Climate Change Projections for the Canadian Arctic

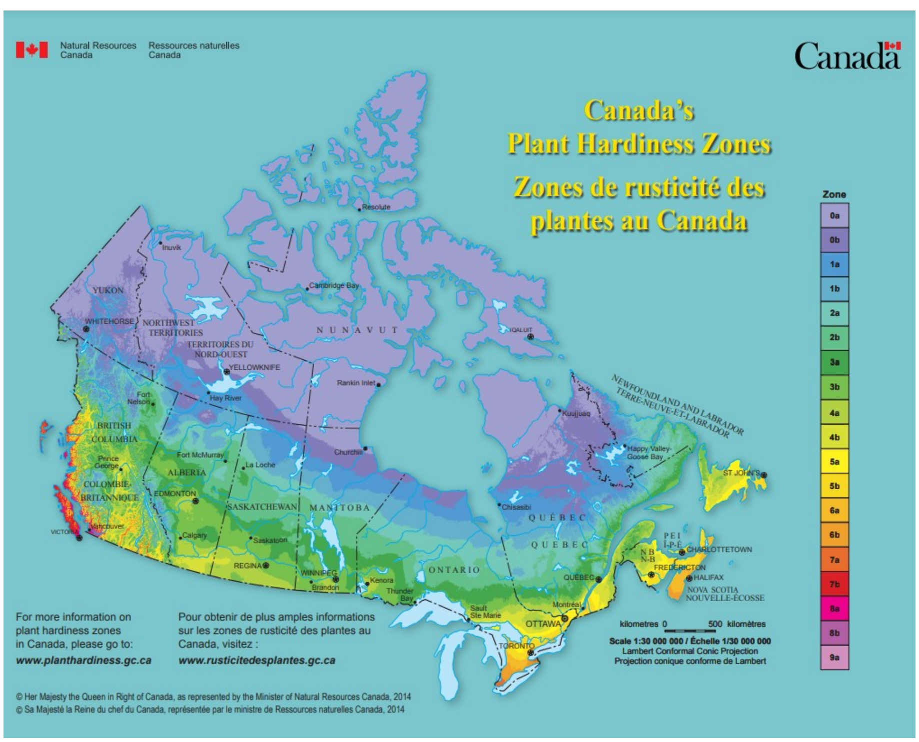
Joshua Palmer, Daniel A. Herms and Scott E. Maco

The Davey Climate Change Fact Sheet Series projects the future impacts of climate change on the tree care industry over the next 30-70 years, with emphasis on changes in temperature, precipitation, storm intensity, tree health, pest pressure, wildfire, and worker stress. Temperatures across Canada have risen 1.7°C since 1948, which is twice the global average. By the end of the century, temperatures are expected to increase between 1.8-6.0°C, with the future trajectory of greenhouse gas emissions providing the largest source of uncertainty. The Intergovernmental Panel on Climate Change (IPCC) projects future climates by modeling different emissions scenarios called "Representative Concentration Pathways (RCP)." This fact sheet focuses on changes expected to occur in the Canadian Arctic and Northern Territories based on lower (RCP2.6), intermediate (4.5RCP), and higher (RCP8.5) emissions scenarios. Currently, global patterns of fossil fuel consumption correspond most closely with the high emissions scenario, while the lower and intermediate emission scenarios will require significant mitigation measures yet to be implemented.

Rapid Warming, Surging Temperatures, and Compounding Impacts

Nunavut, the Yukon, and the Northwest Territories of Canada's north are experiencing the impacts of climate change more rapidly and drastically than almost anywhere else on the planet. Indeed, temperatures in the Canadian Arctic are increasing at three times the global average, having risen by 2.3°C between 1948 and 2016. This warming is happening disproportionately throughout the year, with the winter months having warmed 4.3°C since the mid-20th century, compared to a 1.6°C increase during summer.

Rapid warming has triggered other environmental impacts. Snow cover has decreased significantly in northern Canada, particularly in the spring and autumn. Likewise, the Canadian Arctic has seen a notable reduction in glaciers and ice caps, with the trend accelerating within the past 10 years. The duration of freshwater ice cover in Canada's northernmost lakes has declined rapidly, with some losing their ice cover completely over the last decade, affecting overall lake levels. Arctic Ocean ice cover has diminished substantially, and the fabled Northwest Passage opened to navigation in 2007 for the first time in recorded history. Climate warming in the Arctic has been amplified by feedback effects as the loss of snow and ice has decreased reflectance of solar radiation back to space (albedo), which has increased the amount of heat absorbed by the ocean.



Rapid Warming, Surging Temperatures, and Compounding Impacts cont.

Melting permafrost in the Canadian Arctic may further accelerate climate warming as it continues to thaw, releasing CO_2 that has been stored as frozen soil organic matter for thousands of years. Permafrost in the northern hemisphere comprises 24% of Earth's total land mass and stores over half of the planet's organic carbon. Permafrost temperatures are increasing even faster than the rate of Arctic air, having warmed 1.5-2.5°C in the past 30 years alone. A 3°C increase in mean global temperatures is projected to result in the melting of 30-85% of the top layer of Arctic permafrost, releasing substantial amounts of CO_2 as the thawed organic matter decomposes. In Arctic wetlands, much of the stored carbon is being released as methane, which in the short term is a much more potent greenhouse gas than CO_2. In the long-term, methane converts to CO_2 that will continue to persist in the atmosphere for centuries.

Previously considered a carbon sink, the tundra and forested ecosystems of northern Canada may become carbon sources as these trends continue, emitting more CO_2 than they absorb. Thus, these natural feedback processes have the potential to magnify the warming and impacts of anthropogenic greenhouse gas emissions as tipping points are crossed. If the higher emissions scenario is realized, temperatures by mid-century could warm by 2.7°C relative to 1986-2005, by the end of the century, temperatures could increase by a staggering 7.8°C. Even under the lower emissions scenario, temperatures in northern Canada are projected to increase by an additional 1.8°C and 2.1°C by 2050 and 2100, respectively.

Increased precipitation

Nunavut, the Yukon, and the Northwest Territories have experienced an unprecedented 33% increase in annual precipitation between 1948 and 2012. Precipitation has increased across all seasons, with the most significant increase occurring during winter, when precipitation is now 54% higher than during the mid-20th century. The number of days with heavy precipitation has increased more in in the Arctic than in any other region of Canada.

Total annual snowfall has increased in the northern territories since 1948 even as summer snowfall has decreased as more precipitation falls as rain. The spring thaw now begins earlier in the year, accompanied by increased streamflow in the winter. These trends are projected to intensify as the climate continues to warm.

Migrating forests

Climate change is having significant impacts on the boreal forest which stretches across Canada, Alaska, and Eurasia, encompassing approximately 30% of Earth's forests and storing 20% of the world's carbon sequestered by forests. The boreal forest is expected to experience the largest temperature increase of all forest biomes over the course of the 21st century. Since the 1950s, boreal forests in North America have warmed 2°C, and by 2100, annual mean temperatures across the Canadian boreal zone could increase by an additional 4-5°C.

Canada Plant Hardiness Zones differ somewhat from USDA Plant Hardiness Zones. While the USDA zones range from 0a to 13b and are based on the average lowest temperatures experienced in a region each year, Canadian hardiness zones range from 0a to 9b and are based on seven different climate conditions including rainfall, frost-free periods, maximum snow depth, average temperatures, and wind among others. Northern Canada is predominantly 0a, with intermittent dispersal of zones 0b and 1a along its southern regions. However, between the mid-20th and early 21st centuries, northern Canada experienced a 31% reduction in the area of subzone 0a, suggesting northward shifts in hardiness zones even above 60° latitude. In response to the warming climate, spruce trees are migrating north into the tundra, while cool adapted species such as birch, spruce, and fir are increasingly stressed at the southern ranges of their distribution.

Increased biotic and abiotic disturbances

Natural disturbances such as fires and insect outbreaks, are critical for the renewal of forests in northern Canada, but the increased intensity, severity, and expansion of such events poses significant problems for the northern boreal forest. As winters have warmed, mountain pine beetle has migrated into northern British Columbia, and more recently Alberta, where it has caused widespread mortality of lodgepole pine.

Mountain pine beetle is currently unable to establish in the northern territories due to low temperatures, but as warming continues the range of the mountain pine beetle will continue to expand northward. With a 2.5°C increase, the suitable habitat for mountain pine beetle is projected to extend another seven degrees latitude northward where it threatens to substantially increase mortality of lodgepole pine in previously unaffected forests.

Currently, the most concerning forest insect in the Northwest Territories is the spruce budworm, which is prone to expansive outbreaks that defoliate and kill white and black spruce. Currently, temperatures in the northern reaches of this region are too cold to sustain populations. However, the range of spruce budworm is projected to expand northward as the climate warms, where it will impact large swaths of currently unaffected spruce forests. Willow blotch leaf-miner and gray willow leaf beetle may also experience range expansions.

Melting permafrost, increased evapotranspiration, and a longer season are contributing to increased frequency and size of wildfires in the Arctic. While fires are important for periodic regeneration of species such as aspen and lodgepole pine, increased frequency and intensity of wildfires threaten species diversity and ecosystem function. Smoke from expansive wildfires can degrade air quality for millions of people in southern Canada and the United States. Warming of soils blackened by fire contributes to the melting of permafrost at even faster rates, resulting in yet higher greenhouse gas emissions. Patterns of precipitation across the region are becoming more erratic, resulting in increased frequency of drought-like conditions in some areas that can favor wildfire, even as overall precipitation is increasing.

Mountain pine beetle damage

Human impacts: Effects of climate change on aboriginal communities

The indigenous populations of the northern territories are the most vulnerable of Canada's citizens to effects of climate change, given their relationship and dependency on the environment, limited access to health care services, and the overall rate of warming of Canada's Arctic.

While accounting for nearly 40% of Canada's total land mass, the northern provinces of Nunavut, the Yukon, and the Northwest Territories account for less than 1% of the country's population. Throughout the three northern provinces, approximately 53% of the population is indigenous, including 86% of Nunavut, belonging to distinct cultural groups including Intuit and First Nations, such as Dene, and Métis. Understanding the impacts of climate change on Canada's north requires a holistic approach, recognizing not only the effects on human health, but on culture and overall societal well-being as well.

The many impacts of a changing climate have corresponding human health effects in northern Canada. The prevalence of food insecurity currently ranges from 17% percent in the Yukon to 57% in Nunavut. The impacts of climate change are magnifying food insecurity, affecting food availability, access, and quality, with consequences for physical and mental well-being. Warmer temperatures also increase the incidence and transmission of infectious disease.

Melting permafrost also has important societal impacts. As the permafrost thaws, the soil sinks and contracts. As it refreezes, it rises and expands. Because of this cycle, the ground above becomes destabilized, causing damage to critical infrastructure such as buildings, roads, pipes, railroads, and more. In the Canadian Arctic, damage to infrastructure has resulted in a housing shortage and rapidly increasing prices. Additionally, runoff from melting permafrost has increased flooding which has disturbed important cultural sites such as burial grounds and ancestral lands. Furthermore, the subsistence lifestyle of storing food in the ground, a practice that dates back thousands of years, is becoming increasingly untenable, which is exacerbating food insecurity. Toxic compounds such as mercury, lead, and radon are also being released as permafrost melts. Such events are likely to worsen in scale and effect as the climate continues to warm.

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