
Source: http://visas-services.com/canada-tourist-visa.html

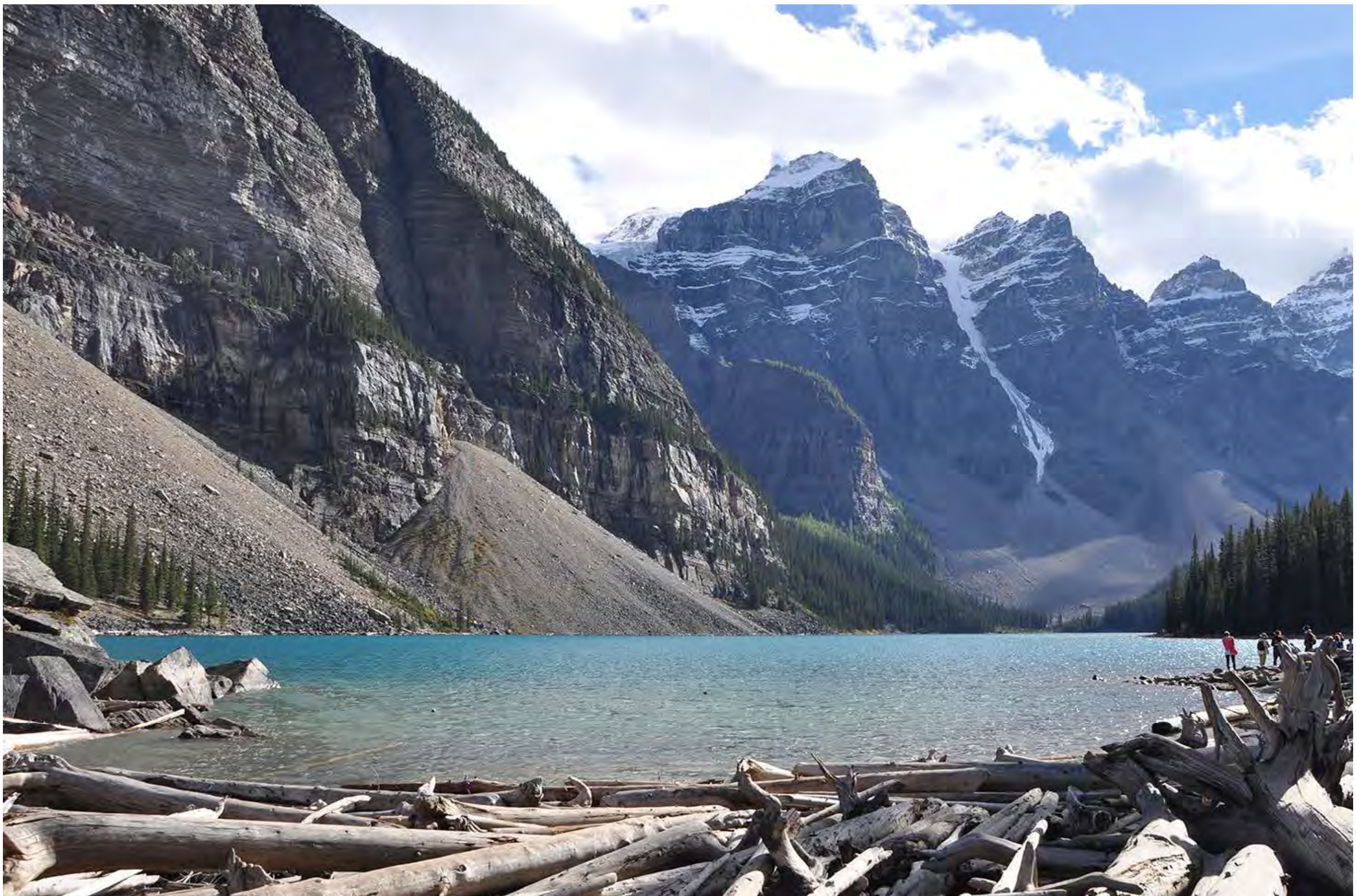
# Canada: Beautiful, liveable, but vulnerable

**Lorraine Chaffer, Vice President GTA NSW**
**Geography Education Consultant**
**Author: Geography teaching resources**

The NSW Geography Syllabus 7–10 requires the study of places at a variety of scales from local to national and global. Some units specify a study of different countries and others require a study that contrasts Australia with one other country. Australians in general have a fondness for Canada and for many it is a destination they have visited or would like to visit in the future. The reality is that Australians know very little about the geography of Canada beyond tourist images of mountains, forests, lakes and ski fields or media reports about its liveable cities.

Canada has a diversity of ***landforms*** and ***landscapes***, ***biomes*** and ***environments*** and its cities rank highly on global ***liveability*** scales. Population and urban places are concentrated in a strip along the southern border and around large water bodies such as the Great Lakes, a distribution heavily influenced by environmental factors. Canada's ***biomes*** support high levels of biodiversity as well as the production of industrial materials, fibres and food. Trade, tourism and migration are ***changing places*** within Canada and illustrate Canada's ***interconnections*** with the rest of the world. The country faces challenges from ***natural hazards*** such as earthquakes, tsunamis, floods and drought and ***human induced environmental change***.

*Below: Moraine Lake Image: L Chaffer*



# PART 1: LANDSCAPES, LANDFORMS and BIOMES

## Syllabus links

**CONTENT** (http://syllabus.bos.nsw.edu.au/hsie/geography-k10/content/1185/)

**Landscapes and landforms**

- Landscapes and the geomorphic processes that create distinctive landforms
- Geomorphic hazards

**Biomes**

- Distribution and physical characteristics of biomes

**GLOSSARY** (http://syllabus.bos.nsw.edu.au/hsie/geography-k10/glossary/)

**Landform:** The individual surface features of the Earth identified by their shape eg dunes, plateaus, canyons, beaches, plains, hills, rivers and valleys

**Landscape:** An area created by a combination of geological, geomorphological, biological and cultural layers that have evolved over time eg riverine, coastal, urban.

**Geomorphic processes:** Natural processes that transform the lithosphere to create distinctive landscapes and landforms eg erosion, weathering, tectonic activity.

**Environment:** The living and non-living elements of Earth's surface and atmosphere. Where unqualified, it includes human changes to the Earth's surface eg croplands, planted trees, buildings and forests

**Biome:** A major terrestrial vegetation community eg a tropical forest, a temperate grassland or desert.

**Geomorphic hazard:** Hazard event originating in the lithosphere eg volcanic eruptions, earthquakes, tsunamis and mass movement (landslides or avalanches).

Canada is the second largest country in the world covering an area of 9,984,670 sq. km. It has the world's longest coastline bordering the Atlantic, Pacific and Arctic Oceans and shares an 8,892 km land border with the USA (Source A) . With a large latitudinal and longitudinal extent (from 42° to 83° N and 52° to 141° W) Canada has a diversity of physical environments that support a domestic population of 35.7 million (estimated April 2015) and provide resources for global markets. A location on tectonic plate boundaries makes Canada's Pacific Coast vulnerable to *geomorphic hazards* such as earthquakes, landslides and tsunamis.

The town of Comox, British Columbia, and environs as seen from the north. Source: https://commons.wikimedia.org/wiki/File:Comox_BC_aerial_view.jpg


Source A: Canada general elevation map

Source http://worldatlas.com/webimage/countrys/namerica/lgcolor/cacolor.gif

## CANADA'S MAJOR LANDFORM DIVISIONS

**Different landscapes and the geomorphic processes that create distinctive landforms**

Canada can be divided into a number of major landform regions (Source B) in which landscapes and individual landforms have been shaped by ***geomorphic processes*** including tectonic activity, weathering, erosion and deposition. It has often been stated that Canada is a "smorgasbord of landforms".

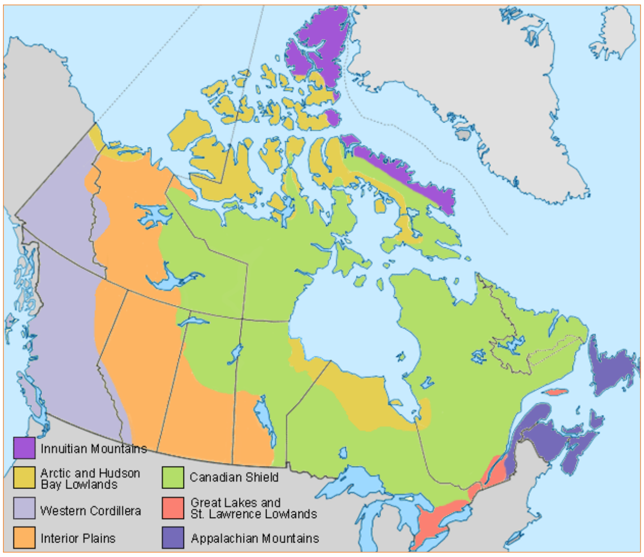
- The ***Canadian Shield*** covers almost half of the country. The landscape consists of hills and plateaus composed of igneous rocks, created by tectonic activity in the past and eroded over time by rivers and ice. The shield is covered with boreal (coniferous) forest in the south and tundra in the north. These ***biomes*** are determined largely by climate. The Canadian Shield has vast minerals resources including emeralds, diamonds and copper but is mainly unsuited to farming.
- ***Mountains and highlands*** to the west, east and north vary in age and characteristics. They include:
  - The ***Cordillera***: young mountains of that extend from the Pacific Coast to the interior plains in the west and comprise the Coastal Mountains, Rocky Mountains and other smaller ranges. These mountains were formed by tectonic activity, where the collision of the North American and Pacific plates caused folding and faulting of sedimentary rocks and volcanic activity. Rugged sharp peaks and glaciers in the Cordillera landscape reflect its more recent formation. Between the mountains are plateaus and valleys running north to south created by rivers and glaciers. Along the coast of British Columbia past volcanic activity created many islands and deeply indented bays and inlets. Biomes in this landform region include coastal ***rainforest***, ***grasslands or shrubs*** in the dry intermontane regions, ***temperate evergreen forests*** of Douglas fir, Western Red Cedar and Hemlock on the higher interior slopes of the Rocky Mountains and ***tundra*** above the treeline. The region is rich in water, forest and mineral resources.
  - The ***Appalachian Mountains:*** older mountains in the east eroded significantly by glaciation leaving a flatter, lower landscape dissected by deep, narrow river valleys (gorges) and U-shaped glacial valleys. Steep cliffs occur where mountains meet the sea.

- *Lowlands and plains* eroded by glaciation and filled with glacial and river sediments to create mostly flat plains with rich soils suited to agriculture and settlement.
  - The *interior plains* are large, flat areas of sediment eroded from the Canadian Shield, crossed by shallow river valleys and covered with lakes gouged by past glaciation. Forested in the north (*boreal / coniferous forest)* and supporting *grassland* (prairie) in the south the plains are considered Canada's breadbasket because they support large areas of grain as well as cattle grazing.
  - *The Great Lakes-St. Lawrence Lowlands* surrounding the Great Lakes and the St. Lawrence River supports large cities, rich farmland and manufacturing with some protected remnants of the original *forest biome* and steep escarpments such as Niagara Falls.
  - *The Arctic and Hudson Bay lowlands* are cold, flat plains underlain by permafrost that can only support tundra. The Arctic climate and frozen ground make development difficult and agriculture impossible.

See Sources C and D

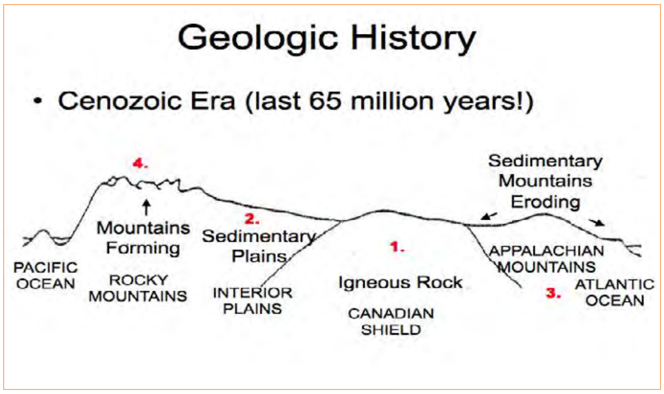
- The *Canadian Arctic Archipelago* refers to the 36,000 islands such as Baffin and Ellesmere to the north of the mainland on the edge of the Arctic Ocean where landforms include the Arctic and Hudson Bay tundra covered lowlands and permanently snow capped mountains.

**Source B:** Major landform divisions of Canada



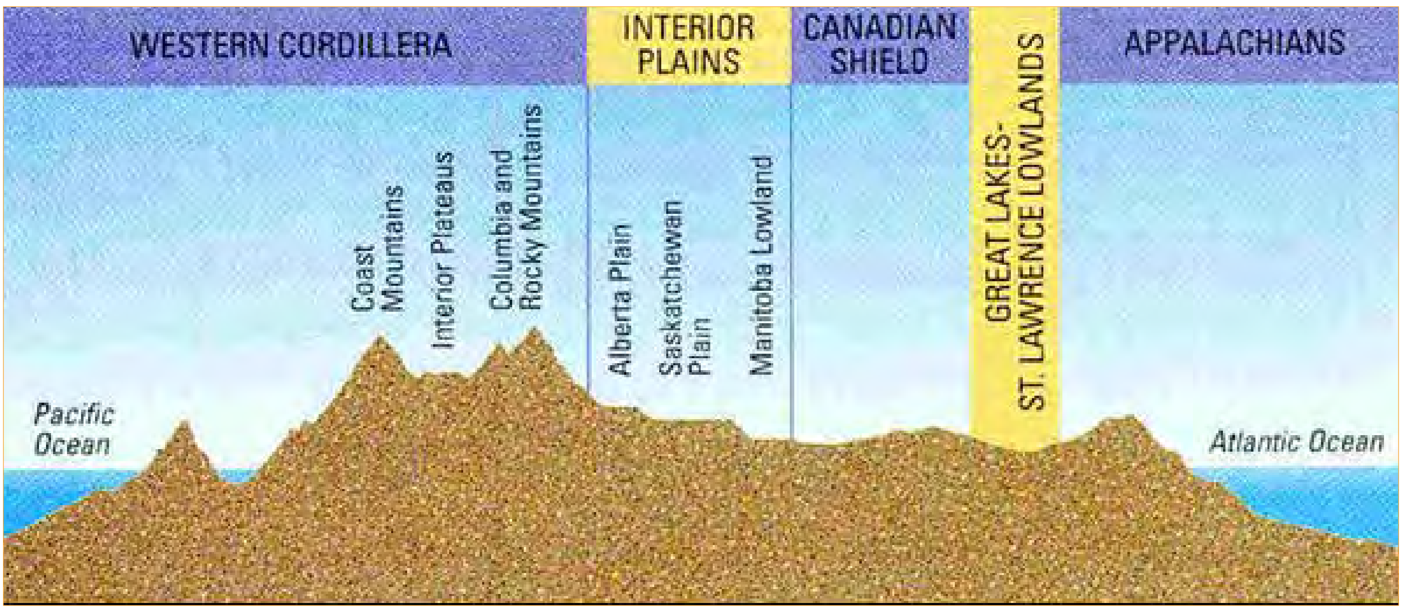

Source: https://s-media-cache-ak0.pinimg.com/originals/24/41/58/2441582 88c85fc9d493773cdd8ccda07.jpg

**Source C:** The processes shaping Canada




Source: http://slideplayer.com/slide/2403761/

**Source D:** Cross section showing the relative altitude of Canada's major landforms




Source: http://slideplayer.com/slide/4196105/

## TECTONIC ACTIVITY, MOUNTAINS, VOLCANOES AND GEOMORPHIC HAZARDS

Canada's west coast sits on a subduction zone where the Juan de Fuca tectonic plate is sliding beneath the North American Plate (Source E, M). This plate movement created the mountains of the Cordillera including the 18 now dormant volcanoes and many fields of volcanic material. Small earthquakes regularly shake the west coast, however it is large Cascadian quakes and subsequent Tsunamis that Canadians fear. The last Cascadian quake occurred in 1700 and the tsunami destroyed First Nations villages and travelled the Pacific Ocean.

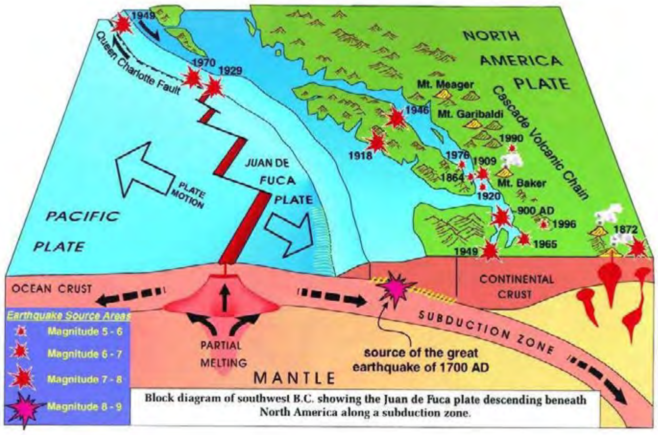
Scientists are predicting a "giant quake" in the future. Coastal communities, aquaculture farms, tourist resorts resorts and the coastal timber industry would potentially be devastated by a large tsunami. The west coast contains many narrow inlets and channels that could amplify the impacts of a tsunami for example, a five-metre tsunamis could become a 15-metre wall of water when restricted by a narrow inlet such as the Skookumchuck Narrows (Source I). Damage from a Cascadia quake and tsunami have been predicted at $75 billion –100% greater than B.C.'s yearly budget.

The region is also vulnerable to earthquakes resulting from landslides in the steep slopes of the coastal mountains and along minor fault lines in the Georgia Strait that separates Vancouver Island from mainland BC. The government is making "catastrophic earthquake preparedness" a priority and signs of this are increasingly evident along the vulnerable west coast of Vancouver Island in British Columbia (Source F). Examples include tsunami-warning signs at low lying coastal areas such as Tofino and earthquake survival events in Victoria, the capital of BC. (Source G and H) A network of GPS satellites track movement to the ground monitoring stations and building codes have been amended in BC to ensure to minimise the impact of earthquakes on new west coast homes and high rise buildings. The biggest obstacle to minimising damage from tsunamis is an effective warning system. A new tsunami warning system is in development. (Source J)

Thousands of landslides cost Canadians an estimated $200 to $400 million every year and vary from minor events involving a few cubic meters of material to over 10 km3. Some landslides have been measured as travelling up to 100 km/hour. Excessive rainfall, earthquakes and human activities are earthquake triggers and can subsequently contribute to tsunamis in coastal areas. (Sources K and L)

**One contemporary geomorphic hazard including causes, impacts and responses**

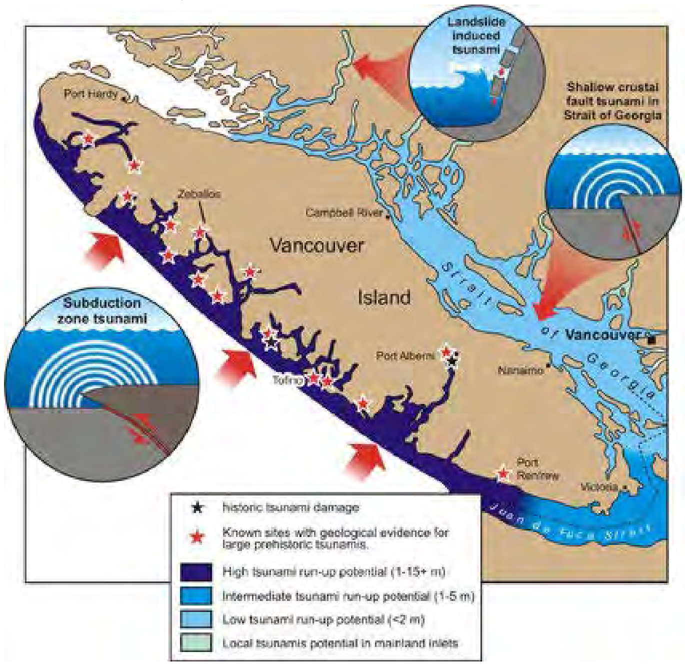
### **Source E:** Cascadia subduction zone




*New ocean floor is being created at the boundary of the Yuan de Fuca and Pacific Plates. As material wells up on ocean ridge, the ocean floor is pushed toward and beneath the continent.*

Source: http://www.pac.dfo-mpo.gc.ca/science/oceans/tsunamis/tsunamiBC-CB-eng.html

### **Source F:** Tsunami Hazard map showing the vulnerability of Vancouver Island




Source: http://www.sfu.ca/~qgrc/research2.html

# Canada: Beautiful, liveable, but vulnerable. Part 1


Source: http://bc.ctvnews.ca/b-c-shakes-up-tsunami-alert-system-1.1035403

## **Source I:** Skookumchuck Narrows

*Twice daily tidal rapids create a spectacular turbulent display. Water builds up to a height of 2–3 metres on one side of the narrow inlet as up to 200 billion gallons of water try to flow through the narrow inlet. "Skookumchuck" is a Chinook name meaning turbulent water or rapid torrent.*

*Image: L Chaffer*

Left: **Source G:** Tsunami warning sign at Tofino, BC

Below: **Source H:** Earthquake preparedness in Victoria, British Columbia


*Image: L Chaffer*

## **Source J:** Landslides are frequent hazards throughout Canada's mountainous and coastal regions

Source: http://www.nrcan.gc.ca/hazards/landslides

## STUDENT ACTIVITIES

1. List factors that help explain why Canada has a diversity of landscapes and landforms.
2. Use Source C to explain where mountain building is still occurring
3. Redraw the cross section in Source D. Add a vertical scale to show altitude and a horizontal scale to show distance on the cross section after conducting your own research.
4. Identify different biomes found across Canada. Explain why there is a diversity of biomes.
5. Explain the connection between tectonic forces, earthquakes and volcanoes.
6. Explain why Vancouver Island and the Pacific Coast of British Columbia are vulnerable to earthquakes and tsunamis.
7. Discuss the ways British Columbia is responding to the threats caused by tectonic plate movements.
8. "Landslides are a more serious threat to British Columbia than earthquakes". To what extent is this statement both true and false?
9. Locate a map showing Australia's main landform divisions and a continental cross section. Compare the diversity of landforms in Australia and Canada.
10. Identify the geomorphic hazards that occur in Australia. Write a statement that compares the vulnerability of Australia and Canada to large geomorphic hazards.
11. Read the media report "Building the ultimate tsunami warning system". Summarise the ideas using a concept map.
12. Use a flow diagram to explain how the NEPTUNE system will work to warn people of an impending tsunami.

Ancient forest along the north west Pacific Coast of Vancouver Island Source: https://commons.wikimedia.org/wiki/File:Klaskish_View_-_Flickr_-_Eye_Steel_Film.jpg

## Source K: Tsunami warning system in development

### MEDIA REPORT

### "Building the ultimate tsunami warning system"

*We can't prevent tsunamis – but a British Columbia project aims to save many thousands of people from their devastation*

In addition to being deadly and devastating, tsunamis tend to arrive without much warning. They're most commonly triggered by undersea earthquakes and landslides. Those are hard to detect, but getting easier thanks to NEPTUNE, an underwater technology network off Canada's West Coast.

People need tsunami information fast. On the afternoon of March 11, 2011, an 8.95- magnitude earthquake hit off the coast of Japan. Within an hour, 10-metre waves washed the coast, sweeping away cars, crushing buildings and buckling roads as if they were twist-ties. The 2004 tsunami that swept the Indian Ocean, triggering more tsunamis as it rolled along, was just as shocking; it killed more than 230,000 people in 14 countries, and caused the entire planet to vibrate by about a centimetre.

"The problem is, how do you tell people they're coming, and more importantly, how do you tell what height they're going to be?" says Benoit Pirenne, Associate Director, Digital Infrastructure at Ocean Networks Canada.

Enter NEPTUNE, or the Northeast Pacific Time-series Undersea Networked Experiments.

Headquartered at British Columbia's University of Victoria, Ocean Networks Canada is using that high-tech underwater, computer-connected system, and others, to map and monitor the seabed — and to improve detection, warning and analysis of the shapes of the giant waves.

NEPTUNE's backbone is an 800-kilometre loop of power and fibre-optic cables, connected to equipment that measures a host of geological and other processes, deep in the Juan de Fuca Strait off the B.C. coast. The cable network lies atop the smallest of the Earth's 12 tectonic plates.

The cables are connected to pressure sensors on the seabed, Pirenne explains. "They're really scales that measure the water column. They do that every second, so you can map, if you will, every wave," he says.

Up to now, tsunami detection has been spotty. But NEPTUNE promises to deliver a continuous stream of data that is much more detailed and nuanced than what has been traditionally gleaned from ship-based exploration — and that information, Pirenne hopes, will soon be used to revolutionize tsunami detection.

"We have proven that our sensors can detect their waves," he notes. "We are now working on the software detection systems and on the models that will help predict more precisely the impacts on specific points along the coast of Vancouver Island." That step would mean far better protection than the minimal warnings that people have received for tsunamis up to now.

The sensor data is transmitted to stations where scientists can analyze the seismic activity to help predict big waves. "Help" is still the operative word. "In a given time range, with three or more sensors, we can identify the source, origin and the speed of a wave coming toward the coast. But it still doesn't tell you how high the wave will be," Pirenne says.

Tsunamis can reach as high as 30 metres – three times the height of the initial waves that caused the first devastation in Japan. Determining wave height is the next puzzle to solve, says Pirenne.

"We're working on a detection system. Waves are influenced by the profile of the seabed as you come close to the coastline; the topography of the water [and the seabed underneath] has a big influence on the final speeds and height.

"It's important take into account the profile of the coastline to see what the wave is going to be doing – whether it's going to be a metre or 10 metres, an acre or a square kilometre," he says.

"We hope to have this part ready by the end of 2016."

The challenge for scientists now is to move tsunami detection forward from its current state of "near-real-time," with a few minutes lag, to actual real time, so that when waves are detected everyone can know precisely how much time there is to take emergency action. Another challenge is to provide detection for both "near-field", imminent tsunamis and "far-field" ones that may be on the way.

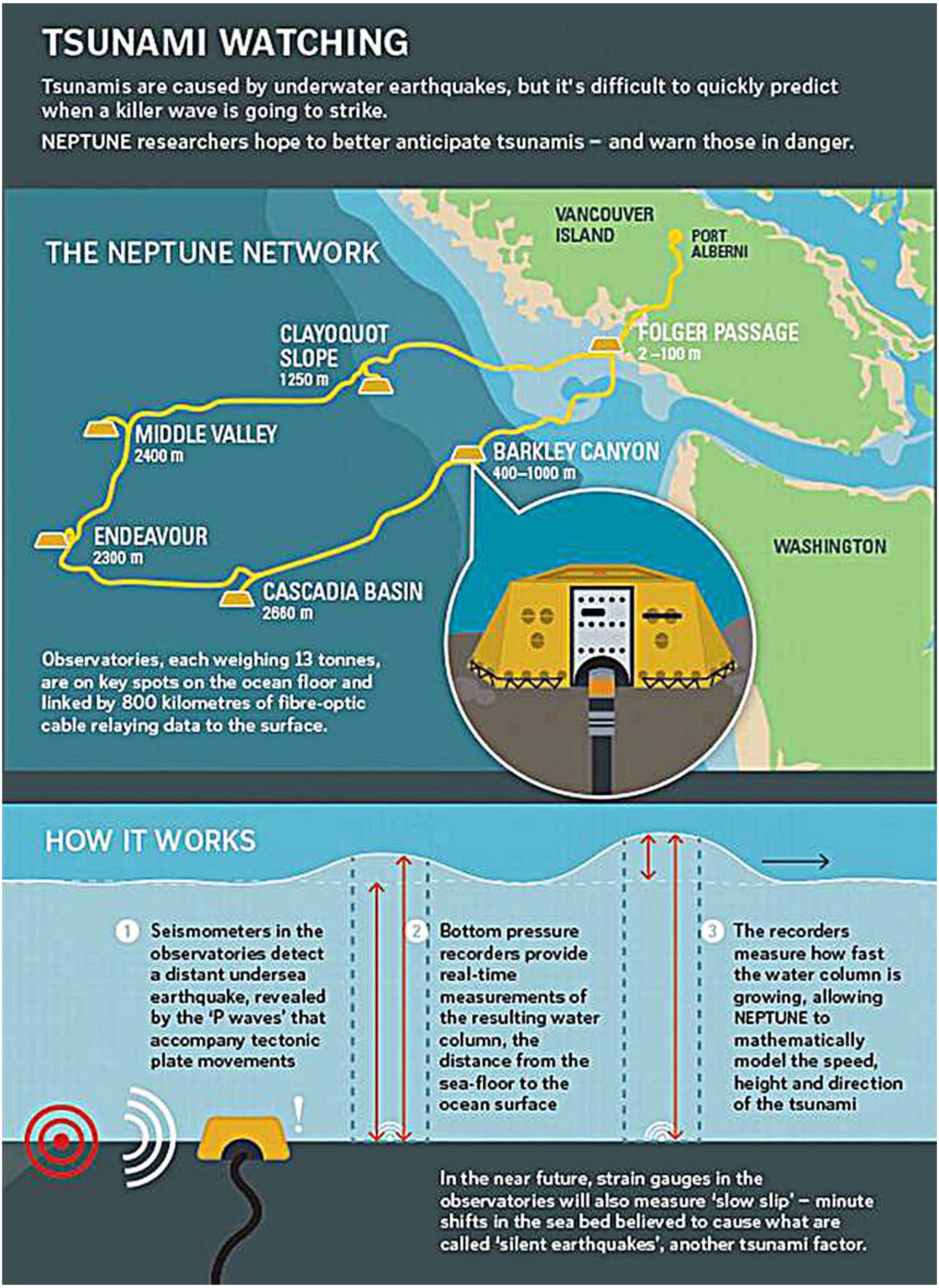
The scientists are busy and the work is ongoing, says Virginia Keast, Ocean Networks Canada's communications officer. Last spring, the organization hosted an international workshop to share the latest advancements in tsunami modeling. And in mid-September, Pirenne was in St. John's, Newfoundland presenting the network's progress to other experts.

"We're sharing what we know with Japan, with South America, with other countries," says Keast. The 2004 Indian Ocean tsunami was the catalyst for action, she says, and this was reinforced by the Japanese disaster in 2011, which sent detritus and debris across the ocean all the way to B.C.

"Canada has one of the most advanced systems in the world in terms of cable sensors supplying data offshore," says Pirenne.

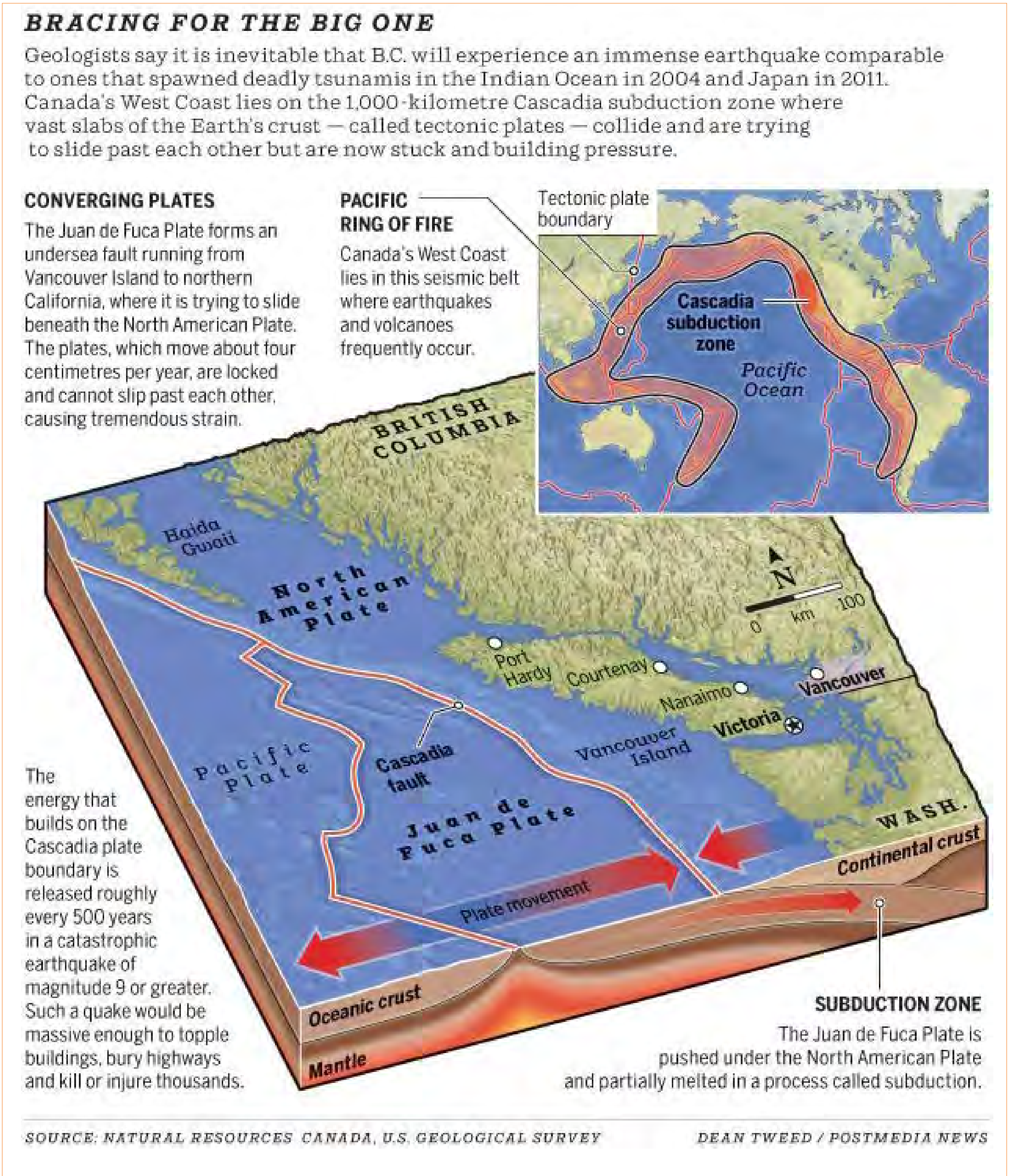
Source: https://gereports.ca/building-the-ultimate-tsunami-warning-system/

**Source L:** NEPTUNE – a tsunami warning system in development




Source: https://gereports.ca/building-the-ultimate-tsunami-warning-system/

**Source M:** The tectonic forces impacting on the West Coast of Canada.




Source: http://www.calgaryherald.com/technology/Catastrophic+earthquake+tsunami+brewing+coast/10682930/story.html

# Canada: Beautiful, liveable, but vulnerable. Part 1

*Canada has a diversity of biomes largely determined by latitude and altitude.*

## BIOMES: DIVERSITY AND INFLUENCES

***Biomes*** are large terrestrial regions of Earth's classified and named according to the dominant vegetation type and climate e.g. temperate forests. Biomes are influenced by precipitation, temperature, humidity and latitude and generally correspond with climate zones, forming parallel bands with changes in latitude. Canada has no tropical forests because of its location 42° to 83° North of the equator. In mountainous regions such as Canada's Rocky Mountains, biomes also change with altitude (Sources N, O and P). Soils, which form under the influence of climatic eg the weathering of rocks and glaciation, also influence the patterns of biomes within countries. Earth's major biomes include tundra, taiga (coniferous forests), tropical rainforests, deciduous forests, grasslands, and deserts. Each biome supports a diversity of wildlife species.

**Distribution and physical characteristics of biomes**

### Canada's main biomes

Canada 's biomes (Source Q) include:

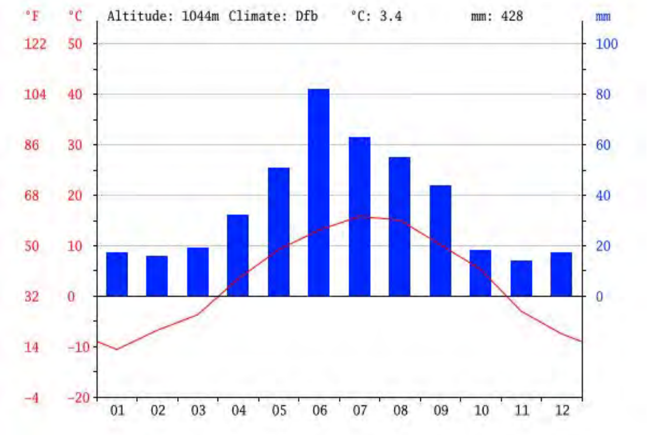
- *Tundra*: in the arctic and mountainous regions where the subsoil is permanently frozen and topsoil thaws for a few months each year allowing plants to grow. Precipitation and temperatures are extremely low and too cold for trees. The dominant plants are mosses, lichens, grasses and herbs.
- *Taiga*: (also called boreal forest, coniferous forest or mountain forest): south of the arctic tundra and below the mountain tundra. Winters are long and summers short with a growing season of 3 – 4 months. The soil is acidic from decomposing pine needles. Snow is the main precipitation and the dominant plants are evergreen coniferous trees (fir eg Douglas fir, spruce and pine) with some ferns and shrubs.
- *Temperate Deciduous forest*: in slightly warmer latitudes and lower slopes where rainfall is more plentiful and the growing season extends to 5 or 6 months. The main plants are broadleaf trees such as maples, birch, poplar and oak.
- ***Temperate rainforest:*** along the wetter Pacific Coast
- *Grasslands* are found on the inland plains where rainfall is generally low, unevenly distributed and insufficient to support trees. Summers are hot and dry, winters extremely cold but soils are fertile from the accumulation of decaying plants making these areas ideal for growing grain crops.

**Source N:** Alberta's grassland biome south of Calgary contrasts with the boreal forests above Fernie in British Columbia's Rocky Mountains and climate graphs (page 21)

Images: L Chaffer

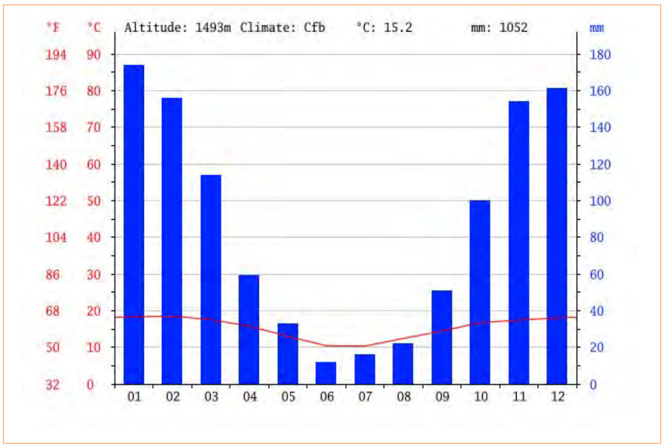
# Canada: Beautiful, liveable, but vulnerable. Part 1

## Climate graph for Calgary (grassland)




Source: http://en.climate-data.org/location/390/#climate-graph

## Climate graph for Fernie (boreal forest)

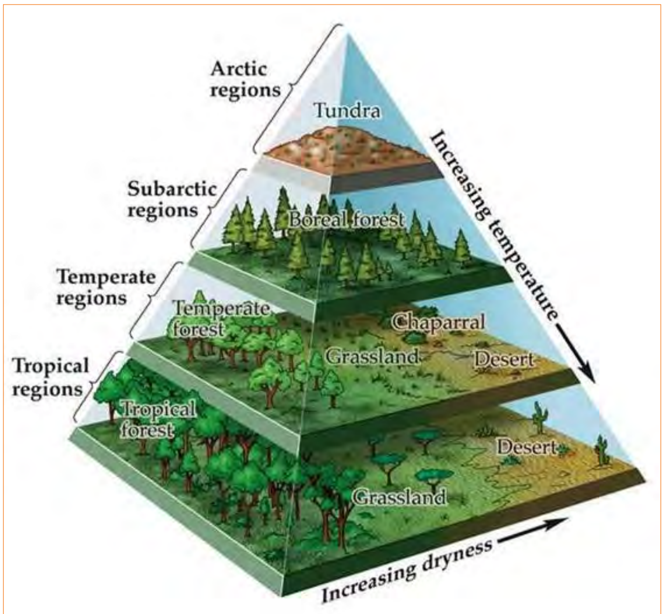



Source: http://en.climate-data.org/location/745522/

The ability of environments to support plant growth is known as its Net Primary Productivity (or NPP). Some biomes are more productive than others and this influences the ability to support agricultural activities that produce food, fibres and industrial materials. Canada's grassland biomes on the interior plains are its most productive agricultural region along with alluvial floodplains and lowlands regions where soils are rich and rainfall is higher or water is available for irrigation.

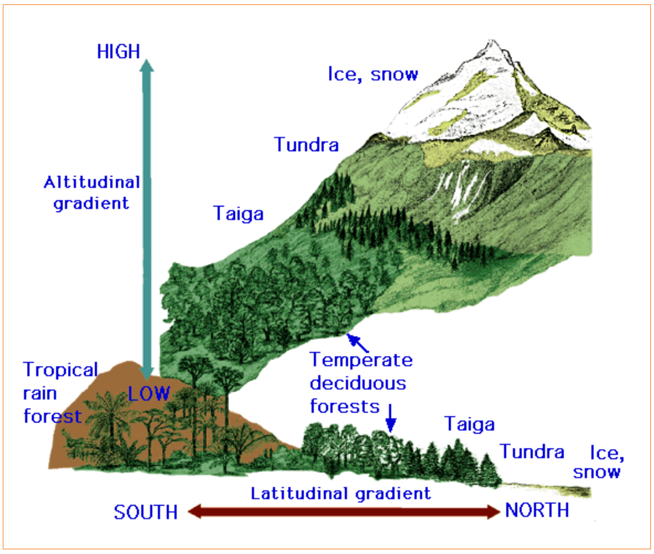
Canada's biomes contribute to the diversity of landscapes in Canada. The alteration to Canada's biomes for the production of food, fibres and industrial products as well as urban growth has led to a significant loss of biodiversity (plant and animal) and land degradation. The sustainable use, management and protection of Canada's biomes will be addressed in future articles.

## **Source O:** The influence of temperature and precipitation on biomes




Source: http://www.globalchange.umich.edu/gctext/Inquiries/Inquiries_by_Unit/Unit_3.htm

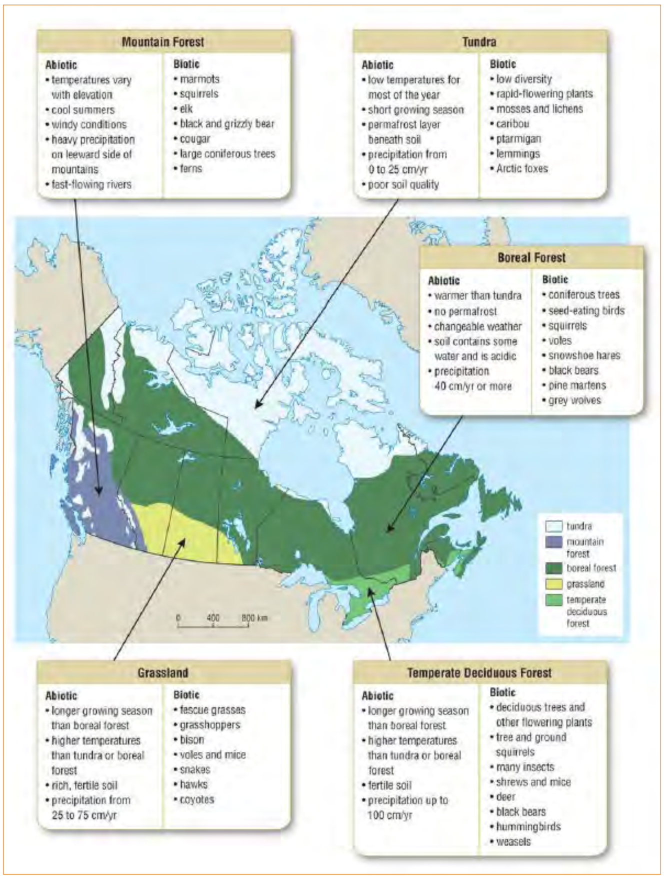
## **Source P:** Biomes vary by latitude and altitude




Source: http://www.globalchange.umich.edu/gctext/Inquiries/Inquiries_by_Unit/Unit_3.htm

*Grasslands around Kamloops (Mara trail), British Colombia, Canada.*
Source: https://commons.wikimedia.org/wiki/File:Grassland.jpg

### **Source Q:** The distribution and characteristics of Canada's major biomes




Source: http://www.dpcdsb.org/NR/rdonlyres/D1342DB1-ADEF-4171-820A-3127C680ECDB/156254/Ch28MajorTerrestrialEcosystems.pdf

### Vulnerability to bushfires

Canada is not usually associated with heatwaves, droughts and bushfires yet these very conditions cause thousands of wildfires in the country's forests and grasslands every year impacting on an average 2.3 million hectares each bushfire season. When conditions are abnormally warm and dry, such as those in 2004, 2014 and 2015, many millions of hectares burn such as the 6 million plus acres burnt during the 2004 fire season. In 2014 lightning, dry forests, and high temperatures caused hundreds of forest wildfires across British Columbia and Alberta. Residents of Vancouver were alerted to high levels of pollutants caused by fires in 2014 and advised to stay indoors. The occurrence and frequency of biome fires in Canada has varied over time (Source S) and been determined largely by variations in climate conditions (wildfires) as well as human influences (Source R).

Fire plays an important ecological role in Canada's forest biomes just as it does in Australia. According to ***Natural Resources Canada*** fires:

- remove aged trees
- expose the land to sunlight
- allow new trees to germinate to create new forest
- release nutrients from the trees into the soil

Climate change is expected to result in more frequent fires in many of Canada's boreal forests as fire-prone conditions increase in frequency and intensity. The burnt area could double and be exacerbated by other environmental responses to climate change such as insect outbreaks that kill more trees, and increased the combustible material on forest floor. The challenge for managing fires is to protect human life, property and iconic landscapes while allowing the important ecological role of fires to continue so that forests survive and regenerate into the future.

### Wildfire in Alberta in 2014

Source: http://globalnews.ca/news/1452255/infographic-how-do-this-summers-wildfires-compare-to-previous-years/

The recovery of forests from fires in Canada is very different to the Australian experience. Some species such as white spruce have no special adaptations to fire and will only reappear after fires if the seeds or plants come from unburned places. Other species will regenerate quickly from the stumps and roots of burnt trees or from seeds blown in for other places. A regenerated forest in Canada grows from the ground up and looks very different to an Australian eucalypt forest where new growth appears from many places on a tree truck and roots below the ground.

NASA satellite imagery shows the complex of forest fires on British Columbia and Alberta border in 2014

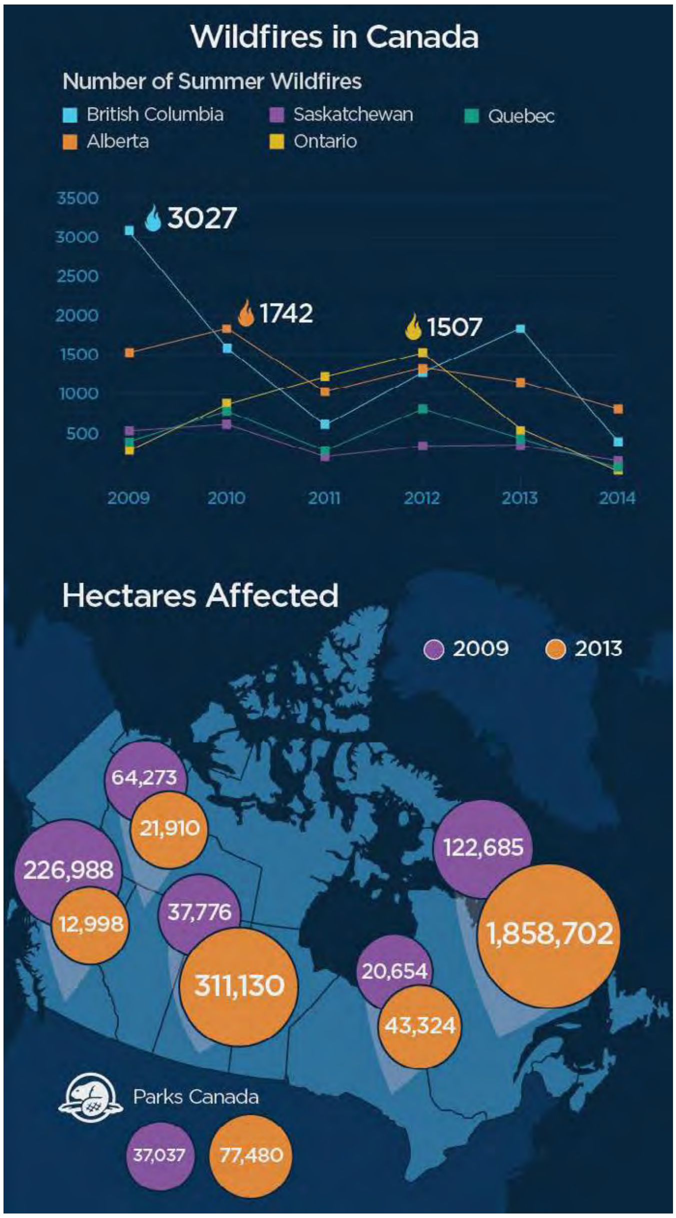

Source: http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=84042

Forest recovery from the ground up at Kootenay National Park in unlike the regeneration of Australian Eucalypt forests.

**Source R:** GIS map shows fires caused by natural and human causes across western Canada in 2015


Source: http://gisuser.com/2015/07/wildfires-in-british-columbia-story-map-how-many-are-caused-by-humans/

**Source S:** Canada's wildfire history




Source: http://globalnews.ca/news/1452255/infographic-how-do-this-summers-wildfires-compare-to-previous-years/

## STUDENT ACTIVITIES

1. Refer to Source O and Source P. Briefly explain the following relationships using examples from Canada.
   - Biomes and climate (temperature and precipitation)
   - Biomes and changes in latitude
   - Biomes and changes in altitude
2. Refer to Source Q and a map (atlas or internet).
   Describe the spatial distribution the following biomes in Canada
   - Tundra
   - Boreal forest
3. Refer to Source N
   - Describe the landscape and biome south of Calgary and above Fernie
   - Explain how the climate of each place would influence its biome.
   - List other factors that might influence the biome at each location
   - Suggest how each biome and surrounding landscape might be used by humans
4. List the main causes of wildfires in Canada.
5. Explain how bushfires affect landscapes and biomes.
6. "***Bushfire management in Canada is not only for protecting people and property***" – Discuss this statement
7. Compare the recover of Canadian and Australian forests following a bushfire. Support your comparison with a collage of photographs showing forest recovery in both countries.
8. Refer to Source R, Source Q and Source B. Identify the states, landform divisions and biomes that experienced fires in western Canada in 2015
9. Explain why summer is the main fire season in Canada.
10. Refer to Source S
    - Compare the impact of Canadian bushfires in 2009 and 2013 by hectares affected
    - Identify the state that experienced the most fires between 2009 and 2014.
    - Calculate the number of fires in Ontario between 2009 and 2011
11. Discuss how modern technology such as satellite imagery and GIS can be used in wildfire management in Canada.

## References


Forces that shape earth: Canadian Geography (Historical explanation) – http://slideplayer.com/slide/2403761/

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Major landform divisions – http://study.com/academy/lesson/major-landforms-of-regions-in-canada.html

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