HEALTH EFFECTS OF EXTREME WEATHER EVENTS AND WILDLAND FIRES

A YUKON PERSPECTIVE

Office of the Chief Medical Officer of Health

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Yukon

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Foreword

Although this report focusses on wildfires and extreme weather events, it does not shrink from documenting the larger context of human-accelerated climate change and the multiple other threats that accompany global warming. Human activity is contributing to a rise in average global temperatures. On average, Canada's climate has warmed at about double the global rate, and the North roughly three times that. More warming is occurring in winter than in summer. Between 1948 and 2016, winters in the Canadian north became 4.3°C warmer on average, while the increase in average summer temperatures has been 1.6°C. Canada's climate will continue to warm in the future; the amount of carbon dioxide and other greenhouse gases emitted will determine how much more warming will occur.

Canada is experiencing the consequences of warming including more extreme weather, increases in severity of forest fires, rising sea levels, diminishing Arctic sea ice and reduced availability of traditional Indigenous foods. There is limited information on the health impacts of climate change on Yukoners; however, given what is documented elsewhere, these are likely to be wide-ranging. Indigenous people, older adults, children and people with pre-existing health conditions are more likely to experience adverse effects of climate change.

Climate change is already threatening our health, and the effects are likely to increase substantially as global temperatures continue to rise. In Yukon, a warmer climate may:

- increase the number and magnitude of wildland fires, resulting in more air pollution and higher risk of personal injury, damage to infrastructure and property;
- result in the formation of higher concentrations of ground-level ozone, affecting lung health;
- lengthen the pollen allergy season;
- increase the risk of flooding, landslides and damage to buildings and other infrastructure from melting permafrost, with a corresponding increase in death and injury;
- increase stress and reduce mental health;
- increase the risk of various conditions associated with sun exposure such as skin cancer and eye damage (cataracts);
- increase the range of mosquitoes, ticks and other pests, which could result in an increase in the risk of vector-borne disease; and,
- affect water bodies and damage water infrastructure, which could then decrease water availability and quality, with an increase in waterborne diseases (infections carried by water).

In Yukon, it is possible that we will experience some positive effects of climate change. For example, warmer temperatures with increased precipitation may benefit local agriculture and forestry, thereby improving access to healthy food and increasing employment and ultimately positively influencing population health. However, overall it is expected that the effects of climate change on human health will be devastating.

Climate change is a public health emergency. It is imperative to keep further increases of global temperatures to below 1.5°C in order to prevent the potentially disastrous effects of a 2°C increase. Only if Canada and the rest of the world reduce emissions of greenhouse gases substantially and achieve near-zero carbon emissions early in the second half of this century will it be possible to limit warming by less than 2°C and avoid the more severe impacts of climate change on health and wellbeing.

This report highlights the personal health impacts of climate change of Yukoners and urges individuals and governments to take concerted action now to ensure a healthier future for Yukon, Canada and the world.

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Introduction

This report is a product of the "Monitoring and Planning for Health Impacts of Extreme Weather Events and Wildfires" project funded by the Government of Canada's Climate Change Preparedness in the North Program. This report highlights the impacts that climate change has on health and wellbeing with a focus on floods and wildland fires, two of the most important climate-enforced weather events in Yukon.

Purposes

- **Monitoring:** This report identifies indicators that could be used to better measure and monitor the health impacts of climate-related events.
- **Mitigation:** While this report will not actually focus on any particular mitigation effort it emphasizes the immediate and profound mitigation efforts needed in order to protect our health and the environment.
- **Adaptation and Planning:** Proposed actions are outlined that could be taken to strengthen the response to extreme weather events, and thus reduce the negative impacts of these events on health. In addition, broader actions that can build the resilience of communities and people in Yukon are outlined.
- **Advocacy:** Through this report and the ongoing work on climate change and health, we will continue to promote evidence based best practices, policies and programs in order to protect the health of the public.

The changing climate

The World Health Organization has described climate change as the biggest challenge to health in the 21st century.[i] The 2018 special report from the Intergovernmental Panel on Climate Change emphasizes that we are already seeing the impacts of a 1°C increase in global average temperature.[ii] The Arctic has seen larger temperature increases than the rest of the world.[ii] The report stresses the importance of limiting warming to less than the 1.5°C target set in the November 2015 Paris Agreement.[iii] An additional 1°C warming would have more severe impacts on the ecosystems we depend on, making it even more difficult for humans to adapt. The 1°C warming is already having negative effects on human health. In fact, likely the "most immediate and personal impact of climate change is the health impact."[iv]

There is now overwhelming evidence that global temperatures have increased since the beginning of the Industrial Revolution and that human influence is the main cause of this warming.[v] Higher levels of greenhouse gases in the atmosphere are causing temperatures to rise. This is producing unusual weather patterns, more frequent and intense storms, as well as more overall precipitation in some areas, and less in others (Figure 1).

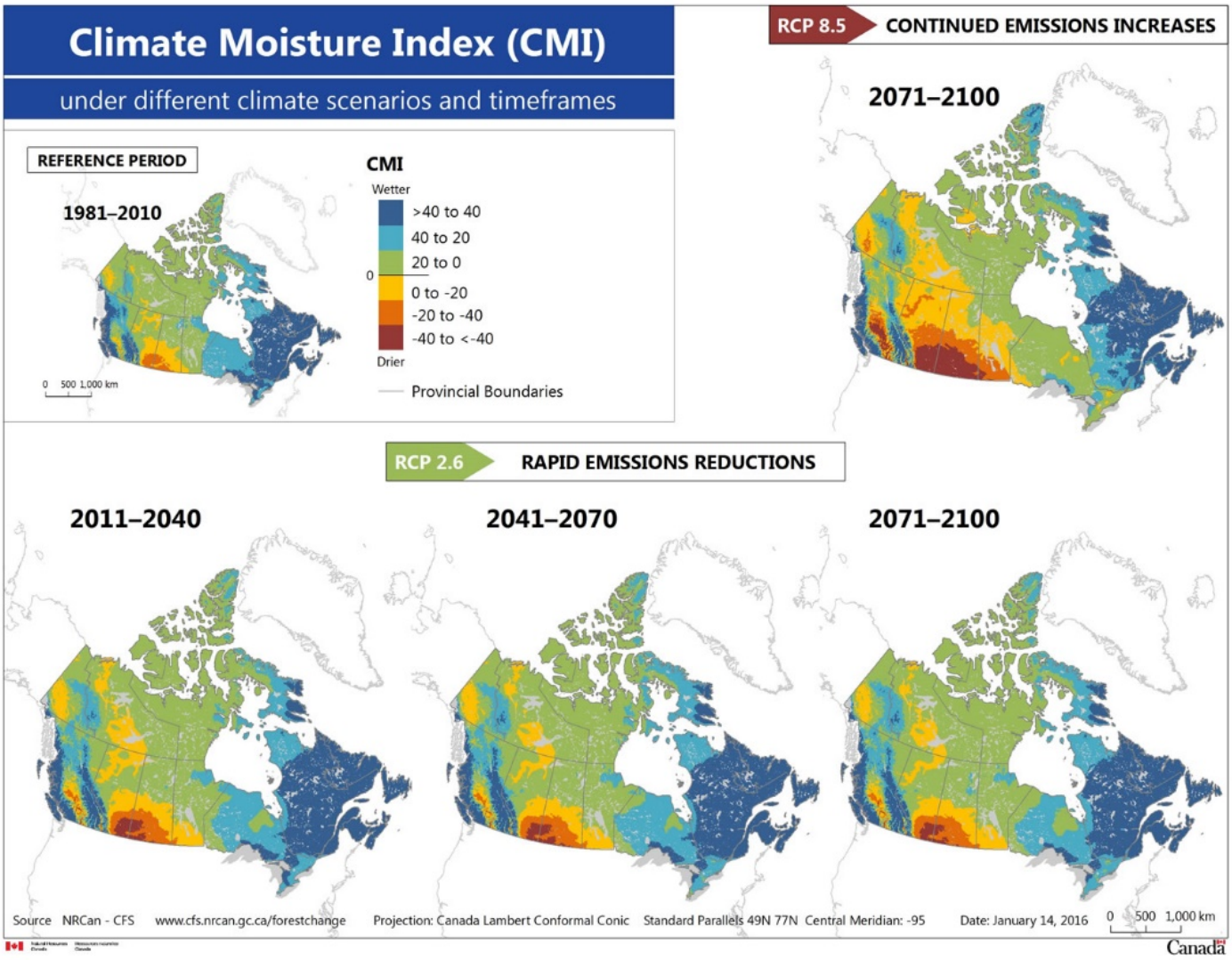

Figure 1: Expected change in rainfall in Canada under climate change[vi]

The Intergovernmental Panel on Climate Change developed four greenhouse gas emission projections or Representative Concentration Pathways (RCP). RPC 8.5 refers to the scenario with continued increases in greenhouse gas emissions, which could be described as "business-as-usual"; RCP 2.6 refers to the scenario with a rapid reduction in emissions, which could be described as "best-case."

Yukon's Climate

Yukon's climate is characterized by hot summers and cold winters. Temperatures of 36°C have been recorded in summer and have reached -60°C in winter. The frost-free period varies from year to year and across Yukon – the average is 93 days in the Watson Lake area and 21 days in Haines Junction. Precipitation also varies, with average annual precipitation of less than 20 cm west of Whitehorse and more than 40 cm in Watson Lake. South-west Yukon is susceptible to droughts between April and July.[vii] There is great variability in temperature and precipitation from year to year, and large variations can occur from day-to-day as well.[viii,ix]

Figure 1 shows how some parts of Canada and Yukon could become wetter and others drier as levels of greenhouse gases increase in the atmosphere. It also shows how a rapid reduction in emissions could reduce the magnitude of the changes. The southwestern part of Yukon is projected to receive less precipitation than at present. Under a scenario with a rapid reduction in greenhouse gas emissions, the

decrease in precipitation is projected to be between 0 and 20 per cent; if emissions continue at their current rate, this decrease is expected to be between 20 and 40 per cent. The Selwyn, Ogilvie and Saint Elias mountain ranges are projected to see an increase in precipitation.

Warmer temperatures have already had an impact on glaciers in Yukon. The Western Cordilleran glaciers are shrinking rapidly and are now smaller than they have been for thousands of years.[x] Between 1958 and 2008, glacial ice in Yukon has retreated by 22 per cent. The retreat of the Kaskawulsh Glacier, which led to a sudden diversion of water from the Slims River to the Alsek River in 2016, is an example of how climate change can have a dramatic impact on the ecosystem. [xi]

Climate Change and Health

While some benefits to a warming world are recognized, such as milder winters, scientists agree that the majority of health effects from climate change will be adverse.[xii] Climate change can have both direct and indirect effects on human health and wellbeing, some of which may have already experienced, even without knowing. The magnitude of the impact depends on the resiliency of individuals and communities as well as adaptation measures adopted to reduce the negative impacts of climate-related changes. There is also increasing recognition of the mental health effects of injuries, death of loved ones, displacements, property damage and impacts on livelihood and food security associated with severe weather events.[x]

Yukon Context

Climate change-related hazards in Yukon include floods, wildfires, thawing permafrost and extreme weather and precipitation. The small size of Yukon communities, large distances between them, limited access to health and social services, greater dependence on the environment and the more rapid change occurring in Canada's North make Yukon particularly vulnerable to the population health effects from a changing climate.[x] In addition, colonial legacies and persistent inequalities make Indigenous people living in Yukon especially vulnerable to the impacts of the changing environment.[ii,xiii] People whose livelihood depend on renewable natural resources, including agriculture, fisheries and forestry, and those who rely on non-commercial food supply are also more likely to be affected.[xiv,xv]

Extreme weather[1]

The health impacts of extreme weather events vary depending on both the severity of the event and the level of preparedness and resilience of communities and individuals affected. Many of the health impacts of extreme weather are indirect. For example, extreme weather can damage energy, transportation, communication, water and waste treatment infrastructure. Such disruption may not only compromise the response to the event, it can also affect overall health and wellbeing of the population affected, especially if the capacity of communities and local governments is overwhelmed. The health of people with disabilities or existing chronic conditions may be put at risk when infrastructure is damaged or when the demand for services exceeds the available capacity to respond. Changes in climate and the subsequent disruption to the social, economic and environmental determinants of health can influence an individual's mental health and wellbeing.[xvi] An example of this occurred in 2012 when the Alaska Highway was closed as the result of washouts, flooding and mudslides resulted in the disruption of supply and service delivery.[xi]

[1]Extreme weather: cold, heat, high precipitation and drought.

Precipitation

Extreme weather can also diminish food security and access to safe drinking water. Frequent and intense rainfall can increase the risk of water contamination and waterborne disease, especially when run-off carries contaminants into waterways and groundwater.[xvi] Extreme precipitation can result in floods and landslides and increase risk of injuries and deaths from on- and off-road motor vehicle collisions because of poor driving conditions.[xv,xvii]

Hot and dry weather increases the risk of wildland fires, in turn affecting agricultural production and fisheries.[xviii,xix] Droughts have also been linked to waterborne disease outbreaks.[xvi]

Temperature

Both cold and hot temperatures are associated with increased death and exacerbation of various illnesses, including cardiovascular disease, respiratory disease and diabetes.[xx,xxi,xxii]

Research shows an increase in mortality when temperatures rise above 25°C.[xvi] High temperature variability (within and between days) is also associated with increased mortality, possibly because it is more difficult for people to adapt to rapid changes in temperature.[xxiii,xxiv,xxv] Colder days are responsible for the larger part of the temperature related illness in Canada because cold days are more common than hot days, even though the risk to health from hot temperatures is higher.[xxii] In areas such as Yukon, where milder winters are expected, this could mean that the overall burden of illness-related exposure to temperatures could stay the same or even decrease, as any increase in death or illness related to heat would be counterbalanced by reductions in cold-related impacts.[xxii]

The majority of temperature-related illnesses in Yukon are due to exposure to cold. A review of health records from 2011-12 to 2017-18 showed an average of 50 emergency department visits a year for temperature-related illness in Yukon, which is less than one per cent of total visits. The majority of these, 87 per cent, were due to cold. The number of hospitalizations for temperature-related illness during that period has typically been less than five per year.[2]

Older adults, infants and children, and people with underlying health issues are more susceptible to heat-related illness. Other factors that influence vulnerability to heat include housing conditions, access to cool spaces or air conditioning, social isolation and the use of certain medications.[xvi]

In Canada, cases of food-borne illnesses increase during the summer months.[xvi] The longer and hotter summers are expected to increase the risk for these diseases.[x,xvi] Some algae produce toxins (cyanotoxins) that impact the quality of surface water and contaminate fish and shellfish. Warmer weather is one of the factors contributing to an increase in blue-green algae blooms in Canada, including Yukon.[x]

Warmer temperatures are causing glaciers to retreat.[xxvi,xxvii] The impact of shrinking glaciers is not fully known, but is expected to influence stream flows, affect access to safe water and contribute to flooding. Catastrophic effects, such as the formation of unstable glacial lakes and outburst floods, are likely to occur more frequently.[xxvi]

[2] Custom extraction from Canadian Institute for Health Information; National Ambulatory Care Reporting System; extracted by S. Kinsella, Yukon Health and Social Services, November 2018.

Wildfires

Wildfires are common in Yukon, with an average of 140 wildland fires each year that burn a total of about 120,000 hectares.[xxviii] Wildland fires are an important part of the boreal forest ecology. About half of wildland fires are caused by lightening.[xxix] Climate projections suggest that the risk of fire and area burned could double by 2069.[xxx]

The number and size of fires in Yukon vary greatly from year to year (Figure 2). One year stands out in particular – 2004. Weather conditions were hotter and dryer than normal; over 40 thousand lightning flashes ignited about 250 fires. In total, 282 fires burned over 1.7 million hectares, about four per cent of Yukon's land area.[xxix,xxviii] The 2004 fires had a measurable impact on air quality in Whitehorse. Monthly average fine particle (PM2.5) concentrations were 15, 13 and 12 µg/m^3 in June, July, and August, respectively. This compares with the average of three, three and four µg/m^3 for these same months in other years (based on 2001-2016 data). While some days the concentrations were above the 2020 Canada Ambient Air Quality Standard 24-hour average of 27 µg/m^3, the annual average concentration of 5 µg/m^3 was still below the annual standards of 8.8 µg/m^3.

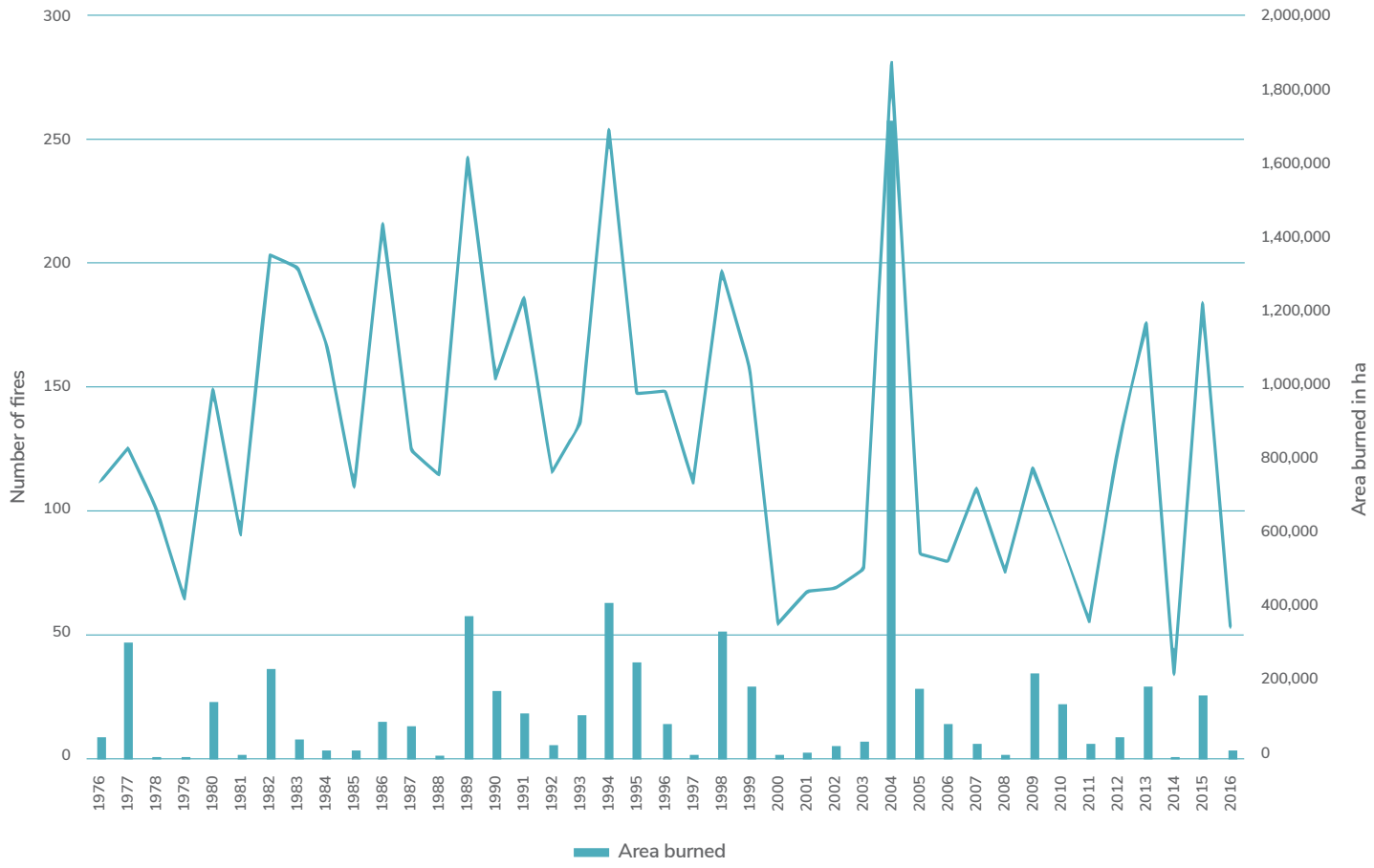

Figure 2: Number of fires and area burnt in Yukon 1976–2016[xxxii]

Wildfires affect health in the following ways:

- direct exposure to flames and radiant heat;
- exposure to smoke from burning or smouldering material;
- exposure to land/soil contaminated by fire residue; and,
- contamination of water by combustion by-products.[xxxiii]

Two of these impacts are examined in more detail since they are more commonly experienced. Disruptions to daily life, damage to property and injuries or death of loved ones that occur as the result of a wildland fire can have an impact on mental health.

Burns and heat-induced illness

People who are in very close proximity to a wildfires run the risk of burns and sometimes death if they come in direct contact with the flames. There is also a risk of heat-induced illness (heat exhaustion, heat cramps or heatstroke, for example) from the intense heat of the fire, especially among those directly involved in fighting it.[xxxiii]

Effects from exposure to smoke

Smoke from wildland fires can affect a large number of people, both close to the fire and in areas up to hundreds of kilometres away.[xxxiv,xxxv] Much of the evidence available on the impact of air pollution on health comes from studies on urban air pollution. While the substances found in wildfire smoke are the same as those of urban air pollution, the concentration of the different components varies.

Smoke from wildland fires is a complex mixture of particles and gasses that depends greatly on what is being burned, the temperature it is burning, and the age of the smoke. The composition of smoke changes over the course of a fire. Smoke from buildings that catch fire can include additional toxic components, depending on the contents and building material of the structure. Smoke generally includes particulate matter, carbon monoxide, nitrogen oxides, polyaromatic hydrocarbons and volatile organic compounds. People are generally exposed to wildfire smoke at higher concentrations for a relatively short time (days or weeks) compared to typical urban air pollution, where concentrations of pollutants are lower but people are exposed for many years.[xxxvi] There is still much to learn about how smoke from wildfires affects health, and about differences between the effects of wildfire smoke and air pollution from other sources.[xxxiii,xxxiv,xxxvi,xxxvii,xxxviii]

Wildfire smoke can cause eye irritation, sore throat, coughing and wheezing.[xxxvi] In addition, the information available indicates that exposure to smoke from wildland fires could result in the following health effects:

- exacerbation of asthma and chronic obstructive pulmonary disease;
- bronchitis and pneumonia;
- increase in death from all causes;
- cardiovascular outcomes;
- adverse birth outcomes;
- childhood respiratory disease; and,
- anxiety.[xxxvii]

The available evidence indicates that wildfires are associated with increased use of medical services (emergency room visits, hospitalizations, medical consultations), particularly for respiratory problems.[xxxiv,xxxviii]

Populations that are more susceptible to ill effects from smoke from wildland fires include:

- infants and small children;
- the elderly;
- women who are pregnant;
- populations with pre-existing respiratory conditions;
- populations with cardiovascular disease; and,
- populations involved in strenuous work or exercise.[xxxvii,xxxviii]

Floods

Floods are a regular occurrence in Yukon. The Canadian Disaster Database records six major floods in Yukon between 1900 and 2018, including the 1925 and 1979 floods in Dawson City and the 2012 floods in Upper Liard, which led to the closure of the Alaska Highway.[xxxix] Based on Yukon Emergency Measures Organization situation reports there were 17 floods between 1998 and 2018 that resulted in either evacuation, property damage or road closures. The cost of damage for the 1979 Dawson City flood was approximately $1.85 million; total damage of the 2012 floods, $1.5 million.[3,xl]

It is still unclear how climate change might impact the risk of flooding in Canada. There have been increasing winter flows in rivers in northern Canada including in the Yukon and Mackenzie River basins. Annual flows in rivers and streams in these basins are expected to increase as the result of the projected increase in precipitation.[v]

Although the most common causes of death during floods are drowning and physical injury, floods may affect health in the following ways:

- death from drownings or collisions;
- injuries from contact with debris, due to collapse of structures or overexertion (for example lacerations, skin irritations, bruises, wound infections, sprains, strains and orthopedic injuries);
- shock and hypothermia;
- bacterial, viral and fungal infections, including gastrointestinal and other illnesses from being exposed to or drinking contaminated water;
- cardiovascular effects (for example, high blood pressure, heart attacks and strokes) from exertion and stress;
- lung infection, pulmonary swelling, lung irritation from aspiration of water into the lungs;
- respiratory problems/symptoms from exposure to mould, bacteria, fungal growth on damp structures;
- electrical injuries from contact with downed power cables/lines, circuits and electrical equipment in contact with standing water;
- preterm birth and low birth weight;
- damage to essential infrastructure (including roads, water treatment facilities, and power generating facilities);
- mental health impacts related to the fear, loss and disruption to daily life;
- exacerbation of existing illnesses, including chronic diseases, especially if people are not able to access needed medicines or medical equipment like ventilators and oxygen supplies.[x,xxxv]

[3]Note that in 2016 CBC reported: "The Yukon government is looking for help from Ottawa to help cover some of the $8 million bill associated with severe flooding in the territory four years ago."

Certain populations are more likely to be adversely affected by a flood. They include:

- older adults (especially those who are frail, medically incapacitated, or residing in long-term care facilities) because they are less able to independently get out of harm's way;
- children;
- people with pre-existing health conditions;
- people with disabilities;
- people who are economically disadvantaged; and
- indigenous communities.[x,xxxv]

The direct impacts are those caused by the floodwaters themselves and any debris carried by the flood. Indirect impacts are those caused by other circumstances related to the flood such as disruption of power or transportation infrastructure, or impacts on the availability of services. The severity and extent of health effects associated with an extreme event also depend on the size of the event and the human, societal and environmental circumstances that surround the event, such as how prepared an individual or community is, the preventive measures that are in place at the time of the flood and the overall resiliency of the community that is affected (Figure 3).

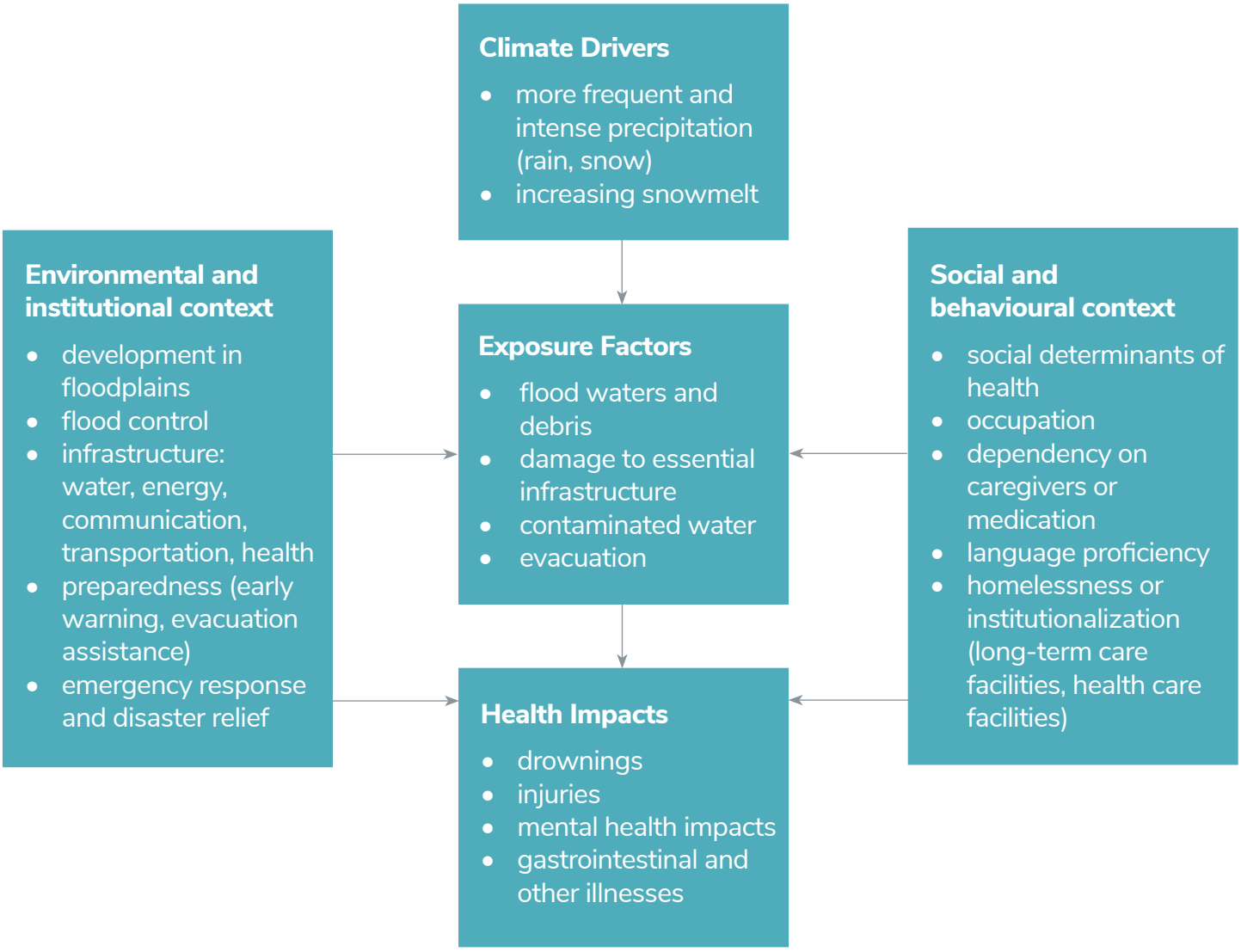

Figure 3: Relationships between climate change, flooding and health[4]

[4]Adapted from Climate Change Impacts in the United States: The Third National Climate Assessment (2016).

Mental health

Climate change can influence the social, economic and environmental determinants of health, which influence an individual's mental health and wellbeing (Figure 4).[xvi] Concern about climate change and the future can bring on different emotions, including fear, anger, feelings of powerlessness or exhaustion. Worrying about what the future will bring, especially to the younger generations, can increase stress, which some have described as ecoanxiety. As climate change alters the landscape people may experience a sense of loss of place, a phenomenon called solastalgia.[xvii] These changes have implications for cultural, social and mental health among people for whom the connection to the local environment is important. This is especially true for the health of Indigenous peoples whose ability to go on the land, travel, hunt and fish or collect berries, and to feel safe in their environment is critical to their sense of wellbeing.[xv]

As for more immediate mental health impacts, disasters can result in immediate and severe psychological trauma due to personal injury, injury or death of a loved one, damage to or loss of personal property (e.g., home or business) and pets, as well as disruption to or loss of livelihood.[xvii,xxxiii]

When a person feels that they are not able to respond and adapt to a given situation this can result in stress. People's initial response to a disaster includes terror, anger, shock, depression, anxiety and other intense negative emotions. Stress can be accompanied by worry about future disasters and feelings of vulnerability, helplessness, mourning, grief and despair. The disruption caused by a disaster may result in strained family relationships, removal of social support networks and loss of a sense of place. Stress may lead to unhealthy eating, substance use and other unhealthy behaviours. Studies have reported an increase in violence, including sexual assault and domestic abuse, in communities that have experienced disasters.[xvii,xli]

Post-Traumatic Stress Disorder (PTSD), depression, general anxiety and suicide all tend to increase after a disaster.[xvii,xlii] While most people symptoms experience mental health symptoms that stop once their life becomes more stable, in some, psychological effects can continue for much longer.

The severity of mental health impacts following extreme weather events depends in part on the capacity of the individuals affected to cope and the availability of support services during and after the event. The impact on wellbeing of people living in rural and northern communities is of particular concern. These communities tend to have limited resources and insufficient support services.[xvi] Disruption to the way of life due to changes in weather, snowfall, ice stability and changes to wildlife populations and vegetation availability also affect the cultural identity and social connectedness of Indigenous people.[xvi] Younger children are at especially high risk of PTSD symptoms.[xvii,xxxiii] The elderly, women (especially pregnant and post-partum women), individuals, families and communities with fewer resources, people with disabilities or pre-existing mental illness, Indigenous communities and first responders are also more likely to experience greater negative impacts on their wellbeing after living through a disaster.[xvi,xvii,xix]

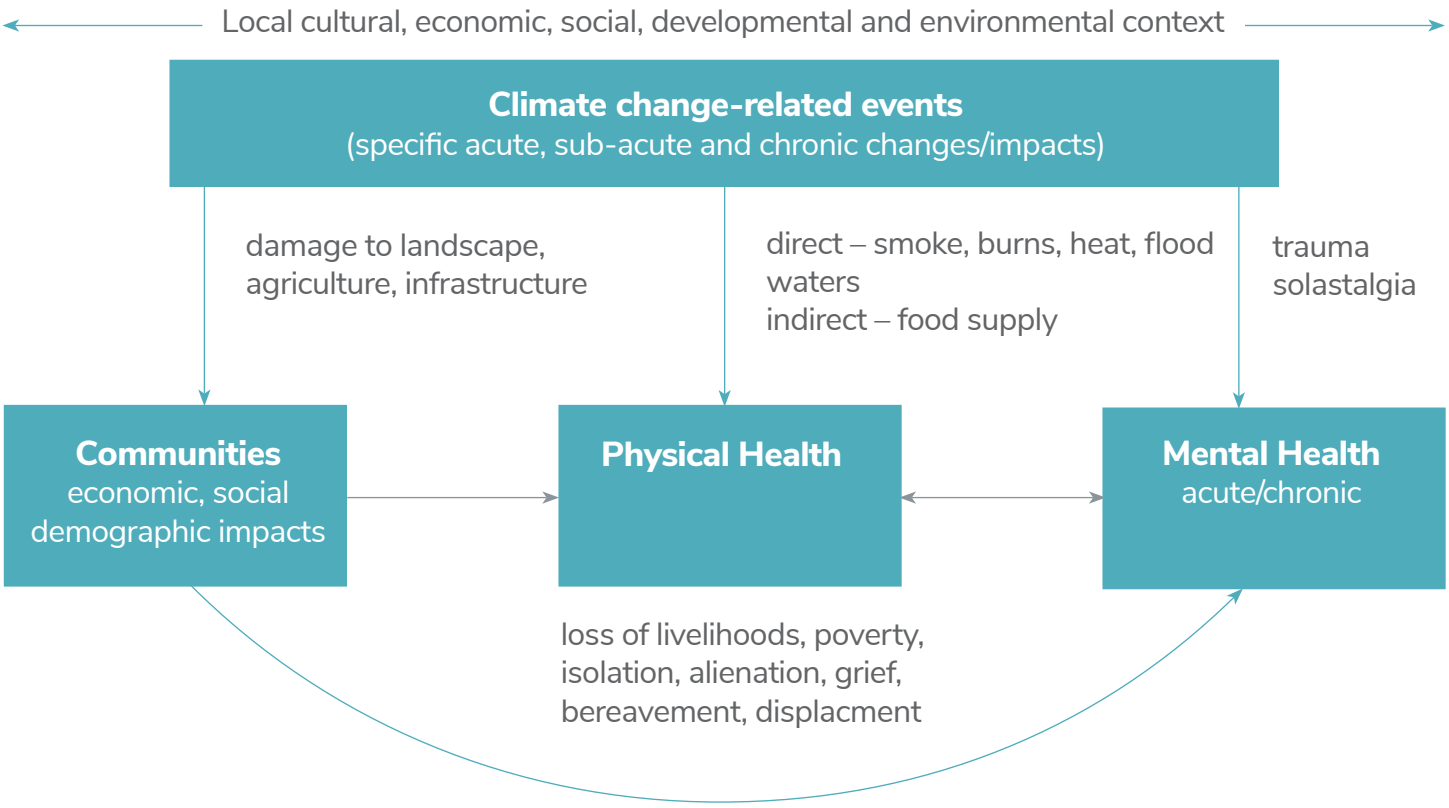

Figure 4: The ways climate change and mental health are linked[5]

Food Security

Access to nutritious food and a healthy diet are critical for health. The influence of climate change on food security in Canada's north is complex and difficult to predict. There will likely be both beneficial and negative effects of climate change on food security in Yukon.[x] Gathering, preparation and sharing of food is also central to cultural identify and social relations, which are also important for health.

Food security of northern residents could be affected by changes to the access, availability or quality of locally harvested wildlife and plants. Climate-induced changes to ecosystems are likely to alter yields and species composition and change their historic range.[x] For example, members of the White River First Nation of Beaver Creek have seen changes in the availability of species and the ease of harvesting them.[xv] Similarly, the Kaska people of Ross River have noted that earlier spring thaws, warmer and extended summers and increasing wildfires are affecting the feeding grounds, distribution and abundance of caribou populations.[x]

Traditional foods are an important source of nutrition for Indigenous populations. They contribute significant amounts of protein to the total diet and help individuals meet daily requirements for several vitamins and essential nutrients.[xv] In Yukon, Indigenous people and people living further from urban centres rely more on traditional foods. In addition, the traditional and cultural aspects of traditional food-related activities are important for building social relationships and maintaining cultural identity.[xv] These activities contribute to health and wellbeing.

[5]Adapted from Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. (2014). Natural Resources Canada, Ottawa.

Longer and warmer growing seasons that allow more crops to be grown further north and lengthen outdoor feeding seasons for livestock could benefit local food production in Yukon. However, the greater variability in weather, increased occurrence of extreme weather and more favourable conditions for pests and disease could have a negative impact on production and economic viability of farm operations.[x] As well, transportation network disruptions related to extreme weather events or melting permafrost could interference with the distribution of market foods.[xv]

Other health effects of climate change

UV radiation

One of the results of increasing greenhouse gas concentrations is the trapping of more heat below the stratosphere, which results in stratospheric cooling. A colder stratosphere will likely increase the frequency and severity of episodes of stratospheric ozone depletion. This would result in higher exposure to UV radiation especially in late winter and early spring. Residents of the north have already reported an increased incidence of sun rashes, burns and snow blindness.[xv] Continued ozone depletion would increase the risk of skin cancers, burns, infectious diseases, eye damage (cataracts) and immunosuppression.[xv]

Ozone

Higher temperatures facilitate the chemical reaction between different air pollutants, resulting in the formation of ground-level ozone. Climate change could reduce gains made by recent improvements in air quality.[x,xliii] Exposure to ground-level ozone is associated with premature death and adverse impacts on the lungs – decreased lung function, respiratory symptoms, inflammation and impaired immunity. This can result in increased emergency room and hospital visits for respiratory ailments, especially asthma-related ones. Ozone can also contribute to cardiovascular illness.[x]

Water security

Climate change is already affecting Yukon's water resources.[xv,xxvi] Climate change is affecting precipitation, snowpack, permafrost, glaciers and stream flow, as well as water quality in Yukon's lakes, streams and rivers.[xxvi] While the health impacts of these changes are difficult to assess, 25 per cent of Indigenous residents in Yukon expressed concern that their water was unsafe for consumption.[xv] Dry periods are becoming more common between April and July in southwest Yukon which is when most agricultural activity occurs.[xxvi]

Ice cover

Ice provides a stable travelling, hunting and fishing platform during the winter season. It is also crucial for some Arctic species. Warming has already resulted in a shorter ice season with impacts on access to wildlife that Indigenous communities depend on, as well as transportation routes over ice. Some communities have reported an increase in the number of accidents and drownings associated with changing ice conditions.[xv]

Permafrost

Melting permafrost is already affecting infrastructure in Yukon.[xi] In zones at risk of thaw, the integrity of structures, roads and other infrastructure that are built on permafrost is vulnerable to climate change. Similar to the damage done to structures during floods or fires, damage that occurs to these facilities impacts human health.[xv] Changing permafrost conditions may also impact the quality of Yukon's groundwater.[xxvi] An example of this occurred in 2009 when the combination of melting permafrost and torrential rains resulted in the release of untreated water from the Minto Mine.[xi,xviii]

New and emerging species

It is not yet clear how changes in distribution of infectious and communicable diseases in future will affect Yukon. However, warming has been associated with illness in marine mammals, birds, fish and shellfish, which has the potential to impact human health.[xv] The spread of the spruce bark beetle and its contribution to increasing forest fire risk in Yukon is an example of how insect activity and climate change are related to human health.[xv]

Monitoring Population Health Effects of Yukon's Changing Climate

Indicators

An indicator is a tool that shows a change. When indicator measurements are made over time, they can be used to describe how a situation is changing and assess progress made to reach a certain goal.[xliv] To be useful, indicators need to be tailored to the needs of the jurisdictions where they will be used. A good climate-related indicator should meet several criteria:

- The indicator will be simple, relevant and understandable.
- The indicator will be specific and defensible – it must identify a relationship between environmental factors and health status and measure a factor related to climate change that is only slightly affected by other factors.
- The data used for the indicator needs to be of good quality, comparable over time, geographic areas and benchmarks, and be easily available.[xliv,xlv]

The first question to ask when identifying indicators is what is the purpose of the indicators? In this case, the main aim is to monitor the health effects related to climate change in Yukon, with a focus on climate change-related emergencies or events. This can ensure sufficient and timely reporting necessary for responding to the health impacts of climate change. As a developed northern region, it is all the more important to document and report these impacts globally, given how the North is among the first and the most affected of all areas.

Indicators can provide information on the hazard, the exposure to the hazard, the impact of the hazard (i.e., health effect) or the interventions that are taken to prevent or reduce the hazard. While the health effect or impact is what is of most interest, it is rare to have a health effect that is very specific to the hazard (in this case climate change). Therefore, measures of hazards or exposure to the hazard are often used as proxies – if exposure to the hazard is reduced, it is expected that the impact will also be reduced. Interventions aim to reduce or eliminate the adverse impacts caused by a hazard. Indicators related to these actions are useful – if they are effective, health will be protected. Given the complexity of climate change and its impact on health, more than one indicator is needed to provide a sense of the situation.

A literature search was conducted in the EBSCO databases and on the internet (including Google Scholar) using the keywords "climate change" and "health indicator." This identified 20 different lists of indicators from organizations and publications of potential relevance.[6] A comparison of the elements included in each of the lists showed a great variation between the number of indicators in each list as well as the parameters selected as relevant (Appendix 1).

[6]This can be made available upon request for those interested.

Proposed indicators

Climate change and health indicators are a combination of health indicators and environmental indicators that are based on data collected by other agencies. Given the similar context, the list of indicators compiled by the Qaujigiartiit Health Research Centre, "Exploring Health-Related Indicators of Climate Change in Nunavut," was selected as the best starting point for identifying indicators for Yukon (see Appendix 3).[xlvi]

These indicators could be reported on periodically (for example every three to five years) similar to the Health Status Report or the cannabis health indicators. These indicators are used denote the state of the issue at a certain point in time. As a whole, this list of indicators should support efficient and timely reporting not only locally but also nationally and globally. Thus they will need to be harmonised with national and global indicators as they are developed. The list presented here is therefore an initial list and starting point for further development. These proposed indicators are a valuable tool to ground the conversation about climate health indicators within Yukon, for engaging other sectors and for developing indicators within the Department of Health and Social Services. The possible climate change and health indicators for Yukon include:

Environmental status indicators

1) average annual atmospheric concentrations of carbon dioxide;
2) levels of particulate matter and ground-level ozone;
3) average, maximum and minimum temperatures;
4) number and duration of heat alerts/warnings[7];
5) pollen counts, ragweed presence;
6) wildland fire (number, size and duration, distance from population centres);
7) droughts (intensity; area);
8) hazardous algal blooms (number);
9) permafrost (temperature, depth, area);
10) sea ice (thickness, areal extent, location, duration);
11) date of Yukon River break up;
12) water quality (number of water advisories)[7];
13) flooding (number of flooding events);
14) landslide frequency;
15) vitality of terrestrial and aquatic ecosystems (number of species at risk; invasive species; annual bird count).

Health indicators

16) number of emergency department visits, hospital admissions and deaths related to temperature extremes (heat or cold)[7];
17) number of injuries/deaths attributed to weather events, floods, wildland fires or ice instability[7];
18) number of reports of environmental infectious disease in reservoirs/sentinels/vectors and locally acquired infections in humans[7];
19) increase in number of physician visits during and after climate change-related emergencies[7];
20) increase in demand for mental health or other support services during and after climate change-related emergencies[7];
21) number of search and rescue operations in Yukon.

[7]Health and Social Services could take the lead in compiling data for these indicators. Appendix 3 highlights the rationale and identifies potential sources of information for these indicators.

Climate change mitigation indicators

22) annual emissions of greenhouse gases in Yukon;
23) proportion of total energy use that is from renewable energy sources;
24) proportion of people who walk, cycle or take transit to work;
25) proportion of Yukon communities that have access to clean air shelters during wildland fire emergencies[7];
26) number of communities participating in health surveillance systems related to climate change[7];
27) proportion of public health workforce available/trained in climate change research/surveillance/adaptation[7];
28) number of municipalities that have completed climate change and health vulnerability assessments and are implementing health action plans.

Population vulnerability indicators

29) number of elderly living alone, poverty status, children, infants and individuals with disabilities in Yukon communities;
30) proportion of the population that is food insecure, including more vulnerable populations (elderly, those in poverty, infants and disabled);
31) number of people living in 100- and 500-year flood zones;
32) culture loss vulnerability (due to loss of access to harvesting grounds and reduced availability of country/traditional foods and traditional medicines).

Surveillance[8]

An early warning (detection) and surveillance system consists of near real-time data reporting and could be used for floods and wildland fires. Below, several examples of possible surveillance systems for Yukon are outlined. There is a need to evaluate and develop real-time surveillance to detect and assess climate-related health effects for Yukon and these examples provide a starting place.

Vector-borne diseases

In endemic areas, surveillance activities are conducted to vector-borne diseases (e.g., West Nile virus, Lyme disease, equine encephalitis virus). If national and international trends indicated a need, Yukon could enhance communicable disease surveillance to include these diseases which currently do not occur at this latitude. The Canadian north also participates in the International Circumpolar Surveillance System which includes a climate change and infectious disease working group.

Temperature

Many jurisdictions have a heat-warning system in place. Many municipalities provide cooling/warming centres during periods of extreme heat or cold and/or increase their outreach activities for vulnerable populations.

Floods

Since the mid-1970s, the Yukon Department of Environment, in collaboration with the federal government, monitors water levels and flow in about 70 sites in Yukon rivers and lakes. The department also collects historical flow data on small streams. This data provides information on longer-term climate and hydrological changes and can be used to monitor current conditions and assess seasonal flooding risks. The Yukon snow survey and water supply forecast is issued three times a year in March, April and May. The Department of Environment issues flood warnings. However, some events, such as flash floods, are difficult to predict.

[8]Public health surveillance is "the ongoing, systematic collection, analysis, and interpretation of health-related data essential to planning, implementation, and evaluation of public health practice." – Centers for Disease Control and Prevention.

Wildfire

The wildfire season in Canada spans from April to October. The Canadian Wildland Fire Information System provides daily fire risk maps. In addition, hot spot maps are produced during the fire season (May through September). Geographical coverage includes the southern Yukon. The Yukon Current Wildfire Information Application displays wildfire locations and status (new, active, extinguished) and fire conditions (low, moderate, high, extreme) at weather stations across Yukon. Wildland Fire Management has lead responsibility for assessing risk and issuing warnings (event notifications) related to wildland fires.

Smoke

The BlueSky Canada system as well as the FireWork application provide an up to 48-hour forecast of ground-level concentrations of smoke particles from wildfires. British Columbia has developed the BC Asthma Prediction System. The system uses data on asthma-related physician visits and pharmaceutical dispensations to evaluate whether populations are being affected by forest fire smoke. This data is combined with information about smoke from the air quality monitoring network, satellites and the BlueSky/FireWork pollution forecasting model, to provide near-real-time reports to medical officers of health. It may be possible to customize the system to include forecasting for areas in Yukon where health and air quality data are available.

Reporting on climate-related events

Studies of the health impacts of wildfire, flooding and extreme weather events also exist.[xli,xlvii,xlviii,xlix,l] Reporting and evaluating the response to these events after the fact can strengthen future responses within Yukon and elsewhere by sharing our lessons learned with others. Reporting on factors such as health services use, medication dispensations, rates of communicable diseases and environmental effects as a collaborative effort among multiple government departments can be a useful way to report on the impacts of past events. If data is available in real-time, the use of data such as dispensation of pharmaceuticals or physician visits can serve an additional surveillance function. (Appendix 3).

Mitigation

There are two streams of actions to address climate change: mitigation and adaptation. Mitigation focuses on reducing emissions of greenhouse gases; adaptations are actions that reduce the impact of climate change. Both are necessary to ensure health and wellbeing. As the 2018 Lancet Countdown report highlights, the "lack of progress in reducing emissions and building adaptive capacity threatens both human lives and the viability of the national health systems they depend on…".[li]

The Lancet Commission on Health and Climate Change

In 2015, the Lancet Commission identified the following actions to promote health in a world with a changing climate:

1. invest in climate change and public health research, monitoring and surveillance;
2. scale up financing for climate resilient health systems;
3. phase out fossil fuels;
4. create healthy communities;
5. establish a framework for carbon pricing;
6. expand access to renewable energy;
7. quantify the health benefits of climate action;
8. integrate health and climate into government-wide strategies;
9. set ambitious and enforceable greenhouse gas reduction targets[liii].

The Government of Yukon, Yukon First Nations and municipal partners are finalizing a Climate Change, Energy and Green Economy Strategy this year. The strategy will create a framework for the actions needed to reduce the emissions of greenhouse gases and to increase the resiliency of communities in the territory.

The challenge that climate change poses to human society is highlighted in the Intergovernmental Panel on Climate Change Special Report that states: Warming of 1.5°C is not considered 'safe.' The warming of 1.5°C above pre-industrial temperatures "poses significant risks to natural and human systems as compared to current warming of 1°C."[ii] Any further increase in temperature will compound this effect. In addition, the impact of a 2°C increase would be substantially greater than keeping the increase to less than 1.5°C. Such warming would make it even more difficult for society to adapt. Therefore, achieving a low-carbon economy by 2050 is critical for protecting health. Limiting warming to 1.5°C means that we must reach net-zero carbon dioxide emissions globally around 2050 and make deep reductions in emissions of other substances that contribute to warming, methane in particular.[ii] This will require:

- a large reduction in the demand for energy;
- a shift to zero-carbon sources of electricity and other fuels;
- reductions in agricultural emissions; and
- the adoption of carbon dioxide removal through increased forestation, ecological preservation and improved agricultural practice and/or carbon storage in geological reservoirs.

To facilitate this transition, the Intergovernmental Panel on Climate Change identifies the following mechanisms:

- a doubling of investment in low-carbon energy and energy efficiency combined with investment in smart grids, energy storage and other technologies and a reduction in fossil fuel use;
- an increase in energy efficiency and electrification of energy end use (for example, in manufacturing, transportation, buildings and domestic uses);
- expansion of electric vehicles and a shift to non-motorized transport;
- transformation of energy-intensive industry to the use of non-carbon sources of energy (for example, electricity, hydrogen, biofuels);
- changes in consumption patterns to ones that emphasize products that are less energy, land and greenhouse gas intensive;
- adopting diets with lower emissions and requirements for land, along with reduced food loss and waste;
- carbon pricing that is sufficiently high to act as an incentive to change;
- a transformation of financial systems, including changes in fiscal policies and instruments, to 1) encourage innovation, investment and deployment of low-carbon technology and 2) reduce the demand for carbon-intensive services and promote a shift away from fossil fuel-based technology[ii].

A transition to a low-carbon economy will affect people in different ways, depending on their occupations, locations, and lifestyles. To ease the transformation of society and ensure a just transition, it is necessary to implement policies and programs that reduce the social and economic costs to those affected negatively by the shift.

Planning and Preparedness

Understanding the vulnerability of Yukon and its communities to the changing climate is a first step to identifying actions that can reduce the adverse impacts of climate change. Once vulnerabilities are identified, it is then possible to explore and identify actions to reduce them.

Adaptation includes actions that reduce the negative impacts of climate change on human health and wellbeing.[lii] Climate change adaptation measures strengthen the social and economic resilience of society.[x] Resilience describes the ability of an individual, community, organization or ecosystem to respond to stresses, recover and thrive.[liii] Actions that build resilience include:

- building or modifying structures and infrastructure to better withstand changes to the environment;
- improving emergency preparedness and response to minimize the adverse impacts of disasters;
- strengthening the financial, physical, social and psychological capacity of individuals, families and communities to respond to climate change events and emergencies; and
- adopting measures to address the mental health impacts of climate change events.[ii,x,liv]

An important first step to adaptation planning is to conduct a climate change and health risk and vulnerability assessment.[liv,lv] Community level assessments allow the tailoring of the assessment and recommended actions to local circumstances. Early detection of potential health hazards provides a warning of potential climate change-related emergencies and allows for improved preparedness and response to these events.

Promoting health requires that all who work within the health and social sector be aware of the implications of climate change and be knowledgeable of effective approaches to minimize them. This includes:

- increased capacity to provide psychosocial support to individuals and communities;
- expanded monitoring of the health impacts from extreme weather events; and
- making health and social service infrastructure resilient to extreme weather events and other impacts of climate change.

Appendix 1: Climate change and health indicators identified in selected sources

Indicator	Source/Agency													
	US EPA	Navi et al 2017	US CDC	NZ	PHAC	Ontario MHLTC	CSTE	QHRC	CCME	Cheng & Berry 2013	Yukon CC Indicators	GCRP	Schramm 2017	English et al 2009
Health effects indicators														
Heat-related deaths (number, underlying cause /contributing factor)	✓	✓	✓		✓	✓	✓			✓			✓	✓
Heat-related illnesses (incidence, hospital admissions, emergency room visits, ambulance calls)	✓	✓	✓	✓	✓	✓	✓						✓	✓
Cold-related deaths (number)						✓								
Cold-related illnesses						✓								
Cardiovascular and respiratory diseases related to air pollution and exacerbated by heat (hospitalizations, emergency room visits)					✓	✓	✓	✓		✓			✓	
Preventable deaths/DALYs										✓			✓	
Asthma (incidence)					✓	✓	✓	✓						
Allergic disease (incidence)						✓	✓	✓					✓	✓
Anti-allergy medication sales							✓							
Sunburns, skin cancers, cataracts and eye damage from ozone depletion (incidence, preventable deaths, hospital admissions)						✓	✓						✓	
CCE-related injuries and deaths (e.g., drowning)				✓		✓		✓					✓	✓
Injuries/death from ice instability								✓						
Mental health and other impacts of displacement, property loss, cultural impact				✓	✓	✓		✓						
Vector-borne disease incidence (e.g., Lyme disease/West Nile virus)	✓	✓		✓	✓	✓	✓	✓		✓			✓	✓
Food-borne illness incidence		✓			✓	✓	✓						✓	
Waterborne illness incidence				✓	✓	✓	✓						✓	

Indicator	Source/Agency													
	US EPA	Navi et al 2017	US CDC	NZ	PHAC	Ontario MHLTC	CSTE	QHRC	CCME	Cheng & Berry 2013	Yukon CC Indicators	US GCRP	Moulton & Schramm 2017	English et al 2009
Shellfish poisoning (incidence)							✓	✓						✓
Exposure/hazard indicators														
Distribution of disease vectors and length of transmission season					✓	✓	✓						✓	
Exposure to pollen/ allergens (counts, duration of pollen season)	✓				✓	✓	✓						✓	✓
Harmful algal blooms (occurrence)							✓	✓						✓
CCEs such as flood, wildfires, storms (incidence; projections)		✓			✓	✓	✓						✓	✓
Number of people directly affected by a CCE														
Access to food/water (country/traditional food, disruptions to, advisories, exposure to contaminated water)				✓			✓	✓						
Temperature (mean, min max)		✓				✓							✓	✓
Surface temperatures												✓		
Sea surface temperatures												✓		
Sea-level rise												✓		
Extreme heat or cold (projections/events/days/ warnings)			✓			✓	✓	✓	✓		✓		✓	✓
Arctic oscillation											✓			
Heat vulnerability/heat index			✓			✓	✓						✓	
Heating and cooling degree days	✓								✓			✓	✓	
Length of growing season/ frost-free days/date of first bloom	✓								✓			✓	✓	
Snow cover	✓													
Permafrost (distribution, melt, shift)								✓						
Sea ice (thickness, extent, duration)								✓	✓		✓	✓		
River and lake ice (duration, freeze/breakup date)									✓					
Glaciers									✓			✓		
Sea-level rise						✓			✓					
Precipitation (total annual, max, projections)		✓	✓			✓	✓							
Extreme precipitation			✓			✓	✓				✓	✓	✓	

Indicator	Source/Agency													
	US EPA	Navi et al 2017	US CDC	NZ	PHAC	Ontario MHLTC	CSTE	QHRC	CCME	Cheng & Berry 2013	Yukon CC Indicators	US GCRP	Moulton & Schramm 2017	English et al 2009
Drought (e.g., drought severity index)			✓			✓	✓		✓				✓	✓
Air quality (ozone, PM exposure)		✓			✓	✓	✓						✓	✓
Greenhouse gas emissions											✓	✓	✓	✓
Atmospheric CO2 concentrations												✓		
Terrestrial carbon storage/ emissions												✓		
Health of ecosystems (land, aquatic); polar bear condition								✓	✓					
Land use trends (e.g., deforestation)													✓	
Flood vulnerability (e.g., number of people living in flood plains, number of dwellings, near the sea coast)			✓			✓	✓							✓
People living in wildfire risk zones							✓							
Wildfires – area burned, fire severity index											✓		✓	✓
Ocean chlorophyll concentrations												✓		
Vulnerable populations (e.g., Indigenous populations, outdoor workers, older adults, low income, with chronic health conditions)						✓	✓	✓					✓	✓
Migration							✓						✓	
Traditional ways of life								✓						
Behavioural risk factors							✓							
Intervention indicators														
Access to air conditioning/ cooling centres						✓	✓						✓	✓
Heat wave warning systems/urban heat island mitigation plans						✓	✓	✓					✓	✓
Flooding, extreme weather warning systems														
Food safety surveillance programs						✓		✓					✓	✓
Vector management programs						✓		✓					✓	✓
Allergen plant removal programs							✓							
Water use practices following disasters							✓							

Indicator	Source/Agency													
	US EPA	Navi et al 2017	US CDC	NZ	PHAC	Ontario MHLTC	CSTE	QHRC	CCME	Cheng & Berry 2013	Yukon CC Indicators	US GCRP	Moulton & Schramm 2017	English et al 2009
Access to safe drinking water and sanitation							✓	✓						
Use of renewable energy/ use of fossil fuels/vehicle miles travelled								✓					✓	✓
Public workforce trained in CC research, surveillance, adaptation								✓					✓	✓
Community-based education initiatives								✓						
Municipalities/government departments/institutions with (or participating in) plans that address CC mitigation, adaptation, resilience								✓					✓	✓
Communities with surveillance/ environmental monitoring programs that incorporate climate/weather observations								✓						✓

Note: The Expert Panel on Climate Change Adaptation and Resilience Results (2018) identified 54 indicators, mostly intervention indicators.

Appendix 2: Indicators for Yukon

Indicator	Rationale	Possible Data Source
Exposure/hazard indicators		
Yearly global atmospheric carbon dioxide (CO_2) concentrations	Carbon dioxide is the major greenhouse gas. Higher concentrations of CO_2 are an indicator of increased global warming risk	U.S. National Oceanic and Atmospheric Administration Global Greenhouse Gas Reference Network
Levels of particulate matter ground-level ozone	A warmer climate is expected to increase the levels of ground-level ozone	Environment Canada and climate change air quality monitoring data
Maximum and minimum temperatures	Looking at trends of daily maximum and minimum temperatures will provide a measure of the degree of warming occurring over time	Environment Canada and climate change weather data
Number and duration of heat alerts/warnings	The number of warnings will indicate if the occurrence of days when temperatures are very high is increasing	Environment and Climate Change Canada
Pollen counts, ragweed presence	Climate change is expected to result in a longer pollen season and an increase in airborne pollen, which is an allergen and can exacerbate asthma symptoms	To be determined (pollen forecasts are available for some Yukon communities)
Number, size, and duration of wildland fires Distance from population centres	Occurrence and severity of wildland fires are expected to increase in a warmer climate; fires at close proximity to a community are likely to have greater impact	Yukon Wildland Fire Management
Droughts (intensity, area)	Risk of drought is expected to increase in some regions	Canadian Drought Monitor
Hazardous algal blooms (number)	Increase in number of algal blooms is expected in a warmer climate	Yukon Dept. of Environment (Yukon Water)
Permafrost (temperature, depth, area)	Melting permafrost can affect building and infrastructure	Yukon Energy, Mines and Resources/Yukon Geological Survey/Yukon Permafrost Network
Sea Ice (thickness, areal extent, location, duration) Date of Yukon River break up	The minimum sea ice extent in the Arctic, measured in September of each year, has decreased by about 32 per cent since 1979. It is an indicator of the impact of warming in the Arctic region over long term Yukon River break ups have been measured since 1896. The trend has been towards an earlier break up, an indication of less severe winters	Canadian Ice Service; US Global Change Research Program/ National Snow and Ice Data Center
Water security (number of water advisories; water quality parameters such as temperature, dissolved oxygen, total dissolved solids)	More frequent and intense weather events are expected. Extreme weather can have an impact on water quality	Office of the Chief Medical Officer of Health/Health and Social Services (advisories) Yukon Dept. of Environment; Pacific-Yukon network; Environment and Climate Change Canada Open Data Portal
Flooding (number of flooding events)	More frequent and intense weather events are expected, with increased risk of flooding	Yukon Dept. of Environment (Yukon Water)

Indicator	Rationale	Possible Data Source
Landslide frequency	High precipitation can create ground instability, resulting in landslides	Emergency Measures Organization Yukon Energy Mines and Resources
Terrestrial and aquatic eco-systems (species at risk, invasive species, annual bird count)	A healthy ecosystem supports human health and wellbeing . Climate change will be an additional stressor that will affect the number and range of plant and animal species	Presence of alien and introduced species (Yukon Invasive Species Council) Density of snowshoe hares (Keystone Boreal Species Trends project) Winter tick surveillance (Animal Health Unit) Number of spawning Chinook salmon (The United States and Canada Yukon River Joint Technical Committee; Yukon River Panel) Monitoring breeding waterfowl (U.S. Fish and Wildlife Waterfowl Population Status; Cooperative Yukon Roadside Waterfowl Breeding Population Survey; Canadian Wildlife Service Waterfowl Committee; North American Wetlands Conservation Council; U.S. Fish and Wildlife Service) Number of species at risk in Yukon (Committee on the Status of Endangered Wildlife in Canada)
Health effects indicators		
Excess mortality due to extreme heat	Heat alerts have been issued in the past. The number of hot days is expected to increase. Hot weather is associated with increased mortality	Health and Social Services – data analysis of health records
Excess morbidity due to extreme heat	Heat alerts have been issued in the past. The number of hot days is expected to increase. Hot weather is associated with increased hospitalization and emergency room visits	Health and Social Services – data analysis of health records
Number of injuries/mortality from weather events and wildland fires	Wildfires and floods increase the risk of injuries and death Icy conditions can increase the numbers of slips and falls	Health and Social Services – data analysis of health records
Number of injuries/mortality from ice instability	Degraded ice conditions increase the risk of incidents when travelling across rivers and lakes	Health and Social Services – data analysis of health records
Human cases of environmental infectious disease/positive test results in reservoirs/sentinels/vectors	Risk of vector-borne diseases is expected to increase. Spread of vectors and disease in neighbouring jurisdictions and animal pests in Yukon can act as an early warning of risks	Health and Social Services – data analysis of health records
Incidence of respiratory/allergic disease and mortality related to increased air pollution and pollen	Earlier spring and later fall are expected to increase the amount of pollen and other allergens in air; warmer temperatures and increase in wildland fires are also expected to reduce air quality	Health and Social Services – data analysis of health records (including proposed CCE monitoring & surveillance data)
Mental health – reports of depression, anxiety due to climate change-related events	Death, injuries, loss of property from floods, wildland fires and melting permafrost as well as a changing ecosystem can affect mental health	Health and Social Services – data analysis of health records (including proposed CCE monitoring and surveillance data)

Indicator	Rationale	Possible Data Source
Health effects indicators		
Annual emissions of greenhouse gases (GHGs) in Yukon	To limit increases of global average temperatures to 1.5° C or less, emissions of GHGs will have to be reduced to net zero by 2050. This will indicate if progress is being made to achieve this goal in Yukon.	Yukon Dept. of Environment
Proportion of total energy use that is from renewable energy sources	This indicator will help determine if there is progress towards the goal of net zero emissions by 2050.	Yukon Energy Mines and Resources
Proportion of people who walk, cycle or take transit to work	About 80 per cent of people travel to work by private vehicles; transportation is the largest source of GHG emission in Yukon; walking, cycling or taking transit to work provides health benefits	Yukon Bureau of Statistics (national health survey)
Proportion of Yukon communities that have access to clean air shelters during wildland fire emergencies	Clean air shelters provide respite from exposure to smoke	Emergency Measures Organization
Number of communities participating in health surveillance systems related to climate change	Health and Social Services is establishing a monitoring and surveillance system for CCE	Health and Social Services
Proportion of public health workforce available/trained in climate change research/surveillance/adaptation	Education on the science behind climate change and its connection to core public health services supports a successful public health response to the health effects of climate change	Health and Social Services
Number of municipalities that have completed climate change and health vulnerability assessments and are implementing health action plans	Vulnerability assessments help identify priority areas for action to reduce the impact of climate change on health	Health and Social Services
Vulnerability indicators		
Number of elderly living alone, poverty status, children, infants and individuals with disabilities in Yukon communities	Vulnerable people are less likely to have the resources to adapt to the effects of climate change on an individual level. Knowledge of where vulnerable populations are can help ensure their needs are met during climate change emergencies	Yukon Bureau of Statistics
Proportion of the population that is food insecure, including more vulnerable populations (elderly, those in poverty, infants and disabled)	Impacts of climate change on availability of country/traditional foods; disruption of food distribution due to a climate change event (flooding, fire) can increase food insecurity among those who are already or at risk of experiencing food insecurity	Household food insecurity in Canada (Health Canada)
Numbers of people in 100- and 500-year flood zones	Fewer people living in areas prone to flooding, especially vulnerable populations, will reduce the impact of floods on health	Food risk mapping (Emergency Measures Organization)
Culture loss vulnerability (due to loss of access to harvesting grounds and reduced availability of country/traditional foods and traditional medicines; increased risk to structures/homes/ buildings	Loss of cultural identity, increased lack relevance of traditional knowledge, or loss of heritage can result in stress/depression	Testimonials/case studies

Appendix 3:
Climate change events – public health surveillance

Indicators that can be used to monitor the impacts of climate change and inform vulnerability plans include the:

- number of heat and cold alerts for the summer and winter seasons respectively;
- number of air quality advisories per year;
- number of extreme weather events requiring public health emergency interventions per year;
- surveillance data for vector-borne illness rates (e.g., West Nile Virus, Lyme disease);
- syndromic surveillance data (such as hospital admissions coinciding with extreme heat, extreme cold, poor air quality events); and
- number of climate change adaptation measures implemented.[lvi]

Post event assessment

Studies of the health impacts of wildfire, flooding and extreme weather events also exist. These are the types of measures that could be used as part of a surveillance system. They are most useful as a way to report on the impacts of past events. If data is available in real-time, the use of data on dispensation of pharmaceuticals or physician visits can serve a surveillance function. Data on Health and Social Services service demands are potential indicators of impact. Tables 1 and 2 below identify potential measures that could be used to estimate the impact of climate-related emergencies on health.

Forest fires in British Columbia in 2003/Fort McMurray fires 2016 [xlvii,xlviii, xlix, l]

Measure	Health end point [9]	Data source
Number of physician visits [10]	Respiratory disease (ICD-9 460-519) [11] Cardiovascular (ICD-9 390-459) Mental illnesses (ICD-9 290-319)	Physician-visit billing data
Number of hospital admissions	Respiratory disease (ICD-9 460-519) Cardiovascular (ICD -9 390-459)	Hospital records
Number of emergency department visits	(as above) [12]	Hospital records
Salbutamol dispensations (daily counts)	Asthma	BC PharmaNet database
Self-reported health Use of alcohol, tobacco, recreational drugs, medication	Respiratory health Mental health (anxiety, depression)	Survey
Hospital Anxiety and Depression Scale score		
Particulate matter (24-hr air concentrations)	Exposure	Air quality monitoring network

[9]Cardiovascular outcomes were largely null.
[10]Weeks with PM2.5 concentrations higher than 10 μg/m^3 for at least three days were considered to have elevated PM levels. Weekly rates of physician visits were compared to 2003 and aggregates of the 10 previous years.
[11]Henderson and colleagues (2011) also considered asthma-specific end point.
[12]The studies referenced here did not include emergency department visits, though other investigators have done so.

Calgary floods (2013) surveillance period was defined as the six weeks after the flood [xli]

Measure	Health end point	Data source
Number of emergency department visits [13]	Abrasions/lacerations Injury Electrical injury Chemical injury Noxious inhalation/carbon monoxide poisoning Gastrointestinal illness Diarrhea Vomiting Rash Respiratory complaints (cough/congestion, nasal congestion, shortness of breath, wheezing) Cardiac events Mental health Sexual assault Violent behaviour Substance use	Emergency departments and urgent care centres
Number of post-exposure prophylaxis against tetanus administered (weekly)[14]	Indicator of injury	Immunization registry
Incidence of enteric illnesses reported [15] Microbial drinking water quality	Infectious gastrointestinal disease: waterborne and foodborne pathogens and those infections with outbreak potential, including shigellosis, campylobacteriosis, salmonellosis and giardiasis ameobiasis, verotoxigenic E. coli O157:H7, rotavirus and norovirus	Communicable Diseases Reporting System Drinking water surveillance
Number of total and new prescriptions dispensed in the post-flood period for antidepressants (ATC codes: N06A, N06CA) anti-anxiety/ anxiolytic medications (ATC codes: N05B) and hypnotics and sedatives (ATC codes: N05C) [16]	Mental health: Dispensed prescriptions for depression, anti-anxiety and sleep-aid medications	Prescription information network

[13] Comparisons were made between the pre-flood period (June 6 to 18) and the post-flood period (June 26 to date of analysis).
[14] Comparing the baseline period (April 1 to June 16) with the post-flood period.
[15] Counts and seven-day rolling averages were used to compare the number of incidents (non-travel associated) cases of enteric diseases in the pre-flood period (June 1 to 18) with the post-flood period (starting June 19). As enteric illnesses tend to increase in the summer months, three-year historical averages of the pre-flood and post-flood periods were also used to account for any seasonal trends.
[16] Dispensed prescriptions in the post-flood period compared with data from the year before the flood.

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