

## TUNDRA INVESTIGATIVE STUDY

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NOTE: This is a condensed and adapted version of the original article in Edition 51, Vol 3, 2019. For information on environmental management see the original article.

Arctic tundra FloridaStock/Shutterstock  
Source: <https://theconversation.com/polar-bear-invasion-how-climate-change-is-making-human-wildlife-conflicts-worse-111654>

This is a comparative study between Heard Island and McDonald Islands Reserve and World Heritage Site, (Australian Territory) and Churchill Wildlife Management Area, (Canada).

*"Tundras are among the world's coldest, harshest biomes, with extreme temperatures and low rainfall. But these environments are far from invulnerable, displaying sensitivity to human disruptions and climate change."*

### Tundra environments

Tundra refers to treeless regions found at high latitudes (Arctic and Antarctic circles) and altitudes (mountains), where the climate is cold and windy, and rainfall is low. Tundra is covered with snow for much of the year and the ground permanently frozen, only thawing in summer and bursting to life with wildflowers and wildlife.

A range of **biophysical processes** are essential to the functioning of tundra environments. These processes occur within and between the four interconnected spheres of the environment – lithosphere, atmosphere, hydrosphere and biosphere.



Source: Shutterstock

### SOURCE A: Comparative locations



Churchill (Canada) and Heard and McDonald Islands (Australia) are separated by over 110 degrees of latitude.

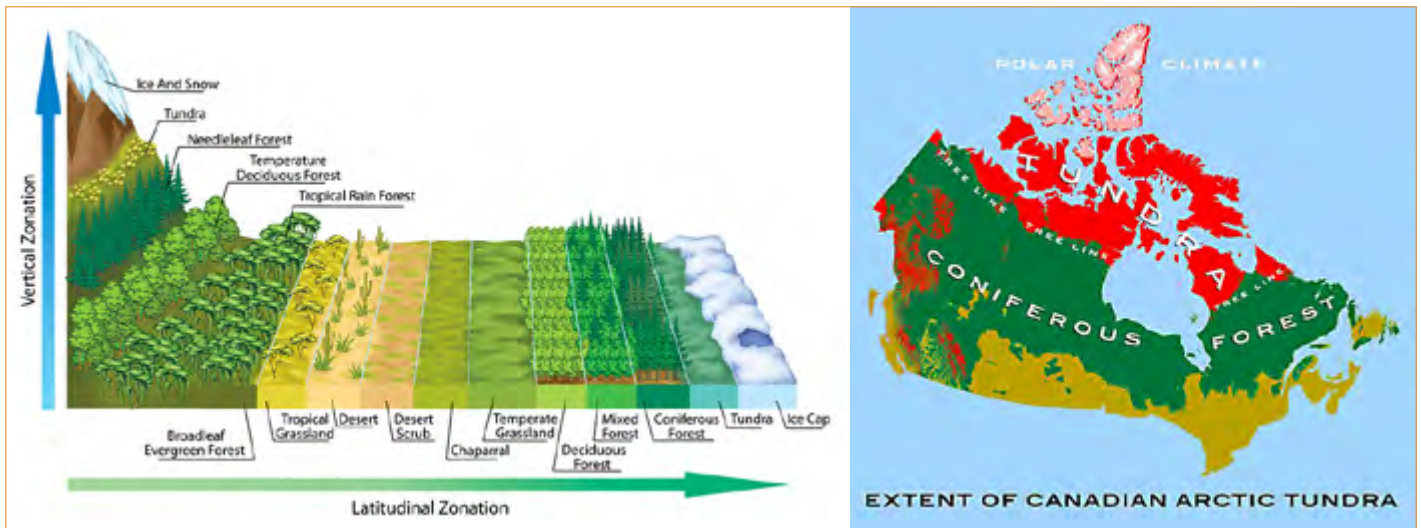
**Heard and McDonald Islands** are located at approximately 53°S and 73°E. Subantarctic places are located in the Southern Hemisphere, just north of the Antarctic Circle.

**Churchill Wildlife Management Area** is located at approximately 58°N and 93°W. Subarctic places are located in the Northern Hemisphere which is just south of the Arctic Circle.



# ENVIRONMENTAL CHANGE: TUNDRA

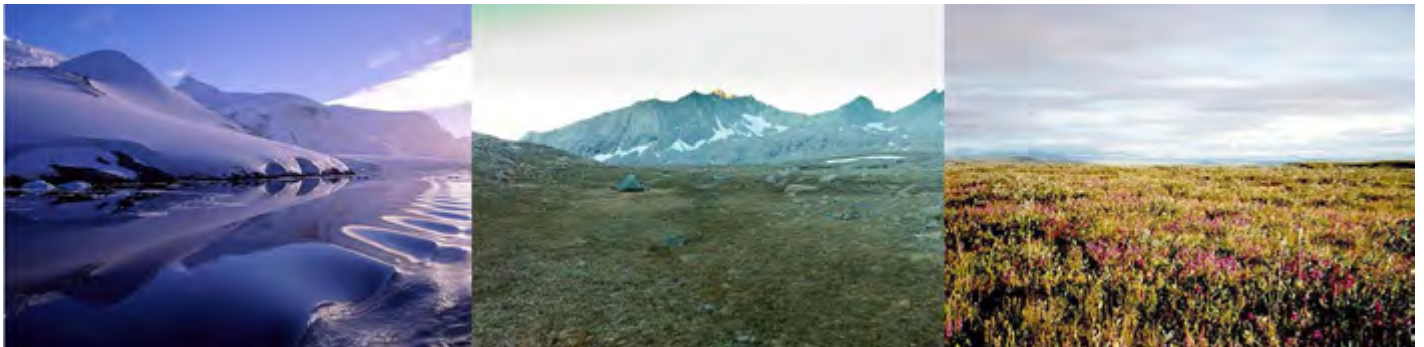
SOURCE B: Zone of transition – diagram and map



Source: Shutterstock

Canadian tundra. Source: [https://en.wikipedia.org/wiki/Canadian\\_Arctic\\_tundra](https://en.wikipedia.org/wiki/Canadian_Arctic_tundra)

SOURCE C: A diversity of physical features



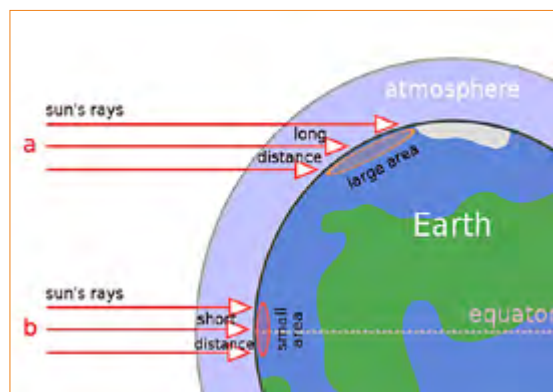
Three photos of tundra - they are all tundra because of their climates and the types of plants. Left is Antarctic tundra, centre is alpine tundra, right is Arctic tundra. Source: <https://askabiologist.asu.edu/explore/tundra>

SOURCE D: A cold, dry climate

Statistic	Units	Metric Units											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Temperature	°C	-22.90	-21.20	-15.30	-5.20	2.70	10.90	16.90	15.60	8.80	1.40	-8.80	-18.80
Minimum Temperature	°C	-30.90	-29.80	-25.30	-14.80	-5.10	1.40	6.80	6.90	2.30	-4.30	-16.30	-26.80
Precipitation	cm.	1.73	1.28	1.83	2.26	3.05	4.45	5.07	6.05	5.26	4.65	3.55	1.97

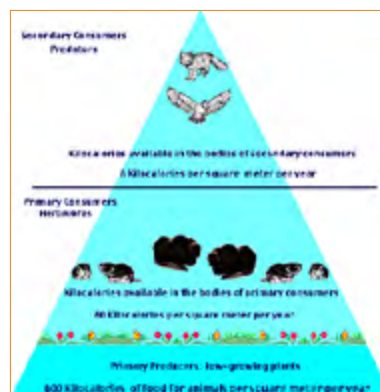
Climate statistics for Churchill, Canada. Source: <https://www.climate-charts.com/Locations/c/CN71913.html>

Source E: Cold climate



Reason for cold temperatures. Source: <https://askabiologist.asu.edu/explore/tundra>

Source F: Low productivity



The tundra is the short growing season limits plant growth. The tundra produces only 600 KiloCalories per square meter per year for the herbivores to eat. Source F and G: <https://www.world-builders.org/lessons/less/biomes/tundra/tundraweb.html>

Source G: Low biodiversity



## PART 1 : Heard and McDonald Islands Reserve and World Heritage Site

### A. BIOPHYSICAL PROCESSES AND ENVIRONMENTAL FUNCTIONING

#### Lithosphere

##### Volcanism

The Heard and McDonald Islands formed via the Kerguelen Hotspot, a site of volcanic activity in the Southern Ocean. Heard Island formed from flows of lava, while McDonald Island had explosive volcanic eruptions. Heard Island has experienced volcanic activity and fresh lava flows in the last few decades, continuing to shape the island and increase its size and elevation. Big Ben volcanic summit dominates Heard Island. As a result of volcanic activity all vegetation on the island has been lost.

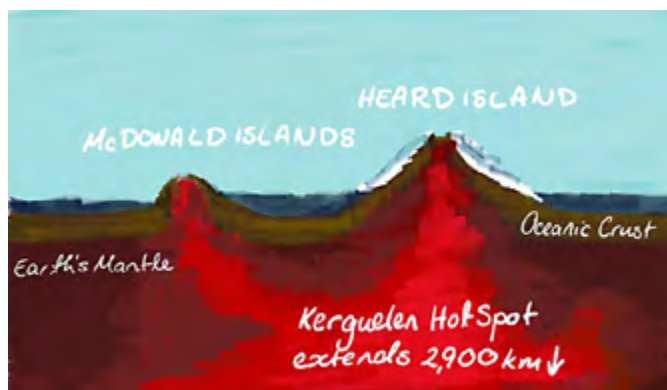
The volcano on McDonald Island, thought to dormant, has erupted several times since 1992. Over the long term volcanic material erodes and adds valuable nutrients to soils including phosphorous, potassium, calcium, magnesium and sulphur. Lava flows create fragmented and irregularly shaped landforms.

##### Erosion and weathering processes

Heard Island has twelve major glaciers and several smaller ones. About 70% of the island is covered by glaciers. Glacial weathering and erosion processes include abrasion, plucking and freeze-thaw. On Heard Island, glacial activity has eroded soft volcanic rocks to create rock buttresses.

There are no glaciers located on McDonald Island. The tundra environment on the islands is particularly affected by physical weathering and erosion particularly from strong winds. Soil erosion is influenced by the limited vegetation in the tundra.

#### SOURCE H: Volcanic origins



A hotspot under Heard Island and the McDonald Islands. Source: <https://www.abc.net.au/news/2019-01-25/a-volcanic-hotspot-is-underheard-and-mcdonald-islands/10726330?nw=0>

#### Hydrosphere

##### Ocean currents

The location of Heard and McDonald islands in the Southern Ocean is south of the Antarctic Convergence, a marine zone where the cold waters of the Antarctic sink under the lightly warmer waters of the subantarctic. This zone circles the globe between 45° and 60° South and is an approximate boundary for the Southern Ocean. The mixing of the cold and slightly warmer water creates local variations in weather, such as fog. The current is associated with strong, westerly winds.

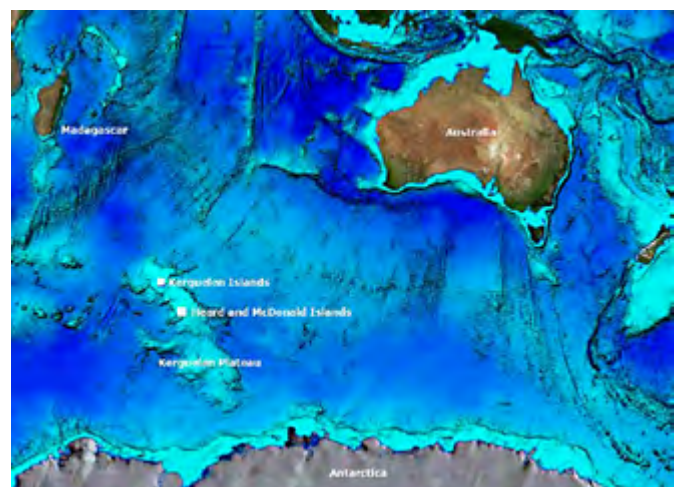
##### Water cycle

Annual precipitation on Heard Island is between 1.3 –1.9m, mostly in the form of snow. Any rain generally soaks into the ground and then freezes becoming permafrost, or is absorbed by plants. Permafrost is a barrier to infiltration and percolation. The water in the uppermost layer of permafrost is stored until it melts in spring and summer.

During winter, snow, river and lake ice accumulate, and in summer, meltwater forms many wetland areas, ponds and lakes. River flow increases when snow, river and lake ice melts. Surface and soil water is frozen for most of the year so there is little evaporation and low stores of water in the atmosphere. There is limited transpiration due to the limited amount of vegetation.

There has been a substantial reduction in glacial cover in the past century resulting in more lagoons and ice-free ground for colonisation by plants and animals.

#### SOURCE I: Location and volcanic origins



Location of Heard and McDonald Islands Source: <http://www.ga.gov.au/scientific-topics/national-location-information/dimensions/remote-offshore-territories/heard-and-mcdonald-islands>



## Atmosphere

### Climate

#### Air temperature

Seasonal and daily temperature ranges are low, and monthly average temperatures range from 0.0 to 4.2°C. The latitude of the Heard and McDonald Islands impacts on the intensity of the light and heat from the sun. High latitudes receive less intense sunlight and it is spread over a large area of land.

#### Air pressure and wind

This is an area of strong, persistent westerly winds, and associated with deep low pressure. East moving depressions move across the islands throughout the year creating persistently severe weather such as strong westerly winds, frequent precipitation, and low seasonal and daily temperature ranges.

#### Humidity

Surface and soil water is frozen for most of the year so there is little evaporation from the land, but water is evaporated over the ocean.

#### Cloud cover

Cloud cover is persistent, but low due to relatively high humidity, mountainous topography and strong winds.

#### Precipitation

Annual precipitation on Heard Island is between 1.3 – 1.9m. Most of this precipitation is in the form of snow.

#### Radiation Fog

Radiation fog is common. It is fog that forms overnight as the air near the ground cools and reaches saturation point. Radiation fog will begin to form near the surface and then thickens as the air continues to cool.

**Heard Island and McDonald Islands are unique in that they make up the only sub-Antarctic island group which has an intact ecosystem with no known species introduced by humans, ensuring the ongoing evolution of plants and animals in their natural state.**

### SOURCE J: Low productivity



LEFT: Cushion plants. Image credit: Mike Dillon. Source: <https://www.australiangeographic.com.au/topics/scienceenvironment/2015/04/heard-island-the-unchanging-magnificence/>

## Biological processes

### Vegetation

Vegetation is impacted by the harsh climate and limited ice-free ground available. Due to the diversity of landscapes a range of different vegetation communities are found. Most of the vegetation occurs in low-lying areas along the coast. Plant diversity is low, and the diversity of flowering plants is particularly low. No trees or ferns are found on Heard and McDonald Islands. In the tundra areas vegetation is minimal and includes low shrubs, mosses and liverworts. Mosses and lichens make up a large proportion of plant communities.

Vegetation covers about 20km<sup>2</sup> of Heard Island. Plant communities on Heard Island include open cushion carpet, mossy fieldmark, wet mixed herbfield, coastal biotic, salt spray and closed cushion carpet. A total of 44 moss and 12 liverwort are found on Heard Island. Lichens are also common, with 34 species. There are no known introduced plant species on the islands.

Recent volcanic activity on McDonald Island has altered vegetation.

### Animals

Heard Island is considered to be a biological hotspot. There are large colonies of penguins and petrels, and harems of fur seals and elephant seals. There are also high numbers of seabirds and marine mammals. Heard Island contains breeding sites for a large number of seabirds. These include the Heard Island Cormorant, the Heard Island Shearwater, the South Giant Petrel, Antarctic Tern and Wandering Albatross. There are also four species of penguin and three species of seals that breed on the island. There are some terrestrial invertebrates (animals without backbones for example worms), but no native land mammals on the islands.

McDonald Islands had large numbers of penguins breeding, but recent volcanic activity on McDonald Island may have affected bird populations.

### Nitrogen and phosphorous cycle

The nitrogen cycle involves green plants taking in chemicals such as nitrogen and phosphorous from soil. During the growing seasons (spring and summer), plants put carbon-rich litter into the soil. However, due to low temperatures, the decomposition of plant litter will be much slower than in other ecosystems. Guano (bird droppings) is very nitrogen and phosphorous rich. The breeding seabirds and their chicks produce huge amounts of droppings that are able to soak into the ground and provide nutrients for plants.

## B. ENVIRONMENTAL CHANGE

Heard Island and McDonald Islands are some of the least biologically-disturbed regions on the planet.

### Climate change

The average annual air temperature increased by nearly 1 degree C between 1948–1954 and 1997–2001. This is resulting in glacial retreat and the creation of lagoons and lakes. Many glaciers at Heard Island have retreated dramatically. Brown Glacier on Heard Island has reduced in size by 33% in the past 50 years. The Southern Ocean is demonstrating a corresponding warming.

In 2019 an occurrence of sudden stratospheric warming above the South Pole, in which temperatures rapidly heat and wind direction reverses, was anticipated to result in further loss of sea ice. This type of change to normal ocean circulation, reduces the albedo effect, and results in more extreme weather.

### Natural processes

Natural processes such as volcanism, glacial retreat and advance and storms are an ongoing cause of change. Animal population change such as increased fur seal populations can lead to competition over breeding or nesting sites and food sources, vegetation trampling and the eutrophication of water.

### Human contact

Since the first recorded visit in 1855, there have only been about 240 shore-based visits, and only two lists to McDonald Islands. The purpose of visits include sealing (in the past), research and management, private expeditions and surveillance. Visitors must apply to the Australian Antarctic Division for a permit to visit Heard Island. It's vast distance from populated areas, extreme weather, sailing conditions and high cost to deter many potential visitors. No commercial tours operate.

### Introduced Species

Many Southern Ocean islands have been affected by introduced species such as cats, rabbits and rodents which can impact on the breeding of native species reducing biodiversity and causing local extinctions. McDonald Island has no alien species currently. Heard Island has two introduced plants and two introduced insect species.

### Physical disturbance

Physical disturbance could include pathways, soil and vegetation compaction, damage to geological features, buildings or destruction of cultural artefacts. Most of Heard and McDonald Islands are free from physical disturbance as a result of a limited number of recorded visits. This is one of the islands' greatest values.



### Wildlife disturbances

Where human activity and wildlife habitat overlap disturbances such as burrow collapses, changes to wildlife movements or breeding can occur. Wildlife colonies are concentrated in the ice-free coastal areas that are also the most popular sites for human activities. Wildlife may react to disturbances by relocating, refraining from breeding, or deserting certain locations. It can also result in increased likelihood of mortality rates. Marine disturbances including boat collisions, noise and lights and illegal fishing can also impact on population numbers and diversity.

### Marine and terrestrial pollution

Fuel spills, discharged waste water and sewage and rubbish from shipping activities impact on marine mammals and seabirds through entanglement in floating debris such as discarded fishing nets. Impacts include reduced mobility, starvation, amputation, smothering and drowning.

Land can include grey water and sewage, which may increase nutrients or risk of disease. Fuel and chemical spills could result in soil contamination, vegetation degradation or harm to wildlife.

### SOURCE K: Humans on nearby Macquarie Island



Macquarie island. Source: <https://commons.wikimedia.org/w/index.php?curid=7137164>

## PART 2: Churchill Wildlife Management Area

### A. BIOPHYSICAL PROCESSES AND ENVIRONMENTAL FUNCTIONING

#### Lithosphere

##### Glaciation

The most recent ice age occurred during the Pleistocene, beginning about 2 million years ago and ending around 10,000 years ago. During this time glacial activity shaped the topography around Churchill. Glaciers form when snow falling in winter is greater than snow melts the following summer. The following winter, snow weighs down the remaining snow and it turns to ice. Over time, following further accumulation of ice, gravity pulls the ice and it slowly moves downhill. The most extensive Pleistocene ice mass was the Laurentide ice. The Laurentide ice covered Canada and a large part of north east United States.

##### Bedrock and soils

Churchill is located on the Canadian Shield. The Canadian Shield is a rock structure from hundreds of millions of years ago by mountain-building activity. The Canadian Shield stretches over 8 million square kilometres. It has been shaped by glacial processes. As the ice moved south it scraped the land of weathered rock, and created a landscape that is rocky, with smoother, low hills, basins, lakes and swamps.

Churchill is built on an outcrop of Proterozoic sedimentary bedrock of subgreywacke and conglomerates. Subgreywacke is a dark-coloured sedimentary rock with grains 0.06-2 mm in diameter containing free quartz, a low mud content and high carbonate content. The wider Churchill province contains sedimentary, metamorphic and volcanic rock. Glaciation, marine inundation and weathering have covered these bedrocks with gravel, silt, boulders, sand, clay, and organic materials.

##### Soil properties and vegetation

Close to the Hudson Bay Coast, salt marshes and mangroves are found, but soil properties are different as you move further inland. Tundra vegetation, bogs and boreal forests are supported by better developed soils inland. Permafrost is widespread and the region also contains ice-related coastal features as a result of sea ice.

#### Hydrosphere

##### Hydrology

Churchill is located at the mouth of the Churchill River where it feeds into Hudson Bay. The Churchill River flows 487km east to west from Saskatchewan, through

Manitoba to where it drains into the Hudson Bay. The river is made up of a large number of lakes joined together by rapids and waterfalls. Hudson Bay completely freezes over in winter. The river is located within a drainage basin called the Canadian Shield. Both sea ice and river water contribute to the region's freshwater budget.

##### Sea Ice

Churchill Wildlife Management Area is located on the western edge of Hudson Bay. Hudson Bay is seasonally covered in sea ice for 5 to 10 months of the year. Sea ice accumulates between September and December and melts between May and August. The amount and timing of sea ice is determined by atmospheric temperatures, wind, the freshwater and sea water mix, precipitation and currents. It is also impacted by an ice-albedo feedback loop. This is when the heat stored in the water impacts on the accumulation and/or melting of sea ice. The ice can be mobile (shifted by water currents) or landfast (attached to land in some way and immobile).

#### Atmosphere

##### Climate

The latitude of Churchill is significant because it impacts the climate. Being just south of the Arctic Circle it experiences a Continental Subarctic climate. Hours of daylight vary between 6 hours in December to approximately 18 hours of sunlight in June. These climatic conditions are integral to providing the conditions suitable for polar bears, belugas and arctic foxes, etc.

##### Air temperatures

Mean monthly temperatures are below zero for six to eight months and on average 50-90 days in a year are frost free. Temperatures can vary from -30°C to 17°C. Winters tend to be long and bitterly cold, while summers are short and mild. The warmest month is July and coolest month is January.

##### Air pressure and wind

Winds blow continuously over the Hudson Bay into Churchill. High winds occur between September and May, with average wind speeds of about 20 km/hr during this period. Wind mostly comes into Churchill from the north, but Churchill experiences westerly winds during October and March. High winds result in the krummholz effect on any trees in the Churchill Wildlife Area. The krummholz effect results in trees exposed to winds having stunted growth on one side.



## Humidity

Humidity in Churchill ranges from 70% to 89%, with higher humidity in November. The average annual humidity is 82%.

## Cloud Cover

There is significant seasonal variation in cloud cover in Churchill. Clearer skies occur from April to November, while the cloudier part of the year is between November to April. At its cloudiest (January), Churchill is overcast or mostly cloudy 87% of the time.

## Precipitation

The wettest months occur from April to November.

August is the wettest month. February is the driest month.

The snowy period occurs between September and June.

## Aurora Borealis

The latitudinal location of Churchill corresponds with the location of the Aurora Borealis. The Aurora Borealis (also known as the northern lights) is a display of coloured lights in the night sky. The shades of red, green, blue and violet occur above the magnetic pole and are the result of gas particles colliding. The Aurora Borealis is best viewed in locations which are not affected by light pollution in places that are latitudinal relatively close to the magnetic north pole. Churchill's latitude and isolation make it an excellent site for viewing the Aurora Borealis.



Churchill Wildlife Management Area. Photographs by Louise Swanson

## Biological processes

Churchill is in close proximity to Wapusk National Park and Caribou River National Park. Organisms found in this area include polar bears, beluga whales, and more than 270 bird species including the snowy owl, gyrfalcon and ptarmigan.

## Plants

Plants in tundra of Churchill wildlife Area occur in ground-hugging, dense clumps. In some areas there is considerable bare ground. Permafrost can extend up to 1,500 metres below the ground. Tundra plants are a mix of low plants including dwarf shrubs, mosses, lichens, grasses, and forbs. No trees occur in tundra environments because the summer is so short that the conditions don't allow their growth. However, as Churchill is a convergence of tundra, forest, freshwater and marine ecosystems, there are some trees in close proximity to the tundra environments in Churchill. Plants are perennial, meaning they survive for several years or are long lasting. During the brief summer season, plants quickly complete their annual cycles. They have short reproduction cycles and some plants reproduce asexually. This is enabled by the moisture in the soil during this time. Seeds are dispersed by the strong winds. Many of the plants have small leathery leaves to reduce moisture loss. A variety of fungi can be found amongst the tundra heaths.

## Animals

Birds and insects (including mosquitoes and flies) dominate animal life in the tundra during summer. Insects eggs are able to survive the winter. Tundra becomes an important site for nesting in summer, for birds migrating south in winter. While there are very few species of reptiles and amphibians, there are some species of mammals and freshwater fish. Tundra animals in the Churchill region include hares, foxes, polar bears, ringed seals, foxes, birds. There are 75 mammals, 240 bird species, 5 amphibians, 2 reptiles, and 3,300 insect varieties. Many animals migrate to warmer locations in autumn.

Polar bears are attracted to Churchill in the ice free season, in search of food. They are attracted by seasonal berries and often food scraps in rubbish. Polar bears access seasonal ice areas for hunting. As sea ice is melting faster each year, polar bears are spending more time on land, thus increasing human and bear interactions.

For more information and images of tundra environments visit National Geographic – <https://www.nationalgeographic.com/environment/habitats/tundra-biome/>

## B. ENVIRONMENTAL CHANGE

### Climate change

Climate change is resulting in a milder, shorter winter season and longer, warmer summers. Average yearly arctic temperatures are increasing. The shrubs are growing taller on the tundra and the surface temperature of water in Hudson Bay has increased by 3 degrees in the past 20 years. In the long term Churchill is expected to continue experience warming air temperatures. Wetter conditions are resulting from increased annual precipitation, permafrost is thawing and degrading. There has been an increase in the number of natural disasters impacting Churchill.

Climate change is likely to change migratory patterns, population numbers and physical characteristics of species. Organisms are increasingly moving north into the Churchill Wildlife Management Area such as red fox. Migratory birds are changing their movement patterns.

The reduction in the thickness of sea ice, is making it difficult for polar bears to hunt for their primary dietary staple seals. In turn, this is changing polar bear feeding patterns, migration paths and many are experiencing a reduction in body weight. Bears are staying on shore longer to wait for the ice to form.

Ice on the Hudson Bay is forming more slowly and melting more quickly, and as a result polar bears are struggling to hunt for food. Polar bears generally hunt seals on the pack ice, and the last of ice is resulting in some bears starving or being underfed, and the survival rates of cubs declining.

### Thawing permafrost

Increased temperatures are resulting in sea ice melts and reduced ice cover on Hudson Bay. Permafrost melts are likely to result in increased decomposition and microbial activity and release of greenhouse gases like carbon dioxide and methane.

### SOURCE L: Climate change impact



Source: Shutterstock

Environmental Change and Management  
**Tundra - Churchill, Canada**

**Overview**  
Churchill is located on the Hudson Bay at the mouth of the Churchill River. It is located at an ecotone, where three ecoregions meet: to the south the boreal forest, to the north and east the Hudson Bay and to the north west the tundra.

**Causes of change...**



#1 Climate Change   #2 Natural Resources   #3 Human settlement   #4 Tourism

### Tourism

Tourism in and around Churchill focuses on polar bears, beluga whales, nature photography and the Aurora Borealis. While activities are intended to minimise human impacts on wildlife, the actions of individuals are difficult to predict and control. Two companies are permitted to take visitors for viewing by tundra buggy. The buggies allow access on the difficult terrain, but also provide protection from the polar bears for visitors. Permission has been sought for more vehicle permits to operate here.

In attempts to ensure polar bear viewing tundra buggies may use any tracks or trails that are available rather than using the roads designed for the purpose. This could result in erosion of tracks or destruction of vegetation.

Some operators have tundra buggy lodges that provide accommodation for tourists and researchers for part of the year. These are mobile structures made up of customised buggies, with sleeping quarters, kitchens and bathrooms. The number, location and disposal of waste and treatment of wastewater are all impacts which must be carefully managed.

### SOURCE M: Tundra buggies



Source: L. Swanson



# ENVIRONMENTAL CHANGE: TUNDRA

SOURCE N: Churchill Canada Map



Churchill, Manitoba and Churchill Wildlife Management Area. Source: Lemelin, Raynald. *Tourism in Churchill, Manitoba. Current Issues in Tourism*. 9. 516-534. 10.2167/cit294.0.



Source: L. Swanson



Source: L. Swanson

## Resource extraction and industry

Canada has considerable natural resources, and Manitoba has world-class deposits and large underexplored remote regions of mineral potential. Extensive oil fields are located in northern Manitoba. The coast of Manitoba, along Hudson Bay, has been proposed for an energy corridor (pipeline development) for shipping oil, Alberta bitumen, with Churchill is a possible port location due to its deep water port and railway line.

Natural resource exploration and extraction can impact greatly on tundra environments. Activities can result in the thawing of permafrost, damage to soil and vegetation. There is also increased risk of toxic spills. Climate change and reduced sea ice would make the use of Churchill's port more economically feasible and logistically easier from the water, and less land ice cover may make developments easier on land.

SOURCE P: Town of Churchill



Source: Shutterstock

## Tundra Glossary

<b>Albedo</b>	The fraction of solar radiation that is reflected back into space.
<b>Antarctic Circle</b>	The parallel of 66.5 degrees south latitude.
<b>Arctic Circle</b>	The parallel of 66.5 degrees north latitude.
<b>Atmosphere</b>	The gaseous envelope surrounding Earth.
<b>Biosphere</b>	The living organisms of Earth
<b>Boreal forest (taiga)</b>	A needle-leaf forest in sub-arctic regions of Eurasia and North America.
<b>Carrying capacity</b>	In the case of tourism, carrying capacity refers to the number of visitors or activities that can take place in an area without environmental degradation occurring.
<b>Climate</b>	Weather conditions of a long period of time.
<b>Evaporation</b>	When liquid water is converted to gaseous water vapour.
<b>Glacier</b>	A large natural accumulation of land ice that flows downhill, or outwards from the point of accumulation.
<b>Hydrosphere</b>	All water on Earth, including lakes, rivers, oceans, groundwater, etc.
<b>Ice Sheet</b>	A blanket of ice that completely covers the underlying terrain.
<b>Lithosphere</b>	The solid, inorganic portion of the Earth's surface.
<b>Polar High</b>	A high pressure system over either polar region.
<b>Subpolar Low</b>	A zone of low pressure situated at about 50–60 degrees latitude (either North or South). Also known as a polar front.
<b>Taiga</b>	See boreal forest.
<b>Tundra</b>	A treeless region, where low growing plants such as moss, heath and lichens grow and where subsoil is permafrost or permanently frozen soil.
<b>Permafrost</b>	Permanently frozen, impermeable ground (upper layers may thaw during summer). It results when ground surface temperatures remain below freezing point for long periods.
<b>Weather</b>	Short-term atmospheric conditions (day-to-day).



Morning light on fresh ice, Heard Island. Source: <https://upload.wikimedia.org/wikipedia/commons/>



Polar Bear statue, Churchill, Manitoba. Source: <https://commons.wikimedia.org/wiki/>