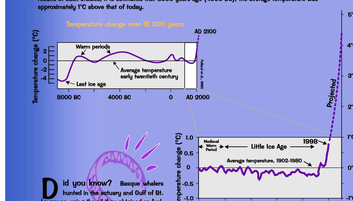
Scientists anticipate that in 40 to 60 years, the quantity of CO_2 in the atmosphere will be double that of the pre-industrial era. They also consider that this dramatic increase in the concentration of CO_2 and other greenhouse gases will have an impact on climate.

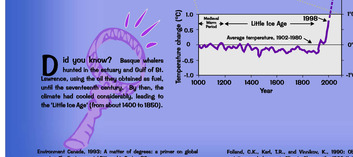


Bernard et Villeneuve, 1989

A climate in constant flux

Quebec's climate has seen significant fluctuations since the end of the last ice age. Climate variations over the past 10 000 years have been reconstructed through the analysis of pollen in lake sediments and peat. From the results of such studies, it is estimated that 6000 years ago (4000 BC), the average temperature was approximately 1°C above that of today.



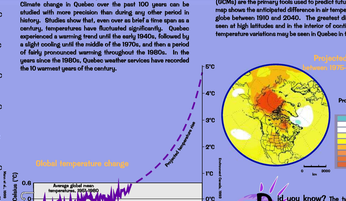


Did you know? Basque whalers hunted in the estuary and Gulf of St. Lawrence, using the oil they obtained as fuel, until the seventeenth century. By then, the climate had cooled considerably, leading to the 'Little Ice Age' (from about 1400 to 1850).

Environment Canada, 1993: A matter of degrees: a primer on global warming: The Environmental Citizenship Series, 89 p.

Significant climate events of the twentieth century in Quebec

Climate change in Quebec over the past 100 years can be studied with more precision than during any other period in history. Studies show that, even over as brief a time span as a century, temperatures have fluctuated significantly. Quebec experienced a warming trend until the early 1940s, followed by a slight cooling until the middle of the 1970s, and then a period of fairly pronounced warming throughout the 1980s. In the years since the 1980s, Quebec weather services have recorded the 10 warmest years of the century.

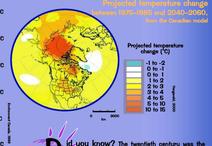


Did you know? The Earth is heating more rapidly than it has at any other time during the past 10 000 years.

Hengeveld, H.G., 2000: Projections for Canada's climate future: a discussion of recent simulations with the Canadian Global Climate Model: Environment Canada, Climate Change Digest CD-01, 27 p.

A much different future

Powerful computer simulation models called 'general circulation models' (GCMs) are the primary tools used to predict future climatic conditions. The map shows the anticipated difference in air temperature at the surface of the globe between 1990 and 2040. The greatest difference is expected to be seen at high latitudes and in the interior of continents, which is why major temperature variations may be seen in Quebec in the decades to come.



Did you know? The twentieth century was the warmest century in 1200 years, with 1998 and 1990 the warmest years on record.

Mann, M.E., Bradley, R.C., and Hughes, M.K., 1999: Northern hemisphere temperature during the past millennium: inferences, uncertainties, and limitations: Geophysical Research Letters, v. 26, no. 6, p. 759-762.

Our health

Climate change is likely to have an impact on human health. The most direct risk is heat stress. Increasing frequency and severity of heat waves may lead to more deaths and an increased occurrence of illness and exposure, especially among the very young and the elderly. Temperatures are likely to be higher in the major centres, and the heat can be expected to lead to poorer air quality and increased urban smog.

On the other hand, less cold stress in winter would reduce loss of life due to exposure to extreme cold and other winter hazards.

There could also be a number of indirect impacts on human health:

- Respiratory disorders and allergy problems may worsen as a result of increased heat and humidity, and declining air quality (higher levels of dust, pollen, and moulds) in some areas.
- Extreme weather events could result in more deaths, injuries, and stress-related disorders.
- Infectious diseases may extend their range northward into Canada, making it necessary to increase control measures.
- Health disorders related to environmental contamination by bacteria, viruses, and parasites are also likely to increase with climate change. Both water contamination and problems with the food supply are concerns.

Did you know? The fire-starting liquid used to light barbecues is an overlooked source of volatile chemicals that undermine air quality.

Did you know? One third of greenhouse gas emissions in Quebec are the direct result of human activities.

Taking public transit, driving a more environmentally friendly automobile, and using fewer fossil fuels and products containing volatile chemicals can help reduce smog.

Extreme weather: what are the risks ?

Did you know? Flooding affects over 80% of waterfront municipalities and costs an average of 400 million to 115 million annually. Floods, which occur most frequently in the southern part of the province, are the most common type of natural catastrophe in Quebec.

Climate anomalies have occurred in the past and are clearly part of the 'ordinary' characteristics of our cold eastern climate. But what lies in wait if they take grave o future climates altered by human activities?

These are only two examples of extreme weather, but every region of Quebec is vulnerable to such events.

Did you know? In summer, the parts of Quebec most affected by violent weather phenomena are the regions of Montréal and Montérégie, where over 20 events — violent winds, torrential rains and flooding, and hail — are reported each year.

Recent violent weather events may be completely natural phenomena. However, we cannot dismiss the possibility that the climate is changing. Studies suggest that these extreme events are in many ways illustrative of the type of situation that could be generated by global warming.

The projected climate change could result in an increased number of violent summer events because a warmer, wetter climate is conducive to the development of severe thunderstorms. Moreover, regions that have thus far escaped relatively unscathed could also be affected. The potential consequences are numerous, for both inhabited areas (e.g. more frequent flash floods) and natural ecosystems, where forest fires caused by lightning could become more frequent occurrences.

Climate change also implies a decrease in the number of intense cold waves, which should meet with widespread approval. It also implies an increase in the number of winter warm spells and thaws. This could mean more frequent rainstorms during winter, bringing flooding and causing more potholes to plague beleaguered motorists...

Could a warmer climate mean a shortage of water ?

Water resources are essential to our society and our economy. They are of paramount importance to our natural ecosystems.

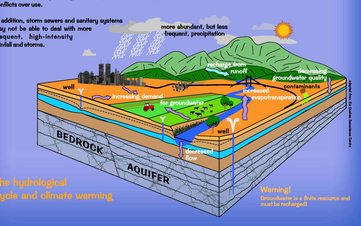
Projected climate change could alter snow and rainfall patterns, resulting in less frequent, but heavier, precipitation. Intense, heavy rainfall leads to significant runoff and therefore does less to recharge groundwater than a long-lasting, steady rainfall because the ground can only absorb a certain amount of water in a short period of time.

Did you know? Relatively modest changes in temperature and precipitation can have a marked effect on the volume and duration of spring runoff, as well as the intensity of flooding and drought.

Groundwater generally moves from higher to lower elevations. It feeds rivers and lakes and maintains flow when precipitation is light. Because it is cold, groundwater keeps rivers from becoming too hot for fish such as trout and salmon. If groundwater supplies dwindle, the health of rivers and the aquatic life they sustain will be threatened.

One serious impact of climate change may be droughts, resulting in decreased surface-water levels and flows, and diminished groundwater quantity and quality, which could lead to less water available for consumption, agriculture, and recreation and more conflicts over use.

In addition, storm sewers and sanitary systems may not be able to deal with more frequent, high-intensity rainfall and storms.



The hydrological cycle and climate warming

Normal
Groundwater is a finite resource and must be recharged

The St. Lawrence has its ups and downs

Below the giant boats that ply the St. Lawrence River are rich and diverse ecosystems. When the river waters rise or fall, naturally or as a result of human activities, all these ecosystems are affected.

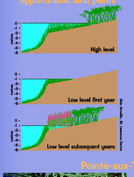
The St. Lawrence River is the dominant feature of the Quebec landscape. It flows a total distance of 1500 km, and over 70% of Quebec's population lives along its 4200 km of shoreline. The St. Lawrence is not a homogeneous unit. It is divided into three sections, (1) the freshwater reach, (2) the estuary, and (3) the gulf, on the basis of its natural characteristics: tides, salinity, vegetation, and sources of water.

Reduced flow of freshwater

The freshwater reach is fed by the Great Lakes basin and two large tributaries — the Ottawa River and the Saint Maurice River, and extends from Cornwall to Lake Saint-Pierre. This freshwater reach has no tides. The impact of climatic changes on this ecosystem may be felt on several levels, including a drop in water flow, which would effect access to quality water, and modification of wetland areas.

The very low water levels observed in 1998-1999 in the freshwater reach caused, among other things, a change in available habitat area, leading to an invasion of opportunistic land plants on bare and dry ground. The ecosystem was impoverished, notably because these species are of little interest to the fauna of the St. Lawrence — fish, ducks, amphibians, and reptiles.

Invasion of opportunistic land plants



Examples of potential impacts in the freshwater reach:

- deterioration in water quality
- modification of habitat distribution
- loss of wetland habitats because of drying out
- reduction in biodiversity
- increase in dredging to maintain navigability
- greater risk to navigation and increase in the number of assistance and rescue operations

Examples of potential impacts in the estuary and gulf:

- increased erosion
- less riparian habitat
- more vulnerable waterfront development (roads, property, buildings)
- reduced ice cover owing to warming of the water
- modified distribution of marine species
- possibility of accommodating larger ships

Did you know? The freshwater levels of the St. Lawrence River have been monitored and recorded since the mid-1800s. The river's lowest levels were recorded in 1930 and in 1960. Now the trend is once again at the bottom of the curve.

Rich but Fragile Shoreline Habitat

Rioux, C., 1997: Impact of water level fluctuations on St. Lawrence River aquatic vegetation: Canadian Journal of Aquatic Science, v. 54, p. 2953-2965.

Rising sea level

Between Lake Saint-Pierre and the Atlantic Ocean, the estuary and the gulf are sectors with tides in which the water ranges from fresh (upstream of Ile d'Orléans) to brackish and saline. The saltwater portion of these reaches is being affected by increased erosion that climate warming could worsen.

General circulation models (GCM) are very imprecise at regional scales, although they all predict to varying degrees atmospheric warming above the Gulf of St. Lawrence. The main impacts likely to be felt in the estuary and gulf are a reduced flow of fresh water from the freshwater reach, an inflow of colder fresh water from Labrador, and an increase in ocean levels.

Examples of potential impacts in the estuary and gulf:

- increased erosion
- less riparian habitat
- more vulnerable waterfront development (roads, property, buildings)
- reduced ice cover owing to warming of the water
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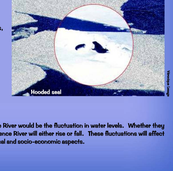
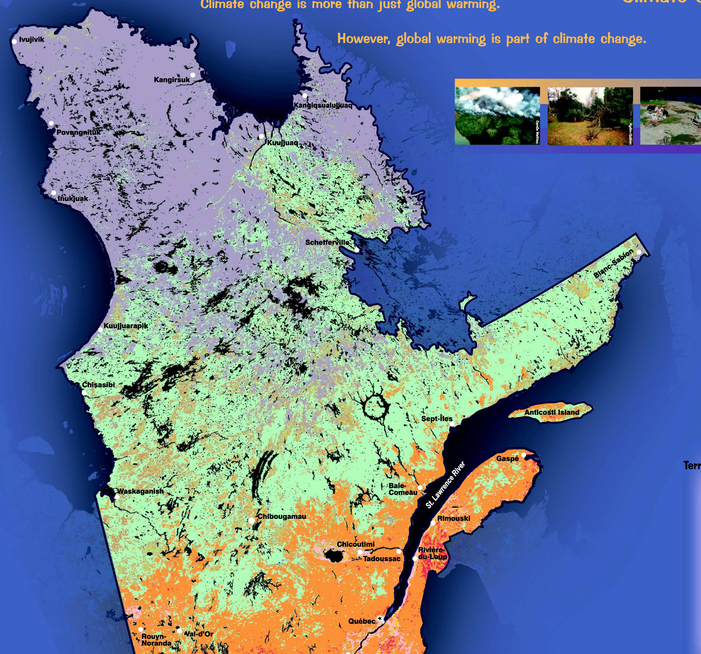
- possibility of accommodating larger ships



Too little water or too much?

The main impact of climate warming on the St. Lawrence River would be the fluctuation in water levels. Whether they are fresh, brackish, or saline, the waters of the St. Lawrence River will either rise or fall. These fluctuations will affect various riparian and aquatic habitats, as well as biophysical and socio-economic aspects.

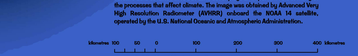


Terrestrial ecozones of Quebec

Forest areas
- Coniferous forest
- Deciduous forest
- Mixed forest

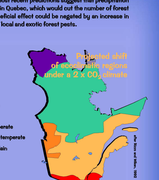
Open areas
- Shrubland
- Wetland
- Grassland
- Barren land
- Water
- Populated place
- Capital

The map shows the distribution of land cover types in Quebec, based on satellite data obtained in 1995. Land cover plays an important role in many of the processes that affect climate. The image was obtained by Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA 14 satellite, operated by the U.S. National Oceanic and Atmospheric Administration.



A dynamic forest

Forests are always adapted to their environment. Just 10 000 years ago, the St. Lawrence River valley was covered by arctic tundra as the glaciers began their final retreat. At an estimated rate of about 50 km a century, the forests gradually reclaimed the land liberated by the melting ice. Today, the diversity of the forests covering Quebec is largely a reflection of the province's climate patterns.



The forest landscape of Quebec could be transformed by the projected climate change. Climate conditions are expected to change at a rate unprecedented in the past 10 000 years and it is anticipated that these changes will be more rapid than the capacity of the vegetation to relocate. The stress effects that would be felt by forests are difficult to predict, but they have the potential to change the makeup of forest ecosystems, particularly in more southerly areas.

A warmer and more humid climate should encourage forest growth, but could also hamper the reproduction of some species. The most recent predictions suggest that precipitation could increase in Quebec, which would cut the number of forest fires. This beneficial effect could be negated by an increase in the numbers of local and exotic forest pests.

The overall long-term effect of a warmer climate could be to push the treeline farther north, while gradually changing the abundance and distribution of species. Despite ongoing research, predicting the impact of climate change on the forest remains a difficult task. The watchword therefore is vigilance.

Ecological Stratification Working Group, 1995: A national ecological framework for Canada: Agriculture and Agri-Food Canada and Environment Canada, Ecoclimatic Regions of Canada, scale 1:7 500 000.

Did you know? Climate change is only one aspect of global change. The introduction of exotic pests such as the Asian long-horned beetle and the pine shoot beetle is accelerating with increased trade. These introduced species pose a significant threat to our forests. The increased number of extreme climatic events makes ecosystems more vulnerable to a greater number of pests.

Rizzo, B. and Wilson, E., 1992: Assessing the sensitivity of Canada's ecosystems to climatic change: Climatic Change, v. 21, p. 37-55.

What about the Far North ?

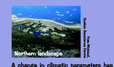
Water resources

Research in northern Quebec (above latitude 50°N) has shown that water levels there have been high over the past century. Between 1930 and 1980, winter snowfalls and summer rains were heavy. Drier conditions in the years since have resulted in increased evaporation and lower water levels.

The low flow coefficient in some hydroelectric reservoirs is cause for concern. Projects have been shut down because of, in part, a result of a regional anomaly in the flood-caused hardening precipitation. The anomaly may be generated by air masses shifting southward in the fall and winter, leaving the more northerly areas open to the influence of cold, dry air.

Permafrost

Permafrost (permanently frozen ground) is a feature that is sensitive to any change in temperature. Recent data obtained on frozen soil profiles indicate that winter temperatures moderated over the 1990s, particularly since 1993.



A change in climatic parameters has a direct impact on permafrost, causing a change in the thickness of the active surface layer and an increase in the temperatures within this layer. Indirect effects are also seen in soil instability and subsidence, which have an impact in terms of the growth rate and density of vegetation, snow accumulation, surface drainage, and erosion in coastal areas.

The most significant infrastructures in northern Quebec are the landing strips and small road networks in coastal villages. Some of these infrastructures would be particularly threatened by climate-warming because they have been built on thaw-sensitive terrain.

Did you know? Northern regions are likely to be most affected by the warmer climate that is projected for the coming decades.

The northern forest

The northern forest is the bioclimatic domain of the black spruce, characterized by mosses and lichens (boreal forest), and the forest-tundra zone. North of the 57th parallel, the plantscape of the arctic tundra (Arctic Region) prevails.

Climate-warming would undoubtedly enhance the reproductive capacity of species now at threshold levels, and communities would move northward. Tree growth would also be improved both in terms of size and shape.

Wildlife acclimates

The global consequences of increased annual temperatures for wildlife species are difficult to predict, mainly because of the complex dynamics of the ecosystems of which such species are an integral part.

Examples:

- A decrease in flow in the Rivière Des Prairies in June would reduce the population density of lake sturgeon.
- A drop in water levels in the St. Lawrence and Sainte-Anne rivers in January could compromise Atlantic tomcod reproduction.

Did you know? An increase in temperature would reduce the size of caribou herds through the destruction of winter habitats by summer forest fires.

Torrential rains along the North Shore in July 1996 had significant impact on many rivers, watersheds, altering fish habitat by limiting benthic organisms and moving sediments great distances.

Extreme weather events

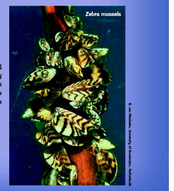
Violent or severe weather events threaten the lives of many individuals and their offspring. The total cost of damages resulting from the ice storm of 1998 has still not been assessed.... For example, many birds, including doves, jays, chickadees, and woodpeckers, that are known to be hardy and are permanent residents throughout southern Quebec, perished during this period.

http://www.qcn.ec.gc.ca/faune/faune/html/climate.html

Heavy winter snows force animals to expend more energy to feed themselves. Conversely, a mild winter enhances the reproductive capacities of some species, leading to a gradual northward expansion of their populations.

Did you know? Quebec is now home to many nonindigenous species, including the zebra and quagga mussels, round goby, and tench, that have significantly modified the province's ecosystems. In most cases, increased trade along waterways is responsible for the spread of such species. Changes in temperature, water levels, and flow rates can also help these and other species become established, at the expense of the biodiversity of native habitats.

Wildlife is sensitive to climate variations. The results of recent studies show that any change in average climatic conditions could likely have rapid adverse or climatic effects on wildlife populations as their habitats shift or are disturbed.



Turner, R.J.W. and Clague, J.J., 1999: Temperature rising – Climate change in southwestern British Columbia: Geological Survey of Canada, Miscellaneous Report 67.

Our farms

An important aspect of the relationship between climate and agriculture in Quebec is the diversity of production conditions from region to region. Projections based on the interpretation of climate change models suggest that

- the rate of development of grain crops may increase, with the time between seeding and harvesting being reduced (by up to three weeks) in most regions. In northern regions, the increased development rate could also reduce the risk of frost-induced crop injury
- production may expand northward. Southern Quebec could therefore see the current geographic extent of its fruit and vegetable production shift into more northerly regions.

The production of maple syrup is closely tied to freeze-and-thaw phenomena. A change in temperatures could significantly affect the volume of maple syrup produced.

Possible impacts of climate change on Quebec agriculture

Emissions – How do we measure up ?

Activities that generate greenhouse gas emissions in Quebec

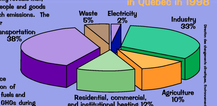
An analysis of greenhouse gas (GHG) emissions produced by various sectors of activity reveals that, in Quebec, the transportation of people and goods (38%) is the primary source of such emissions. The increased rate of household car ownership, urban sprawl, and the popularity of sport utility vehicles and trucking of goods are all factors that account for these figures.

Industry ranks in second place (33%), contributing to the emission of GHGs through both the use of fossil fuels and the production and use of certain GHGs during processing.

The contribution of residential, commercial, and institutional heating to emissions of GHGs (12%) is significantly lower than that of the two previous sectors, despite its third-place ranking.

Agriculture (10%) and landfill sites (5%) are the two least significant categories. The electricity category (2%) covers emissions generated by thermal power stations.

Greenhouse gas emissions in Quebec in 1998



Despite its northern geographic location, Quebec performs well because over 95% of the electricity it consumes is hydraulically generated. Electricity is used by 75% of housing units for heating, and by 95% for hot water.

Did you know? Methane is a very powerful greenhouse gas because it can retain 21 times more heat than CO_2.

Did you know? The average car emits over three times its weight in CO_2 every year.

The amount of methane produced in Quebec by buried garbage (4.3 megatonnes of equivalent CO_2 emission) corresponds to the exhaust emissions of almost one million passenger cars. As long as we continue to bury garbage, this problem will persist unless solutions are introduced.

We can all help

To counter the effects of climate change, we must all simply consume less energy.

Reduce energy consumption!

When buying a new house, consider an energy-efficient one or use alternative approaches to energy consumption.

Plant trees and care for trees on your property! Trees help slow climate change in three ways: they absorb CO_2, their shade can reduce the energy used for air conditioning, and they serve as a wind block in winter.

Travel smart!

Fewer vehicles on the road mean fewer emissions of GHGs and cleaner air! Look into carpooling. Think of the car as just another way to get around, to be used only when other methods are not feasible.

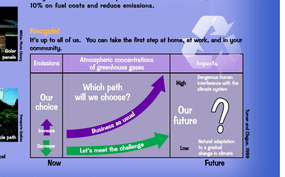
Walk!

Bicycle for short trips whenever possible. It's good for your health and the environment!

Every 10 km/h reduction in speed between 90 and 120 km/h can save 10% on fuel costs and reduce emissions.

Recycle!

It's up to all of us. You can take the first step at home, at work, and in your community.



A change in the wind – Climate change in Quebec

Geological Survey of Canada, Miscellaneous Report 78, 2001

Lead agency:
Natural Resources Canada, Geological Survey of Canada

Other participating agencies:
Natural Resources Canada, Canadian Forest Service
Environment Canada, Environmental Conservation Branch, Quebec Region; St. Lawrence Centre and Canadian Wildlife Service
Fisheries and Oceans, Maurice Lamontagne Institute
Agriculture and Agri-Food Canada, Research Branch, Eastern Region
Sécurité publique du Québec, Direction de la sécurité civile de l'Est and office of the Associate Deputy Minister
Environnement Québec, Direction des changements climatiques and Direction des communications
Transport Québec
Ressources naturelles Québec, Secteur des forêts
Société de la faune et des parcs du Québec, Direction de la recherche sur la faune
INRS-ÉAU
Laval University
University of Montréal

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Satellite image: Information supplied by the National Atlas of Canada, Canada Centre for Remote Sensing, Natural Resources Canada (ftp://atlas.gc.ca)
Project manager: Beth Lavender
Contributors: Michel Allard, Alain Armellin, Georges Beauchemin, Gilles Bélanger, Pierre Bérubé, Pierre Y. Bernier, Yves Bégin, Michel Campagna, François Caron, Michel Crête, Pierre Demers, Jean-Luc Desforges, Jacques A. Dagnè, Jacinthe Lacroix, Gilles Lemaingre, Louise Lajoie, Rolande Lavoie, Denis Lefaivre, Michel Legault, Yves Michaud, Marc Mingelbier, Danielle Mcgregor, François Morneau, Taha Ouarda, Serge Paquette, Jean-Pierre Plamondon, Monique Plamondon, François Potvin, Jean-Claude Raymond, Pierre J.H. Richard, Philippe Rochette, Michel Slivitsky
Translation: Bégin, Québec Geoscience Centre, Natural Resources Canada

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