Chapter 3

Vulnerabilities to Natural Hazards and Extreme Weather

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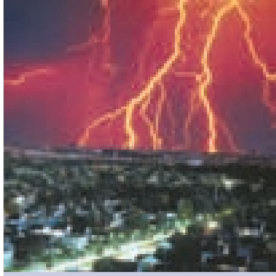

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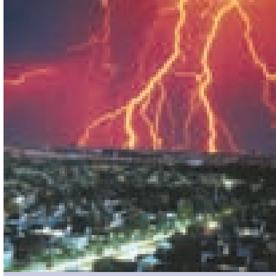

3.1 INTRODUCTION

This chapter examines how natural hazards affect the health of Canadians, how climate change is influencing natural hazards and related risks across the country, and what conditions determine individual and community vulnerability to these risks. From the perspective of the emergency management community, three factors combine to create a hazard: the probability of occurrence of events that can impact a community, the vulnerability of the population to such impacts, and the resources of the community to cope with those impacts. All three factors are examined in this order in this chapter, leading to conclusions about the preparedness of Canadians, knowledge gaps and needed policies and programs. Because climate change does not influence all types of natural hazards (e.g. earthquakes), the scope of this chapter focusses on weather and weather-related events. However, some data and statistics quoted in the chapter include information on all hazards and natural disasters.

Generally, weather and weather-related events relate to conditions defined in terms of heat and cold, wet and dry, and wind and pressure conditions, which often come in combinations such as snow and ice storms, and floods and droughts. These weather conditions then generate related hazards such as landslides, wildfires, avalanches, storm surges, and melting ice and permafrost (some of which may also be considered geological hazards). A hazard is the potential for a negative interaction between extreme events (of a natural or technological origin) and the vulnerable parts of the population. Numerous scientific studies have established that changes in temperature, barometric pressure, humidity, and other determinants of weather and climate can affect human health and well-being.

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Landslide (Saguenay, 1996)

While many natural hazards have the potential to affect human health, they become disasters when certain vulnerabilities are present (Etkin et al., 2004). Around the world, the impacts of natural disasters have been increasing dramatically; the number of natural disaster events was 10 per year from 1900 to 1940, 65 per year in the 1960s, 280 per year in the 1980s, and 470 per year since the beginning of this century (Emergency Disasters Database, 2007). Although part of the reason for this increase may be better systems for reporting disasters, this does not explain the observed increase in the number of extreme weather events. The greater frequency of these events and the higher vulnerability of human systems to them are important for explaining this observed increase in the number of disasters.

> A disaster is defined as "a serious disruption of the functioning of a community or a society causing wide-spread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources" (United Nations International Strategy for Disaster Reduction (UN/ISDR), 2004).

In Canada, people living in all parts of the country can be affected by natural hazards, and should be concerned about how their exposure to these hazards may be changing over time because of climate change. Public Safety Canada (PSC) (formerly Public Safety and Emergency Preparedness Canada) maintains a database of Canadian disasters dating from 1900 to the present. Information in this database is useful for determining the current frequency and longer-term trends of events of a certain size, based upon their

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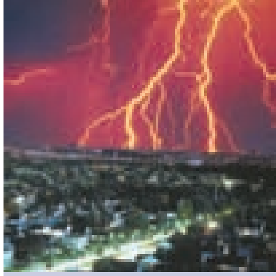
costs and related injuries and fatalities. However, these records do not provide information on the range of health impacts that are caused or exacerbated by natural hazards, nor do they include estimates of health sector costs associated with these events. Instead, it is through detailed examples provided by case studies that researchers begin to understand the scope of health impacts. This chapter highlights the health impacts and the economic costs associated with a range of events drawn from the PSEPC database and Canadian case studies.

In the 1990s, natural disasters caused 170 deaths and 1000 injuries, and affected over 700,000 Canadians. Those people affected were evacuated from their homes, lost power, or were made homeless. The largest number of these resulted from the 1998 Ice Storm that affected eastern Canada (PSEPC, 2005a). Although mortality in Canada attributed to natural disasters has decreased in the past several decades, injuries and the number of people affected have risen.

At the global scale, weather and weather-related events together make up most of all natural disaster events, with floods (33%), storms (23%, which includes hurricanes, typhoons, tornadoes and mid-latitude winter storms), and droughts (15%) as the major contributors. Most avalanches and many landslides are also weather-related. The *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC) confirmed that meteorological and hydrological events that can impact human health are expected to increase in the future, irrespective of near-term efforts to reduce greenhouse gas (GHG) emissions (IPCC, 2007a). Risks to Canadians and their communities will therefore increase, and will require concerted efforts to plan for, and where possible, reduce the impacts on health.

Although the characteristics of specific weather events are important for assessing the risks that individuals and communities face, existing social and economic conditions and emergency management strategies for coping with an event are also critical in determining the scope of the impacts. Canadian experience has shown that highly resilient communities prepare for and respond more effectively to disasters, and that these communities are better able to protect the most vulnerable people in the population (Federal/Provincial/Territorial (F/P/T) Network for Emergency Preparedness and Response, 2004).

3.2 METHODS AND LIMITATIONS



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This chapter reviews Canadian and international literature to assess the impacts of natural hazards on health, the geographic scope of such hazards in this country and the special characteristics that make Canadians vulnerable to impacts related to climate change. Using case studies and examples, current adaptations to protect individuals, communities and property are highlighted. To support future adaptation efforts, current knowledge gaps are identified, and the actions needed to increase health risk management capability and the resilience of Canadians are examined.

The focus of the chapter was guided by recommendations arising from consultations and workshops organized by the Institute for Catastrophic Loss Reduction (ICLR) and Health Canada, respectively. Participants included emergency sector experts and practitioners from academia; municipal, provincial and federal governments; and non-governmental organizations. In addition, a workshop was held in 2003 to identify key natural hazards to be examined in this chapter. Floods, heat waves, cold waves, wildfires, convective storms, and snow and ice storms were highlighted as priority hazards in terms of health impacts for Canadians. Workshop participants also identified the need to examine psychosocial impacts of natural hazards and disasters, the effectiveness of risk management activities to protect people from current and future risks, and the adaptive capacity of institutions and individuals (Health Canada, 2003).

Photo Credits: Communications New Brunswick, Govt. New Brunswick

Man setting sandbags during flooding

Baseline information on the spatial distribution of natural hazards and on the occurrence of extreme weather events for all regions of Canada is presented throughout the chapter, along with evidence of health impacts from case studies. The chapter has drawn its analysis from original data sources and reviews of published and grey literature. The literature review targeted both peer-reviewed scientific publications, and a variety of technical and government reports. Search terms included global warming, climate change, cold, heat, natural hazards, storms, floods, drought, wildfires, disasters and other terms related to natural hazards and disasters in Canada that might be influenced by climate and weather. Particularly useful sources included maps from the Atlas of Canada, published by Natural Resources Canada (NRCan), and information from Public Safety Canada's searchable Canadian Disaster Database. This database summarizes information on past weather-related disasters in Canada that are defined as historically significant events, or those in which either:

- 10 or more people were killed;
- 100 or more people were affected, injured, evacuated or became homeless;

- an official appeal was issued for national or international assistance; or
- damage to or interruption of community functions was so great that it prevented recovery of the community on its own.

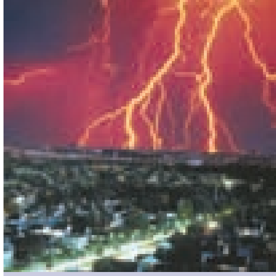
The database is continually updated and, at present, it covers the years 1900 to 2005. Unless otherwise indicated, most of the statistics cited in this chapter have been obtained from this source. Another important source of information was the Meteorological Service of Canada, which is the principal source of weather and climate information for Canadians. It provides forecasts, advisories, maps and other information related to weather and climate (Environment Canada, 2007a).

Limitations in time and space for this project resulted in an uneven coverage of topics, geographic regions and events that have been illustrated by selected graphics, statistics and case studies. More comprehensive information can be found in the many references cited herein. More detailed information on some hazards relevant to the health of Canadians living in Quebec and the North can be found in Chapter 6, Health Impacts of Climate Change in Quebec, and Chapter 7, Health Impacts of Climate Change in Canada's North, respectively. As well, Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, more fully addresses the problems of how to anticipate, cope with, and prevent natural disasters related to climate change.

Photo Credits: British Columbia Ministry of Forests and Range

Wildfires in British Columbia, 2003

As well, there are few studies on long-term health impacts and the role of health services in the recovery process following a natural disaster. While recovery processes would be expected to play a role in influencing the resilience of communities that have had to cope with natural disasters, few Canadian studies have examined the factors that could have led to successful recoveries. In some rare cases, journalists and photographers have vivid on-the-spot accounts of the experiences of victims and emergency personnel during and soon after a major disaster (Anderson et al., 2003). But as yet, there are few comprehensive accounts of whether and to what extent neighbourhoods or communities have recovered from such disasters. The August 2003 wildfire disaster in the southern interior of British Columbia seems to be the only one in which health authorities commissioned a report that is easily accessible on the performance of emergency medical services and related matters (Lynch, 2004).



3.3 NATURAL HAZARDS AND HEALTH IMPACTS IN CANADA

3.3.1 Overview

Each region of Canada has unique susceptibilities to extreme weather, and to weather-related natural hazards; these are greatly influenced by specific geographic and geologic features of the region. Examples include the so-called storm paths and “tornado alleys” along the Great Lakes-St. Lawrence River corridor, the unstable hillsides and river valleys in mountain regions that are susceptible to rock-, mud- or landslides, and severe droughts in the southern Prairies that can lead to dust storms and wildfires. Some coastal regions are vulnerable to storm surges and the decrease in winter sea ice which protects the coast from erosion. In addition, many inland river basins are also subject to flooding and erosion.

There is a lack of reliable and comprehensive data on disasters and weather-related events in Canada (Etkin et al., 2004). The Canadian Disaster Database is the most comprehensive database of Canadian information on natural hazards. However, it records only events and related injuries, deaths and economic losses that meet the defined disaster criteria; many weather-related hazardous events of concern reviewed in this chapter (e.g. fog occurrences, thunder and rain storms, heat waves) are not typically recorded in this database. Consequently, statistics from this database underestimate both the total number of occurrences of weather events as well as the scope of their impacts. Despite these limitations, according to records dating back to 1900, there is an increasing trend in the occurrence of natural disasters and associated costs, with considerable year-to-year variability. The total number of Canadians affected by natural disasters increased from 79,066 between 1984 and 1993, to 578,238 between 1994 and 2003 (Health Canada, 2005a). Another database, using different inclusion criteria than the Canadian Disaster Database, also showed that 51% of all Canadian disasters were weather-related (Jones, 2003).

Figure 3.1 A century of natural disasters in Canada

	1900–1960s	1970s	1980s	1990s	2000–2002
Estimated number of disasters	160	92	114	151	29
Estimated number of deaths*	3,010	114	283	179	18
Estimated number of affected*, †	162,462	25,477	50,285	712,625	154
Estimated direct damage costs (CAN$)‡, §	4,882 billion	9,712 billion	17,617 billion	13,710 billion	0.203 billion

Notes: Data compiled using natural disaster information about meteorological events.

* Health data were either not available or could not be confirmed for a number of disasters.

† The number of people affected was calculated using the number of people injured plus the number of people evacuated during a disaster event.

‡ Disaster damages are based on 1999 Canadian dollars for those disasters occurring between 1915 and 2002. Total amount of disaster damages is based on cost data for 76 of 160 disasters occurring between 1900 and 1969, and for 324 of 388 disasters occurring between 1970 and 2002.

§ Damage estimates are conservative and include only direct costs, excluding uninsured and indirect costs, such as hospitalization costs, which are difficult to quantify.

Source: Data from PSEPC, 2005a.

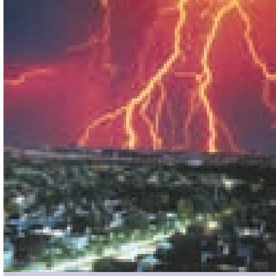
The human health implications of climate change across the globe have been examined under the combined sponsorship of the World Health Organization (WHO), the World Meteorological Association (WMO) and the United Nations Environment Programme (UNEP) (McMichael et al., 1996; McMichael, 2003). They concluded that weather-related disasters might increase in frequency and intensity as a result of climate change, but noted that the secondary effects and delayed consequences of such events are poorly documented and reported.

Weather-related disasters pose a threat to human life, health and well-being in a variety of ways (Health Canada, 2003; ICLR, 2003) (Table 3.1). Some events result in more direct and more immediate impacts than do others. For example, flooding, drought, severe storms and other weather-related natural hazards can damage health by leading to an increased risk of injury, illness, stress-related disorders and death (Hales et al., 2003). Other impacts on health are less direct and longer-term, such as mould in buildings as the result of flooding, which can have resulting impacts well after the waters have receded (Solomon et al., 2006). Still others may not be felt for weeks or months and may last for years, such as a drought causing economic hardship with a resulting strain on health.

Although dramatic events like tornadoes and floods receive most media attention, evidence suggests that changing temperature and other weather variables also affect human health. Weather variables are associated with hospital admissions for respiratory diseases over certain periods (Makie et al., 2002; Hajat et al., 2004), and relationships between weather variables and hospital presentations for asthma and asthmatic syndromes have been examined (Celenza et al., 1996; Harju et al., 1997; Ehara et al., 2000).

Table 3.1 Key weather-related natural hazards in Canada and their associated health impacts

Extreme Weather Event	Examples: Health Impact Pathway(s)	Examples: Potential Health Effects	Populations at Higher Risk
Extreme heat	• Body temperatures are elevated beyond normal range • Increased growth and abundance of disease-causing organisms and/or vectors • Air quality is negatively affected	• Dehydration • Heat-related illnesses (heat stroke, fainting, heat cramps, heat rash) • Existing medical problems made worse, such as asthma and allergies • Physical and mental stress • Respiratory and cardiovascular disorders • Food-borne diseases • Vector-borne infectious diseases	• Young children • Seniors (especially those who are bedridden, unable to care for themselves or socially isolated) • Chronically ill individuals • People with compromised health status • People living in areas with poor air quality • People working or exercising outdoors • People without access to air conditioning • People on certain medications
Extreme cold	• Body temperature is reduced below normal range	• Frostbite • Hypothermia • Death • Increased risk of injury due to accidents (car, slipping on ice, shovelling snow)	• People without shelter • People who play or work outdoors • Children • Seniors



Extreme Weather Event	Examples: Health Impact Pathway(s)	Examples: Potential Health Effects	Populations at Higher Risk
Extreme rain or snowfall	• Flooding and its after-effects (e.g. poor indoor air quality from growth of moulds) • Increase in populations of mosquitoes and other disease carriers • Contamination of drinking water by chemicals or wastes in surface runoff • Failure of essential infrastructure (e.g. sewers, water treatment facilities) • Algal blooms and other changes in aquatic ecology	• Physical injury, shock and trauma • Death by drowning • Respiratory illnesses • Outbreaks of vector-borne infectious diseases • Outbreaks of crytosporidiosis, giardiasis, amoebiasis, typhoid and other water-borne infections	• Children • Seniors • People living along coasts or waterways • People with chronic illnesses • People with compromised health status • People with impaired immune systems • People with inadequate or no housing
Extreme drought	• Water shortages • Crop failures • Reduced water quality • Wildfires • Air pollution due to dust and smoke	• Respiratory illnesses from dust and smoke from fires • Outbreaks of water-borne illness due to increased concentration of contaminants • Hunger, malnutrition and associated stress disorders due to crop failures and economic hardship • Injury or death (in extreme cases) • Stress from loss of property, livelihood, displacement and community disruption	• People living in drought-prone areas • Agriculturally dependent communities • People without insurance • People without resources (e.g. financial and social)
Severe storms	• High winds • High waves and storm surges • Flooding • Property damage • Damage to essential infrastructure (e.g. power lines, hospitals, water treatment plants) • Damage to personal property • Increased risk of automobile accidents	• Physical injuries or death from falls, collapsing buildings, windblown debris, house fires, motor vehicle accidents, etc. (especially head injuries, fractures and lacerations) • Hypothermia • Electrocution • Food-borne disease • Respiratory illness and asthma due to pollen and spores • Drowning • Stress disorders from loss of loved ones, property and livelihoods	• People living in storm-prone areas • People living in low-lying coastal areas or in regions prone to flooding • People living in areas where environmental degradation has created hazardous conditions

Source: Adapted from Health Canada, 2005a, 2005b.

Some population groups are more vulnerable to natural hazards than others.[1] The degree to which people are vulnerable to these hazards varies significantly across the country and is influenced by, among other things, where people live, their age, the socio-economic conditions of family and community, and institutional services and infrastructures. Research into the impacts of natural hazards on health in Canada is in its infancy. Attributing illnesses to natural hazards is difficult, and requires the application of appropriate methodologies and analytical approaches to draw causal relationships. However, lessons

1 See section 3.5, Individual and Community Vulnerability, for a discussion of vulnerable populations.

can be drawn from analysis of recent events within Canada and internationally to profile hazards, vulnerable populations, and ways to reduce the impacts on individuals and communities.

The sections that follow review the many weather-related hazards in Canada, organized according to their importance in terms of the number of Canadians exposed to the natural hazard, and the known health impacts on the Canadian population.

3.3.2 Extreme Temperatures

Each year, large regions of Canada experience periods of very hot (above 30°C) and very cold weather (below -15°C) that can have both direct and indirect impacts on human health and well-being. Across Canada, average temperatures have increased by 1.2°C between 1945 and 2006, and this trend is expected to continue (Environment Canada, 2007d). As the mean temperature rises, the frequency of occurrence of extreme events increases (IPCC, 2007c). Therefore, temperatures above some threshold, such as 30°C, will become more common and temperatures below a cold threshold will become less common.

Temperature patterns vary significantly across the country. Communities in some regions (e.g. southern Alberta) can experience sudden winter temperature increases of up to 27°C in a few minutes, caused by warm chinook winds (Nkemdirim, 2007). In the high Arctic, temperatures may range from -55 to +22°C over the course of a year (Environment Canada, 2005e). Temperatures in urban and rural communities tend to differ because of the “urban heat-island effect” in city core areas (Oke, 1997; Lo and Quattrochi, 2003; Clean Air Partnership (CAP), 2004). This makes for milder winter temperatures in large urban areas, but higher summer temperatures that can exacerbate the effects of heat waves.

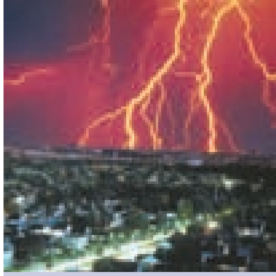
Humans and animals can acclimatize to a fairly narrow range of temperatures (their thermoneutral or comfort zone), but can suffer from excessive heat loss (hypothermia) or heat gain (hyperthermia) at extreme temperatures, which can result in illness or death (Campbell and Norman, 2000).

3.3.2.1 Heat waves

Heat waves are periods of abnormally and uncomfortably hot temperature lasting from several days to several weeks, and may be accompanied by high humidity and air pollution (American Meteorological Society, 2000). Canadian communities, especially in the Windsor-to-Quebec corridor along Lakes Erie and Ontario and the St. Lawrence River, portions of British Columbia, the Prairie region and even the northern territories may experience spells of uncomfortably or stressfully hot weather (Environment Canada, 1999; Smoyer-Tomic et al., 2003).

According to the Canadian Disaster Database, between 1900 and 2005, five major heat waves causing multiple deaths occurred in Canada. In 1936, the worst of these extended across much of Canada with temperatures ranging from 32 to 44°C, resulting in close to 1,180 deaths, mostly of seniors or infants. About 400 of the victims drowned while trying to escape the heat by cooling off in rivers, lakes or the sea (Environment Canada, 2005a). Four other severe heat waves occurred in the years 1912, 1953, 1963 and 1988 in the Prairie region or in southeastern Canada; together these resulted in at least 23 deaths and 186 illnesses requiring medical attention (PSEPC, 2005a).

Prolonged exposure to a sudden increase in environmental temperatures above 30°C (i.e. heat waves), especially when accompanied by high humidity and severe air pollution, can be especially dangerous for infants, seniors and for people in frail health, particularly those taking certain medications (Havenith, 2005). This danger is heightened early in the year when people have not yet had an opportunity to acclimatize to severe heat (Havenith, 2005). The health problems associated with extreme heat increase with longer periods of high temperatures (Toronto Public



Health, 2007). Heat-related illnesses include skin rashes, cramps, unconsciousness, exhaustion and heat stroke. The special vulnerability of economically disadvantaged people and of seniors in urban environments to heat stress was particularly evident in the disastrous heat wave of August 2003 in Europe, when an estimated 33 000 excess deaths occurred across western Europe, mostly among the very old (Kosatsky, 2005). Heat illnesses are preventable by limiting exposure to hot weather to a short period of time and by accessing cool areas to lower body temperature. Drinking plenty of liquids to maintain adequate body fluids and abstaining from alcoholic or caffeinated beverages also helps to prevent heat-related illnesses.

A study of four Canadian cities showed that from 1954 to 2000, about 120 people died each year due to heat-related causes in Toronto, 121 in Montreal, 41 in Ottawa, and 37 in Windsor (Cheng et al., 2005). In Toronto between 1980 and 1996, temperature values of 30° to 35°C (based on a humidex value) were accompanied by increased mortality for all ages, especially among those over the age of 64. In 2005, there were six heat-related deaths among residents of rooming houses and boarding houses in that city. Persons of low socio-economic status, including homeless persons, are considered to be at high risk of heat-related illness or death (Smoyer-Tomic and Rainham, 2001; McKeown, 2006).

Smoyer-Tomic et al. (2003) reviewed heat wave hazards and their health impacts across Canada, and found that the highest summer temperatures and most frequent heat waves occurred in the Prairies, southern Ontario and the St. Lawrence River valley, including Montreal. They also judged Montreal residents to be particularly vulnerable to extreme heat because the city has a high proportion of older high-density housing without air conditioning. In southern Ontario, Smoyer et al. (2000) found the population in the Windsor-to-Toronto corridor, especially those older than 64 years, to be at greatest risk of heat-related mortality because of frequent hot and humid summer weather conditions. At temperatures above 32°C, heat-related deaths were most frequent in Toronto, London and Hamilton. However, even urban areas located next to mountains and large bodies of water (e.g. Vancouver and its suburbs) can act as urban heat islands (Roth et al., 1989).

Urban heat island research in Canada has focussed on three principal metropolitan regions: Montreal, Toronto and Vancouver. As of 2007, active research programs are ongoing in each of these three cities. In Montreal and Vancouver, research is being undertaken by the Environmental Prediction in Canadian Cities (EPiCC) network (EPiCC, n.d.). Its goal is to improve the safety, health and well-being of Canadians through a better understanding of urban climates.

The Clean Air Partnership, a Toronto-based non-governmental organization, has maintained an ongoing urban heat island research program since 2002 (CAP, 2007). It has been responsible for the “Cool Toronto” initiative, which includes the production of a number of public education products (e.g. website, fact sheets).

More recently, the Canadian Centre for Remote Sensing (Natural Resources Canada) and the Clean Air Partnership have begun a multi-year research project called the Assessment of Urban Heat Island Impacts in the Greater Toronto Area Region. The research project involves detailed data collection and modelling exercises to assess the microclimate associated with various land uses and building types.

3.3.2.2 Cold waves

Cold waves are unusually large and rapid drops in temperature that can be accompanied by high winds and heavy snowfalls, and are usually followed by prolonged periods of intensely cold weather. They are a common occurrence in some regions of Canada, although all parts of the country can be affected. In the past century (from 1900 to 2005), nine have reached the scale of a recorded disaster by causing a total of 35 deaths (PSEPC, 2005a).

Mortality statistics, however, do not accurately describe the full health impact of cold waves. For those who are exposed to bitterly cold air, injuries such as frostbite and hypothermia may occur. The risk of cold injuries is increased at high wind speeds, which accelerate heat loss from the body. Therefore, Environment Canada issues weather warnings for cold waves, high winds and wind chill (Environment Canada, 2003e, 2005b). During cold alerts, vulnerable groups are usually people living in sub-standard housing, those engaged in outdoor occupations, alcoholics, the homeless and seniors (Ranhoff, 2000).

Cold-induced stress can lead to viral and bacterial infections and contribute to a pronounced peak in mortality in Canada during the cold season (Trudeau, 1997). In a study of temperature-related injuries in Montreal, most of the injuries and deaths due to extreme temperatures were caused by cold (Koutsavlis and Kosatsky, 2003). The principal determinants of cold-related injury include male gender, alcohol intoxication, psychiatric illness, older age, and homelessness. The Montreal study is unique within the Canadian context, given the lack of data on determinants of environmental-temperature injury in other cities (Koutsavlis and Kosatsky, 2003).

3.3.3 Floods

Floods are defined as water flowing temporarily over normally dry land, due to a variety of causes such as excessive rain during hurricanes or thunderstorms, rapid melting of snow or ice, blocked watercourses, storm surges in coastal areas, land subsidence or the failure of dams. Large parts of Canada's inhabited areas are susceptible to flooding because of excessive precipitation and surface run-off, rapid melting of snow and ice in the spring, and other causes identified in the Atlas of Canada (Etkin et al., 2004).

Floods have been the most commonly reported disasters in Canada (Tudor, 1997). From 1900 to 2005, at least 170 major floods occurred in Canada (PSEPC, 2005a), many of these in southern Ontario, southern Quebec and New Brunswick, and in Manitoba (Figure 3.2). They were frequently caused by spring snowmelt run-off combined with rain, and ice jams on rivers (Geological Survey of Canada, 2006; Atlas of Canada, 2007a).

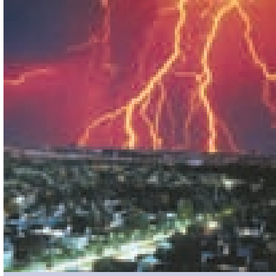
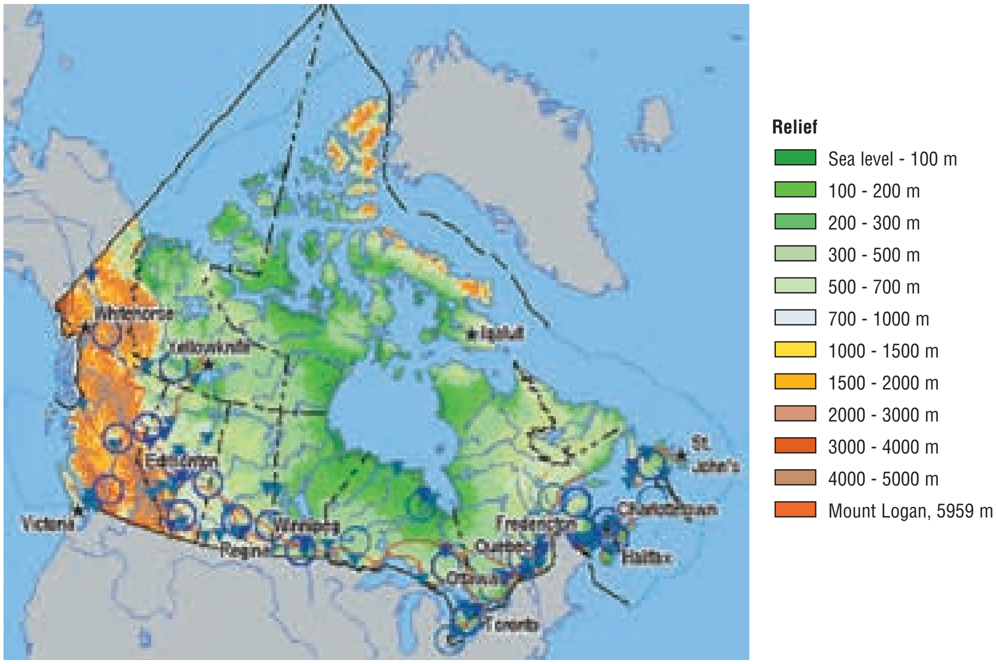


Figure 3.2 Occurrence of major floods in Canada during the 20th century



Note: Triangles indicate floods with local effects and circles represent floods with regional effects.

Source: Atlas of Canada, 2007a.

The number of flood disasters along Canadian rivers seems to be on the rise, with 70% of floods of the past century occurring after 1959. This may be due partly to more intense precipitation events, but also to population growth that has led to the expansion of settlements in vulnerable flood plains. Better reporting during the last few decades may also have led to an increase in the number of documented natural disasters, including floods (Brooks, 2006).

There are several major categories of floods, which have different causes. The first of these are "flash floods" caused by local storms with heavy rainfalls that quickly saturate the earth, leading to major run-off and unusually high peak flows in the rivers, especially in mountain areas. They usually occur along quickly flowing rivers in relatively narrow valleys, and can happen so quickly that there is little time to prepare for them. Flash floods tend to be of relatively short duration, and occur mostly during the peak thunderstorm season in the summer. The fast-flowing water can cause massive erosion, undermining roads, dams, dykes and bridges. Examples are the 1996 Saguenay and 2003 Bois Francs floods in Quebec (NRCan, 2005a; Couture, 2006). In cities, flash floods can cause sewer backups into buildings, flooding of underpasses, tunnels or below-grade expressways, and may cut off electricity supplied by vulnerable power lines or substations. This happened in July 1987 in and around Montreal after thunderstorms dropped more than 100 mm of rain. As a result, at least 40,000 homes and one health care centre were flooded, about 350,000 homes lost electricity, and the flooding of a major expressway and other roads caused over 400 cars to stall and to be abandoned, with many of their occupants requiring rescue by emergency services (Environment Canada, 2005d).

The second kind of flood results from a quick thaw following a winter with unusually deep snow and ice cover. This flooding usually takes place during the spring along large, flat river basins with gentle slopes; this results in large peak flows of slowly moving water. The run-off meltwater inundates wide areas that tend to remain flooded for a long time because of slow water drainage. Examples are the rivers of the central Prairie region that flow through a rather flat landscape with poor drainage, such as the Red River and Assiniboine River basin of North Dakota, Minnesota and Manitoba (Brooks et al., 2001; Environment Canada, 2005c). Similar conditions prevail along the Saint John River valley in New Brunswick, the upper St. Lawrence River basin, and the Fraser River and Mackenzie River deltas (Environment Canada, 2004b).

Photo Credits: Communications New Brunswick, Govt. New Brunswick

Flooding in New Brunswick, 2005

The third kind of flood is caused by storm surges, when strong winds that cross open water push large waves against shorelines. Some shore areas around the Great Lakes, as well as coastal areas of Nova Scotia, Prince Edward Island, New Brunswick and Newfoundland and Labrador are vulnerable to storm surges (Environment Canada, 2004b).

The implications of climate change for coastal regions in Canada include accelerated sea level rise, warmer ground temperatures in high latitudes (therefore enhanced melting of permafrost in the North), reduced sea ice extent in the Arctic and mid-latitude seas such as the Gulf of St. Lawrence (therefore increased wave energy) and changes in large-scale atmospheric circulation patterns causing an increase in storm frequency and severity. All of these impacts can increase the risks of flooding in coastal regions.

Table 3.2 provides information on the health impacts of floods. The existing literature suggests that the less tangible, psychosocial effects can be the most damaging (Menne et al., 1999; Hutton, 2005). Studies in Europe and the United States (U.S.) establish a correlation between flooding and subsequent increases in a range of common mental disorders (e.g. anxiety, depression, post-traumatic stress disorder) that can last, in some instances, for years (WHO, 2002; Hutton, 2005). It is hypothesized that certain vulnerable groups, such as children and low-income families, are more susceptible to such long-term impacts (WHO, 2002).

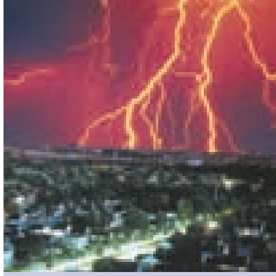


Table 3.2 Impacts of floods on human health

Direct Effects

Causes	Possible Health Concerns
Stream flow velocity, topographic land features, absence of warning, rapid speed of flood onset, deep floodwaters, landslides, risk behaviour, fast-flowing waters carrying boulders and fallen trees	Drowning, injuries
Contact with water	Respiratory diseases, shock, hypothermia, cardiac arrest
Contact with polluted waters	Wound infections, dermatitis, conjunctivitis, gastrointestinal illnesses, ear, nose, and throat infections, water-borne diseases
Increase of physical and emotional stress	Increased susceptibility to psychosocial disturbances and cardiovascular incidents

Indirect Effects

Causes	Possible Health Concerns
Damage to water supply, sewage and sewage disposal damage, insufficient supply of drinking water, insufficient supply of water for washing	Water-borne infections (enterogenic *Escherichia coli, Shigella,* hepatitis A, leptospirosis, giardiasis, campylobacteriosis), dermatitis, conjunctivitis
Disruption of transportation systems	Food shortage, disruption of emergency response
Underground pipe disruption, dislodgement of storage tanks, overflow of toxic-waste sites, release of chemicals, rupture of gasoline storage tanks leading to fires	Acute or chronic chemical pollution
Standing water, heavy rainfall, expanded range of vector habitats	Vector-borne diseases
Rodent migration	Rodent-borne diseases
Disruption of social networks; loss of property, jobs, and family members and friends	Psychosocial disturbances
Clean-up activities following floods	Electrocutions, injuries, lacerations, skin punctures
Destruction of primary food products	Food shortage
Damage to health services, disruption of 'normal' health services activities	Decrease of "normal" health care services, insufficient access to medical care

Source: Menne et al., 1999.

Despite the frequent occurrence of floods in Canada, very few deaths and relatively few injuries have occurred: fewer than one recorded death per year during this past century (PSEPC, 2007). This low number may be because, for most large floods, the water rose gradually, allowing for preventive measures and safe evacuations. Several large-scale floods since 1900 led to the evacuation of more than 200,000 people; almost half of these were due to the Red River flood in Winnipeg in 1950 (PSEPC, 2005a). The psychosocial effects of flooding can be substantial. Although commercial insurance coverage is available, the recovery of affected families and individuals can be potentially arduous because residential flood insurance does not exist in Canada (Etkin et al., 2004).

The literature on the health impacts of floods is limited in scope due to the lack of relevant data and indicators, as well as tools to assess health risks and vulnerability (Hutton, 2005). The assessment of the medium- to long-term impacts of flooding, especially the psychological impacts on human health and well-being, is an area in significant need of greater research (Hutton, 2005).

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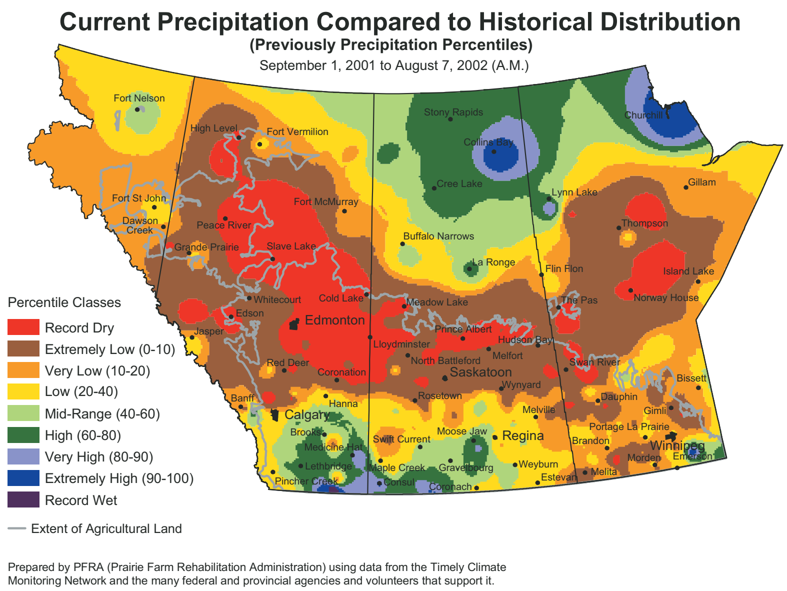
3.3.4 Droughts

A drought is a temporary period of insufficient precipitation (mostly rain or snow), resulting in inadequate surface and subsurface water supplies for ecosystem and human needs. Droughts are most common in the Prairie provinces where long-term average precipitation is already quite low, amounting to about 500 to 900 mm annually (King, 2007). Between 1950 and 2000, Canada experienced at least 37 major droughts, about two thirds of which occurred in the Prairie provinces (PSEPC, 2005a). The most recent severe drought to affect Canada occurred in 2001–2002, and extended over most of southern Canada, although the most affected regions were Alberta and Saskatchewan. It caused large crop and livestock production losses in other regions as well (Wheaton et al., 2005; Agriculture and Agri-Food Canada, 2006, 2007).

Figure 3.3 Extent of the record drought in Western Canada, 2001–2002



Note: Areas shaded in yellow, orange, brown and red indicate increasing levels of precipitation deficits.

Source: Agriculture and Agri-Food Canada, 2006.

While no deaths have been directly attributed to drought in Canada, the effects of economic damage and dust may have contributed to excess morbidity and mortality. Droughts particularly affect farmers and ranchers through greatly reduced crop yields and livestock production, with resulting economic losses (Herrington et al., 1997; Wheaton et al., 2005). The 2001–2002 drought led to the loss of more than 41,000 jobs, economic losses amounted to $3.2 billion, and net farm income in several provinces was zero or negative for the first time in 25 years (Wheaton et al., 2005). Some of the economic losses of the drought in the Prairie region were partly offset by crop insurance payments, which amounted to about $2.5 billion for Alberta and Saskatchewan (Wheaton et al., 2005).

Stress related to financial pressures resulting from droughts, combined with the effects of an environment degraded by dust storms and wildfire smoke, can have many adverse health impacts, such as respiratory illnesses, exhaustion, depression or even suicide (Walker et al., 1986; Deary et al., 1997; Malmberg et al., 1997; Smoyer-Tomic et al., 2004; Soskolne et al., 2004). Surface-water evaporation during droughts lowers water levels and causes suspended and dissolved matter to become more concentrated. This may stimulate the growth of toxic algae (U.S. Environmental Protection Agency (U.S. EPA), 1995). During droughts, some communities have to curtail their water use and hydroelectric power production is reduced, as are recreational and tourism-related activities.

3.3.5 Wildfires

Wildfires and forest fires are closely associated with droughts and thunderstorms. Droughts favour the accumulation of dry plant materials that burn easily and can serve as starter material for wildfires. Wildfires may occur in grass, peat, shrub and forest regions, but they tend to become largest and most persistent in forests, where there is abundant fuel. Lightning strikes associated with thunderstorms often ignite the dry material; they cause 35% of all forest fires (NRCan, 2004b, 2004c). On average each year, there are more than 8,000 forest fires in Canada that burn 0.7 to 7.6 million hectares (Figure 3.4). While the vast majority of wildfires occur far from human settlements, an increasing number occur at the "wildland-urban interface," as community expansion, cottages, tourist camps and other economic development initiatives encroach upon forests or lands with abundant shrubs, trees and other vegetation.

In British Columbia alone, several hundred thousand people, as well as thousands of private and business properties, are at risk from such fires, which will likely become more frequent (Bothwell, 2004; Filmon et al., 2004; Lurie, 2004). The same problem likely also exists in other parts of Canada, but has not yet been assessed.

Figure 3.4 Occurrence of forest fires in Canada, 2005

Percentage of Productive Forest
- < 1%
- 1% - 10%
- 10% - 25%
- 25% - 50%
- 50% - 75%
- 75% - 98%

Note: orange dots represent reported forest fires.

Source: Atlas of Canada, 2008.

In Canada, 52 nationally significant forest fires occurred in all provinces and territories between 1900 and 2005; most occurred in Quebec (8), Ontario (16), Saskatchewan (7) and British Columbia (6) (PSEPC, 2005a). Since 1900, major forest fires have forced the evacuation of at least 44 communities and more than 155,000 residents, and caused the deaths of at least 366 people (NRCan, 2004b; PSEPC, 2005a). Most of these deaths occurred in the first half of the 20th century, before the development of modern communications networks and airborne forest fire-fighting teams and equipment, such as water bombers.

For those directly exposed to wildfires, the health impacts can be acute and may include hyperthermia and dehydration, eye irritation and respiratory irritation leading to bronchitis caused by exposure to smoke and ash. As well, physical and mental exhaustion, stress-related hypertension and post-traumatic stress syndrome may be experienced, especially by fire fighters and other emergency personnel. Some of these impacts may also be experienced by people who have lost their homes to fire and by those who are evacuated for safety reasons (Mackay, 2003).

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Apart from the immediate deaths, injuries and loss of property and community services, large wildfires can cause long-lasting economic hardship for communities that depend on forest product industries. In addition, they can have far-reaching effects on air quality; wildfire smoke plumes are rich in toxic air pollutants, such as aldehydes, benzo[a]pyrene, carbon monoxide, ketones, nitrous oxides, organic acids and ozone (Chepesiuk, 2001; Scala et al., 2002; Sapkota et al., 2005; Langford et al., 2006). In July 2002, due to unusually large-scale air movements, smoke from large forest fires near James Bay in northern Quebec formed dense haze clouds that drifted without significant dispersion to the East Coast, a distance of over 1,000 kilometres. There and along the way, the smoke adversely affected both outdoor and indoor air quality, and caused short-term but significant health risks for millions of inhabitants of Baltimore and other major cities in the northeastern U.S. (Scala et al., 2002).

Photo Credits: British Columbia Ministry of Forests and Range

Lillooet, British Columbia, 2004

Research on the human health impacts of wildfires in the Canadian context is limited, and the results have been mixed. Although the findings of one Canadian study of rural residents in northern Saskatchewan were not conclusive with respect to the relationship between wildfire smoke and hospitalizations (Langford et al., 2006), a more recent study of the health and economic effects of a major wildfire in Chisholm, Alberta, estimated that costs related to the impairment of the health and well-being of the affected population amounted to between $9 and $12 million, second only to the cost of lost timber. The estimate took into account the increased risks of mortality, restricted activity days, lost wages and acute respiratory symptoms due to wildfire smoke (Rittmaster et al., 2006).

3.3.6 Storms and Other Extreme Weather Events

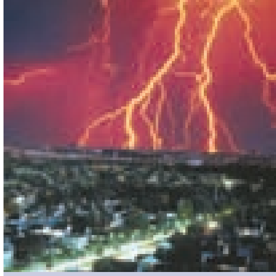
3.3.6.1 Tornadoes

Tornadoes are violent destructive whirlwinds characterized by a funnel-shaped cloud that descends from thunderstorm clouds to the ground. The funnels can vary greatly in size, speed and the amount of damage they can cause. Tornadoes most usually occur in southern Ontario and Quebec, southeastern Manitoba, southern Saskatchewan, and southern and central Alberta.

Barrie, Ontario tornado, May 1985

An exceptionally strong tornado hit Barrie, Ontario, on the afternoon of May 31, 1985, killing 12 people, injuring 281 people, and destroying and damaging many buildings. Those who died had received severe injuries, and almost all died before they reached a hospital. Nearly one half of the serious injuries were to the head and/or neck (49%), and consisted mostly of concussions and brain injuries, with less serious wounds located mostly on legs and arms. Flying objects, including broken glass, caused many of the wounds.

Many of the 605 houses along the tornado path had their roofs or upper floors torn off, windows shattered or brick walls blown apart, while some were lifted off their foundations or destroyed completely. About 200 of these houses were left uninhabitable. In addition, 16 factories were destroyed and 400 people were left at least temporarily unemployed (Etkin et al., 2002).



The Canadian Disaster Database lists 31 disasters caused by tornadoes in Canada from 1912 to 2005 (PSEPC, 2005a). Of these, one occurred in Nova Scotia, seven (22%) in Quebec, 13 (42%) in Ontario, four each (13%) in Saskatchewan and Alberta, and three (10%) in Manitoba. They caused 142 deaths (an average of 4.6 deaths per tornado), injured 1,930 persons (an average of 62 per tornado) and caused the evacuation of nearly 6,500 people. The most destructive tornado in Canada happened on July 31, 1987, in Edmonton, Alberta. It killed 27 people, injured about 600 and led to the evacuation of approximately 1,700 people.

Most tornado occurrences in Canada do not result in injuries and deaths and are therefore not captured in the Canadian Disaster Database. The average number of tornadoes per year is sixteen each in Alberta, Saskatchewan and Ontario; nine in Manitoba; five in Quebec; and one each in Nova Scotia, New Brunswick and Newfoundland and Labrador. The annual number of tornadoes in Canada seems to have increased between 1950 and 2000, from fewer than 10 to about 40, but this could be partly due to an observation bias resulting from population growth, better communications and more intensive news media coverage (Eisen, 2000). If this trend were confirmed, and were to continue along with the growth of communities in southern Canada, the Canadian population would face an increasing risk to its health and well-being from tornadoes.

3.3.6.2 Freezing rain and ice storms

Between the months of December and April from 1900 to 2000, six of seven major ice storms occurred in eastern Canada; the other was in Manitoba (PSEPC, 2005a). Of these events, the 1998 Ice Storm in early January in the northeastern U.S. and eastern Canada caused the greatest damage, and the greatest number of fatalities and injuries. Electrical power failures caused by the collapse of towers and poles, and other damage to transmission lines, affected over 1.6 million Canadians, in many cases for several weeks. An estimated 2.6 million people could not perform their ordinary work at all or could do so only partially, and economic losses amounted to $5.4 billion. Many thousands had to be evacuated to emergency shelters. The 1998 Ice Storm caused 28 deaths in Canada, mostly due to injuries resulting from the indoor use of open flames, barbecues, or propane or kerosene heaters that caused carbon monoxide poisoning or fire; only four people died of hypothermia. This natural catastrophe was exacerbated by the unpreparedness of governments, power transmission agencies, telecommunications enterprises and citizens alike to an event of this magnitude and duration (Lecomte et al., 1998).

3.3.6.3 Thunderstorms and lightning

Thunderstorms are violent winds accompanied by lightning, thunder, and often also by rain or hail, or tornadoes. They most often occur during spring and summer (Environment Canada, 1995). Lightning flashes created by thunderstorms occur mostly in low-lying areas in southern Canada. Since 1998, the Meteorological Service of Canada has operated a lightning detection network. This network has made possible the identification of lightning "hot spots" and has helped to make severe weather alerts and warnings more accurate. It can also be used to determine where lightning strikes might start wildfires. Maps showing lightning activity in Canada, as well as lightning safety information, are available from the Environment Canada Internet site (Environment Canada, 2003b, 2003c, 2007b).

In Canada an average of six to 10 people are killed each year, and another 90 to 160 are injured by lightning (Environment Canada, 2003a; ICLR, 2007). Young, healthy survivors of lightning strikes have been known to suffer from debilitating long-term damage to their nervous systems (Cooper, 1998). However, because there are few studies of medical records documenting lightning-related injuries and deaths, and many of the numbers appear to be based on news reports, it is likely that the number of people hit by lightning in Canada is under-reported. During the past 100 years, the rates of death and injury resulting from lightning strikes have declined considerably, despite a significant increase in population. In part, this may be due to better lightning protection systems for buildings, the concentration of much of the population in cities where building protection has increased in comparison with rural areas, improved individual awareness and protective behaviour, and improved weather forecasting (Aulich et al., 2001).

3.3.6.4 Hurricanes and related storms

Hurricanes (tropical storms or cyclones) consist of very strong winds (with speeds of 120 km/h or more) accompanied by heavy rain and lightning, often initially forming a spiral pattern. They generally originate over the warm waters of the southern Atlantic or in the Caribbean, and move toward Canada along storm tracks that usually pass along the East Coast or through the eastern U.S. They reach Canada at fairly frequent intervals; three to four tropical storms or hurricanes pose a threat to Canada or its territorial waters each year (Environment Canada, 2004a). The frequency of intense hurricanes is likely to increase as a result of climate change (IPCC, 2007d).

In 1985, the Meteorological Service of Canada (Environment Canada) established the Canadian Hurricane Centre (CHC) in Halifax, Nova Scotia. The CHC advises Canadians on the threat of hurricanes and tropical storms so that they can take necessary precautions to protect their health and property.

From 1950 to 1999, Ontario, Quebec, Atlantic Canada and British Columbia experienced 18 disasters related to tropical cyclones (typhoons and hurricanes), resulting in extensive damage and 137 deaths. During the same period, Canada experienced 145 disasters related to other major storms, accounting for 499 deaths. A significant number of these fatalities occurred in weather-related marine accidents such as the wreck of the "Edmund Fitzgerald" on Lake Superior in 1975 (29 deaths) and a 1982 blizzard off the coast of Newfoundland that cost 117 lives when an oil rig and an ocean-going vessel sank (PSEPC, 2005a).

The two tropical storms that probably had the greatest impact on Canada during the last 100 years were Hurricane Hazel, which passed through Ontario and Quebec in August 1954, and Hurricane Juan, which passed through Nova Scotia in late September 2003. Hurricane Hazel alone resulted in 81 deaths and over 7,400 evacuations.


Photo Credits: Peter Young

Damage from Hurricane Juan, 2003

The greatest mortality originates from the secondary disasters that are triggered by hurricanes, such as small tornadoes, flash flooding and storm surges. Historically, in the U.S., nine out of 10 deaths from a hurricane are directly correlated with the preceding storm surge (National Oceanic and Atmospheric Administration (NOAA), 2005). Individuals in the storm path consistently underestimate a hurricane's ability to cause coastal flooding, and many are caught unprepared for the consequences.

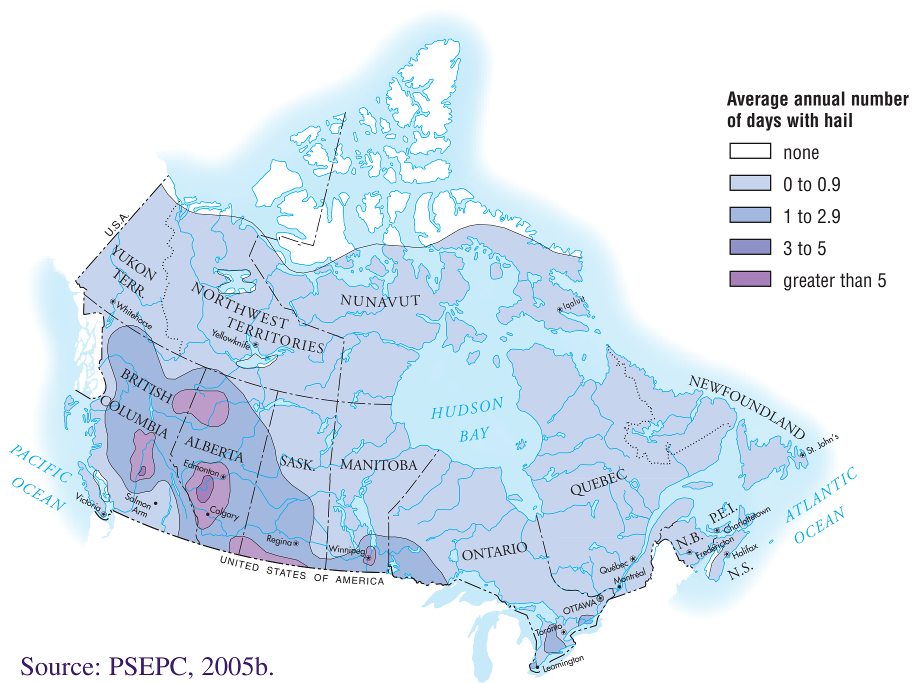
Winds are the second deadliest aspect of a hurricane. They are often responsible for property damage, including the collapse of houses and other structures. Crushing injuries caused by the collapse of structures, similar to injuries caused by earthquakes, are common during severe storms especially in areas with substandard construction. Breaking windows and doors, caused by flying objects or wind pressure, are common precursors to major damage to a building, and can cause injuries as well (WHO, 1989).

Like other natural disasters, hurricanes typically produce longer-term, yet more intangible, psychosocial impacts. Little research on this subject has been done within the Canadian context. In the aftermath of Hurricane Andrew (1992) in northwestern Bahamas and southern Florida, 30% of respondents in the most affected areas reported experiencing major depression, while a further 20% reported anxiety disorders (David et al., 1996). Parker (1977) and Hutton (2005), in a study of Cyclone Tracy (1974), which destroyed Darwin, Australia, concluded that stress arising from the event could be classified into short-term "mortality stress" (fear of injury or death) and longer-term "relocation stress" related to the loss of possessions, support networks and familiar patterns of interaction. Cyclone Tracy killed 30 and left 100 people hospitalized. One conclusion from the research is that people's capacity to recover from psychosocial impacts is linked to basic health determinants (Hutton, 2005).

3.3.6.5 Hailstorms

Hail consists of ice pellets that are produced during thunderstorms and are typically larger than 5 mm; on rare occasions pellets may reach the size of an orange or grapefruit. In Canada, major hailstorms tend to occur most frequently in southern and northwestern Alberta, in the southwestern interior of British Columbia, southern Saskatchewan, and less frequently in southern Ontario and Quebec, especially along the St. Lawrence Valley (Figure 3.5).

Figure 3.5 Average frequency of hailstorms in different regions of Canada



Source: PSEPC, 2005b.

Of the 25 hailstorms listed in the Canadian Disaster Database that occurred between 1985 and 1998, 21 (70%) took place in the Prairie provinces. They caused damages of $1.95 billion, mainly through the destruction of agricultural crops and damage to automobiles, buildings and other property. The most frequently and most severely affected city during this timeframe was Calgary, with eight major hailstorms and total damages exceeding $1.4 billion (PSEPC, 2005b). Information on hailstorms in the Canadian Disaster Database (PSEPC, 2005a) attributes seven deaths and no injuries to this hazard since 1900.

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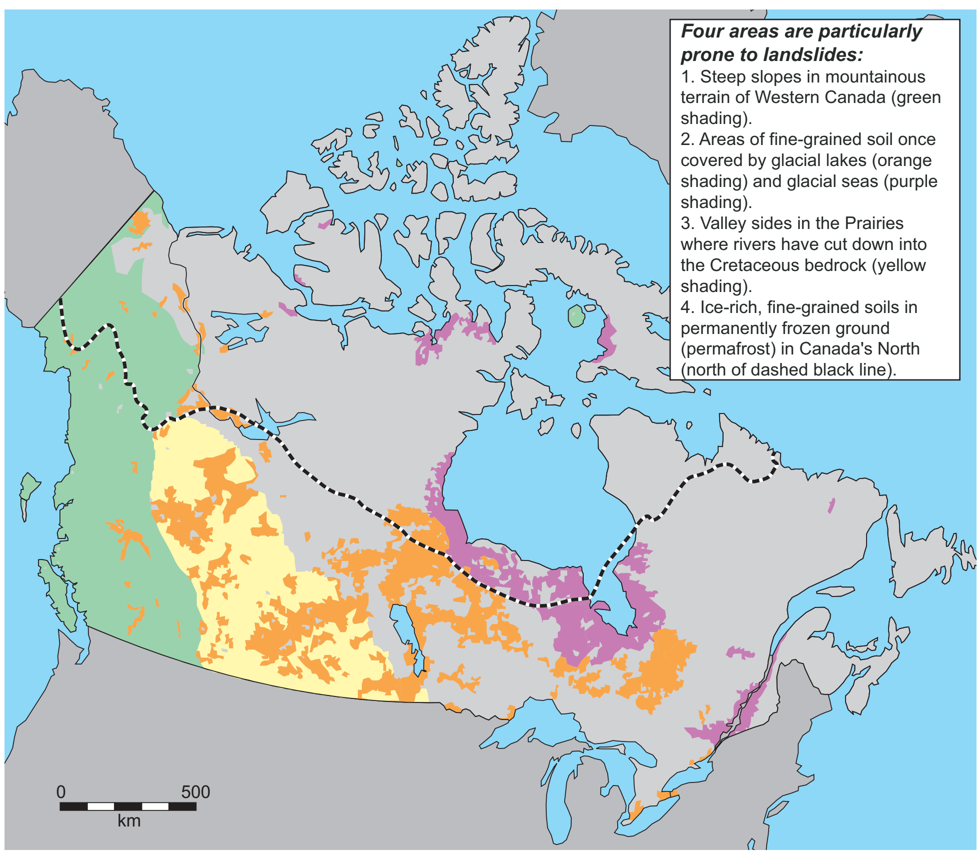
3.3.7 Avalanches, Rock-, Mud- and Landslides, and Debris Flows

A warmer climate increases the rate of evaporation, atmospheric transport, and precipitation as either rain or snow. Mountain regions are subject to heavy rains or snowfalls, and may experience glacier, snowfield or permafrost thaw. Therefore, the risk of avalanche and of excessive runoff that can trigger rock-, mud- and landslides or debris flows is likely to increase in these regions as a result of climate change.

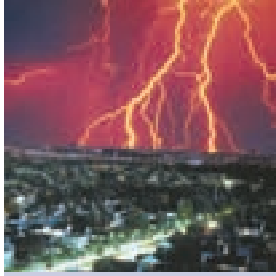
In Canada, mountain regions with steep slopes and heavy precipitation are found in the Rocky Mountains in British Columbia, Alberta and Yukon, as well as in northeastern Quebec and Labrador, and along the Great Lakes-St. Lawrence shorelines and the Atlantic coast (Evans et al., 2002; Atlas of Canada, 2007b). The geographic features of these areas favour increased precipitation, which during winter may result in snowslides (avalanches). In addition, the infiltration of rainwater and meltwater into soils, subsoils and rocks creates unstable layers that are highly susceptible to land-, mud-, rock- and debris slides.

The busy transportation and communications corridors along the river valleys of the Rocky Mountains, which are also lifelines for the communities depending on them, are at high risk of catastrophic avalanches and landslides, rockfalls and mudslides. This risk may be increased by greater precipitation resulting from a warmer climate (Miles & Associates Ltd., 2001; Evans et al., 2002).

Figure 3.6 Regions of Canada with unstable sedimentary rocks or clay deposits that are susceptible to rockfalls, debris flows or landslides



Source: J. Aylsworth, Natural Resources Canada.



In the Peace River lowlands of Alberta, unstable sedimentary Ice Age deposits favour the development of large landslides, which in the past have disrupted highways and partly blocked rivers (Cruden et al., 2000). In southern Saskatchewan, rivers have cut through deep silt and clay deposits that are susceptible to erosion and landslides, and have formed valleys with steep and unstable slopes. The deep gravel, clay, sand and silt sediments of past glaciers and huge lakes, which existed in the Prairie region at the end of the last Ice Age, are susceptible to river erosion and landslides; these threaten parts of Calgary and Saskatoon (NRCan 2005b, 2006b, 2006c). In eastern Canada, the up to 70-metre-thick Leda clay and silt deposits of the former Champlain sea are very susceptible to large-scale slumping and mudflows after heavy precipitation (Hugenholtz and Lacelle, 2004).

Between 1900 and 2005, there were at least 38 major rock-, mud-, debris- or landslides (mostly in British Columbia, but also in Alberta, Quebec and Newfoundland and Labrador) that killed 371 people, injured 56 others and led to the evacuation of more than 2,230 people. Such events have also caused significant economic damage (PSEPC, 2005c; NRCan, 2007). The long-term average occurrence for major rockfalls or landslides in Canada is 1 per 3.7 years. Rockfalls or landslides in western Canada, and landslides of Leda clay in eastern Canada have been the most destructive, and have together caused nearly one-half of the deaths (Evans, 2001). They are of particular concern when they occur along rivers, as this can result in damming or flooding along highways, railways, and power or gas transmission lines, where they can interrupt vital energy supplies and communications, or when they hit human settlements, causing injuries and deaths.

Avalanche at Kangiqsualujjuaq, Ungava Bay

On New Year's Day 1999, an avalanche at Kangiqsualujjuaq, Ungava Bay, an Inuit community in northeastern Quebec, struck a school where the community had gathered for a celebration, as well as six other buildings. The avalanche occurred on a steep slope in an area that frequently experiences heavy snowfalls, killing nine people, five of whom were children under 8 years old, and injuring 25. The avalanche also exposed the 400 to 500 children and adults in the school gymnasium to 100 km/h winds and a temperature of -20°C. Those who were seriously injured had to be transported in the very cold weather and strong winds on snowmobiles and an open flatbed truck on a 300-kilometre road to the nearest community with a hospital. Bad weather prevented medical teams from reaching the site immediately; they reached the community only nine hours after being notified.

3.3.8 Fog, Smog and Mist

Reduced visibility, caused by dense fog along major aerial, marine or terrestrial transportation routes is a common natural hazard in Canada, particularly during the transitional seasons of fall and spring. Low visibility caused by fog, smog or mist was a major contributor to several mass road vehicle collisions and fatalities in the past decade. These weather conditions contributed to three times more fatalities than freezing rain. On average, between 40 and 80 fatal road vehicle collisions occurred annually in Canada between 1988 and 2000 due to fog conditions. However, insufficient driver attention, highway congestion, high speed, increased truck traffic and other factors also typically contribute to accidents of this type (Whiffen et al., 2004).

3.4 EVIDENCE AND IMPLICATIONS OF CLIMATE CHANGE FOR NATURAL HAZARDS IN CANADA

3.4.1 Evidence of Climate Change

Over the past recent decades, numerous national and international efforts have sought to ascertain the causes, progression, and environmental and public health implications of climate change. Among them, the periodic assessment reports of the Intergovernmental Panel on Climate Change are the most comprehensive. Its *Fourth Assessment Report* concluded that warming of the climate system is “unequivocal” and that most of the warming in the last 100 years is very likely due to the observed increase in GHGs, such as carbon dioxide, largely as the result of human activity (IPCC, 2007c). This warming is evident in the increase in global average air and ocean temperatures, sea level rise and the decline in snow and ice cover (IPCC, 2007c). Numerous long-term changes in climate variables have been observed, including changes in precipitation, ocean salinity, wind patterns and aspects of extreme weather, such as droughts, heavy precipitation, heat waves and tropical cyclone intensity (IPCC, 2007c).

These climate variables are important indicators for assessing the risks associated with natural hazards described earlier, such as storms, floods and landslides. By looking at historical records to derive trends, researchers can use sophisticated models to obtain more accurate projections of a future climate. According to the IPCC (2007c), it is “virtually certain” that throughout much of the world there will be further increases in average and extreme temperatures, and that the increase in average temperatures in turn will increase the rate of surface water evaporation and precipitation, thereby increasing episodes of violent weather.

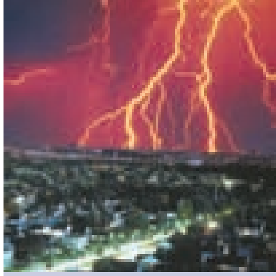
The IPCC provides judgments on the estimates of confidence based on existing scientific literature.[2] Table 3.3 provides information on recent trends and projections for extreme weather events for which there is an observed late 20th-century trend.

Table 3.3 Recent trends and projections for extreme weather events for which there is an observed late 20th-century trend

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century	Likelihood of future trends based on projections for the 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	Very likely	Virtually certain
Warmer and more frequent hot days and nights over most land areas	Very likely	Virtually certain
Warm spells/heat waves. Frequency increases over most land areas	Likely	Very Likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	Very likely
Areas affected by droughts increases	Likely in many regions since 1970	Likely
Intense tropical cyclone activity increases	Likely in many regions since 1970	Likely
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	Likely

Source: Adapted from IPCC, 2007c.
Climate Change 2007: The Physical Science Basis (Table SPM.2, p.8)

2 Judgments are based on the following scale: virtually certain (>99% chance) that a result is true; very likely (90 to <99% chance); likely (66 to <90% chance); medium likelihood (33 to <66% chance); unlikely (10 to <33% chance); very unlikely (1 to <10% chance); exceptionally unlikely (<1% chance).



3.4.2 Future Climate in Canada and Risks of Natural Hazards

Over the past 50 years, Canada's average temperature has increased 1.2°C. However, this average temperature increase hides important regional variations. The Yukon and the Northwest Territories are experiencing the greatest warming. Across the country, the percentage of precipitation that falls in heavy events is increasing. In Canada, governments at all levels, businesses and the general public have recognized that climate change will increase the risk of certain natural hazards.

Although the work of the IPCC provides projections of trends on a continental scale, its assessment of scientific literature does not constitute forecasts; it cannot predict where and when some of these events will occur or what their intensity will be. It does, however, provide information to identify where action is required to further investigate the risks or introduce measures to protect the health of Canadians.

Regional climate modelling combined with technical aids, such as projections of population changes, information about vulnerability provided by geographic information system tools, and photographic or satellite images and databases, have been used to identify where human populations might be exposed to natural hazards, and specifically those natural hazards that climate change is expected to exacerbate. Such models generally show that in the U.S. and Canada, heat waves and heavy precipitation events are very likely to become more common during this century (Easterling et al., 2000; IPCC, 2007d). In Canada, researchers have access to some regional data from the Canadian Regional Climate Model, Canadian Centre for Climate Modelling and Analysis, Environment Canada. The Ouranos Consortium provides support for the development of this model and has used scenarios based on regional climate models for the analysis of climate change impacts. For example, in recognition of the growing need to plan institutional responses to the effects of climate change, Vescovi et al. (2005) assessed the potential impact of extreme heat on southern Quebec communities. To accomplish this, they integrated climate variables and socio-economic parameters by using a geographic information system tool to create maps that estimate present and future health risks (Vescovi et al., 2005).

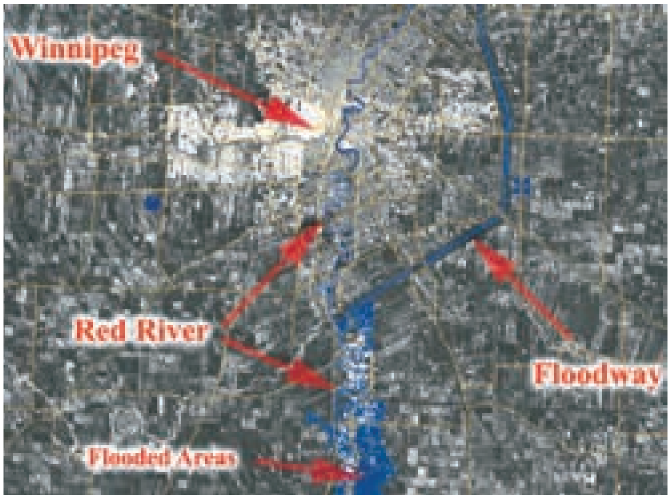
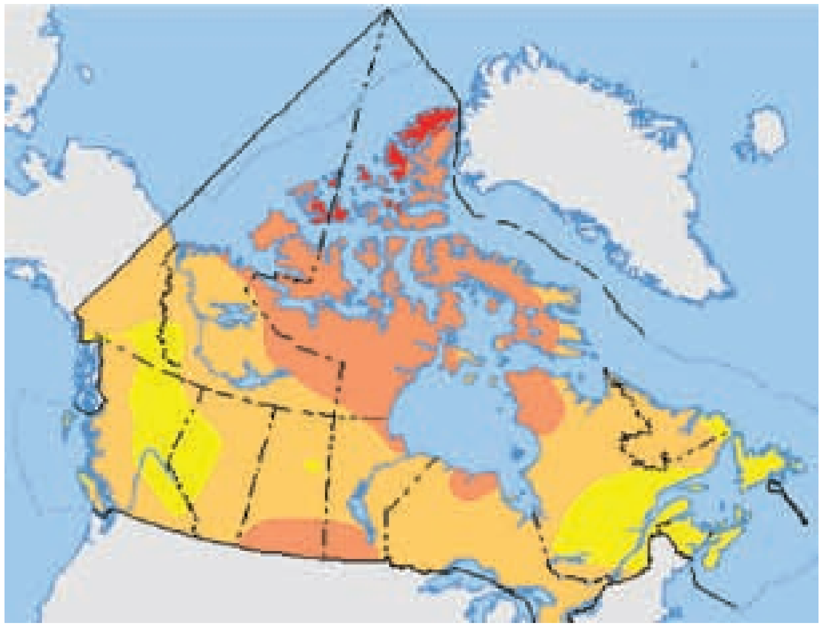


Photo Credits: RADARSAT-1 (c) 2006 Canadian Space Agency, Courtesy NRCan/ESS/CCRS

Figure 3.7 shows a projected scenario of how much the annual mean temperatures might change in different regions of Canada during the years 2040 to 2060. However, there are inherent uncertainties in projections; these increase when calculating what is likely to happen many decades from now compared with what is likely to happen just a few years from now.

Figure 3.7 Projected increases in annual mean temperatures in different regions of Canada, 2040 to 2060

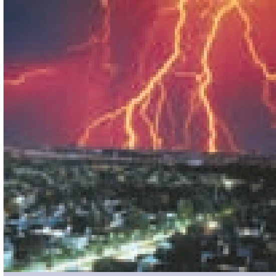


Notes: Projected increases are those compared with annual mean temperatures during 1961 to 1990, based on the Coupled Global Climate Model developed by Environment Canada. Yellow, up to 3°C; light orange, 3–4°C; dark orange, 4–5°C; red, 5–6°C.

Source: Atlas of Canada, 2003.

Climatic changes and weather events that increase slowly over time may also indirectly cause or aggravate natural hazards. For example, they may alter changing structural geologic or geographic components of the landscape (i.e. its geomorphology), or contribute to alterations in biologic components of ecosystems. Such hazards may not become obvious until gradual changes in climate or weather conditions exceed a critical threshold and trigger a disaster in a vulnerable community. For example, a warmer climate in mountain regions can release water from glaciers or thawing permafrost, creating slope instabilities that may result in landslides. In boreal forests in British Columbia, a warmer climate is reducing the winter mortality of bark beetles and leading to beetle population explosions, followed by large-scale forest die-offs and forest fires. Natural Resources Canada has published a series of maps showing regional vulnerabilities of Canadian landscapes and ecosystems to such effects (NRCan, 2000).

The extent to which climate change might cause an increase in weather-related disasters will depend very much on the extent to which communities, governments and individuals recognize hazards and work to mitigate the risk of their occurrence and the potential scope of the effects. A natural hazard triggers a disaster when it interacts with various factors (i.e. physical, social, economic and environmental) that increase the vulnerability of a community to the impacts (F/P/T Network for Emergency Preparedness and Response, 2004). Because natural disasters often occur unexpectedly or with little advance warning, they strain or overwhelm the capacity of affected communities or regions to cope. There is therefore an urgent need to improve capacities to foresee and to cope with climate change and its related natural hazards through greater national and international cooperative efforts.



3.5 INDIVIDUAL AND COMMUNITY VULNERABILITY

3.5.1 Human Health Vulnerabilities to Natural Hazards and Disasters

Risk is the product of the likelihood of an event happening and the vulnerability associated with the population affected (Etkin et al., 2004; F/P/T Network for Emergency Preparedness and Response, 2004; PSEPC, 2007). Consequently, it is important to understand the characteristics of individuals and communities that contribute to their vulnerability to natural hazards, as well as their ability to alleviate and cope with the impacts. This information informs decision making and reduces health risks before, during and after an extreme weather event occurs (PSEPC, 2007). Not all natural hazards lead to disasters. Disasters occur when the demands created by a larger-scale event exceed the community's normal coping resources; this is often called the disaster threshold (F/P/T Network for Emergency Preparedness and Response, 2004).

3.5.2 Vulnerable Individuals

Inherent vulnerabilities are found in populations and communities across Canada. The sections below examine how age, health status, socio-economic conditions and livelihoods affect the ability of people to reduce exposure and protect themselves from natural hazards, as well as cope during an event and recover afterwards.

3.5.2.1 Age

Seniors

The cohort of seniors is rapidly growing in Canada. Between 1981 and 2005, the over-65 segment of society increased by roughly 3% (from 10% to 13%) (Statistics Canada, 2006). This proportion of the population is expected to almost double to 24.5% by 2036. From this date, the seniors population will continue to increase, but at a slower rate, with their population reaching 11.5 million (27.2% of the total population) by 2056 (Turcotte and Schellenberg, 2007). The proportion of the oldest seniors (80 years and over) will also increase sharply; by 2058, about one in every 10 Canadians will be 80 years or older. In 2005, only one in 30 was older than 80 years. Compared with other adult populations, seniors are often more vulnerable because increasing age is highly correlated with increasing illness, disability, medication use and reduced fitness (McMichael, 2003). The specific vulnerabilities of seniors are important to investigate, because they may rely more heavily on the health system to reduce their vulnerabilities (Powell, 2006) and because their proportion within the Canadian population is increasing. It is, however, important to note that age alone cannot be used as the sole predictor of vulnerability; many older people continue to have good health and mobility, and remain socially active into their older years (Powell, 2006).

Nevertheless, aging for most individuals is associated with a decline in general health. Seniors may have limited physical capabilities (Turcotte and Schellenberg, 2007), and their physiological systems are generally less capable of handling stressors, such as extreme heat (McMichael, 2003). Seniors are more likely to have underlying health problems that need regular medical attention, cause limited mobility or impair their ability to care for themselves (Turcotte and Schellenberg, 2007). These vulnerabilities are important because several types of natural hazards (e.g. severe snowstorms, floods) can exacerbate existing conditions causing illness or death (e.g. older men are at increased risk of heart attack while shovelling snow). Furthermore, natural hazards may disrupt the management of existing illnesses or the provision of health services (e.g. unable to attend chemotherapy or dialysis). Seniors are also more likely to be reliant on others to ensure their personal and property safety before, during and after an event (e.g. power outages may leave a

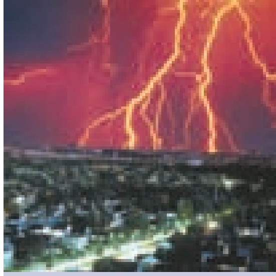
senior without heat). They may also lack the required mobility to move out of harm's way, thus increasing the likelihood of physical stress and harm.

Turcotte and Schellenberg (2007) found that many of the 25 chronic conditions most reported by seniors can influence their vulnerability to natural hazards. These conditions include arthritis, high blood pressure, cataracts, heart disease, diabetes, chronic bronchitis, effects of a stroke, and Alzheimer's or other dementia. It should be noted that stress tends to decline with age, and seniors are less likely to report emotional distress following a disaster (Powell, 2006; Turcotte and Schellenberg, 2007).

Seniors are at particular risk for heat-related illnesses and death because heat tolerance and thermoregulatory capacity decrease with age (Flynn et al., 2005). When a heat wave struck France in August 2003, causing almost 15,000 excess deaths, the observed excess mortality first affected those 75 years of age and over (Vandentorren and Empereur-Bissonnet, 2005). However, excess deaths were also severe for 45- to 75-year-olds (Vandentorren and Empereur-Bissonnet, 2005). In addition, medications commonly used by seniors, such as those used to treat chronic cardiovascular disease, may exacerbate the effects of extreme heat along with the effects of physiological changes associated with aging (Flynn et al., 2005).

Seniors are often on fixed incomes, which can make it more difficult for them to meet additional costs associated with natural hazards. For example, limited income may mean that individuals are unable to purchase adequate insurance coverage or an air conditioner, or to pay to replace property losses. Furthermore, they are less likely to apply for and receive financial aid (Powell, 2006), leaving them overwhelmed and unable to cope or recover from their losses (Shrubsole, 1999; Soskolne et al., 2004). In addition, medical expenses resulting from a natural hazard, such as unexpected prescriptions, ambulance rides or mental health services, can have a significant economic impact on low-income seniors who are without insurance.

Because networks of family and friends tend to decrease in size as people age, social isolation and loneliness tend to increase (Hall and Havens, 2002). Although only 2% of Canadian seniors reported that they had no close friend or relatives to talk to (Turcotte and Schellenberg, 2007), during a disaster or natural hazard severe disruption in existing networks can occur, and individuals may be hidden from social service providers and left alone to cope with the emergency (Powell, 2006). These contacts and networks are often key to maintaining good health or managing an illness for seniors. For example, a close friend or relative living in another community may not be able to provide timely assistance. Seniors are also more likely to be fearful during an event. During the Chicago heat wave, fearing for their safety, seniors were more likely to keep their windows and doors closed, which increased their risk of heat-related illnesses and death (Klinenberg, 2002).



Children

Statistics Canada (2006) estimates that approximately 24% of Canada's population are children (aged 0–19 years). Young children are especially vulnerable to natural hazards because their perception of danger is not fully developed, and they require more assistance to move out of harm's way and to adopt protective behaviours. After a natural hazard event, they are particularly at risk from subsequent hazards such as water, soil and air contamination. This is because their physiology, metabolism, and behaviours increase the risk of disease or illnesses. Furthermore, disruption of their growth and development at critical times may cause irreversible damage, and their exposures to contaminants per unit of body mass are higher via water and air than an adult (Tamburlini, 2002; Health Canada, 2005b).

Young children and infants are much more vulnerable to water- and food-borne illnesses than adults because they have immature immune systems and are unable to avoid risks alone (e.g. follow boil water advisories) (Jermini, 2002; Pond, 2002). Children also tend to take in more water and food per unit body mass than adults, which increases their exposure to water- and food-borne pathogens (Health Canada, 2005b). For example, after a flood a child is more likely to ingest or be exposed to contaminated water than an adult because of their inability to understand the health hazards associated with floodwater contamination, as well as their hand-to-mouth behaviour.

Thermoregulatory capacity in children is underdeveloped until 1 year of age, and their higher ratio of surface area to body mass (up to age 5) makes them more vulnerable to heat stress (Longstreth, 1999; Mathieu-Nolf, 2002; Health Canada, 2005b). As a result, infants are particularly at risk during heat waves. However, their greatest vulnerability to extreme heat may be that they are reliant on caregivers to be diligent by requiring them to drink fluids and retreat to cooler environments (Health Canada, 2005b).

As young children are dependent on others for their health and well-being and safety, they also carry the vulnerability of their caregivers. Compounding this situation is the fact that they have little or no means with which to change their situation. For example, children from low-income families are more vulnerable to heat waves if they reside in substandard housing without access to air conditioning. Children rarely have the capacity or resources to reduce their own exposure or vulnerability; they do not go to cooling centres on their own, may not understand how to relieve the stresses from heat (e.g. more fluid intake), or adopt other protective measures.

Natural hazards can also contribute to psychological trauma during and after the event (Heinz Center, 2002; Shea, 2003; McDermott et al., 2005). In his review of hazard literature, Shrubsole (1999) found that children's reactions to a natural hazard depended, in part, on the ability of their parents to deal with it; if the parents handled the disaster period adversely, so did the child. It was also found that children are more at risk from the psychological trauma of natural hazards because they have lower coping capabilities, and perceive the world according to their level of cognitive and emotional development Shrubsole, 1999; Hutton, 2005). Children can experience any number of psychological illnesses as a result of the trauma inflicted by a disaster. The effects can be as severe as losing recently developed skills, eating and sleeping disorders, as well as behavioural issues (Heinz Center, 2002; Hutton, 2005).

3.5.2.2 Underlying health problems

Chronic health conditions, acute illnesses, neurological disorders, mental illnesses (including addictions) and limited mobility increase the vulnerability of individuals to natural hazards. Chronic and acute illnesses are exacerbated by subsequent degraded environmental conditions and contamination, resulting in a lack of safe food and clean drinking water, and exposure to disease-causing pathogens and poor air quality (Mokdad et al., 2005). Illnesses that require regular medical attention can be worsened by the stress of a disaster, and can lead to death. Problems arise when people are not able to access required medications or life-sustaining treatments. Natural hazards may damage health equipment that is required to sustain life, such as ventilators or oxygen generators (Powell, 2006).

Access to medical services during an event or disaster is essential for individuals with a compromised health status. High demand for needed medical services, as well as availability of medication and equipment, can become life-determining factors. Health centres can be overwhelmed with ill or injured people during an event or disaster, placing chronically ill patients at further risk. In addition, emergency shelters may not have the equipment to deal with their special needs (Powell, 2006). Those with limited mobility will likely require aid from others to evacuate or reach a safer location. For example, individuals who are bedridden in nursing or extended-care facilities, who have spinal cord injuries or who have acute arthritis which restricts movement will require the assistance of others.

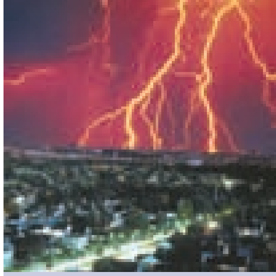
Neurological and mental illnesses can have a serious impact on a person's ability to function effectively in the face of a natural hazard event or during a disaster. Mental illness can take various forms, such as mood disorders, schizophrenia, anxiety disorders, personality disorders and eating disorders (Health Canada, 2006c). Neurological illnesses include brain diseases that impair cognitive functions, such as Alzheimer's and dementia (National Advisory Council on Aging (NACA), 2004). Depending on the illness, a hazardous event may cause serious disturbances in thinking, behaviour or mood. As a result, mental illness can affect one's ability to make the right decisions regarding health and safety before, during and after a natural hazard event or disaster. It should be noted that McMurray and Steiner (2000) concluded that patients with severe mental illness who had access to psychiatric services during the 1998 Ice Storm in Quebec coped well with the disaster.

Drug or alcohol dependency also increase vulnerability to natural hazards. Long-term consequences of substance abuse include impairment of judgment, interference with learning and retention of new material, and loss of self-control (Health Canada, 2007a). In addition, individuals on specific medications or those addicted to drugs are less capable of thermoregulation during heat waves (McGeehin and Mirabelli, 2001). Individuals who are impaired, or preoccupied with obtaining a substance, are less likely to make appropriate decisions about their health and safety, before, during or after a natural hazard event or a disaster.

3.5.2.3 Socio-economic conditions

Two key determinants of health are socio-economic status and education. Those with higher socio-economic status and education tend to have better overall health (Public Health Agency of Canada (PHAC), 2004). Income and education allow for greater control over one's circumstances, especially during stressful situations. Those with higher income and education usually have more coping options available to them before, during or after a disaster (PHAC, 2004). Education equips people with skills and knowledge to access the information and resources to better their outcomes.

Canadians with low literacy levels are more likely to have low income or be unemployed (PHAC, 2004). Lower income often creates conditions that limit the ability of individuals and families to reduce their risk to natural hazards by, for example, choosing where one lives (e.g. avoiding floodplains, avalanche chutes), adopting protective behaviours and adaptations



(e.g. air conditioners), and accessing measures that facilitate recovery (e.g. insurance, financial resources). Although it is possible to protect one's self and limit exposure to some hazards, it is not possible to avoid all exposures. If low-income individuals have a harder time staying healthy under "normal" conditions, when a natural hazard occurs they are especially vulnerable and their ability to recover may be limited.

Homelessness is often associated with drug and alcohol addiction, and mental illness (Fisher and Breakey, 1991; Hwang, 2001). People without permanent shelter are more vulnerable to extremes in temperature because they are more exposed (Hwang, 2001), and they are also less able to physiologically adapt to extreme heat (Koppe et al., 2004). Furthermore, they may not have the means to protect themselves from the effects of extreme cold, such as hypothermia and frostbite. A study in Montreal showed that homelessness, along with alcoholism, mental illness and advanced age increased the risk of cold injuries (Koutsavlis and Kosatsky, 2003). Other groups at risk of cold weather-related injuries or death are people in frail health and outdoor workers.

3.5.2.4 Aboriginal peoples: First Nations, Inuit and Métis

The Aboriginal population of Canada comprises First Nations, Inuit and Métis peoples. In 2001, 3.4% of Canadians identified themselves as Aboriginal (Statistics Canada, 2003). More specifically, 2.1% identified themselves as First Nations, 1% Metis and 0.1% as Inuit. Children under 14 years of age represent 33% of the Aboriginal population, compared with 19% in the non-Aboriginal population (Statistics Canada, 2003). Thus, many Aboriginal communities have a high proportion of children; as discussed earlier, children have particular sensitivities, including the fact that they are dependent on adults to protect them from hazards.

Many factors come together to create unique vulnerabilities for Aboriginal people and communities, such as poor health status and socio-economic conditions and inadequate infrastructure. Compared with the general population, there is a higher incidence of some chronic diseases among First Nations and Inuit people. For example, the prevalence of heart disease and diabetes are 1.5 and 3-5 times higher among Aboriginals, respectively, and 15% of new HIV infections occur in Aboriginal people (Health Canada, 2000; Health Canada, 2006b). Alcohol consumption has been identified as a problem in some Aboriginal communities, as is the increasing use of prescription or illicit drugs (Health Canada, 2006d). Poor health status renders individuals more vulnerable and less resilient to natural hazard events.

Vulnerability among Aboriginal people is compounded by existing infrastructural deficits (e.g. roads, housing, water and wastewater infrastructure). In 2000–2001, only 55.8% of homes on First Nations reserves were deemed adequate (Health Canada, 2007b). The isolation of many First Nations and Inuit communities makes evacuation and access to emergency and health services difficult, traumatic and costly during disasters. Further information on the vulnerabilities of Aboriginal people and communities is provided in Chapter 7, Health Impacts of Climate Change in Canada's North.

A warmer climate causes new natural hazards for Inuit

Aboriginal people who live off the land, especially Inuit, are vulnerable to climate change because their environment is changing rapidly and becoming more dangerous. A warmer climate is compromising the health and safety of Inuit people; melting sea ice and permafrost are causing damage to infrastructure, such as houses and health centres, and decreasing the availability of some traditional wildlife for food. Deviations from a traditional diet have been linked to a decrease in nutritional status. More unpredictable weather also makes travel dangerous (Health Canada, 2005b). Although a warmer climate may be outside the definition of a natural hazard in terms of an extreme event, it is considered a natural hazard for the Inuit people—it is a threat that increases the risk of adverse health outcomes, such as poor nutrition, injury and death (Arctic Climate Impact Assessment (ACIA), 2004).

3.5.2.5 People relying on natural resources

Individuals whose livelihoods depend on natural resources as a source of employment or as a direct source of food for themselves and their family can be particularly vulnerable to the impacts of natural hazards. Financial concern is one of the most important aspects of farming that tends to increase personal stress and distress levels (Deary et al., 1997; Simkin et al., 1998; Soskolne et al., 2004). Stress in farmers, which is related to financial pressures, has the potential to lead to many negative health outcomes such as depression or suicide (Malmberg, et al., 1997). Stress in agricultural occupations also negatively impacts family life (Plunkett et al., 1999).

Industries that rely on natural resources cannot completely protect their assets from natural hazards and changes in climatic conditions. Droughts can cause substantial decreases in crop yields and large export losses of agricultural products unless farms are equipped with reliable irrigation. This can lead to an increased reliance on financial assistance and crop insurance payouts. When climate-related stressors affect natural resources, they can affect an individual's employment, regardless of whether the employer is small, privately owned, or a large industry. Infrastructure may be affected as well. Increased storm activity, including storm surges and high winds, can cause costly damage to infrastructure that underpins business operations. This was the case in Atlantic Canada in January 2000 when a storm surge drove blocks of ice through coastal buildings and damaged fishing equipment (Canadian Institute for Climate Studies (CICS), 2000). For freshwater fisheries, drought will likely have the largest impact by decreasing water levels; this would increase salinity, and could degrade shoreline wetlands and facilitate the invasion of exotic or aggressive aquatic plant species (NRCan, 2004a). Loss of employment within a predominant sector of a small community can also have a domino effect on the provision of many services within that community and on the employment of individuals in other sectors (Heinz Centre, 2002).

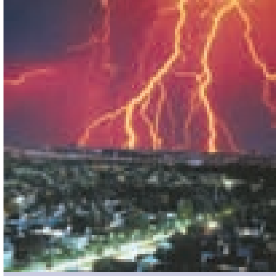
3.5.3 Vulnerable Communities

When individuals in a community are vulnerable, the vitality of that community is often affected. Likewise, when the characteristics of a community make it more vulnerable to a natural hazard, individuals are at greater risk. Lessening community vulnerability will ultimately reduce individual vulnerability and minimize negative health outcomes. Communities become more vulnerable because of increased population and property density, human habitation in high-risk areas, aging infrastructure, poor urban planning, and inadequate municipal capacity and resources, and emergency planning (McBean and Henstra, 2003; Etkin et al., 2004).

3.5.3.1 Infrastructure

Infrastructure refers to facilities with permanent foundations that are the essential elements of a community, and support human activity and improve the quality of life within the community. It includes various types of buildings and structures, such as hospitals and schools, as well as facilities like roads, railways, harbours, power stations, and water and sewage lines. Infrastructure is usually designed for a specific climate.

Questions arise as to whether Canada's current infrastructure will meet the challenges posed by climate change and the projected increase in natural hazards. It is well documented that impacts from a natural disaster can be exacerbated by weaknesses in infrastructure (Henstra et al., 2004). Damaged or destroyed infrastructure has the potential to affect health and well-being. Soskolne et al. (2004) found, in their study of newspaper reporting on disasters in Alberta, that service interruption was one of the most commonly reported outcomes associated with extreme weather, including washed-out roads, disruption of power, telephone and water services, closure of



medical facilities (e.g. hospitals) and water contamination. Palecki et al. (2001) reported similar impacts from the July 1999 heat wave in the midwestern U.S., including a record-setting usage of electric power, a burned-out transformer causing 72,000 residents to lose power at the peak of the heat wave, buckling highways leading to road closures, and small communities with well-water systems facing problems in meeting water demand. The 1998 Ice Storm in eastern Canada caused the collapse of thousands of hydro towers, resulting in massive power outages. Many people were without power for weeks during the coldest time of the year.

While all urban infrastructure is important, special attention needs to be paid to a community's critical infrastructure. Critical infrastructures are the "physical resources, services and information technology facilities, networks and assets which, if disrupted or destroyed, would have serious impacts on the health, safety, security or economic well-being of Canadians" (PSEPC, 2005a). They include infrastructure related to energy and utilities, communications and information technology, finance, health care, food, water, transportation, safety, government and manufacturing. Community vulnerability often depends on where critical infrastructure is located, and its physical capability to withstand the assault of a natural hazard event. Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, examines concerns regarding the state of critical infrastructure in Canada and its implications for vulnerability to the health impacts of climate change.


Photo Credits: Peter Young

Damage from Hurricane Juan, 2003

Infrastructure can also exacerbate the effects of a natural hazard event. For example, materials used in buildings and infrastructures are directly related to the urban heat island effect. This effect is primarily due to an absence of vegetation and the thermal properties of dark surfaces, such as paved roads and tarred rooftops (Frumkin, 2002). Some simple changes in building design and infrastructure, such as living or green roofs and reflective light-coloured surfaces, can mitigate this effect. As well, cities with a high density of impervious surfaces severely limit the potential for the infiltration of water, causing increased surface runoff. This runoff has the potential to overwhelm storm-sewer systems during intense precipitation events, possibly increasing the vulnerability of the population to environmental and public health impacts.

Many cities across Canada face significant pressures from aging infrastructure and the needs of growing populations. The level of deterioration and the age of current infrastructure may render it vulnerable in today's climate (Henstra et al., 2004), let alone for future climate for which extreme weather events are projected to increase. The capacity required to upgrade infrastructures, or to make significant new capital investments, often exceeds the capacity of one level of government (Federation of Canadian Municipalities, 2003). Smaller and rural communities face particular pressures when it comes to investing in infrastructure to protect their populations. In rare cases, protection from and/or mitigation of natural hazards is not possible; relocation of the community is the only option. In many northern communities, infrastructure such as roads and buildings is in danger because of shorter winters, a longer thaw season and melting permafrost (ACIA, 2004).

3.5.3.2 Public health and emergency response services

A successful emergency management program aims to provide communities and individuals with appropriate health care and emergency social services in times of disaster (F/P/T Network for Emergency Preparedness and Response, 2004). Primary health care services are the first point of contact with the health care system and include basic emergency services. Secondary services, such as hospitals and long-term care institutions, provide more specialized care (Health Canada, 2006a). Both primary and secondary services are affected to various degrees during natural hazard events or disasters. Hospitals and emergency centres not only have to cope with people who have acute injuries and illness as a consequence of the event, but also those who can no longer manage their pre-existing health conditions (e.g. diabetes), and those with health conditions that may be exacerbated by the event (e.g. HIV/AIDS) (Powell, 2006).

A natural hazard can quickly become a disaster if the health service infrastructure is not prepared or cannot respond. This may require relocating or retrofitting health infrastructure, such as hospitals, clinics and nursing homes that could be severely damaged by disasters; ensuring continuity of services for current or emergent individuals during times of internal system disruptions and external community impacts; and providing an alternate system of communication (F/P/T Network for Emergency Preparedness and Response, 2004).

Case study: Lessons from the tornado at Pine Lake, Alberta, 2000

In July 2000, a tornado, with winds of up to 300 kilometres per hour, struck a campground and trailer park at Pine Lake, Alberta, killing 12 people and injuring more than 140. Close to 1,000 people were displaced from the site as their recreational vehicles were damaged (PSEPC, 2005a). The experience at Pine Lake demonstrates the importance of disaster planning, the critical role of communications systems and the response of paramedics and other emergency personnel. Sookram et al. (2000) noted areas requiring improvement for future disaster responses, in particular ensuring that the response is proportionate to the disaster and strengthening communication systems (primary and alternate).

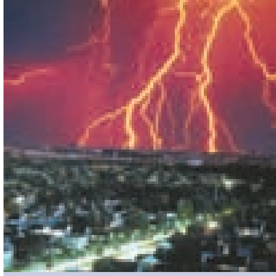
More ambulances than required were dispatched to the disaster site; this resulted in no ambulance coverage for emergencies in other communities. An organized dispatch system coordinating the various emergency medical services should balance the needs of the disaster scene with the needs of the surrounding communities. In addition, the cellular communications system failed, and reliable information could not be passed from the disaster site to the receiving hospitals. A potential solution identified for future disasters was a mobile communications trailer to be used as an on-site command and control post.

Photo Credits: Dan Kulak

Tornado damage at Pine Lake, Alberta, 2000

In the absence of reliable casualty estimates, Calgary and Edmonton hospitals fully activated their disaster plans; hospital beds were vacated, city ambulances were diverted, and physicians and nursing staff were called in. But the number of casualties did not require this level of response. For a disaster of this size, a staged response would have been more appropriate (e.g. call in some extra staff and have others on stand-by) (Sookram et al., 2000). A staged response permits staff rotation and prevents staff fatigue if the disaster proves more serious or prolonged.

Sookram et al. (2000) also reported that this disaster demonstrated that well trained emergency physicians can contribute to on-scene patient care, although to be most effective, physicians should have experience and be familiar with the protocols, equipment and problems associated with field medicine.



Emergency physicians need to be familiar with their hospital's disaster plan, and be prepared to lead or participate in the disaster response. Support services and staff with appropriate training must also be available. Other ways health care institutions and personnel may be vulnerable during an emergency include:

- hospitals that contract out certain essential services (e.g. laundry and food) may have them interrupted during an emergency;
- overcrowding in emergency shelters during a disaster may increase exposure to infectious diseases (e.g. influenza) of health care workers and as a result make them unavailable to support emergency responses (ICLR, 2003)—mass vaccinations could be required; and
- electronic medical records could face access delays of up to days or weeks in the event of a power outage during a disaster, with a consequent delay in care.

3.5.3.3 Urban planning

Urbanization has increased by 66% over the last 50 years in Canada. Approximately 80% of Canadians now live in cities, with 60% living in urban areas with more than 500,000 people (ICLR, 2003). The occurrence of natural hazards in urban areas with large concentrations of people increases the likelihood of disasters. With increased urbanization and population pressures, people are moving into more marginal land, such as coastlines, floodplains, unstable slopes and wildland-urban interfaces (Robert et al., 2003; Roy et al., 2003). For example, there has been a surge in the population of the Lower Mainland region of British Columbia despite the high risk of earthquakes and floods in the area (McBean and Henstra, 2003).

New construction and urban plans and design rarely incorporate adequate resistance to natural hazards, such as tornadoes or flooding. Inappropriate land-use planning puts people in harm's way. The lack of protection or mitigation measures leaves the inhabitants of vulnerable communities to bear the full cost of disaster losses (McBean and Henstra, 2003). This settlement pattern increases the likelihood that the number of people affected by natural hazards will continue to grow. Key to resolving this issue is, among other practices, strategic and smart land-use planning.

3.5.3.4 Community structure and characteristics

Urban communities are highly vulnerable because of greater population densities, placing more people and property at risk (McBean and Henstra, 2003). However, community structure also plays a role in the capacity of communities to adapt to natural hazards. Communities with more "high-risk" inhabitants will require more resources to effectively manage health emergencies. For example, a retirement community has more people with special health needs. In addition, communities with a greater proportion of lower-income families that may have special needs during an emergency will have a lower tax base for resources to implement emergency programs.

Communities can face very different challenges. For example, First Nation communities are often more isolated, making evacuation plans more difficult and emergency medical response times greater. Economic engines of a community, such as agriculture or fisheries industries, may increase a community's vulnerability to natural hazards and disasters. Destruction of infrastructure is likely to have impacts beyond the cost of repairing damage; not only are the services and products lost because of the disaster, but jobs and the community tax base are also reduced. This can have lasting effects on the entire community (Heinz Center, 2002). It is important that communities identify their socio-demographic characteristics and the inherent vulnerabilities to hazards that may exist within or around their boundaries. This knowledge assists decision makers in the design and implementation of programs to improve preparedness and the ability of vulnerable populations to cope. This process is necessary to improve the resilience of the community to the impacts of natural hazards.

3.6 MANAGING RISKS FROM NATURAL HAZARDS AND REDUCING VULNERABILITY THROUGH ADAPTATION

3.6.1 Emergency Management Approach

The field of emergency management is structured around well-defined concepts, approaches and frameworks that should guide the process of adaptation to climate change. However, terminology used in this field and in the field of climate change can lead to confusion because different terms are sometimes used to express similar concepts, while occasionally the same terms mean different things. For example, disaster mitigation and climate change adaptation refer to similar sets of activities—those aimed at reducing risks from hazards. However, in the climate change field mitigation refers to actions taken to reduce the emission of GHGs. In the following sections, the terms disaster mitigation and mitigation are used interchangeably.

Mitigation: The prevention of natural hazards from becoming natural disasters. It includes policies and actions taken before or after a disaster to reduce the impacts on people and property, such as building public awareness and support, developing local and regional plans for land use to prevent inappropriate development in hazardous areas, and changing building codes and standards to protect people, property and infrastructure.

Preparedness: The activities and measures taken in advance to ensure effective response to the impact of hazards, such as the issuance of effective early warnings and the temporary evacuation of people and property from threatened locations.

Response: Actions taken immediately before, during and after a disaster to protect people and property and to enhance recovery, such as emergency public communication, search and rescue, and medical assistance to those in need.

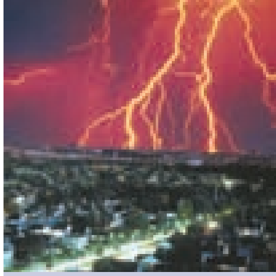
Recovery: Actions taken after a disaster to restore critical systems and return a community to pre-disaster conditions.

Hazard or disaster risk management is defined by the International Strategy for Disaster Reduction as the "systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters" (UN/ISDR, 2004). Emergency management[3] uses a risk-based approach to hazards—that is, a systematic assessment of hazards, threats, risks and vulnerabilities relating to people in a geographic area, or an organization, to develop an effective emergency management plan (PSEPC, 2007). Effective emergency management incorporates overlapping, complementary components: mitigation (prevention), preparedness, response and recovery.

In the international community, there is a growing consensus that emergency management policies must incorporate a greater emphasis on mitigation. The Hyogo Declaration of the 2005 United Nations World Conference on Disaster Reduction stated:

> "We, delegates to the World Conference on Disaster Reduction...are deeply concerned that communities continue to experience excessive losses of precious human lives and valuable property as well as serious injuries and major displacements due to various disasters worldwide... We recognize as well that a culture of disaster prevention and resilience, and associated pre-disaster strategies, which are sound investments, must be fostered at all levels, ranging from the individual to the international levels... We affirm that States have the primary responsibility to protect the people and property on their territory from hazards, and thus, it is vital to give high priority to disaster risk reduction in national policy, consistent with their capacities and the resources available to them." (UN/ISDR, 2005c, p. 1)

3 In the literature emergency management and disaster management are often used interchangeably. For the purposes of this Chapter, the term emergency management will be used.



In addition, based on global consultations held in 2006 which brought together experts in emergency management from around the world, the WHO released *Risk Reduction and Emergency Preparedness: Six-Year Strategy for the Health Sector and Community Capacity Development.* The strategy, which is to inform both developed and developing countries, has the following priorities (WHO, 2007):

- assessing and monitoring baseline information on the status of risk reduction and emergency preparedness in the health sector at regional and country levels;
- institutionalizing risk reduction and emergency preparedness programmes in ministries of health and establishing an effective all-hazard whole-health programme for this purpose;
- encouraging and supporting community-based risk reduction and emergency preparedness programmes; and
- improving knowledge and skills in risk reduction and emergency preparedness and response in the health sector.

Many governments around the world have changed, or are in the process of changing, their disaster management policies to incorporate a greater emphasis on mitigation. Although Canada endorsed the Hyogo Declaration, Canadian emergency management policies do not yet incorporate significant mitigation activities. However, in January, 2008 the federal government released Canada's National Disaster Mitigation Strategy which incorporates disaster mitigation into Canada's evolving emergency management framework. The Strategy sets out a common vision for disaster mitigation activities in Canada through enhanced leadership and coordination, education and outreach activities, scientific research and increased federal, provincial and territorial mitigation investments (PSC, 2008).

Another important element in the development of mitigation policies is federal Bill C-12, the *Emergency Management Act,* which received Royal Assent in June, 2007. It provides for enhanced emergency management activities in Canada by granting the federal Minister of Public Safety the responsibility for exercising leadership relating to emergency management in Canada. To this end the Minister coordinates emergency management activities among government institutions and in cooperation with the provinces. The Act assigns responsibilities for all aspects of emergency management including mitigation, preparedness, response, and recovery to protect Canadians from disasters. Requirements for prevention and mitigation activities in the new Act provide an important opportunity to make progress on adaptation efforts aimed at reducing risks to health from climate-related natural hazards in Canada by adopting a more balanced and comprehensive approach to emergency management.

Canada still faces a number of challenges in implementing a national disaster mitigation strategy (McBean and Henstra, 2003). As a federal state, Canada relies on intergovernmental collaboration for the development and implementation of policies on disaster mitigation. A strong federal desire to move forward with and sustain an initiative may not be sufficient to support the implementation of programs and policies across Canada. There is also uncertainty regarding current risks from natural hazards and existing vulnerabilities, which makes it difficult to identify areas where policies should be targeted to be most effective. More information is needed through community-level assessments and research to develop appropriate responses or mitigation measures to protect health.

As well, because disasters occur infrequently, interest in disaster mitigation can be sporadic and short-lived, and citizens generally perceive a low probability of loss from such events. As a result, officials are not inclined to make adequate investments in mitigation. The post-disaster opportunity and policy window for improving mitigation measures is usually overtaken by the primary goal of returning the community to "normal" as quickly as possible.

Chapter 3

3.6.2 Emergency Management in Canada: Current Capacity and Initiatives

3.6.2.1 Overall capacity and advances in preparedness

Photo Credits: Canadian Red Cross

In Canada, all levels of government and a wide range of sectors have important and generally well defined roles in managing risks to health from natural hazards and disasters. Inter-governmental collaboration between federal and provincial authorities is essential for the development and implementation of emergency management policies. Municipal governments play a key role in Canada in reducing risks to health from climate change through their activities related to police, fire and ambulance services, utilities, local public health and social services, and community emergency preparedness and planning. Most emergencies in Canada are local in nature and are managed by municipalities or at the provincial or territorial level (PSEPC, 2005a). Non-governmental organizations (e.g. Canadian Red Cross, Salvation Army), the business community (e.g. insurance companies) and individual Canadians also play key roles in reducing risks from natural hazards.

Concern about existing vulnerability to the impacts of natural hazards on the health of Canadians and their communities has resulted in recent efforts to better prepare for disasters and appropriately manage existing risks. The actions taken by the Government of Quebec to revise and extend public safety legislation to improve the emergency preparedness of local and regional municipalities in response to the Saguenay flood and other events (Beauchemin, 2002) is one example. In Ontario, the new *Emergency Management and Civil Protection Act* stipulates that all communities and the provincial government must establish an emergency management program based on hazards and risks that the people of Ontario may face (Government of Ontario, 2006). The Act provides the emergency powers necessary for the provincial government to react quickly to an emergency (e.g. evacuations, closing private and public places to limit access, disposing of environmental or animal waste) (Government of Ontario, 2006). In recent years, considerable progress has also been achieved within the health sector to develop a more integrated and robust emergency management capacity (Health Canada, 2005b). A number of the actions that have been taken to increase the ability of communities and governments to manage health risks associated with extreme weather events and natural hazards are presented in Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada.

3.6.2.2 Health emergency management

The health sector plays a key role in efforts aimed at protecting Canadians from extreme weather events and natural hazards which can turn into disasters. Health emergency management plans and activities set up processes to guide and prepare the health and social services sectors at all levels of government, or within institutions, for a range of public health emergencies. The National Framework for Health Emergency Management in Canada highlights the key stages and requirements of health emergency management for decision makers (Figure 3.8).

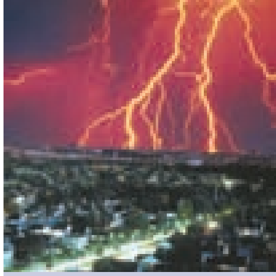
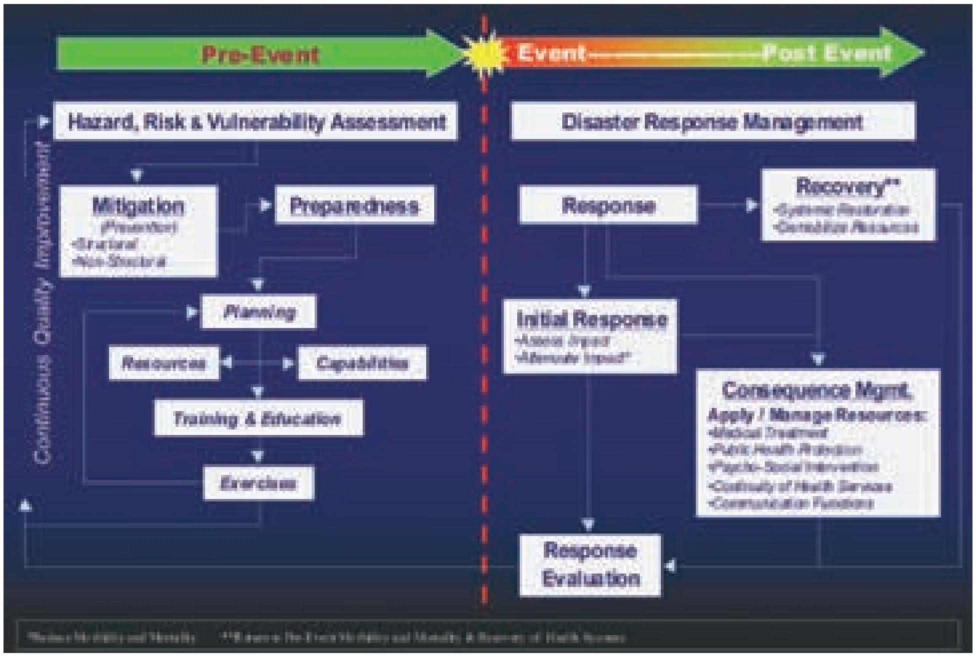


Figure 3.8 National Framework for Health Emergency Management



Source: F/P/T Network for Emergency Preparedness and Response, 2004.

Health emergency management activities are aimed at reducing vulnerabilities, at the individual and community levels, to the risks associated with extreme weather events and natural hazards. The Framework provides information and an organizational structure for Canada's health and emergency social services sectors to properly mitigate hazards, prepare for emergencies, respond quickly and help communities recover (F/P/T Network for Emergency Preparedness and Response, 2004). The Framework is pan-Canadian and trans-jurisdictional in scope in order to ensure that the information is useful to community-based programs, companies in the private sector, local jurisdictions (municipalities, provinces, territories) and federal departments.

Under the Framework, four facets of the health and social services sector are emphasized: physical health (individual perspective), public health (population perspective), emergency social services (societal perspective), and maintenance of activities (organizational perspective). Each facet is examined in every phase of emergency management (i.e. mitigation, preparedness, response, recovery) with a view to minimizing the health impacts associated with natural hazards (F/P/T Network for Emergency Preparedness and Response, 2004). Work continues on the development and implementation of Canada's National Health Emergency System, based on the principles and guidelines set out in the National Framework for Health Emergency Management. Key activities include (Expert Group on Emergency Preparedness and Response, n.d.):

- National Health Incident Management System, which is intended to facilitate a coordinated response capacity across the F/P/T health system during health emergencies or crises;
- Memorandum of Understanding on Mutual Aid, which provides a mechanism for F/P/T governments to provide and to receive assistance from one another during a public health emergency in an efficient and timely manner;
- Pandemic Preparedness Health Operations Coordination Working Group to enhance operational capacity and consistency across all jurisdictions on pandemic issues; and
- National Surge Capacity Strategy to facilitate a timely and efficient response to the increased health demands placed on health care systems across all jurisdictions during emergencies.

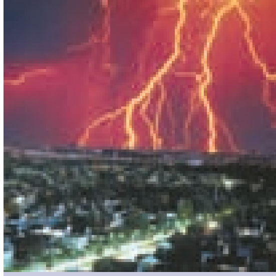
3.6.2.3 Identifying hazards and issuing warnings

The identification and analysis of hazards at the local level is the cornerstone of emergency management and is necessary for the establishment of community response plans. In a survey of eight cities across Canada conducted in 2005 for this Assessment, it was found that all municipalities had identified and analyzed the hazards that were prevalent in their geographic regions (Health Canada, 2005c). Natural hazards, particularly extreme weather events and situations involving hazardous materials, were generally considered to pose the highest risks. For emergency management officials, public health hazards, particularly pandemic influenza and risks associated with water or food were considered to be of somewhat lower priority. The methods used to analyze and rank the hazards varied considerably. In Ontario, the provincial government introduced a process called Hazard Identification and Risk Assessment (HIRA) which provides a standardized technique for assessing risks to communities and establishes a common foundation for the development of emergency plans. In other cases, cities integrated the assessment of hazards and their potential consequences into a broader risk management process which helped identify preventive and mitigation actions in addition to effective emergency response measures. It was noted by many officials that without available methods for analyzing hazards and ranking risks, smaller municipalities with fewer resources would not be able to undertake comprehensive analyses.

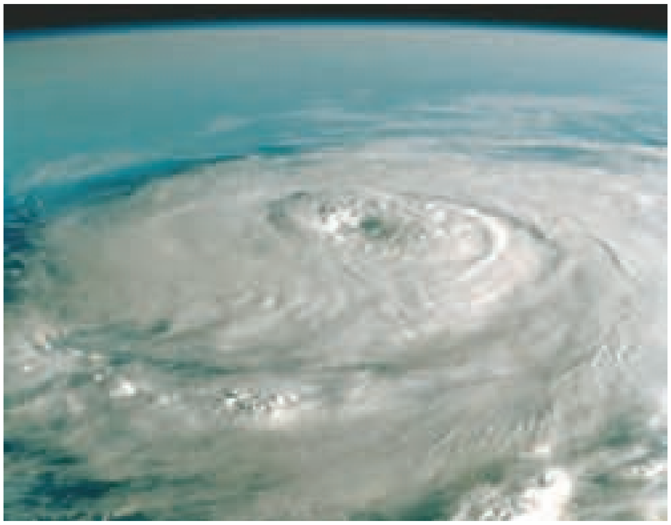
In the emergency management context, early warning implies the means by which a potential danger is detected or forecast and an alert issued (UN/ISDR, 2005a). The goal of early warning systems is to maximize the probability that people at risk will take the appropriate actions to protect themselves from a natural hazard event, whether its onset is sudden or gradual (Thomas and Mileti, 2003). Several recent international conferences have focussed on early warning systems as key strategies for reducing the health impacts of natural hazards. The Third International Conference on Early Warning in 2006, the Potsdam International Conference on Early Warning Systems for the Reduction of Natural Hazards in 1998, and the Yokohama Conference on Natural Disaster Reduction in 1994 recognized the importance of early warning systems as part of overall disaster reduction strategies. Among the many benefits of implementing an early warning system, the most important is a reduction in the loss of life and impacts on human health (O'Neill, 1997; National Health Assessment Group (NHAG), 2001; Comerford, 2005; Rego and Subbiah, 2005; World Meteorological Organization (WMO), 2005). Ancillary benefits include a reduction in impacts on individual property and on a range of economic sectors (e.g. construction, agriculture and shipping) that contribute significantly to a nation's prosperity and to the health and well-being of individuals.

Due to an increase in the power of new technologies and a decrease in their costs, early warning systems are becoming easier to implement all over the world. However, proper development and implementation are essential for recognizing the full benefits provided by such systems. The disseminated message must have a clear meaning, and the public must have adequate knowledge of the procedures to follow during a response to effectively reduce risks to health.

An "all-hazards" approach provides benefits to all segments of society by using one system to warn against multiple hazards. Canada has yet to implement an all-hazards approach to emergency management. At present, it relies on several systems that issue warnings for a number of specific natural hazards. Some communities have recognized their vulnerability to extreme weather events or natural hazards and, along with other levels of government, are taking action to reduce health risks associated with such events. Early warning systems for a range of natural hazards (e.g. heat waves, storms) have been implemented in jurisdictions across the country. A frequent problem with the systems is the weak linkage between the technical capacity to issue the warning and the capability of the public or institutions to respond effectively to it. Often, the capacity



of the warning to trigger the appropriate response by emergency management agencies, community-based organizations and the public at large is not adequate (UN/ISDR, 2005b). Efforts are under way in several communities around the world to increase public awareness of hazards and to promote individual protective measures. Canada could draw useful lessons from international experience in developing and implementing warning systems to protect health.



Satellite data, in combination with geographic information systems, are very useful for ascertaining the causes, progression, extent and impact of extreme weather events, and for discerning how natural disasters might be avoided or impacts reduced. Satellite images can help planners and emergency response teams to quickly pinpoint vulnerable locations and populations affected by natural hazards (Jedras, 2003). Weather and climate monitoring data from satellites are provided or used in this way by the Canada Centre for Remote Sensing, the Meteorological Service of Canada, the Canadian Hurricane Centre, the Canadian Wildland Fire Information Service, the Canadian Lightning Detection Network, and the Earth Observatory of the U.S. National Aeronautics and Space Administration. Current measures to identify and monitor the progression of extreme weather events in Canada that may pose health risks are highlighted below.

Heat waves

Environment Canada defines a heat wave as three or more consecutive days when the air temperature reaches at least 32°C, and issues weather advisories when a heat wave is expected to occur (Environment Canada, 2005a). A comprehensive scan of public health websites revealed that only a small number of communities in Canada presently engage in heat management activities, including heat alert systems. These systems are found largely in urban communities in Ontario and Quebec (Paszkowski, 2007). Examples of warning systems used in communities across Ontario are found in Table 3.4. Few urban communities in other regions, including the Atlantic and the Prairie provinces, have formal warning systems in place, although some communities do include heat response information and advice for vulnerable populations on their websites. However, the majority of urban communities and many small urban communities engage in "greening" activities that may contribute to a reduction in the urban heat island effect. In most cases though, heat mitigation is often not explicitly mentioned as a purpose or benefit of the existing activities (Paszkowski, 2007).

Cold waves

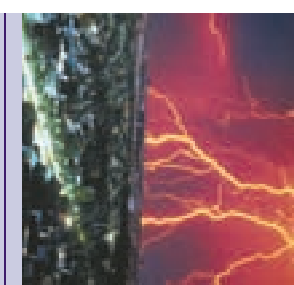
When unusually low winter temperatures, cold waves or winter storms are expected, weather forecasts issued by Environment Canada usually include short-term warnings to take protective measures (Environment Canada 2003e, 2005b). These forecasts are used by municipal and regional health agencies to issue local-level cold weather alerts or warnings. It would be helpful to have more accurate long-term forecasts of cold waves that communities can use to aid in preparations aimed at protecting vulnerable populations.

Table 3.4 Examples of heat warning and response activities of urban communities in Ontario

	System	Threshold	Alert	Response	Information
1	No dedicated system – mention health unit system	Not indicated	Notification to media, notice posted on website	Information about cooling options: community centres, libraries, and pools	Heat risk and protection information. Vulnerable: seniors, children, the disabled, the chronically ill
2	No dedicated system – link to health unit heat alert program	Not indicated	Notice on website; link to health unit alert program	Not indicated	Heat risk and protection information, no vulnerabilities specified
3	No dedicated system – post health unit heat alerts	Not indicated – high temperature humidex, smog	Notice on website; link to health unit	Information about cooling options: shopping centers, libraries, pools	Link to health unit information; health unit identifies vulnerabilities
4	No dedicated system – mention health unit alert system	Issuance of humidex advisory by EC	Post health unit notice on website	Air conditioned public facilities used as cooling centers. Pool hours extended.	Heat risk and protection information. Vulnerable: seniors, children, the disabled, the chronically ill
5	Mention of health unit heat alert system	Extreme heat day: humidex of 40	Issue media advisory	Extend hours for city owned pools and splash pads	No heat risk or protection information
6	No dedicated system – mention EC humidex advisory system	EC humidex advisory: Humidex of 40	None indicated	None indicated	Heat risk and protection information. Vulnerable: seniors, children, overweight or ill individuals
7	No dedicated system – mention EC humidex advisory system	EC humidex advisory: Humidex of 40	Notice on website; media release	Community centres used as cooling centres; water is distributed	Heat risk and protection information. Vulnerable: seniors, children, overweight or ill individuals
8	Humidex-based system. Three phases: *Phase 1* – heat advisory *Phase 2* – heat warning *Phase 3* – heat alert	*Phase 1* – humidex of 40, 1 day *Phase 2* – humidex of 40, > 1 day *Phase 3* – humidex of 40, > 3 days OR 45, 1 day	Notification to media; notice posted on website	*Phase 1* – issue media advisory *Phase 2* – issue media advisory with additional info *Phase 3* – control group determines response; may include cooling centres, extended pool hours, targeted outreach	Heat risk and protection information. Vulnerable: seniors, chronically ill, infants/small children, the socially isolated, individuals with limited mobility and on certain medications, those who work or exercise vigorously outdoors
9	Have a heat alert plan, no details provided	Not indicated	Notice posted on website; may notify media	Not indicated. Have an emergency response plan	No heat risk or protection information; extreme heat identified as a potential risk faced by a community
10	Humidex-based system; extreme heat alert issued by MOH	Maximum humidex: 40	Notice on website; media alert issued, may call 311 phone line for information	Air conditioned recreation facilities opened 7 days a week	Heat risk and protection information. Vulnerable: seniors, children, the frail, individuals who live alone

	System	Threshold	Alert	Response	Information
11	Humidex-based system. Three phases: *Phase 1* – heat advisory *Phase 2* – heat alert *Phase 3* – extreme heat alert	*Phase 1* – humidex of 36, 2 days *Phase 2* – Phase 1 and smog OR humidex of 40, 2 days *Phase 3* – Phase 2 and smog OR humidex of 45, 2 days	Notification on community and health unit websites; media release	Information dissemination, extension of pool hours, extension of shelter hours; community indicates presence of a heat emergency plan	Heat risk and protection information. Vulnerable: seniors, the socially isolated, those with low income, those with chronic/ pre-existing illnesses (including mental illness), children, the homeless
12	Humidex-based system	Humidex of 40, 1 day OR 36, 3 days; other factors may be considered	Alerts issued by the public health unit; no further details	Not indicated. Have an emergency response plan	Heat risk and protection information (from the health unit). Vulnerable: seniors, young children, work or exercise vigorously outdoors, have chronic heart/lung conditions, individuals on certain medications, have risk factors like obesity, fever, dehydration, poor circulation, sunburn
13	Temperature or humidex based system, 3 levels: *Level 1* – heat alert *Level 2* – heat warning *Level 3* – heat emergency	*Level 1* – 36, 2 days *Level 2* – Level 1 and smog OR 40, 2 days *Level 3* – Level 1 and situational factors OR Level 2 and smog OR 45, 2 days	Notification posted on website; notify public via media releases	*Level 1* – information disseminated, air conditioned locations promoted *Level 2* – level 1 actions plus cooling centres open to vulnerables *Level 3* – level 2 actions plus “municipal control group” determines further action	Heat risk and protection information. Vulnerable: children, unacclimatized persons, seniors, persons with chronic medical conditions
14	Humidex-based system, 3 phases: *Phase 1* – heat alert *Phase 2* – heat warning *Phase 3* – heat emergency	*Phase 1* – humidex of 36, 2 days *Phase 2* – humidex of 40, 2 days *Phase 3* – humidex of 45+, situational factors	Public is notified via website, notification of media, notification to service providers	Information dissemination, extension of pool hours, extension of shelter hours; community indicates presence of a heat emergency plan, no further details	Heat risk and protection information. Vulnerable: the isolated, homeless, those on certain medications, those with health conditions (heart/kidney disease, respiratory problems), seniors, young children, the unacclimatized – specific info for service providers to the homeless
15	Synoptic classification system, 2 phases: *Phase 1* – heat alert *Phase 2* – extreme heat alert	*Phase 1* – 0.65 probability of excess death *Phase 2* – 0.90 probability of excess death	Public is notified via website, notification of media, notification to service providers	*Phase 1* – Red Cross operates a phone line, information disseminated, water distributed, transportation provided as necessary, extended hours at shelters *Phase 2* – All phase 1 steps plus 5 cooling centres opened, extended pool hours	Heat risk and protection information. Vulnerable: seniors, individuals with chronic illnesses or impaired mobility or on certain medications, infants/preschool children, people who work/exercise outdoors, homeless or marginally housed persons, the overweight; specifics on children and persons on medication

Source: Paszkowski, 2007.



Thunder and lightning

When there is a risk of severe storms, including thunderstorms, Environment Canada issues severe weather warnings. Lightning strikes in Canada are monitored by an automated Lightning Detection Network (Environment Canada, 2003b). In combination with weather (Doppler) radar systems, this enables high-risk areas for thunderstorms and lightning flashes ("hot spots") to be identified and mapped as thunderstorms progress (Environment Canada, 2003a, 2003b, 2003c, 2007c). Often triggered by lightning strikes, the threat of wildfires can pose an ongoing risk to communities, particularly during summer months. Daily updated maps and satellite images of wildfire risk and wildfire hot spots across Canada are prepared and made accessible on the Internet by the Canadian Forest Service (NRCan, 2006a). GeoEye Incorporated also frequently publishes satellite images of wildfires and their air pollution plumes.

Floods

There are several flood forecasting centres in communities and provinces across Canada. (e.g. Alberta, British Columbia, Great Lakes, Kennebecasis River, Saint John River). Each system reflects the characteristics of the community that it serves to protect through variations in data acquisition, allocated resources, information services, administrators and partners, education and outreach activities, and nomenclature of event (e.g. High Water Advisory versus Flood Warning). Most systems integrate information on factors affecting flooding, such as snow conditions, temperature, precipitation patterns, water level and stream flow conditions. This information is provided by public agencies in Canada and in the U.S., as well as by private enterprises. The flood warnings are distributed most commonly to emergency measures organizations, local government officials, pertinent provincial and federal government officials and the news media (Environment Canada, 2007e).

Tornadoes

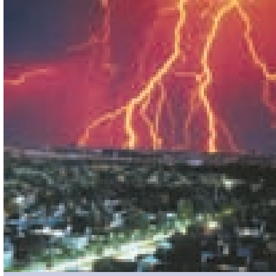
The identification and forecasting of tornadoes relies on weather radar surveillance systems and on satellite images; this allows only short-term forecasts (Marsh et al., 2007). Presently, available weather and climate models are not sophisticated enough to be used for simulating and accurately predicting tornadoes, which tend to be localized. Nevertheless, the models can be used to simulate the conditions under which such events occur.

Hurricanes

Since the 1970s, satellite data and images have been used to forecast the development and movement of hurricane-force storms in the Atlantic (Böttger et al., 1975). Since then, improvements in satellite instrumentation, monitoring instruments dropped from planes, weather radar equipment, computer programs, communications technology and international cooperation have greatly improved the accuracy of hurricane forecasts and their availability to the public. The Canadian Hurricane Centre of Environment Canada in Dartmouth, Nova Scotia, used these and other means to provide early warnings of Hurricane Juan and other tropical storms that have threatened the inhabitants of the Canadian East Coast. Among the improvements made since Hurricane Juan is a new and more secure building for the Atlantic Storm Prediction Centre (Environment Canada, 2006a, 2006b).

Landslides

For some populated high-risk areas such as the Saguenay-Lac-Saint Jean region, the shores of the lower St. Lawrence River in Quebec, and parts of southern British Columbia, government agencies have established risk maps and risk zoning guides to help protect people and property from landslides (Lajoie, 1974; Miles & Associates Ltd., 2001; Evans et al., 2002; Bilodeau et al., 2005; Rouleau et al., 2006).



3.6.2.4 Response, recovery and resilience

In the past decade, many regions and large cities in North America have fallen victim to large-scale disasters and emergencies. This has tested existing capacity to protect the lives and health and well-being of citizens, and has exposed weaknesses in the ability of governments to respond to such events and support the recovery of communities. As a result, several investigations have been conducted to examine preparedness for a range of large-scale emergencies and disasters. One such investigation was undertaken in Canada in mid-2000 by the Standing Senate Committee on National Security and Defence, with the purpose of determining where federal government leadership was most needed "to ensure that the nation provided its citizens with the best protection possible at a reasonable cost" (Standing Senate Committee on National Security and Defence, 2004). Findings from this study, which focussed on first responders, were based on extensive interviews with key emergency preparedness officials at all levels, field visits and survey results. Key findings from this study are presented below.

- Larger cities are generally better prepared than smaller communities to deal with emergency or disaster situations.
- More than half of medium and large cities are able to respond effectively to an emergency, according to interviewed officials.
- Few smaller communities are able to respond effectively to an emergency, according to interviewed officials.
- The major capacity issues identified were related to communications and coordination among response agencies, communications with the public, and access to critical supplies and professional training.
- There was a strong desire for better linkages on emergency preparedness matters among municipal, provincial and federal governments, and for the large cities, between municipal and federal governments.
- A national plan for critical public health emergencies should be developed and municipalities should be fully informed about the plan.

Further evidence suggests that, overall, larger cities are generally better prepared to deal with emergency or disaster situations than small communities. A survey of emergency management officials in eight large Canadian cities in 2005 revealed that almost all medium and large communities had designated a full-time official to be responsible for emergency preparedness, and officials in most large cities felt able to effectively respond to an emergency (Health Canada, 2005c). However, in most cases, the development of response capabilities has used an increasing share of the municipal budget, resulting in fewer funds for other municipal functions. For many of the communities very little funding has been provided for first responders from higher levels of government (e.g. provincial or federal). As well, many activities related to preparedness training have been constrained by tight municipal budgets (Health Canada, 2005a).

Because many Canadians exposed to natural hazards live in small communities and regions outside metropolitan areas, efforts are needed to increase the capacity to manage hazards present in these areas. Table-top simulation exercises in two small communities in New Brunswick and Newfoundland and Labrador to test local capacity to respond to a storm surge provided insights into the kind of support and improvements that are needed to manage future emergencies (Health

Storm surge table-top simulation excercises in Shediac, Newfoundland and Labrador, 2005

Chapter 3

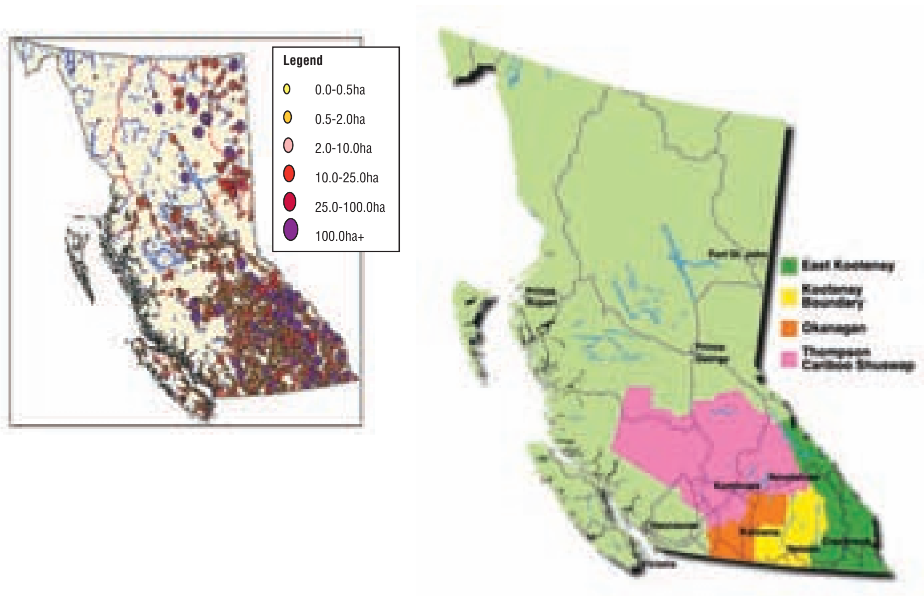
Canada, 2007c). While there is capacity in small communities to deal with events of a smaller scale and duration, the kinds of hazards that extreme weather events can trigger may often overwhelm local services and, in some situations, regional capacity. Both exercises found benefits in examining how authorities across municipal boundaries, sectors and agencies, as well as across different levels of government, coordinate and collaborate in responding to large-scale emergencies and identify ways to improve preparedness (Health Canada, 2007c).

Case study: Forest fires near Kelowna, British Columbia, 2003

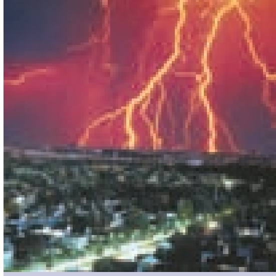
During 2003, the driest spring and summer since 1929 occurred in the southern interior of British Columbia (B.C). The previous year, local, regional and provincial firefighting and emergency plans had been revised to better deal with "interface" fires in areas where buildings had been constructed in wildland environments with flammable vegetation such as grasses, bushes and trees (Government of British Columbia, 2002). However, these plans had underestimated the possibility of a record drought producing huge amounts of dry fuel that might combine with high winds to produce large forest fires. This combination of environmental factors enabled large forest fires which were uncontrollable to develop. Moreover, the emergency plans had not included any provisions for dealing with the aftermath of the physical, health and social consequences of large forest fires.

That summer, over 266,000 hectares of forest in British Columbia were swept by more than 2,500 wildfires. They cost the lives of three pilots engaged in fire fighting, forced the evacuation of more than 45,000 people, destroyed at least 350 homes and businesses, damaged transportation and communications infrastructure, and required the deployment of about 6,000 firefighters; total costs amounted to about $700 million (Anderson et al., 2003; Filmon et al., 2004). Among the wildfire outbreaks with the worst effects on community health and well-being was the Okanagan Mountain Park fire near Kelowna (figure 3.9). This fire started on August 16, 2003, spread rapidly because of strong winds, and required tremendous efforts to bring it under control. The fire invaded the outskirts of Kelowna, where it burned 238 homes and forced the temporary evacuation of about 5,000 residents (Anderson et al., 2003).

Figure 3.9 Forest fires in British Columbia in 2003 (left), and Interior Health Authority administrative districts most affected by the fires (right)



Sources: Filmon et al., 2004; B.C. Interior Health Authority, 2007.



In the Thompson Cariboo Shuswap Health Service Area, patients had to be evacuated over distances of up to 55 kilometres, and emergency accommodations for these patients had to be made available in public and private health care facilities in other regions. In the East Kootenay Health Service Area, patients also had to be transferred to emergency accommodations. This early experience was useful when about 100 patients in a private care facility in Kelowna had to be evacuated to other towns. The evacuation and care of hospital patients and residents of chronic care facilities demanded significant efforts by the health authorities, as well as ambulance services managers and staff, some of whom had also lost their homes to the fire (Anderson et al., 2003; B.C. Interior Health Authority, 2003).

Non-governmental organizations, such as the Canadian Red Cross, the Salvation Army, the Mennonite Disaster Relief Fund and others also provided much needed help to evacuees and other people affected by the wildfire disasters. In October 2003, the federal government provided $100 million to the government of British Columbia for disaster relief.

In November 2003, the B.C. Ministry of Health commissioned a review of the performance of health services during the wildfire disasters of August 2003. The report was completed in January 2004. On the whole, it spoke well of their performance; nevertheless, it included 21 recommendations for improvements (Lynch, 2004). The Government of British Columbia also established a 2003 Firestorm Provincial Review Team to recommend improvements to the provincial emergency program, and to local and regional community emergency plans. It focussed mainly on the performance of provincial agencies responsible for forest management, forest fire prevention and control, emergency services and evacuations, and post-emergency recovery, and made many recommendations for improvement (Filmon et al., 2004). In 2006, the British Columbia Forest Service produced a revised strategy to better cope with future wildfires (Foglam, 2006). The lessons learned by emergency and health services during the 2003 wildfire disasters in British Columbia (e.g. as summarized by Filmon et al. (2004) and Lynch (2004)) can be applied to other regions of Canada at risk from forest or wildfires.

Effective adaptation through emergency management activities increases individual and community resilience to disasters. Resilience refers to the capacity of a system, community or society to persevere, recuperate or change in reaction to an extreme weather event or disaster, in order to reach and maintain an acceptable level of functioning (PSEPC, 2005a). Increasing resilience requires an all-hazards approach and an "all-vulnerabilities" approach that involves identifying and addressing all key aspects of vulnerability (Henstra et al., 2004), including vulnerabilities of specific populations. Resilience also depends on the health of the population; healthier people adapt better to health risks associated with climatic and other environmental changes (McMichael, 2003).

To determine if individuals and communities are resilient to natural hazards, it is necessary to better document and understand the long-term effects of natural disasters on important determinants of health such as employment, health services, social networks and physical environment (e.g., water quality). No multi-disciplinary studies have been undertaken in Canada to address these research needs for any of the natural hazards of concern. This type of research would help identify whether Canadians will be able to cope with the expected increase in frequency and intensity of many natural hazards due to climate change.

3.6.3 Barriers and Opportunities for Adaptation

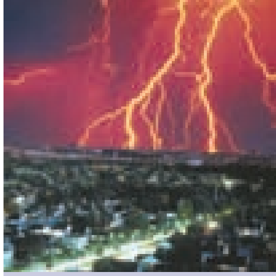
Studies carried out as part of the Canadian Natural Hazards Assessment Project indicated that despite some improvements in planning and response capacity, Canada has become more vulnerable to natural hazards because of population growth, urbanization, an aging population and infrastructure, increasing environmental degradation and over-reliance on technologies (Environment Canada, 2003d). Similarly, a study of fatalities and increasing economic losses due to weather and climate-related extremes during the 20th century in the U.S. indicated that these were due primarily to factors contributing to increased vulnerability—population growth in large urban areas, flood plains and coastal zones, more property subject to damage, higher property values, and other societal changes (Kunkel et al., 1999). As discussed in Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, concerns have been raised about current efforts by all levels of government to reduce health risks associated with natural hazards in Canada. Gaps in efforts to mitigate, plan, and prepare for the impacts of natural hazards contribute to the vulnerability of communities and individual Canadians. Existing barriers to making strides in emergency management efforts in Canada to improve adaptation to health risks from natural hazards are discussed in the next section, as are opportunities for taking needed actions.

3.6.3.1 Barriers

The development and implementation of efficient and effective strategies, policies and measures to reduce current and future vulnerability to climate change-related health impacts face certain barriers. Having the capacity to adapt does not necessarily ensure that individual Canadians or health and emergency management authorities will take the measures needed to reduce risks from natural hazards; this is because societal values, perceptions and levels of cognition are all important in shaping adaptive behaviours (Schneider, 2004). Most adaptive decisions are made by individuals in government, industry and within communities so that they can preserve their interests in areas of immediate concern, including their health, the health of their families, and the value of their assets. Investments and measures to mitigate impacts from natural hazards are often only made after a disaster has taken place in an effort to reduce the risks of similar impacts in the future.

Barriers to adaptation may also arise when there are technological challenges associated with the proposed measures. For example, due to the short timeframe for detection and warning, many extreme weather events, such as tornadoes, allow little time to prepare or to seek shelter, hence morbidity and mortality is proportionally higher compared with some other types of disasters (Greenough et al., 2001). The effects of Hurricane Juan in Nova Scotia in September 2003 also showed that some of the damage caused by severe storms such as hurricanes mays be unavoidable, although emergency management measures for hurricanes envisage both damage prevention and recovery.

Constraints on adaptations at the community level may also include the environmental implications of proposed actions (e.g. stormwalls), economic costs, lack of training and institutional capacity (particularly for small communities), as well as social and legal acceptability (Ebi et al., 2006). The resources available for disaster mitigation may be shared or in competition with those for a variety of public health issues (McMichael, 2003). Deliberations over the distribution of costs for adaptation measures between public and private agencies can be an important barrier to action. Any potential return on investments to mitigate natural hazards is realized only after a disaster is averted, whereas the investment costs are immediate and potentially



significant. There may be little economic incentive for a community to invest in prevention measures because most of the financial costs of recovery are paid by insurers and higher-level governments.

Perceptions, attitudes and knowledge of the roles of decision makers in addressing climate change health risks are important elements in the process of adaptation and can constitute important barriers to action. Interest in disaster mitigation is sporadic, and citizens generally perceive a low probability of loss from such events; this is because specific disasters have occured infrequently and rarely in the same locale within a short time span. However, with an increased frequency of extreme weather events, public perceptions may change regarding the need for disaster mitigation investments. These and other barriers to adaptation are discussed in Chapter 6, Health Impacts of Climate Change in Quebec, and Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada.

Case study: Lessons from the Quebec Saguenay flood, 1996

Photo Credits: Canada Centre for Remote Sensing, Natural Resources Canada, 1996

An official inquiry into the causes and consequences of the 1996 Saguenay flood found a "culture of denial" among residents and municipal and regional governments; all disregarded the possibility of serious flooding (Conseil pour la prévention et la gestion des sinistres et des crises (CPGSC), 1998). This situation was probably not unique to the Saguenay region. Another study found that, in communities along the upper St. Lawrence River, there had been little attention given to flood prevention; flood plain occupancy had continued and in some cases had even greatly increased from the 1970s on, with urban expansion appearing to be unrestricted by flood plain designations. Reliance on government indemnity payments as a kind of insurance may have encouraged this trend (Doyon and Côté, 2006). After the Saguenay flood, recommendations were made for the creation of a "public safety culture": (1) strengthening and integrating municipal and public safety planning and cooperation; (2) providing greater support for Securité publique Québec so that more staff for public safety would be available, along with better training for them and backup personnel; (3) increasing awareness among individuals and organizations about their responsibilities for collective safety; and (4) supporting applied research through a special institute that would focus on training, research and action in the area of public safety (CPGSC, 1998).

3.6.3.2 Opportunities

There is sufficient knowledge about the risks and impacts of natural hazards to take proactive measures to protect health. For example, a suite of tools and technologies such as geological hazard surveys, aerial photographs, satellite images, mathematical modelling and geographic information systems can be used to identify and map geomorphological hazards, such as areas prone to avalanche, landslide or rockfall. Terrain stability mapping can be legislated, and guidelines can be provided for its implementation (Resources Information Standards Committee (RISC), 1997; Evans et al., 2002; Association of Professional Engineers and Geoscientists of BC (APEGBC), 2006; NRCan, 2006a; Klamath Resource Information System (KRIS), 2007; McLaren, 2007). Under the Aboriginal and Northern Community Action Program, studies

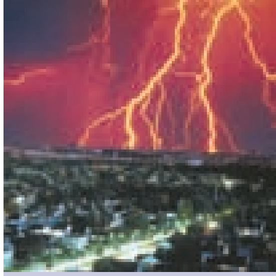
are being funded to assess the implications of climate change for northern communities both above and below the Polar Circle. The purpose of these studies is to ensure the health and safety of northern residents, the sustainable development of communities, and to improve the ability to manage the risks posed by natural hazards related to climate change (Indian and Northern Affairs Canada (INAC), 2006). As well, in some cases, stabilization measures can be taken to reduce the likelihood of property damage or loss, and of injuries or deaths resulting from landslides (Chatwin et al., 1994; Government of Alberta, 2005). This can include the installation of stabilizing or protective structures on slopes, the planting of bushes or trees on slopes, the protection of existing forests, planned releases of hazardous snow burdens, and avoidance of unstable snow masses or unstable ground.

> A floodway was built in 1960 with $63.2 million in public funds to redirect occasional excess water from the Red River around the city of Winnipeg. Although expensive to build and even more to modify, it has saved an estimated $8 billion in potential damage and recovery costs (PSC, 2008).

Many adaptation options are accessible and affordable. For example, buildings can be protected from lightning at limited cost according to a National Standard of Canada for Lightning Protection Systems (CAN/CSA-B72-M87) (International Association of Electrical Inspectors (IAEI), 2000). The effectiveness of such systems was shown in a 10-year survey conducted in Ontario during the 1930s. During that time, 10,079 unprotected structures were damaged by fires caused by lightning, but only 60 such fires occurred in protected buildings, and in most of these the lightning conductors had not been installed properly (Aulich et al., 2001).

Canada's National Disaster Mitigation Strategy recognizes the need for climate change adaptation activities to reduce the risks of disasters (PSC, 2008). Smart land-use planning and development can prevent much harm and property loss from natural hazards. New information about the impacts of natural hazards on health can facilitate the development of needed risk management strategies and can be incorporated, or mainstreamed, into a range of professional practices (e.g. land-use planning, public health and medical practices, environmental management). The concept of mainstreaming climate risks describes processes that bring explicit consideration of climate and related risks into decision making processes. This concept is key to improving the basis upon which decisions are made by institutions and individuals regarding the risks they face today and in the future.

Health studies concerning specific individual vulnerabilities are also yielding knowledge that can inform adaptation. For example, results of laboratory and epidemiologic studies indicate that humans have a well defined "temperature comfort and tolerance range." Temperature-related vulnerability changes with age, and is affected by gender, state of health, degree of acclimatization to seasonal changes, and socio-economic factors. This makes it possible to identify the most vulnerable population groups locally and regionally, to direct protective measures toward them, and to improve the accuracy of mathematical modelling (projections) of the impacts of future climates on health. Professionals in many fields need to take into account new knowledge about climate and its impacts in order to improve current systems, protect growing populations, and communicate with researchers about additional information and data required to improve risk management practices.



3.7 KNOWLEDGE GAPS

Several knowledge gaps have been identified with regards to natural hazards, their implications for human health, and the effects of climate change on the exposure of Canadians to these hazards. Addressing the following knowledge gaps will be crucial to the development of effective public health and emergency management measures to protect Canadians from increased health risks associated with climate change:

- the risks to health from specific natural hazards (e.g. floods);
- data on and indicators of health impacts from natural hazards in Canada, including improved reporting of the impacts of natural hazards on health;
- the social, psychological and mental health impacts of natural hazards, so that communities and health care providers will be able to better anticipate disasters, prepare vulnerable populations and develop adequate programs to address their effects;
- the role of health services in the mitigation of natural hazards and in aiding the victims of natural disasters;
- the effectiveness of warning and prevention systems;
- the characteristics or qualities that make specific populations more vulnerable to climate change and health impacts arising from more frequent and severe extreme weather events, and the distribution of such vulnerable groups within Canada; and
- the effectiveness of messages and outreach strategies for changing individual behaviours to reduce health risks (e.g. appropriate messaging during emergency situations) and of interventions by public health officials.

3.8 CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

Natural hazards pose diverse risks of varying magnitude to the health of Canadians in all regions of the country. Drought, severe storms, extreme heat and cold events, storm surges, floods and other climate-related natural hazards can affect health and well-being by causing increased risk of injuries, illnesses, stress-related disorders and, in extreme cases, death. Natural hazards can also impact health indirectly by causing local or regional economic disruptions, interruption in health care services, infrastructure damage and population displacement. During the 1990s in Canada, natural hazards caused approximately 170 deaths and 1,000 injuries, and affected 700,000 people. Extreme weather events, such as the 1998 Ice Storm that affected eastern Canada, Hurricane Juan that impacted Atlantic Canada in 2003, and recent wildfires and floods across the country are examples of natural hazards that have had important impacts on the economies and health and well-being of people living in the affected communities. Although mortality in Canada attributed to natural disasters has decreased in the past several decades, injuries and economic costs have risen.

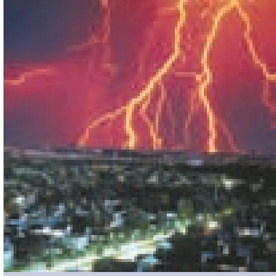
The full scope of the impacts of natural hazards on health is not well understood and documented. Impacts tend to be under-reported because only events of a certain scope and size are taken into account in existing studies and in currently available databases. Comprehensive health data needs to be collected during and after extreme weather events to enable the study of population vulnerabilities. Given the diversity across Canadian regions, it is not possible to apply the findings of a few studies of a specific disaster or extreme weather event to the entire population. Increased funding and new methodological approaches are needed to broaden research in this area and engage the various disciplines required to conduct such research.

Extreme weather events can have significant psychological and social impacts on people, and effects can be felt long after emergency response personnel have left the affected communities. Recent studies have shown that the longer an event disrupts a person's life, the greater the level of stress experienced; as a result, a person's ability to cope may become diminished. Some research exists, mostly outside Canada, on the psychological and social impacts of sudden and devastating weather events on people. More attention should be paid in future investigations to long-term health effects on individuals and on communities of natural disasters of varying magnitude.

Certain populations in Canada are at greater risk from the health impacts of natural hazards. People with low incomes may find it more difficult to cope with the stressful effects of disasters because they may already be experiencing chronic stress due to inadequate housing and nutrition, and because they cannot afford the cost of needed support such as mental health professionals, medications or other aids, and repairs or replacement of belongings. Seniors are one of the highest-risk groups because they may be socially isolated and may have fewer economic resources on which to rely. Some seniors may also lack the required mobility to move out of harm's way, thus increasing the likelihood of physical stress and trauma. Children, like seniors, are considered one of the most vulnerable groups in weather-related disasters.

Climate change will influence a broad range of natural hazards to which Canadians and communities from coast to coast are already exposed. Warming of the climate system is "unequivocal" and the risks of health-impacting natural hazards will increase. Around the globe and in North America, the occurrence of hazardous events, except cold days, that impact on health is expected to increase. More hot days and more frequent and intense heat waves are expected. Cities that currently experience heat waves in Canada (such as Montreal, Toronto, Hamilton, Winnipeg, Saskatoon and Calgary) can expect the challenge of an increasing number, intensity and duration of these events, posing serious risks to health to vulnerable populations. More frequent and intense heavy precipitation events and hurricanes, leading to increased risks from flooding, are expected in various regions of Canada, as are more droughts and wildfires.

There is a strong foundation of emergency management in Canada to build upon to adapt to future risks from natural hazards related to climate change. Although some communities and provincial and federal authorities are taking actions to reduce the risks, greater actions are required by others to safeguard Canadians from the risks. Recent investments in emergency management activities have generally focussed on enhancing warnings, mapping hazards or strengthening response activities; while these are necessary activities, there has been limited investment in prevention and mitigation efforts across the country. Many health risks are heightened by cumulative environmental and social conditions that can increase the impacts of events and lead to disasters; in many cases communities are not prepared for a change in the magnitude of events or in the increasing occurrence of different events in quick succession. The rising costs of natural hazards and disasters may well act as drivers for investments in mitigation but perceptions of limited threats from these events continue to act as a barrier to action.



As well, there are institutional challenges involved in protecting Canadians from natural hazards. In Canada, intergovernmental collaboration on emergency management activities is essential for the development and implementation of effective policies to protect Canadians. While responsibility for emergency management is largely delegated to municipal governments, mechanisms for collaboration and coordination across all levels of government and with the voluntary sector need to be enhanced in order to fully benefit from the capacities present in society.

Because disasters occur relatively infrequently, interest in disaster prevention can be sporadic and short-lived, particularly if citizens generally perceive a low probability of loss from such events. The post-disaster opportunity and policy window for improving preventive measures is usually overtaken by the primary goal of returning the affected community to "normal" as quickly as possible. The successful management of risks from many types of natural hazards can require long-term commitment and significant public and private investments. Awareness of the risks by the population is needed for such actions to be taken. The monitoring and reporting of impacts from the full range of natural hazards is essential to inform decisions on priority areas for action. To this end, climate modelling can be used to predict changes in conditions that may affect the risk to populations and help in identifying potential hazards and vulnerabilities.

3.8.2 Recommendations

Through public and private institutions, Canadians have a wide range of adaptive capabilities, with a number of notable successes and failures in mitigating, preparing for, responding to and recovering from extreme weather events. In most cases, improvements in emergency management systems have been implemented in response to disasters or large scale events; there is now a need to look ahead to the future and take more proactive measures to mitigate and prepare for the expected increase in the frequency and severity of extreme weather events. Knowledge exchange and cooperation in policy and planning among the public health, emergency management and climate change hazards communities should be strengthened. Innovative efforts are needed to work across these areas of responsibility and engage other sectors in reducing health risks. For example, the appropriate design of infrastructure and transportation systems can reduce health vulnerabilities while enhancing resiliency to natural hazards and environmental sustainability. There are many opportunities for collaborative work across levels of government, through the dissemination of best practices, and the integration of warning systems. Priority areas of action to improve the management of health risks from extreme weather events and disasters and enhance resilience include:

Renewing and strengthening infrastructure
Large portions of Canada's infrastructure are slated for service renewal and expansion in many cities and smaller communities. The Building Canada infrastructure plan provides $33 billion from 2007–2014 to help meet infrastructure needs across Canada. Announced in 2007, it provides a framework for the federal government to collaborate with provinces, territories and municipalities to take actions to improve infrastructure in Canada. It is imperative that new or upgraded infrastructure is able to withstand the more frequent and intense natural hazards expected in the coming decades as the climate continues to change. Opportunities exist to make progress in this regard: they include the collaboration between the Canadian Council of Professional Engineers and Natural Resources Canada to upgrade building and design codes and standards to reflect changing climatic conditions. Planners and government officials need to use this information and adopt a long-term outlook in their decision making process to ensure that individuals and their communities are protected.

Investing in knowledge to reduce uncertainty for decision making
Canadian research on natural hazards, existing vulnerabilities and health impacts will help reduce the uncertainties in this area, and highlight the need for immediate actions. More knowledge of climate change risks and effects on health is required by public health and emergency management

professionals, and increased attention needs to be paid to research on the adaptive capacity of health and social services organizations to plan for and manage extreme weather events and natural hazards. This chapter builds on the results of the Canadian Natural Hazards Assessment Project—a joint effort of the Meteorological Service of Canada, Public Safety and Emergency Preparedness Canada, and the Institute for Catastrophic Loss Reduction—which assessed natural hazards in Canada, identified existing vulnerabilities, and sought to inform policy making. Research and advocacy within the emergency management community is becoming better coordinated through the Canadian Risk and Hazards Network (CRHNet), which was formed in 2003 to promote disaster risk reduction and management in Canada. This network provides the opportunity to continue building research capacity in Canada and increase the integration of research results into policy development and planning at all levels of government.

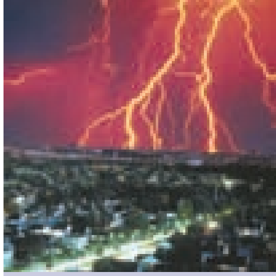
Increasing Canadians' preparedness

All levels of government need to increase efforts to inform and empower individual Canadians so that they can adequately protect themselves from existing risks. Canadians do not yet see the need to take personal action to protect their health from the hazards that will change with the climate. There is a need to increase awareness of the risks and knowledge of the measures that can be taken in order to reduce exposure to them. The development of a culture of disaster preparedness and mitigation, as advocated by the Nicolet Commission which examined societal responses to the 1998 Ice Storm (Government of Quebec, 1999), is an important part of adapting to climate change. It is also important to ensure that Canadians have reasonable access to preparedness information and response and recovery services. This is a common need in communities across Canada, however, rural and remote communities face particular challenges which need to be addressed.

National leadership and advancing prevention

Protecting Canadians and their communities from natural hazards associated with a changing climate requires coordinated efforts to prevent and mitigate risks. Implementing mitigation actions, with a focus on reducing the human health impacts resulting from natural hazards, requires a sustained effort from a wide range of public-and private-sector actors and organizations. Collaboration at all levels of government is critical to ensure that such activities become a key component of emergency management in Canada. The role of volunteers in protecting communities from natural hazards must be more fully integrated into emergency management activities. Important considerations in this regard include bolstering the volunteer infrastructure and capacity to cope with large-scale and multiple events, the training of new volunteers and addressing protection and compensation issues. Collaborative intergovernmental approaches that are developing in other policy fields, such as health care and the environment, may offer encouraging examples and provide useful opportunities for knowledge sharing and program development. Integration across relevant fields is essential. Lessons learned from past successes will help Canadians plan for future risks associated with climate change.

Risks to the health of Canadians from natural hazards and extreme weather events will increase as the climate continues to change and as other factors contribute to vulnerability. To protect all Canadians, in particular those most vulnerable to the health impacts, a comprehensive commitment is required to guide collaborations in order to improve emergency management activities, from mitigation to community recovery, across Canada.



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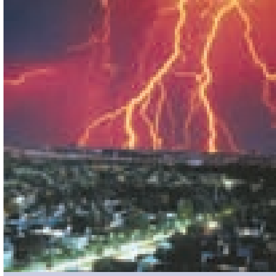

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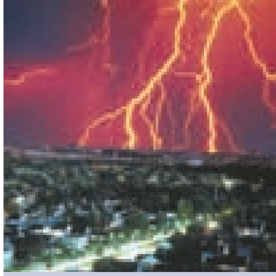

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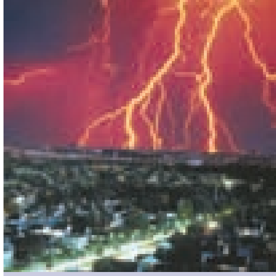

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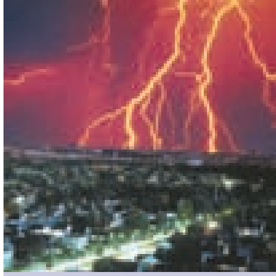

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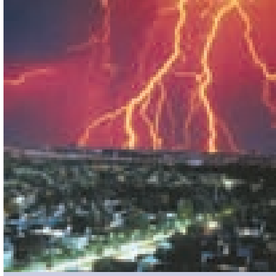

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