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Climate Change in the North Bay-Algonquin Park Region: Effects on Resource Industries, Infrastructure and Human Health

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“Climate has most effect on the natural systems of the landscape. No engineering can shield a forest or cover a watershed. Adapting to change in our terms has largely to do with how we manage our use of natural resources as they react to changing conditions – to temperature and rainfall, fire and insect pests, drought and flooding. Designing and redesigning with nature with as good an eye to the future as uncertain projections will allow, is the only sustainable approach. Adaptive management in the light of ongoing risk assessments means, first and foremost, understanding ecological and hydrological systems as best we can.”

Pearson and Burton (2009)

Introduction

There is now broad international scientific agreement that human activities are primarily responsible for recently documented climate change (e.g., IPCC 2007). This has largely been attributed to the release of greenhouse gases (GHGs) into the atmosphere, which have caused warming temperatures, and have changed precipitation regimes and increased extreme weather events. Since the Intergovernmental Panel on Climate Change (IPCC) released its first report in 1990, average global temperature increases of about 0.2°C per decade have been observed, contributing to an average global temperature increase of 0.74°C during the period 1906-2005 (IPCC 2007).

Long-term changes to temperature and precipitation are expected because of climate change. Under low GHG emissions scenarios, the IPCC (2007) predicts a likely global temperature increase of 1.1°C to 2.9°C by 2100. In their worst case GHG emissions scenarios, however, the IPCC (2007) predicts that average global temperatures could increase as much as 6.4°C by 2100. Increases in temperature and the amount of precipitation are most likely to occur in high latitude regions (IPCC 2007). Furthermore, it is almost assured that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Importantly, scientific observations are increasingly showing that many impacts of climate change are occurring faster and sooner than projected (Pearson and Burton 2009). In this sense, some current projections of climate change likely represent conservative estimates.

While these trends are expected to continue well into the future, the extent of climate change will largely depend on the level of GHG emissions mitigation around the world. Failure to reduce international GHG emissions will lead to more significant changes and increased risk of impacts. However, even if GHGs were dramatically reduced today, anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks. For example, the IPCC (2007) has predicted that even with concentrations of all GHGs and aerosols kept at year 2000 levels, a further warming of about 0.1°C per decade is expected. These predictions point to the need for adaptation to climate change as well as for reducing sources of GHG emissions.

The objective of this report is to address the expected changes and potential effects of climate change on resource industries, infrastructure and property, and human health in the North Bay-Algonquin (NBA) Region of Ontario (Figure 1). It is based on the results of other studies many of which have focussed on the Great Lakes Basin. Roughly half of the NBA Region falls within the eastern portion of the Great Lakes Basin. This report was adapted from Prno and Quinby (2010) and builds on Quinby (2010).

Figure 1 – Core Area of the North Bay-Algonquin Park Region (adapted from Near North Ontario 2017)



Resource Industries

Agriculture

The percentage of jobs directly associated with agricultural production has been declining in Ontario since 1900. However, the economic contribution of agriculture in the province has continued to increase. For example, farm gate sales in Ontario rose from 5.5 billion in 1986 to 7.8 billion in 1996 (3.5%/yr) while employment on farms declined (Harry Cummings and Associates, Inc. 2001). In the North Bay region from 2006 to 2008, agricultural employment declined by approximately 50% and about 1% of the workforce was employed in agriculture in 2008 (City of North Bay 2010a). In the Nipissing District, there are approximately 33,000 acres of crops with 6,000 acres of improved pasture, and 30% of the farmland was in crop production (in 1996), whereas for the entire province, 63% of all farmland is used for crop production.

The key attributes of climate change as it affects agriculture are those related to climatic variability, including the frequency of non-normal conditions (Chiotti and Johnston 1995, Smit et al. 1997, Bryant et al. 2000). For example, 80% of farmers surveyed in southern Ontario stated that drought and excessive rainfall were their most difficult climate-related problems (Smit et al. 1996). Long-term changes in mean conditions, such as cumulative heat and timing of frosts, will have implications for agriculture, but the most significant vulnerabilities are those associated with the variability and extremes of climate change (Smit and Skinner 2002).

As a result of a workshop, CCIARNA (2002) produced a list of potential economic, environmental, policy, and social impacts to agriculture resulting from climate change that include the following:

- Economic Impacts
 - crop/livestock losses due to extreme events
 - crop/livestock losses due to altered levels of soil moisture
 - crop/livestock losses due to change and severity of pests
 - crop/livestock losses due to increased variability in weather
 - costs of current risk management and crop insurance strategies
 - increased opportunities for growing new varieties and finding new markets
- Environmental Impacts
 - soil and water depletion
 - air quality degradation
- Policy Impacts
 - suitability and viability of current income stabilization and safety net programs

- cross compliance of policy and programs both within and between ministries and their various departments/agencies
- effectiveness of current land use policy and resource management programs
- Social Impacts
 - community conflict over scarce water and land resources
 - community conflict over changes in land use management

Exacerbating these numerous and interconnected impacts are the recent agricultural losses due to extreme weather conditions. For example, the 2001-2002 droughts across Canada caused estimated agricultural losses of \$6.14 billion (CCIARNA 2004). In Ontario, for the 35-year period from 1966-2000, payments for insured crops totalled approximately \$1 billion, whereas insurance payments for the five-year period 2000-2004 were \$640 million. This represents an increase of 348% in agricultural insurance payments annually over only a five-year period (CCIARNA 2004).

In some instances, crop yields in Ontario may increase in response to climate change (Singh et al. 1998). For example, an extension of the frost-free season of 3 to 5 weeks in Ontario (Motha and Baier 2005) is expected and will likely facilitate greater corn production in some regions including the clay belts of northern Ontario (Brklacich et al. 1999). Increased yields of soybeans and fruit are also expected to replace decreased grain yields in Ontario (Hauer et al. undated).

Outdoor Recreation and Tourism

In 2007, tourism accounted for \$19.9 billion of Ontario's economy, accounting for 3.4% of the province's gross domestic product; snowmobiling alone is worth about \$1 billion annually to the Ontario economy (Pearson and Burton 2009). In the North Bay region, each year an estimated 1.35 million visitors spend over \$200 million contributing to the roughly 1,300 tourism businesses in the region (City of North Bay 2010c). Almost half of all travel to the North Bay region is recreational travel, far more than for business and to visit friends and family. Compared with the rest of the province, the North Bay region is almost 20% more effective at attracting recreational visitors (Impagination 2005).

Browne and Hunt (2007) expect that climate change will have a positive effect on summertime recreation activities in Ontario, while winter recreation and tourism in the province will be negatively affected. This will occur primarily because of an increase in the summer season and a shortened winter season (Williamson et al. 2009). Weather has a significant influence on almost all tourists in Ontario, particularly outdoor winter activities such as alpine and cross-country skiing, snowshoeing, snowmobiling, and ice fishing, and summer activities including boating, beach recreation, swimming, sailing, hiking, camping, canoe tripping, kayaking, fishing, hunting, golfing, and wildlife viewing (Pearson and Burton 2009).

In addition to affecting individual recreationists, warmer winters will significantly affect the economy in particular by reducing business operations for and associated with skiing, snowmobiling, and ice fishing (Hayhoe and Shuter 2003). For example, due to warmer winter conditions, the Ottawa Winterlude Festival has already been forced to change the schedule to be held over three weekends rather than for ten continuous days. Organizers have also used refrigerated trucks to keep ice available for the ice carving events and for extra snow making (Pearson and Burton 2009).

Lemieux's (2010) research focussing on the effects of climate change on winter recreation in central Ontario indicates that:

- the alpine skiing season in the Orillia area will decrease from 5% to 17% by the year 2020 and will decrease from 8% to 44% by the year 2050;
- the nordic skiing season in the Barrie area will decrease by 52% by the year 2020, will decrease by 65% by the year 2050, and will decrease by 86% by the year 2080;
- the snowmobiling season in the Sudbury area by the year 2020 will decrease by two months (loss of one month at each end of winter), and by the year 2050 there will be no season at all; and
- the ice fishing season on Lake Simcoe by the year 2020 will decrease by 29%, and by the year 2050 will decrease by 45%.

The season for warm weather activities in the southern Great Lakes region is expected to increase from two to seven weeks in the next 20 years (Pearson and Burton 2009). This extended summer season in Ontario is expected to increase outdoor recreational activity up to 27% by the year 2020, up to 56% by the year 2050, and up to 82% by the year 2080 (Lemieux 2010). This will translate into significant additional revenue for businesses associated with summer recreation and tourism.

However, increased visitation will also put greater pressures on park facilities and will result in more severe environmental impacts in recreational areas. Longer summers will also bring more extreme heat, greater frequency of heavy downpours, elevated ozone levels, and possible increases in risk from insect and waterborne diseases, all of which may dampen

enthusiasm for outdoor recreation activities (Hayhoe and Shuter 2003). In addition, millions of anglers will be affected by fish species range shifts and loss of fish habitat. Range shifts and habitat loss will also affect migratory songbirds, shorebirds, and waterfowl, which in turn may negatively affect Ontario's multi-million-dollar birdwatching and hunting industries.

Forestry

The forest industry in Ontario has annual sales of \$19 billion/year with tax contributions of \$2 billion/year (www.ofia.com). It also employs 200,000 people directly and indirectly, which is second only to the automotive sector. In the North Bay region, the forest industry has total sales of \$613 million annually and provides approximately 3,000 direct and indirect jobs (City of North Bay 2010b). Forestry sector employees contribute nearly \$32 million annually to the local retail and service sectors in the North Bay-Sudbury region (Blue Sky Region) and the forestry sector spends about \$50 million on goods and services in this region (Northern Ontario Business 2001). Based on the combined value of direct and indirect salaries, forestry is the most important local industry in the Nipissing-East Parry Sound regional economy. The health and social services sector and the construction industry are a close second and third, respectively (Suthey Holler Associates 1999).

Three effects of climate change are likely to have the greatest impacts on forestry in Ontario (Columbo 2008) including:

- milder winters and increased freeze-thaw activity,
- increased fire frequency and area burned, and
- increased forest tree mortality from insects and disease.

Milder winters and increased freeze-thaw activity will cause problems for winter forestry operations in Ontario, especially in areas where logging and hauling is dependent on frozen ground and frozen watercourses. The length of the season for use of frozen roads will likely be shortened due to later freeze-up and earlier thawing, and frozen road use may be shut down altogether in more southern regions (Pollard 1989). Construction of more all-weather logging roads will be required in order to maintain current timber harvest volumes. These all-weather roads have a greater ecological impact on forests compared to frozen winter roads and they cost more to build and maintain (Williamson et al. 2009). Due to these greater ecological impacts, specialized equipment such as high-flotation tires may be required, which are expensive and require additional maintenance adding to forest harvesting costs.

Currently, the area burned in Ontario's managed forest is relatively low due to high success rates of initial fire fighting attacks (Ward et al. 2001). However, increased fire frequency and area burned has been increasing in Ontario and to maintain the current rate of burn in Ontario's northern forests will require increased investment in fire management. This will require additional funding causing an increase in both forest management costs and the cost of wood products. In addition, in extreme years, increased fire suppression may not be successful at preventing large fires (Flannigan et al. 2005), which will result in reduced wood supply driving costs even higher for the consumer.

Increased forest tree mortality from insects and disease in Ontario will require additional use of pesticides, which will increase forest management costs. In addition, more trees will die resulting in lower timber supply, which will also increase wood product costs (Columbo 2008). In some instances, salvage harvesting following mortality from insects and disease may provide additional timber supply.

At local levels, changes in timber supply may be positive or negative depending on location, time frame, and human adaptation to the effects of climate change (Williamson 2009), however, wood supply in Ontario is generally expected to decline. In fact, Perez-Garcia et al. (2002) predict that Canada will be the only country where the impacts of climate change on the forest industry will be negative and significant mainly because the forest industry in other more southern countries (e.g., in South America) will benefit more from climate change and will be more competitive in the global marketplace.

Infrastructure and Property

Introduction

From a global perspective, Wilbanks et al. (2007) state that communities most vulnerable to climate change are:

- the poor,
- located in coastal areas and river flood plains,
- those with economies closely linked to climate-sensitive resources, and
- located in urban areas, particularly where rapid urbanisation is occurring.

Ontario's cities, where 80% of Ontarians live, are most vulnerable to the risks associated with climate change, particularly extreme weather events, due to direct economic losses and expensive adaptations (Hayhoe and Shuter 2003). These losses and adaptations relate directly to dependence on infrastructure and services including water and energy

distribution, transportation systems to move people and goods, sewers and waste removal systems, and communications systems (McBean and Henstra 2003). Climate change impacts to infrastructure and property are addressed here in the context of cities, transportation systems, drainage and sewer systems, power generation and distribution, and infrastructure interdependence. A case study assessment of roads infrastructure in Sudbury, Ontario is also included.

Cities

Penny and Wieditz (2007) have identified several features of modern cities that exacerbate the risks and increase vulnerability to climate change including the following (quoted directly):

- Asphalt, concrete and other hard surfaces in the city absorb radiation from the sun, causing the urban heat island effect, which exacerbates heat waves and puts pressure on electricity generation and distribution systems.
- Hard surfaces also prevent absorption of rainfall, creating runoff that carries pollution to lakes and streams and can overwhelm storm water systems, leading to sewer backups and flooding during heavy precipitation events.
- Combined sewers that carry both storm water and sewage are common in many city centres. Protracted or intense precipitation leads to overflows in these sewer systems, washing untreated pollutants into local water bodies.
- The concentration of people in urban centres puts pressure on vegetation and green spaces that could reduce heat, storm water runoff, pollution and social pressures.
- Far-flung supply lines combined with just-in-time shipping practices can result in shortages of needed goods when transportation is disrupted by extreme weather.
- Centralized power sources, longer distribution lines, and an increasingly interconnected grid increases vulnerability to blackouts when electricity demands are high – during heat waves, for example – and when storms occur. The impact of blackouts has also grown as homes and businesses have become more dependent on electronic control and communication systems.
- The concentration of people in large cities creates a large demand for water and can strain local water supplies, making them more susceptible to water shortages in drought conditions.

Urban sprawl and competition for building sites has led to construction in locations such as floodplains or steep slopes that are vulnerable to extreme weather (though Canada does a better job of controlling this than many other nations). Low-income, substandard dwellings and poorly insulated buildings increase the risks from heat waves and other extreme weather. Homeless people have almost no protection from these events.

Transportation Systems

The main components of Ontario's transportation system are roads, rail, air, and water, all of which are essential to social well-being and a productive economy. Climate change is expected to affect transportation in Ontario mainly through changes in temperature, precipitation, extreme weather events, and water levels. Impacts will vary regionally; however, the most vulnerable transportation systems include ice roads, Great Lakes shipping, coastal infrastructure, and infrastructure situated on permafrost (Lemmen and Warren 2004). In addition, in some regions the benefit of climate change may outweigh the costs. For example, in southern Ontario an increase in summer temperature will cause increased pavement deterioration and railway buckling. In contrast, however, damage to pavement from winter freeze-thaw events will likely decrease and the costs and accidents associated with winter storms are expected to decline (Lemmen and Warren 2004).

In addition to increased temperature, increases in the intensity and frequency of heavy rainfall events, which are likely in the NBA Region, will have implications for the design of roads, highways, bridges, and culverts to control increased stormwaters potentially causing flooding and debris flows. Although permafrost degradation and a shortened ice-road season are concerns in parts of northern Ontario, the NBA Region will likely not be significantly affected by these changes. However, winter logging roads dependent on frozen ground may become a significant problem.

Drainage and Sewer Systems

In the past, drainage systems have been designed based on the assumption that historical climate data can be used effectively to predict future requirements for effective water drainage designs. As a result, due to rapidly changing climatic conditions, there is increased potential for more frequent drainage system failures, increases in flood damages, and greater risk of health-related water pollution problems (Jobin 2001). For example, the massive flooding of 2004 in Peterborough and the culvert and road washout of 2005 on Finch Avenue in Toronto indicate that stormwater infrastructure throughout Ontario may not be designed to handle the challenges of climate change.

Damage from domestic sewer back-ups, especially in older neighbourhoods, is causing major financial burdens for homeowners and the insurance industry, which is currently paying \$1.5 billion annually in claims due to water damage in Canada (Pearson and Burton 2009). In addition, water and wastewater treatment plants may not be equipped to cope with larger amounts of water, and with larger and longer peak periods. Finally, due to lower water levels that are expected

in some areas, lower water intakes may be needed and odour and taste problems resulting mainly from inadequate lagoon systems may become more frequent (Crabbe and Robin 2006).

Power Generation and Distribution

All cities are becoming increasingly dependent on a reliable and uninterrupted supply of electricity, including North Bay and the smaller municipalities within the NBA Region. However, the methods of producing and distributing electricity are vulnerable to heat waves and severe storms, which are expected to worsen as the climate changes. Wieditz and Penny (2006) have addressed these impacts to electricity production and distribution for Toronto. Much of this review is relevant to the NBA Region and is summarized below.

For example, as water levels in the Great Lakes-St. Lawrence Basin continue to drop, hydroelectric generation capacity will be reduced. This occurred in 1998 when Ontario Power Generation reported a 12% decrease in hydroelectric generating capacity due to low water levels. The worst-case scenario for the 2050s estimates that hydro generation capacity in the Great Lakes-St. Lawrence Basin could be decreased by as much as 54%, resulting in a loss of \$530 million to producers. When a similar loss of hydroelectric production occurred in 1964, Ontario Hydro needed 1.4 million tons of coal to compensate for the loss of hydropower at a cost of \$82.5 million (1994 value).

In addition, nuclear and coal generated electricity production are likely to be adversely affected by warmer water temperatures, which reduce the efficiency of condensers. Warmer ambient air temperatures are also expected to affect the efficiency of draft fans. This could lead to a loss of 1 to 3% in production capacity. The generation of power from alternative sources could also be impacted. For example, the operation of wind turbines can be adversely affected by extreme weather events such as ice storms and high winds, and solar power could be affected by changes in cloud cover, which may increase in various parts of Ontario.

The electricity grid is also vulnerable to extreme weather events such as the January 1998 ice storm, which left 1.5 million people in eastern Ontario without power. The efficiency of transmission lines can be reduced by 3 to 5% from higher temperatures and, in combination with increased demand, can cause sagging transmission lines, transformer failure, and underground distribution systems to overheat. And finally, Ontario's power lines that run north-south are particularly vulnerable to tornadoes that run primarily east to west, maximizing potential intersection of the two. From 1988 to 1998, damage to electricity towers and poles from extreme weather cost Ontario Hydro \$11.6 million, which is likely to increase with climate change.

Infrastructure Interdependence

Most infrastructure systems are interdependent, meaning that a failure in one system will often directly or indirectly affect other systems, resulting in a ripple effect of adverse impacts. For example, the Finch Avenue washout of 2005 in Toronto interrupted cable communications, disrupted natural gas supply, and caused road traffic detours. Another common example is the loss of electrical power, which among many other things, can result in implications for drinking water and wastewater treatment facilities (Pearson and Burton 2009).

In 2008, the report, "First National Engineering Vulnerability Assessment Report: Roads and Associated Infrastructure" was prepared for the City of Greater Sudbury, Ontario by Dennis Consultants. This report assessed the vulnerability to road-related infrastructure in the City of Greater Sudbury to climate change. The following are the conclusions of this analysis (quoted directly):

- The roads and associated structures within the City of Greater Sudbury generally are robust and do not appear to have any major vulnerabilities to the predicted effects of climate change, with the exception of the drainage infrastructure vulnerability to the predicted changes in rainfall events as presented below.
- The assessment revealed the drainage infrastructure (culverts, bridges, ditches, catch basins and storm sewers) to have potentially major vulnerabilities to the predicted increases in the severity and frequency of rainfall events associated with climate change. These vulnerabilities are expected to consist of the surcharging and flooding of the drainage infrastructure, with likely impacts on all performance responses (including structural integrity, functionality, and operations and maintenance). It was, however, not possible to quantify this vulnerability due to the lack of hydraulic information for the existing drainage infrastructure within the City of Greater Sudbury.
- The assessment revealed gravel-surfaced roads to have moderate vulnerabilities to the predicted increases in the severity and frequency of rainfall events associated with climate change. These vulnerabilities are expected to consist of washouts and rutting of gravel-surfaced roads, with likely impacts on the functionality, operations and maintenance, and environmental performance responses.
- The assessment revealed the asphalt-surfaced roads to have minor vulnerabilities to the predicted increases in temperatures associated with climate change. These vulnerabilities are expected to consist of increased softening

and rutting of asphalt surfaces, with likely impacts on the durability and operations and maintenance performance responses. This minor vulnerability should be couched in the knowledge that the relatively short service life of roads (approximately 30 years) will allow the adjustment of asphalt mix designs to accommodate the predicted future temperature increases as the existing inventory of roads is replaced and as new roads are constructed.

- The assessment revealed the embankments and road cuts to have minor vulnerabilities to the predicted increases in groundwater table fluctuations associated with climate change. These vulnerabilities are expected to consist of minor increases in the destabilizing forces on embankments and road cuts, with potential impacts on the structural integrity performance responses.
- Due to a lack of climate prediction data, the assessment was unable to demonstrate (neither qualitatively nor quantitatively) a vulnerability to the potential increases in the frequency and severity of ice accretion/ice storms associated with climate change. However, as this inability is due to a lack of data and in light of the potentially severe vulnerabilities associated with ice on roads and associated structures, a risk and critical assessment should be performed to evaluate the various infrastructures, design standards, and operations and maintenance procedures that are potentially impacted by ice accretion/ice storms.

Human Health

Introduction

Although climate change is expected to result in some benefits to human health such as fewer deaths from cold exposure in temperate areas and reduced transmission potential of Malaria in some parts of Africa, overall most experts agree that the negative effects will outweigh the benefits, particularly in developing countries (Confalonieri et al. 2007). In fact, Costello et al. (2009) state that climate change is the most serious global threat to human health of the 21st Century, particularly to the most vulnerable people including the elderly, the young, the infirm, and the poor. Higher temperatures will continue to increase the occurrence of heat-related illnesses such as heat exhaustion and heat stroke, and will exacerbate existing health problems related to the circulatory, respiratory, and nervous systems (Lemmen and Warren 2004). Climate change is expected to increase health risks of Canadians through the food they eat, the air they breathe, the water they drink, infectious diseases they will be exposed to, and extreme weather events (Séguin and Berry 2008).

Heat-Related Mortality

In the future, winter cold-related mortality will decrease, while summer heat-related mortality will increase in Ontario. Heat-induced mortality has already increased in various parts of the world. For example, in Europe 70,000 people died due to the heat wave of 2003, and most of these deaths were preventable (Fritsch et al. 2007). Closer to home, the number of hot days above 32°C in the Toronto-Niagara region could double by the 2030s and surpass 50 days by the 2080s. Of even greater concern in Toronto, where extremely high temperatures are now rare, is the projected increase in days reaching 36°C or more. Due to these projected increases, the current death rate of 19 people per year in Toronto could increase between 10- and 40-fold by the end of the century (Hayhoe and Shuter 2003, Pearson and Burton 2009).

Air Pollution

The Ontario Medical Association estimated that in 2005, the annual illness in Ontario related to air pollution resulted in 5,800 premature deaths, more than 16,000 hospital admissions, almost 60,000 emergency room visits, and 29 million minor illness days. In 2008, 9,500 premature deaths in Ontario were related to air pollution, an increase of 64%, with more than 1,000 occurring during or immediately after periods of increased pollution (Pearson and Burton 2009).

Air pollution levels have been increasing in Ontario. For example, the number of smog alert days in Toronto during the period 2001-2007 (152) increased by 253% compared to the previous seven-year period (43). This is primarily due to an increase in vehicular traffic as well as increased smog created by warmer weather that drives the chemical reactions responsible for smog production (Pearson and Burton 2009). More frequent and intense forest fires will also produce more particulate pollution, which causes nasal, throat, respiratory, and eye problems (Hayhoe and Shuter 2003, Lemmen and Warren 2004). More smog and particulates also worsens other health conditions such as asthma and allergies. Longer growing seasons will also likely result in more plant growth and pollen production, which could increase allergic reactions (Séguin and Berry 2008).

Infectious Diseases

Higher temperatures, heavier rainfall events, and associated flooding that can flush bacteria, sewage, fertilizers, and other organic wastes into waterways and aquifers will result in the increase of waterborne diseases (Lemmen and Warren 2004). For example, the incidence of infections related to Salmonella and Escherichia coli (*E. coli*), is sensitive to weather conditions, particularly heavy rainfall and high temperatures, and climate change could lead to an increased risk of such infections (Schuster et al. 2005; Walter-Toews 2005).

Historical experience, including the Walkerton outbreak, indicates that Ontario's water supply is vulnerable to weather-induced water-borne disease outbreaks (Chiotti and Lavender 2008; see Richards (2005) for a description of the various health effects from the Walkerton incident). Some other waterborne infectious diseases include cryptosporidiosis, giardiasis, and toxic algal outbreaks (Hayhoe and Shuter 2003), which are encouraged by increased water temperatures.

Climate also plays an important role in the transmission of terrestrial diseases. Warmer and wetter summers combined with land-use changes will likely make conditions more favourable for the establishment and proliferation of vector-borne diseases by encouraging the northward migration of ticks, mosquitoes, and fleas, and by speeding their development rates (Hayhoe and Shuter 2003, Lemmen and Warren 2004).

West Nile virus, which is carried by mosquitoes, has already migrated northward into the NBA Region. Although it is not currently common in the NBA Region, increased mosquito activity and the geographic spread of the virus are all favoured by longer, warmer, and wetter summers (Pearson and Burton 2009). Lyme disease, which is carried by the black legged tick, has also migrated northward into central Ontario and will likely reach the NBA Region by the 2020s due also to a more favourable climate for its host insect (Ogden et al. 2006). Other diseases of potential concern for Ontario include malaria and eastern and western equine encephalitis due to expected climate changes and an increase in mosquito breeding grounds resulting from increased flooding (Greifenhagen and Noland 2003, Lemmen and Warren 2004).

Extreme Weather Events

Extreme weather events in Canada such as floods, drought, violent windstorms, ice storms, forest fires, and heat waves have been increasing in both frequency and intensity, which has caused an increase in health risks to Canadians (Séguin and Berry 2008). Increased death, injury, evacuation, and loss of basic services due to these extreme weather events will not only bring increased pressure on emergency health services but will also increase the occurrence of mental health conditions including elevated anxiety levels, depression, and violence (Lemmen and Warren 2004, Pearson and Burton 2009).

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