GEOGRAPHY BULLETIN

TEACHING RESOURCES and STUDENT ACTIVITIES … for online and classroom learning

Stages 4 and 5 Physical geography edition

The Geography Teachers Association of NSW & ACT Inc.

Volume 52 No 2 2020

IN THIS ISSUE:

PROJECTS • REPORTS • RESOURCES • ARTICLES • REVIEWS

EXECUTIVE 2020

GEOGRAPHY BULLETIN

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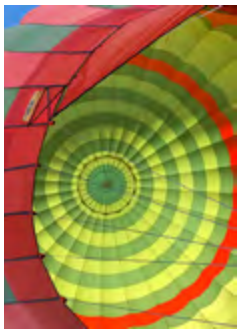

Front cover: Hot air ballooning over Cappadocia, Turkey. Source: Shutterstock
Back cover: Hot air balloon. Source: L.Chaffer

The Geography Bulletin is a quarterly journal of The Geography Teachers' Association of New South Wales. The 'Bulletin' embraces those natural and human phenomena which fashion the character of the Earth's surface. In addition to this it sees Geography as incorporating 'issues' which confront the discipline and its students. The Geography Bulletin is designed to serve teachers and students of Geography. The journal has a specific role in providing material to help meet the requirements of the Geography syllabuses. As an evolving journal the Geography Bulletin attempts to satisfy the requirements of a broad readership and in so doing improve its service to teachers. Those individuals wishing to contribute to the publication are directed to the 'Advice to contributors' inside the back cover.

GEOGRAPHY BULLETIN

Volume 52, No 2 2020
EDITOR: Lorraine Chaffer

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EDITORIAL

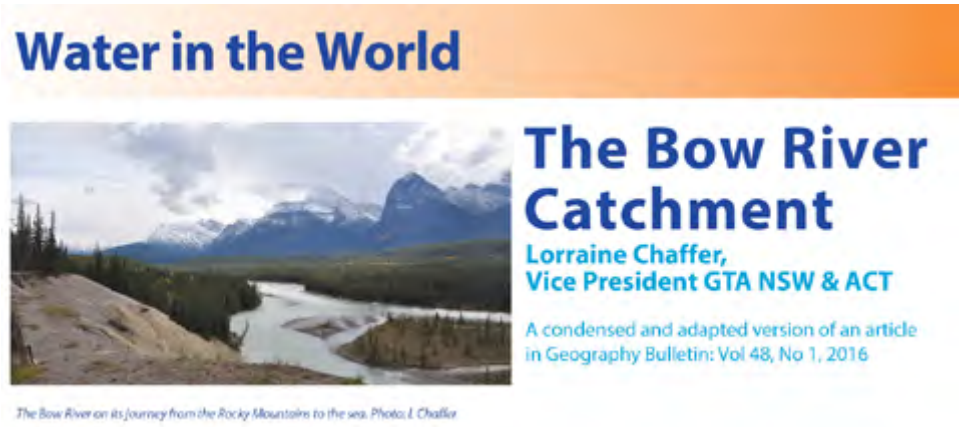
EDITORIAL

Welcome to Edition 2 of the Geography Bulletin for 2020. This is a special edition that is taking on a different format due to the demands on teachers resulting from interruptions to the delivery of lessons to students as a result of COVID-19. The aim is to make existing bulletin resources more useable by turning them into lesson sized or project-based activities with an immediate classroom or online use that does not increase teacher workload.

The edition will consist of three components to provide resources that can be used for online and in class lessons with minimal teacher effort.

- The Geography Bulletin containing condensed and adapted articles for Stage 4 & 5 topics from previous editions. There will be some new material.
- A Geography Bulletin Supplement containing Blackline Masters student activities suited to hard copy and digital use.
- Student activities in PPT format that can be imported into school online delivery methods such as Flipcharts and Google Classroom. These are directed at students e.g. In this activity/lesson you will ….

Example of a condensed and adapted article



The Bow River on its journey from the Rocky Mountains to the sea. Photo: L Chaffer

Example of activities in PPT format

GTA NSW & ACT acknowledge the wonderful work being done by the **NSW Environmental and Zoo Education Centres** in supporting teachers during this time by creating virtual resources for schools to support teaching and learning from home and in the classroom. The centres have given free access to Geography teaching and learning resources and developed virtual fieldwork activities until normal fieldwork activities can resume. These resources will be available to teachers registering for EZEC programs after schools and fieldwork activities return to normal.

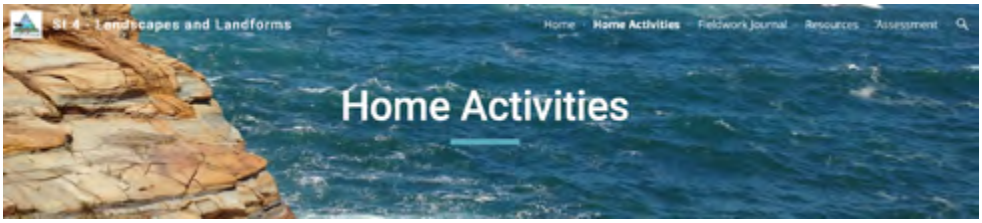
A selection of programs run by EZEC's across the state with links to the free access resources are included in this edition.

An interactive map showing locations and details of the 25 NSW Department of

Lorraine Chaffer, Editor

Education Environmental and Zoo Education Centres (EZEC) can be found here https://www.google.com/maps/d/viewer?mid=153_82bL_wyPWbt5Wn8EbvqFoxgs&ll=-32.81663794608359%2C150.3307552&z=6

Sample EZEC online learning resource. More examples can be found at https://sites.google.com/education.nsw.gov.au/high-school-resources/home



GTA NSW & ACT Semester 1 Program

Annual Conference

GTA NSW & ACT Annual Conference has been postponed for a later date. Members will be notified when a new date and venue are determined.

Geography Cafe Conversations

Organised by GTA NSW & ACT Vice President Sharon McLean, these virtual conversations were an opportunity for Stage 4, 5 & 6 teachers to discuss strategies and experiences on teaching Geography both in online and physical classrooms.

Further Cafe Conversationsare being considered for Term 3 & 4.

Term 1 Webinar Program

1. Nuts and Bolts – Programs, Scope and Sequence Assessment Schedules and Lesson Starters: Keith Hopkins and David Latimer
2. Differentiation in Geography: Rex Cooke and Cassie Crompton

Term 2 Webinar program

1. STEM and Geography Presenter: Kimberly Parnis
2. Primary School Geography Presenters: Gaye Braiding and Theone Ellas

Note: Members can access past presentations through the GTA website under the resources tab.

Upcoming events

HSC Exam Preparation Lectures

These will be presented in a digital format for 2020. Schools can register to access the digital presentations. Check the GTA NSW & ACT Website, Facebook page and HSC Facebook Group for details.

A **link to register** for the HSC Exam preparation package can be found on the GTA website.

Webinar program

Semeter 2 Webinar program to be announced.

EDITORIAL

PRESIDENT'S REPORT

Welcome everyone to this extraordinary time in our teaching of Geography. Only a few months ago we were experiencing and contemplating the 'what now?' and 'what next?' related to environmentally focused events which presented significant future implications for the wellbeing of humans, the more-than-human species, environments, and places. Now, the global pandemic adds another layer of complexity to this challenging and rapid time of change.

Regardless of our education context we are compelled to engage with new ways of being in our teaching and learning practice. Hopefully, as geography teachers, we are also prompted to consider the importance of observing and interpreting the impacts and possibilities related to the current circumstances through a distinctly geographical lens. We would also be considering our pedagogical practice, for example, how can inquiry and fieldwork most meaningfully occur within a socially-distanced, #stayhomestaysafe and newly emphasised online context. Consequently, many of us are probably questioning the existing structures and processes in terms of what it is that becomes important emphasise and also to retain as we move between online and face-to-face presences. To use the words from a group of geography scholars I have recently had the pleasure to work alongside, "an absence of the familiar…opens up the possibility for thinking about different futures." (Rogers et al., 2020)

Thinking about future possibilities for the Association and being adaptive and responsive to the changing circumstances are at the forefront of discussions by GTA NSW&ACT Council. For example, the recent, no-fee Café Conversations series, conceptualised by Vice President Sharon McLean, is one way the Association can provide an accessible networking opportunity for members where lived experience about classroom practice in times of a pandemic can be shared in response to overarching questions. Piloted during the month of May, the feedback suggests there is scope for this initiative to continue. Another example of being adaptive and responsive to change will occur via the reimagining of traditional HSC Student Lectures, led by Councillor Catherine Donnelly. Another example, led and modelled by Immediate Past President, Lorraine Chaffer, is for a selection of case-study, classroom-ready articles from recent Geography Bulletins to be available on the GTA NSW&ACT website for all geography teachers to access.

One future possibility that also requires consideration is the future of geography – as a subject in schools, as a discipline, and as a career pathway. Such possibilities, across each domain are evident in the Strategic Plan for Geography, *Geography: Shaping Australia's Future* released at the end of 2018 by the National Committee of Geographical Sciences. In my previous President Report I invited all readers to download and read *Geography: Shaping Australia's Future* https://www.science.org.au/files/userfiles/support/reports-and-plans/2018/geography-decadal-plan.pdf as part of professional reading and to focus on Chapters 1, 2 and 13. In my previous report I also said that a couple of the recommendations will become a particular focus for the Association over the next 12 months, and that I will provide further clarity and direction within the next issue of the Geography Bulletin.

Chapter 13, Geography in Australian Schools outlines the current, national context for the subject and provides four recommendations to ensure the future of Geography flourishes within the school education context. It is vital for the national view to be considered and included at a state and territory level in order to gain traction. One recommendation is about geography becoming compulsory or core learning up until the end of Year 10 or equivalent (whilst this exists in NSW, it is not the case around the country). Another recommendation focuses on initial teacher education in geography. The remaining recommendations surround recognising geography as a partial STEM subject and increasing opportunities for collaboration between school and university geographers. It is such recommendations that will become part of GTA NSW&ACT work in aligning geography as a subject in schools with the discipline of geography and as an important study and career pathway.

Some of you may know that during March 2020 I was appointed, by Science and Technology Australia, as a STEM Ambassador. In working alongside a Federal Member of Parliament and increasing collaborative opportunities between Associations such as GTA NSW&ACT, the Geographical Society of NSW, and the Institute of Australian Geographers, it is hoped that advocacy for geography education to become more visible in STEM education will occur at a range of levels from various contexts, and that in time geography will become formally recognised in policy and practice as a partial STEM subject. More information is available in the following article *Science Meets Parliament; Geography Meets STEM.*

GTA NSW&ACT is already fortunate to have a long-standing and very positive relationship with the

Geographical Society of NSW. As the year progresses, more information will become available about the way in which geography and geographers at schools and in universities can increasingly connect through a range of formal and informal collaborative opportunities.

In closing I would like to thank Lorraine Chaffer, the journal editor, for the way she has curated this edition of the Geography Bulletin. This Bulletin is designed more-so than usual to assist geography teachers in being able to access relevant, useful resources that transfer easily to a classroom context.

Wishing you all a productive journey throughout the remainder of Term 2 and I look forward to our paths crossing in various forms.

Susan Caldis

President, GTANSW&ACT | STEM Ambassador, Science & Technology Australia

Science Meets Parliament; Geography Meets STEM

Where is the place of Geography in the STEM space? Part 1

Susan Caldis, President, GTA NSW & ACT
2020 STEM Ambassador, Science & Technology Australia

Science Meets Parliament; Geography Meets STEM is a short report about the connection between (i) the Strategic Plan for Geography, ***Geography: Shaping Australia's Future*** (National Committee for Geographical Sciences, 2018); and (ii) a national event, Science Meets Parliament, in November 2019. The context of a future possibility for geography education in schools and for geography as a discipline provides the point of connection. The purpose of such a report is to set the foundation for further thought, discourse and a series of articles to emerge around the question 'Where is the place of geography in the STEM space?'

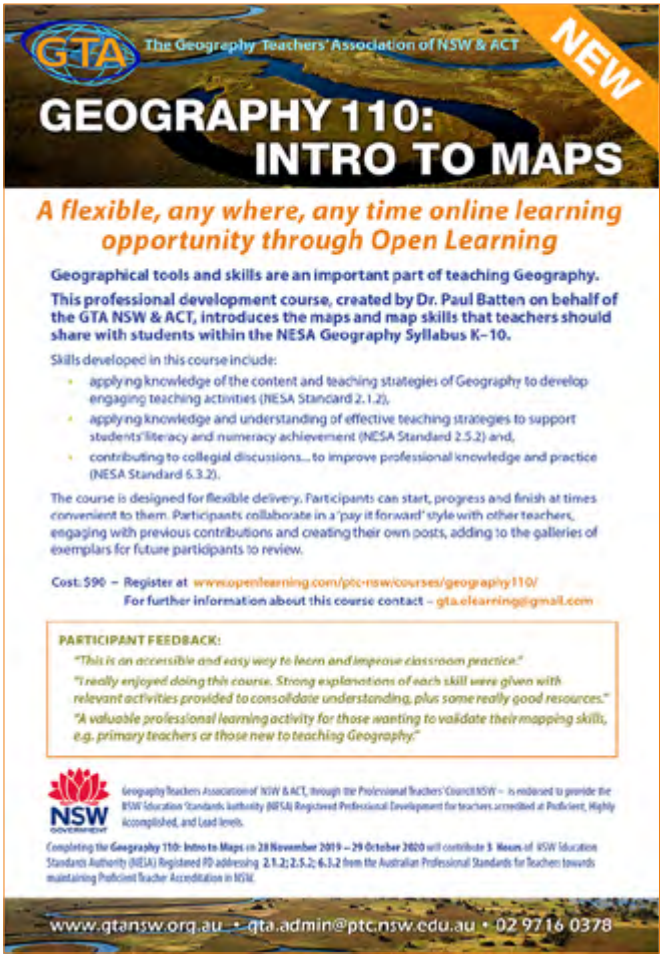
Where is the place of geography in the STEM space?

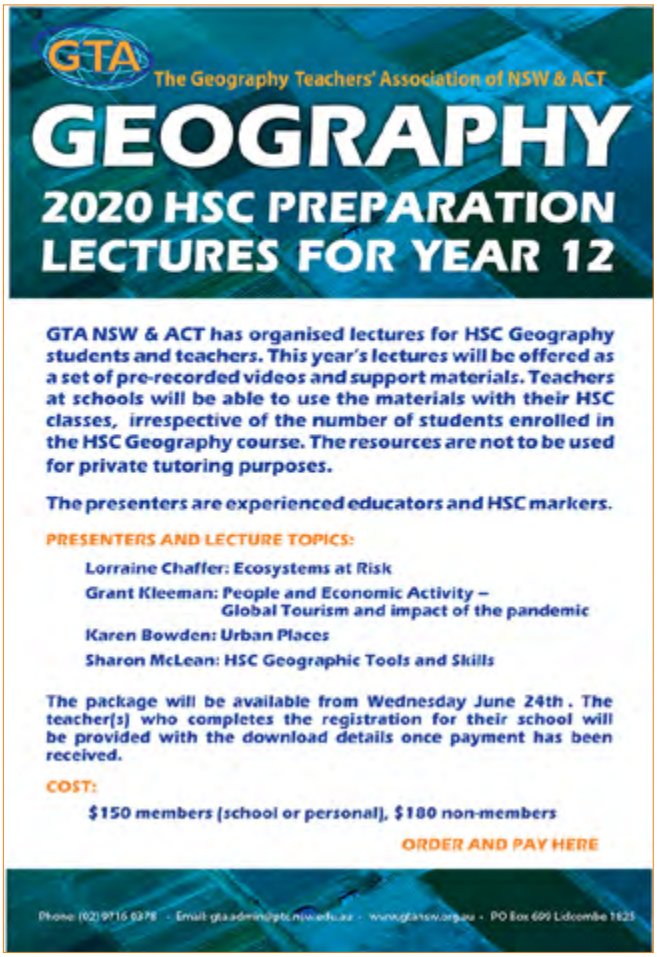
The release of the Strategic Plan for Geography, ***Geography: Shaping Australia's Future*** provides evidence-based direction for the discipline of geography, including its context and representation of geography as a subject in Australian schools. Directions for the discipline of geography occurs through a series of recommendations. One of the recommendations is for a submission to be developed, for Ministers of Education, around the recognition of geography as a partial STEM subject. ***Geography: Shaping Australia's Future*** is accessible via the following weblink https://www.science.org.au/files/userfiles/support/reports-and-plans/2018/geography-decadal-plan.pdf The process of building a submission starts with theoretical musings, such as ***Geography and STEM*** (Caldis & Kleeman, 2019) available in Geographical Education retrievable from https://www.agta.asn.au/Resources/GeographicalEducation/geoged-v32-2019.php Emerging from theoretical positions are discussion forums, surveys, observation of practice and so on. There are typically many components that make-up one submission. At the moment, the place of geography in the STEM space appears as a future possibility and an actionable item in directional policy for the discipline. The place of geography in the STEM space also appears in professional readings for teachers.

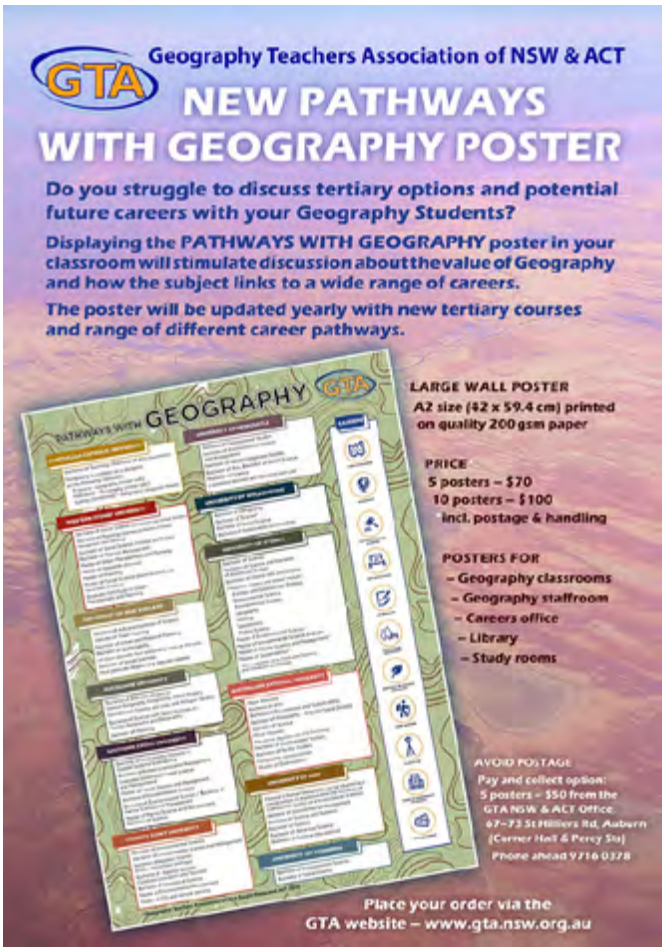
Science Meets Parliament is an annual event hosted by Science & Technology Australia. The event is an opportunity for parliamentarians, industry professionals, academics, and policy makers to engage in reciprocal dialogue and pitching activities about 'What is your science? Why does it matter?'. The dialogue culminates in each delegate putting forward at least one evidence-based proposition related to the future of 'their science'. As the only representative for geography education and with the Strategic Plan and professional readings in hand, my science, pitch and proposition were dovetailed in to "Geography education; Geography as a STEM subject; Geography acts as a bridge between the sciences and social sciences, therefore place-based analysis, spatial reasoning skills, and understanding about human-environment-more than human-interactions add depth and contribute to STEM understandings whereas the intersection between Geography and STEM lies in the pedagogy: inquiry, fieldwork, future-focused problem-solving". I was also able to share the current work of a geography teacher who has embarked upon a GeoSTEM initiative with Year 9 – tune in to an upcoming GTANSW&ACT webinar to hear more about this GeoSTEM project from the teacher! My appointment as a 2020 STEM Ambassador for geography education suggests a willingness from parliamentarians, industry professionals, academics and policy-makers to engage in further dialogue about the place of Geography in the STEM space.

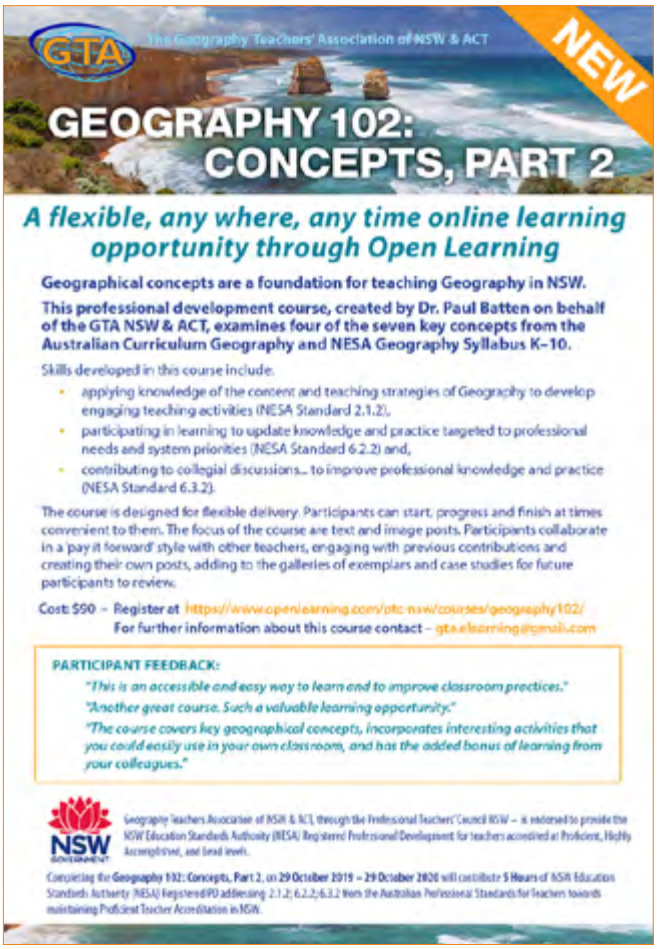
Although at this point in time there is no definitive answer to 'Where is the place of Geography in the STEM space?' there is scope to draw on theory, policy and practice as a guidance towards the potential realisation of a future possibility.

GTA NSW & ACT SUPPORT









Teacher guide to using these resources

Lorraine Chaffer, Vice President GTA NSW & ACT

The focus of these resources and activities is the important biophysical processes, cycles and concepts linked to the formation and transformation of **Landscapes and landforms** and concepts related to **Water in the world**, the way water connects people and places and natural variations in availability of and access to water.

Use the resources and student activities:

- to check student knowledge and understanding of content covered on-line or in class. Students complete activities before or after examining Snapshots provided for each topic.
- as a topic introduction to cover key concepts and content focus
- to apply knowledge and understanding to a 'place' eg. Canada, Bow River, Warragamba, India
- for independent learning OR guided classroom use
- as a stimulus for further inquiry of a landscape or case study

LANDSCAPES and LANDFORMS

- ✓ Snapshot 1: Geomorphic Processes
- ✓ Snapshot 2: Landscape diversity and change
- ✓ Snapshot 3: Meandering Rivers
- ✓ Snapshot 4: Earthquakes
- ✓ Virtual Fieldwork: NSW EZEC programs for Stage 4
- ✓ Canada1: Major landforms, geomorphic processes and geomorphic hazards
- ✓ Canada 2: Unique landforms and geomorphic processes
- ✓ Canada 3: Landscape values and protection

WATER IN THE WORLD

- ✓ Snapshot: Water cycle processes and connections
- ✓ Canada 4: Water resources and hazards
- ✓ Canada 5: The Bow River
- ✓ Stage 4 Skills Stimulus

SNAPSHOT 1: GEOMORPHIC PROCESSES that shape landscapes and landforms

Lorraine Chaffer,
Vice President GTA NSW & ACT

Canyons National Park, USA. Image source: L Chaffer

GLOSSARY

Landscape – the appearance of an area created by a combination of physical and cultural features that have evolved over time e.g. coastal or urban landscapes.

Landforms – individual features of the Earth's crust identified by their shape e.g. beach

Geomorphic processes – natural processes including weathering, erosion, deposition, mass movement and tectonic activity that transform the lithosphere

Geomorphic hazard – hazard events originating in the lithosphere e.g. volcanic eruptions, earthquakes, tsunamis and mass movement (landslides or avalanches).

GEOMORPHIC PROCESSES

1. Tectonic processes (Earth's tectonic plates)

Earth's crust is broken into segments known as tectonic plates which move slowly in different directions due to currents in the mantle. Plate movements create distinctive landforms at the plate boundaries (margins) such as mountains and valleys and also cause geomorphic hazards such as volcanic eruptions and earthquakes.

SOURCE A: Earths tectonic plates

Source: Shutterstock

THINK

How does the location of Australia compare to New Zealand in relation to Earth's tectonic plates.

Is this good or bad for Australia?

The direction of plate movements will determine the geomorphic processes that change the Earth's crust.

- At **DIVERGENT** boundaries the plates move apart allowing molten magma to rise and form new crust in the form of ridges, valleys and volcanoes. Landforms created by divergent plates include the Mid Atlantic Ridge and the Great African Rift Valley.

  * New crust is created on divergent boundaries.

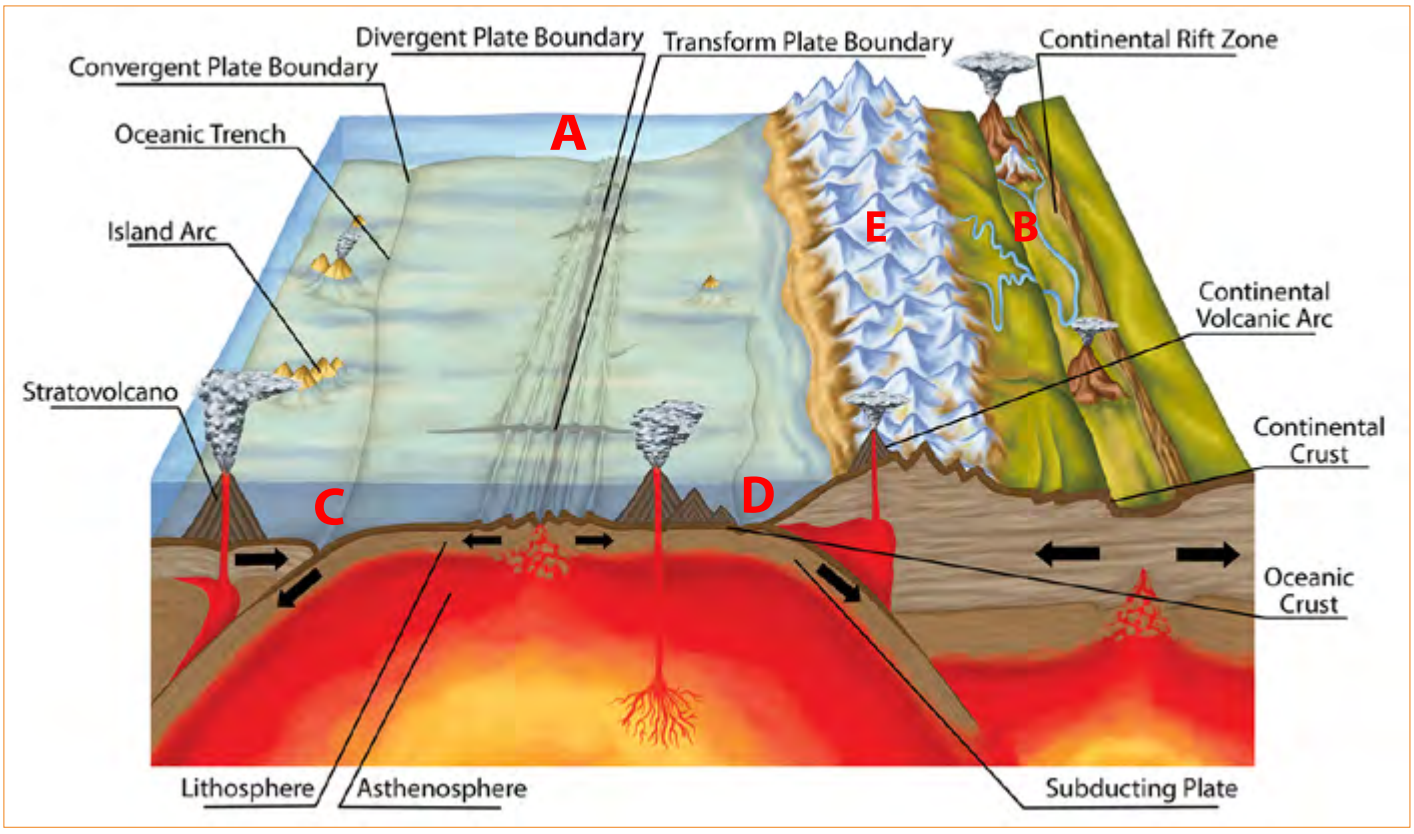
- At **CONVERGENT** boundaries plates collide
  - mountains form where the crust is folded under pressure and forced upwards e.g. Himalayan Mountains
  - trenches and mountains form where an oceanic plate dives beneath a continental plate (this is known as subduction). Crust is destroyed during subduction e.g. Peruvian Trench and Andes Mountains

  * Crust is destroyed on convergent boundaries.

- At **TRANSFORM** boundaries rift valleys and block mountains form when plates move vertically along their boundaries. Eg East African Rift Valley. Plates moving horizontally frequently become stuck resulting in tension building up. Earthquake are common along transform boundaries such as the San Andreas Fault when built up tension caused by plates 'sticking' is released.

  * Crust is cracked and broken at transform boundaries but is not created or destroyed.

SOURCE B: Tectonic processes at plate boundaries

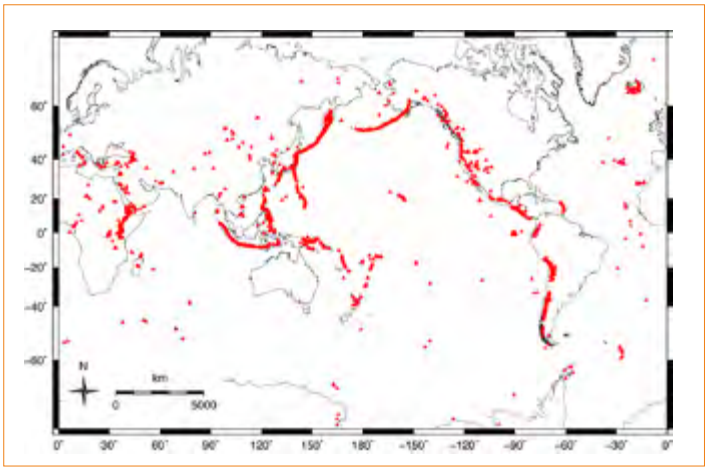


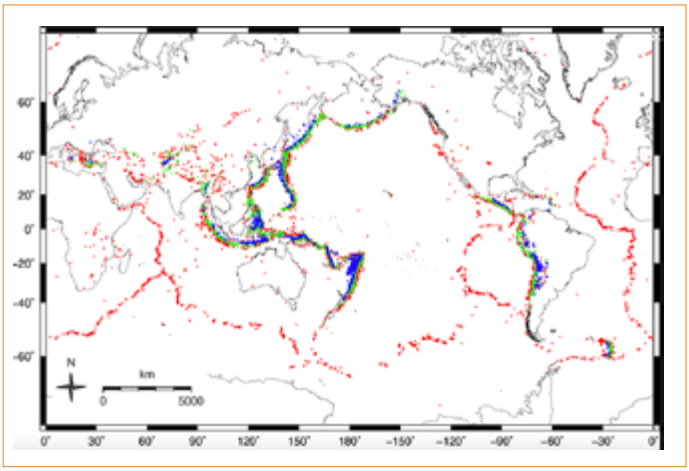
Source: Shutterstock

- **The MID ATLANTIC RIDGE**

  The mid ocean ridge, one of the largest geological landforms on Earth, consists of an underwater mountain range in the Atlantic Ocean running from 87°N to 54°S and rising approximately 3 km above the ocean floor. The ridge is a divergent plate boundary with successive underwater ridges created from magma rising between the tectonic plates. The youngest rocks are nearest to the fault and the combined features extend 1000 to 1500 km wide. There are many transform faults where movements occur sideways or vertically at breaks in the crust. Although mostly underwater there are many volcanic islands of varying size along the ridge including Iceland where many landscapes and landforms are shaped by volcanic and geothermal activity. The ridge, is growing at a rate of about 2.5 cm per year in an east-west direction, widening the Atlantic Ocean in the process.

SOURCE C: Geomorphic hazards at plate boundaries





Source: https://uhlibraries.pressbooks.pub/historicalgeologylab/chapter/chapter01-platetectonics/

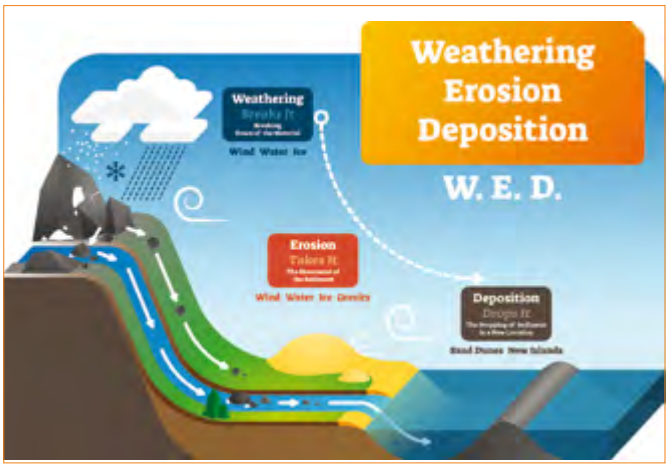
3A This map shows the location of volcanoes that have been active within the past 10,000 years (red triangles).

3B This map shows the locations of all earthquakes with a magnitude greater than 4.5 for the years 2015 and 2016. The colours indicate earthquake depth; red <35 km, green 35-100 km, and blue >100 km.

2. Weathering, erosion and deposition

Weathering, erosion and deposition are the main geomorphic processes transforming the Earth's surface into distinct landscapes and unique landforms.

SOURCE D: Geomorphic processes: Weathering, Erosion and Deposition.



Source: Shutterstock

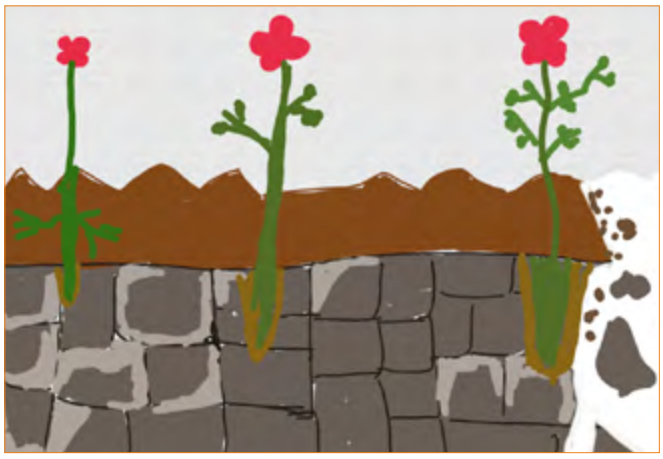
How does weathering shape the land?

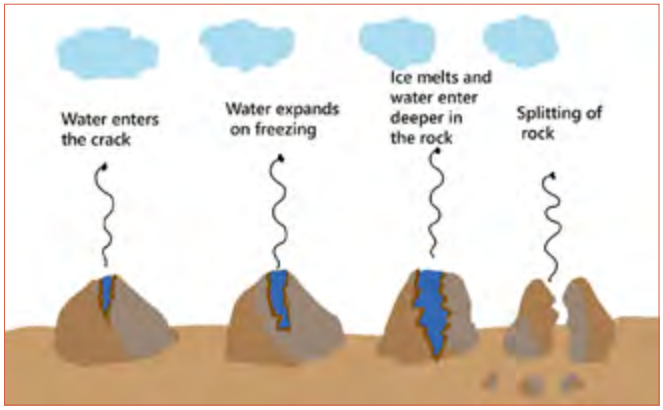
Weathering is the breakdown of rocks or the loosening of surface minerals when exposed to processes caused by climate, chemical reactions, plants and animals. Weathering occurs in place (in situ) and occurs before erosion. Weathered rock is more easily eroded. Physical or chemical processes cause weathering.

Physical weathering processes include the freezing and thawing of water in crevices and joints; the growth of salt crystals; the heating and cooling of surface rock; the action of plant roots and animals.

Chemical weathering occurs when rock minerals react to compounds in the air and water. Some chemical weathering processes include carbonation (a weak acid forms when Carbon dioxide mixes with rainwater) and oxidation (Oxygen reacts to iron in rock).

SOURCE E: How water and plants can physically weather rocks





Source: https://geography-revision.co.uk/gcse/agriculture/coastal-transportation-deposition/

How does erosion shape the land?

Erosion is the natural process of removal and transportation of weathered material from its original location to a place where it will be deposited. **The agents of erosion** include water, ice, wind and gravity. Waterfalls, coastal rock platforms and valleys are formed by erosion.

Moving water collects weathered material with the erosive power of the water increasing with volume and the speed at which it moves. Fast flowing rivers in mountains have more erosive power than slow flowing rivers on floodplains. Glaciers move millions of tonnes of rock to create deep steep sided valleys and waves carve distinctive landform features from rocky headlands on coasts.

Erosion processes include:

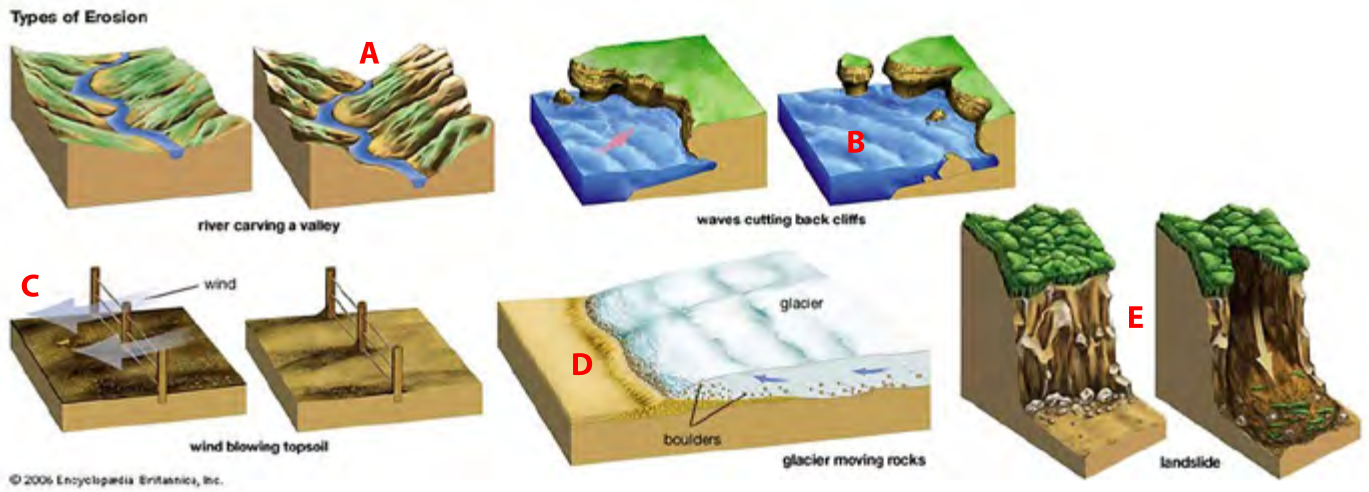
- **hydraulic action** is the physical force of water removing and transporting rock particles and sediment
- **abrasion** is the physical action of rocks and sand transported by water and wind acting like sandpaper to wear away the land
- **attrition** is the physical process of transported rocks colliding and wearing each rock into a smaller, more rounded shape.
- **corrosion** is the chemical process of water dissolving rock minerals and transporting these in solution

Mass movement (mass wasting) is also considered a process of erosion. When weathered rock can no longer resist the force of gravity it falls to a new location at a lower altitude. Gravity transports the rock or sediment downhill.

Landscapes shaped by erosion:

- Fluvial landscapes are shaped by rivers
- Glacial landscapes are shaped by ice
- Mountain landscapes can be shaped by water and/or ice
- Coastal landscapes are shaped by ocean waves and currents
- Arid landscapes are shaped by wind and water
- Agricultural and urban landscapes are shaped by human activities that are influenced by the natural landscape and natural processes.

SOURCE F: Examples of erosion shaping landscapes and landforms



Source: https://www.britannica.com/science/erosion-geology

Fluvial, arid, coastal, karst, mountain and glacial landscapes

These landscapes are recognised by unique features and landforms created by geomorphic processes. It is the landforms that give these landscapes their identity. The vegetation communities and human structures layered onto these features vary globally. The spatial distribution of these landscapes can be mapped at a range of scales because of the common landform features they contain.

How does deposition shape the land?

Deposition occurs when eroded rock particles are dropped in a new location usually after the agent of erosion loses the power to carry the material any further. Glaciers deposit eroded rock known as moraine at the sides and front of the glacier. Rivers deposit sediment when they flow across a flat floodplain. Waves drop sediment on a beach when the water soaks into a beach. Wind moves sand in coastal and desert landscapes to create sand dunes. If dunes are not stabilised by plants dunes will continue to change size and shape over time.

Desert dunes in the Sahara Desert Morocco. L Chaffer

Biotic Landscapes

Some landscapes are recognised by their dominant type of natural vegetation or habitat (biosphere) e.g. rainforest, coniferous (boreal) forest, grassland and tundra. It is the features of the biosphere that give these landscapes their identity, not the underlying landforms. Rainforests for example are found on floodplains and mountains while tundra is found at high latitudes such as the arctic and also at high altitude such as mountain tops above the treeline.

Tundra landscape. Hannes Grobe, AWI - Own work, CC BY-SA 2.5, https://commons.wikimedia.org/w/index.php?curid=2978170

Large coastal dunes in Oregon USA. L Chaffer

Human or constructed landscapes

Some landscapes are recognised by the dominant human activity. These include agricultural, industrial and urban landscapes. These are influenced by the underlying landform features but are not created by them. Sometimes the geomorphic forces that created the landscape can be observed but often these constructed landscapes hide the natural landscape below.

Capetown, South Africa is an urban landscape influenced by the surrounding coastal and mountan landscapes.

Source: Shutterstock

THINK

Can you name one place you know where weathering, erosion and deposition have all shaped the landscape?

SNAPSHOT 2:
Landscape diversity and change

Panorama from the prairies to the mountains in western Canada. L Chaffer

Lorraine Chaffer, Vice President GTANSW & ACT

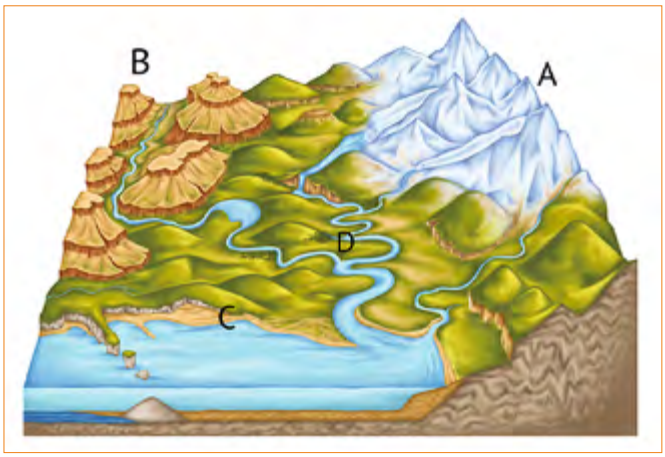
'Shaped and sculpted over millions of years, these stunning landscapes and rock formations hold invaluable clues to Earth's past and future'

http://www.bbc.com/earth/story/20150205-the-15-most-amazing-landforms

The geomorphic processes of weathering, erosion and deposition create a large variety of landscapes and landforms. The processes that form different landscapes and create their unique landforms are largely determined by climate and geology. In the future climate change could influence the geomorphic processes forming and transforming landscapes by changing river flow, melting glaciers and increasing extreme weather events. An understanding of the geomorphic processes that shape landscapes and landform help us to visualise how places looked in the past and predict how they may look in the future.

Topographic maps summarise the features of landscapes using symbols including contour lines to show the relief of the land. When used with satellite and other photographs, maps are powerful tools for investigating landscapes.

SOURCE A Landscape diversity



Shutterstock: GTANSW & ACT Account

SOURCE B: Satellite photo Uluru

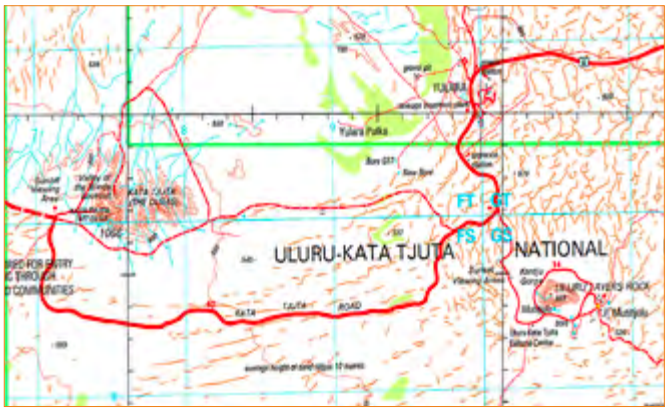
THINK

Imagine how this landscape looked in the past.

Predict what these landforms might look like in the future.

Explain one of your predictions.

SOURCE C: Topographic Map Uluru Kata Tjuta NP



Map: Data.Gov.au Source: https://data.gov.au/dataset/ds-ga-a05f7892-e3e5-7506-e044-00144fdd4fa6/details?q=

Aerial Photo (left): NASA Earth Observatory Source: https://eoimages.gsfc.nasa.gov/images/imagerecords/89000/89288/iss049e010638_lrg.jpg

DESERT LANDSCAPES

Deserts are dry landscapes with large daily (diurnal) ranges in temperature and very little vegetation. The processes of weathering, erosion and deposition shape desert landscapes.

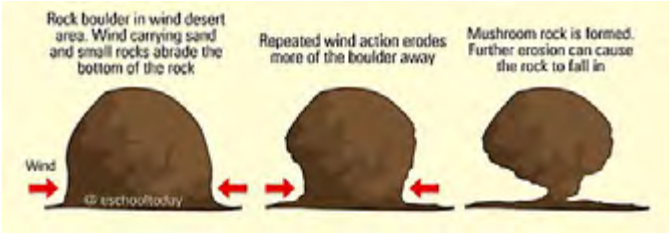
Weathering

Big differences between day and night temperatures cause physical weathering leaving large amounts of broken rock in the landscape. Water plays a role in shaping desert landscapes however wind is the main agent of erosion and deposition.

Wind erosion and deposition

A lack of vegetation allows wind to pick up sand and carry it away, leaving behind rocks that form a reg or rocky desert. This process is called deflation. Wind-blown sand causes further erosion through abrasion or sand blasting creating landforms such as pedestal rocks and arches. Sand is deposited by the wind in another location to form sand dunes in a sandy desert known as an erg.

SOURCE E: Pedestal rock formation



Source: http://www.eschooltoday.com/landforms/erosion-and-landforms.html

Pedestal rock, Arizona, USA

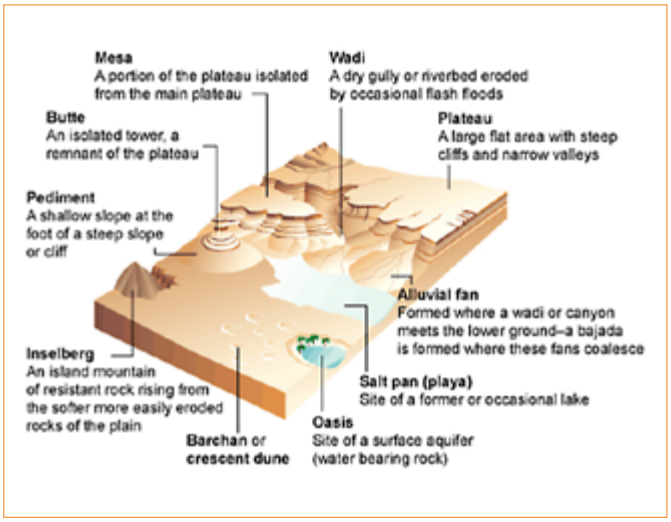
SOURCE F: Monument Valley, USA

Source: Moritz Zimmermann, https://commons.wikimedia.org/w/index.php? curid=166401

Water erosion and deposition

Water erodes plateaus during flash floods, dissecting the landscape with canyons that lead to the formation of mesas and buttes. The eroded rock is deposited as alluvial fans where watercourses leave a plateau. Salt pans (playa lakes) are dry lakes formed when water from floods evaporated and wadis are dry watercourses.

SOURCE D Desert landforms



Source: http://thebritishgeographer.weebly.com/the-physical-characteristics-of-extreme-environments.html

Monument Valley

Monument Valley is a cluster of sandstone buttes reaching up to 300 m above the valley floor on the Arizona–Utah border in the USA in the Navajo Nation Reservation. A large proportion of Monument Valley Navajo Tribal Park (equivalent to a national park) lies within the valley. The buttes show the layers of deposition that created the sedimentary rock and the colour comes from the chemical weathering of the minerals through oxidation. Along with a cultural value to the First Nations people, Monument Valley is an important tourist destination and inspirational landscape.

THINK

Imagine how this landscape looked in the past.

Predict what these landforms might look like in the future.

COASTAL LANDSCAPES

Coastal landscapes form where the land meets the sea and is subjected to physical and chemical weathering, erosion and deposition by wind and water. Salt spray, wind, waves, plants and animals weaken coastal rocks making them more easily eroded. The underlying geology of a coast will influence the landforms that develop with areas of resistant rock forming headlands and areas of weaker rock becoming bays. When headlands are weathered and eroded rocky features such as cliffs, platforms, caves, arches and stacks are left behind.

Rock eroded from headlands and transported by wind, waves and currents is dropped to form depositional features such as beaches, dunes and sand spits. Rivers also provide sand that is deposited on beaches. Dunes form at the back of beaches by wind blowing sand away from the shoreline. Sometimes sand spits and beaches grow across bays and create coastal lagoons such as Terrigal Lagoon and Tuggerah Lakes on the Central Coast of NSW.

SOURCE I: Port Campbell coast

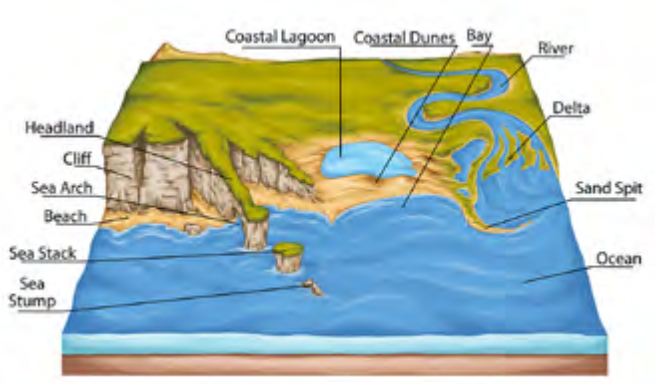
Source: Shutterstock:

THINK

Imagine how the coastal landscape at Port Campbell looked in the past.

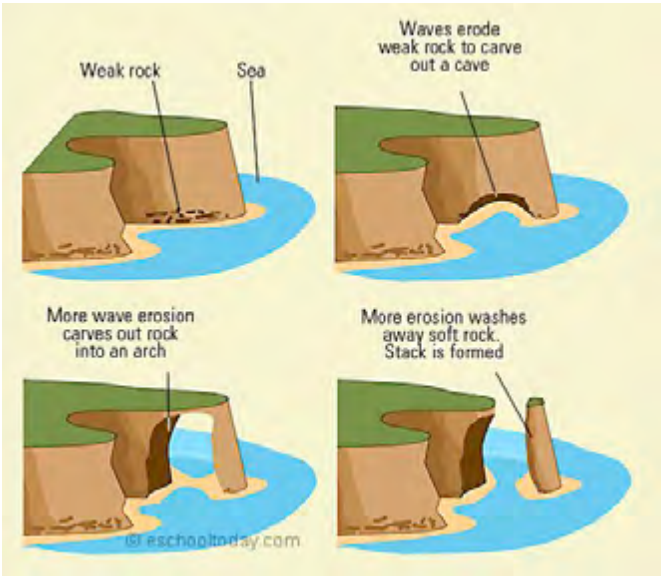
Describe and explain what the landscape might look like in the future.

SOURCE G: Coastal landforms



Shutterstock: GTANSW & ACT Account

SOURCE H: Caves, arches and stacks



Source: http://www.eschooltoday.com/landforms/erosion-and-landforms.html

The Twelve Apostles

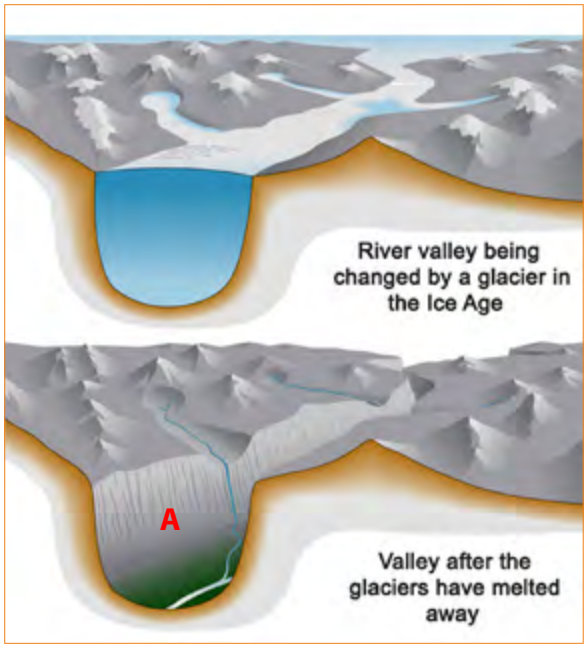
The Twelve Apostles are limestone stacks on the coastline along the Great Ocean Road in Victoria.

These rock formations are the result of weathering and erosion over thousands of years. The soft limestone cliffs easily eroded to form caves, which became arches when caves eroded through a headland. The arches were weakened by continual weathering and erosion until they collapsed leaving stacks behind. The largest remaining stacks measure up to 45 meters in height, although less than eight that remain today. It is estimated that it takes about 600 years for an arch to form in a headland and then a stack before finally collapsing into the sea.

GLACIAL LANDSCAPES AND LANDFORMS

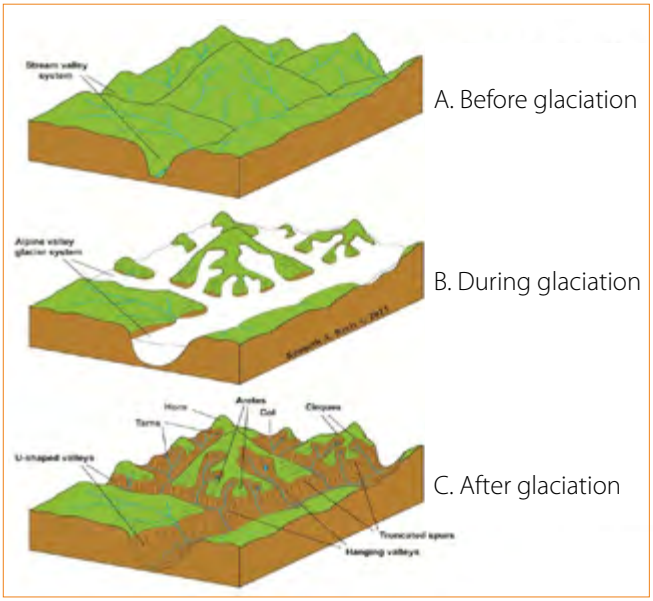
In very cold climates such as Iceland and Canada, snow is the main form of precipitation in winter. The snow accumulates over time to form ice sheets and glaciers which flow slowly downhill, eroding the land. Large continental ice sheets and valley glaciers create distinctive landform features including sharp mountain peaks (horn), narrow ridges (arete), deep u-shaped valleys, hanging valleys and mountain lakes (tarn). Most of these landform features are only visible after a glacier has melted or retreated. Many of the world's glaciers are retreating due to the influence of climate change. The rock eroded by glaciers (moraine) is transported by a glacier within, beside and in front of a moving glacier. When a glacier melts and shrinks back up a valley, the moraine is left behind. Lagoons are created where the moraine traps the melting ice water.

SOURCE K: Glacial U–shaped valley



Athabasca Glacier, Canada. Photo L Chaffer.

SOURCE J: Glacial landscapes



THINK

Predict what the glacial landscapes of Canada and Iceland might look like in the future as the glaciers melt and retreat

SOURCE L: Glacial landscapes in Iceland & Canada

Glaciers and a glacial lagoon in Iceland. Photo L Chaffer.

Icefields Parkway in Canada. Photo L Chaffer.

KARST LANDSCAPES

Karst landscapes are places with a network of caves, sinkholes and rivers below the ground formed by the action of water dissolving limestone rock. Weathering and erosion in these landscapes are influenced by the climate, geology (rock type and jointing) and moving water. After moderate to heavy precipitation, slightly acidic water infiltrates joints in the limestone dissolving the calcium carbonate and joining the groundwater flow. Systems of underground streams, caves, sinkholes and cenotes attract cavers and tourists. Cenotes form at sinkholes where the limestone rock on the surface collapses exposing the groundwater below. In some places, such as the Stone Forest near Guilin in China and Halong Bay in Vietnam, joints in the rocks are gradually widened and deepened creating a jagged landscape of peaks or islands on the land surface.

SOURCE M: Karst landforms

Source: Shutterstock:

SOURCE N: Examples of Karst landscapes

A cenote (sinkhole) in Mexico.
Source: https://www.journeymexico.com/blog/cenotes-in-mexico

Left: Halong Bay, Vietnam

Jenolan Caves

The Jenolan Caves is a complex cave system in the Blue Mountains, NSW. The caves are filled with underground rivers, natural archways, stalactites, stalagmites, columns and straws. Stalactites grow downwards from the ceiling of a cave and stalagmites grow upwards from the ground, both created by drops of water containing dissolved limestone.

According to a Dreamtime story of the Gundungurra people the area was formed by a tussle between two ancestral creator spirits, a giant eel known as Gurangatch and a large native cat known as Mirrigan. Today the caves remain a significant part of Indigenous culture. In the past, the Gundungurra people used the subterranean water, believed have curative powers, to bathe their sick.

THINK

Imagine how these landscapes looked in the past.

Predict what one these karst landscapes and its landforms might look like in the future.

Jenolan Caves, NSW, Australia.Source: https://www.jenolancaves.org.au/the-caves/show-cave-tours~1/river-cave/

RIVER (FLUVIAL) LANDSCAPES AND LANDFORMS

In regions of high rainfall or spring snow melt, water runoff forms into rivers that flow downhill and transform the land into distinct landscapes and landforms. Landscapes shaped by water are also called fluvial landscapes.

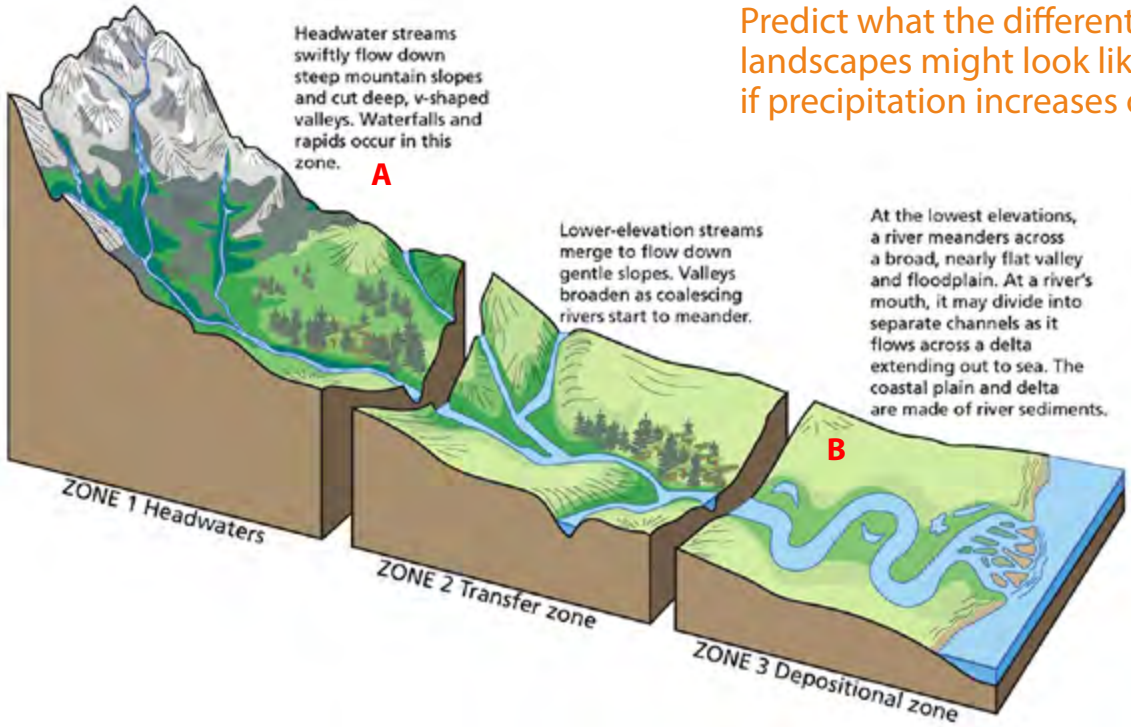
River landscapes transform from source to mouth as rivers change from eroding deep valleys in the mountains to winding across wide valleys and depositing sediment on floodplains and deltas. On floodplains deposition creates floodplains and levee banks while areas of erosion and deposition within a river channel creates meanders and oxbow lakes. Braiding, breaking into multiple channels, occurs where large amounts of sediment fill the river channel where the gradient flattens.

Rivers are often studied in sections which have different landform features:

- Upper Section
- Middle section
- Lower section

River headwaters near Mt Cook, NZ L Chaffer

SOURCE O: A diversity of river landscapes



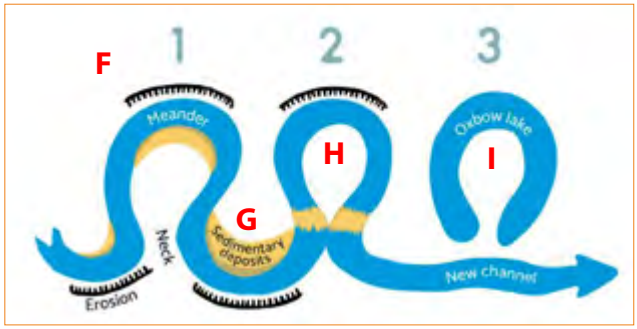
Source: https://www.nps.gov/subjects/geology/fluvial-landforms.htm

THINK

Predict what the different river landscapes might look like in the future if precipitation increases or decreases.

SOURCE P: Floodplain landform – Meandering stream

SOURCE Q: Ox-bow lake formation



Left and above: Shutterstock

SNAPSHOT 3: Meandering Rivers

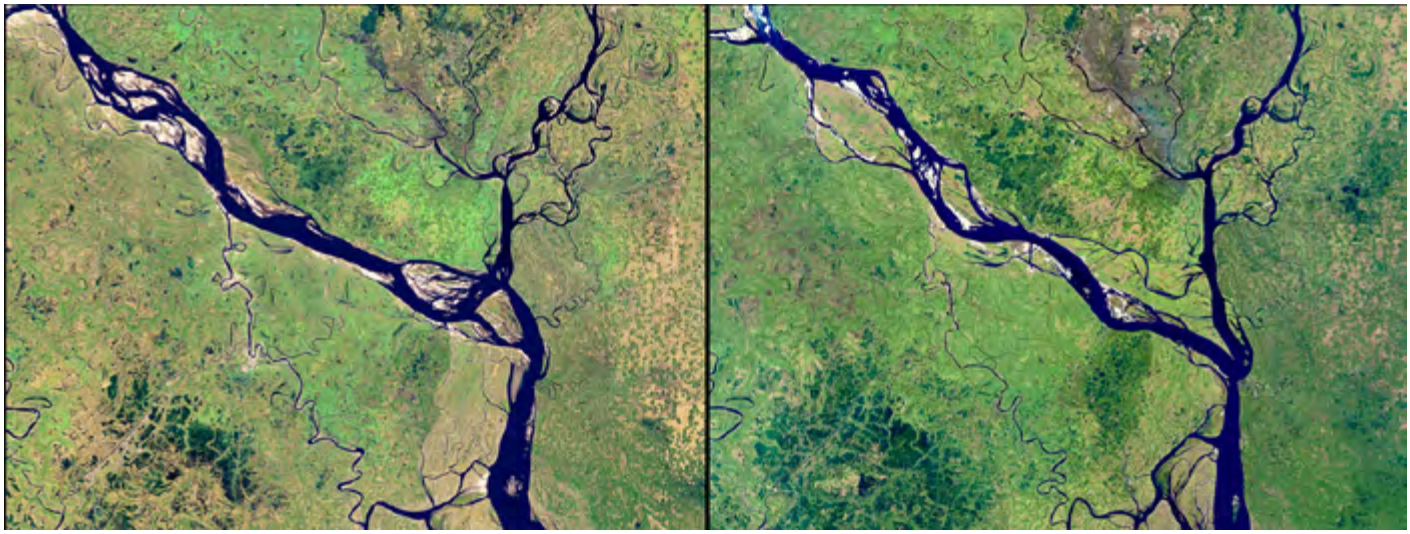
Lorraine Chaffer,
Vice President GTANSW & ACT

Landscapes change over time due to natural geomorphic processes and cycles as well as from human activities.

The Padma River

The size and shape of Bangladesh's Padma River (upper left to lower right) have been changing for decades as seen in these satellite images. The river meanders and straightens, braids and unbraids as the amount of water fluctuates and changing sediment deposits divert the flow. Every year, hundreds (sometimes thousands) of hectares of land erode and fall into the Padma River. Since 1967, more than 66,000 hectares have been lost.

Source A: The Padma River, Bangladesh



https://climate.nasa.gov/images-of-change?id=664#664-changeable-padma-river-in-bangladesh

Over many years, researchers have observed an increase in braiding and sinuosity - the tendency of the river to snake back and forth in an S-shape across its plain. Rivers with high sinuosity are labelled "meandering." Sometimes meandering rivers leave scars where the water once flowed. Each twist and zigzag in the river tell a geologic story about the river.

Meandering rivers can turn into braided rivers, which have numerous channels that split and combine again. Braiding is linked to the amount of sediment a river carries. Where there is a lot of sediment, it piles up in places and diverts the water flow.

Create a meandering River Flipbook

In this activity, you will make a flip book showing the change over time of two different rivers which we can observe using Landsat and other remote sensing instruments.

Follow the steps to create your own time series of Peru's meandering Ucayali River.

Colour-in the line art of Bolivia's Mamoré River on the back of the flipbook.

FLIPBOOK DIRECTIONS

Print out the Flipbook PDF.

Cut along the dotted lines. For best results, cut pages individually, do not stack.

Put images in order and align the images on right edge.

Secure with binder clip and have fun flipping through time!

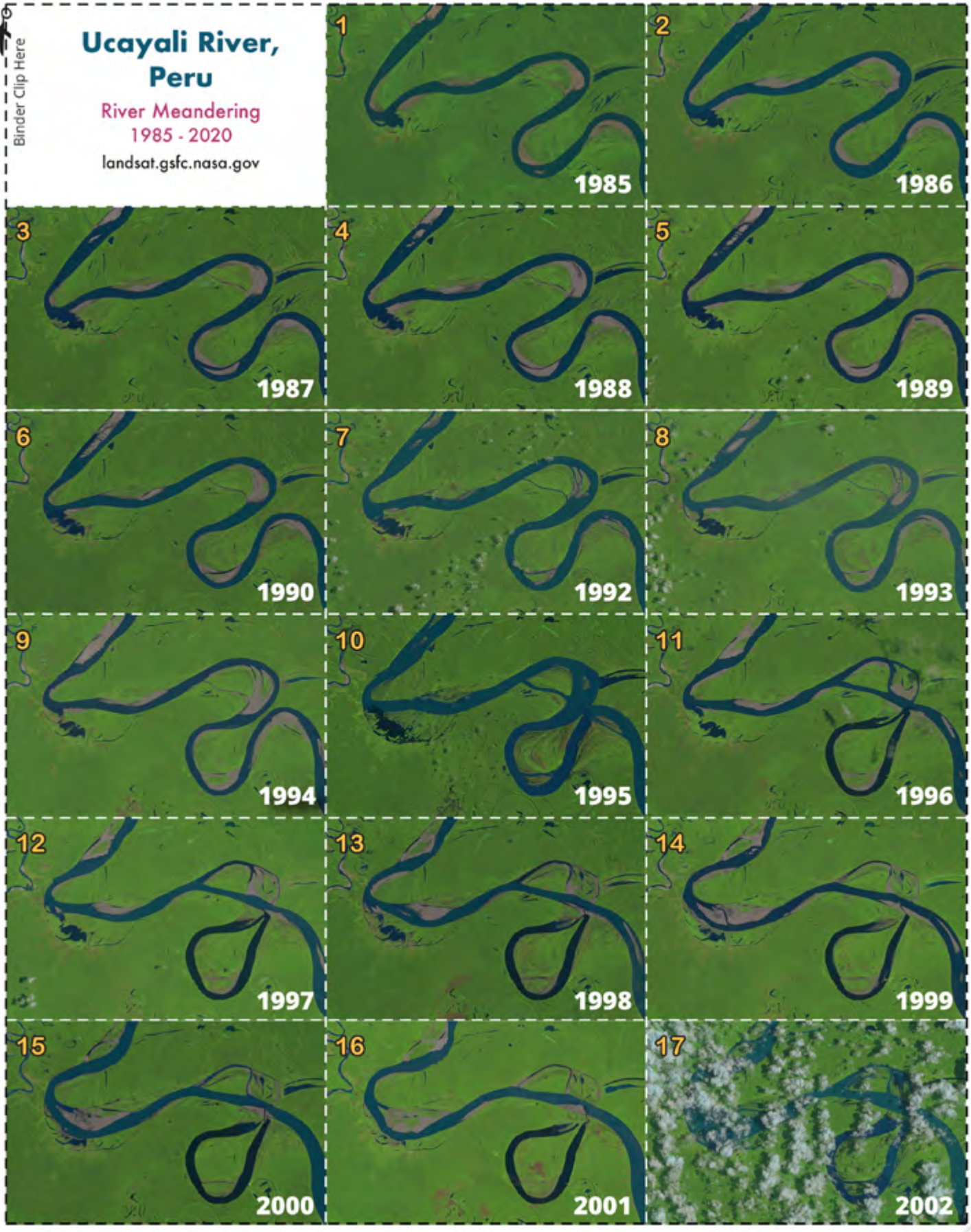
Like a sinuous snake slithering over the landscape, rivers twist and turn to release energy as they journey to the sea. Make your own data visualization of the Ucayali River as it meanders through Peru.

Binder Clip Here

Ucayali River, Peru

River Meandering
1985 - 2020

landsat.gsfc.nasa.gov



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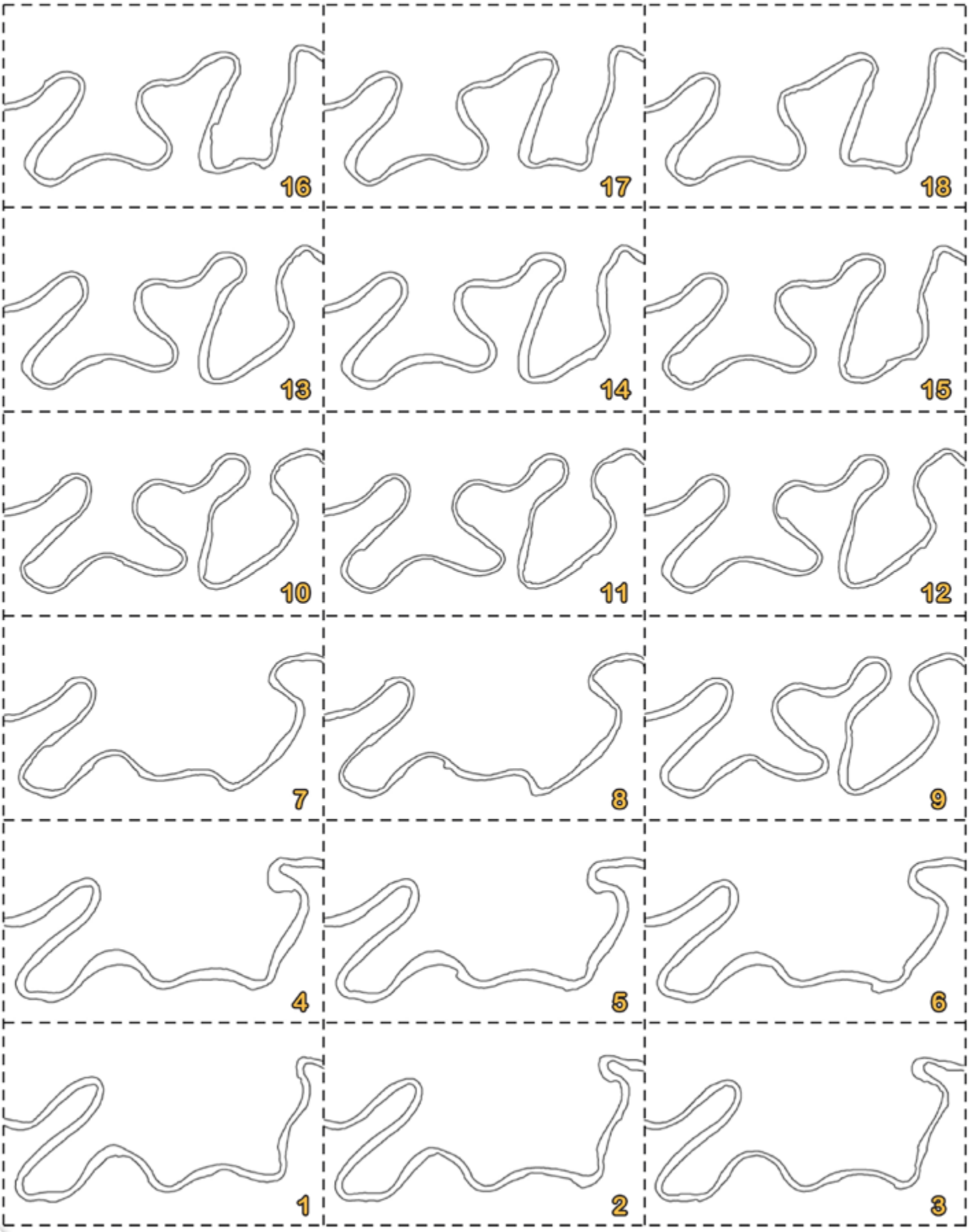

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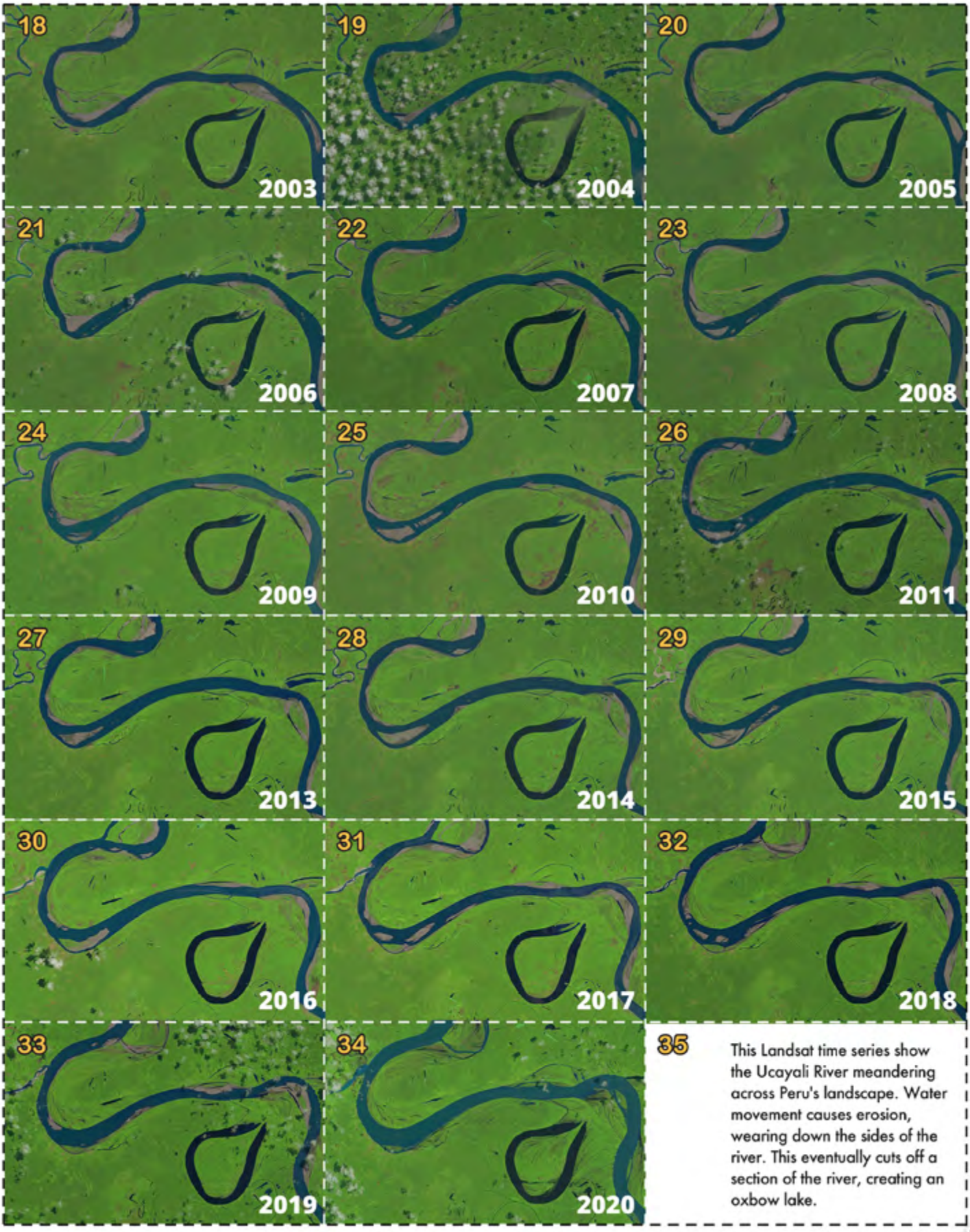
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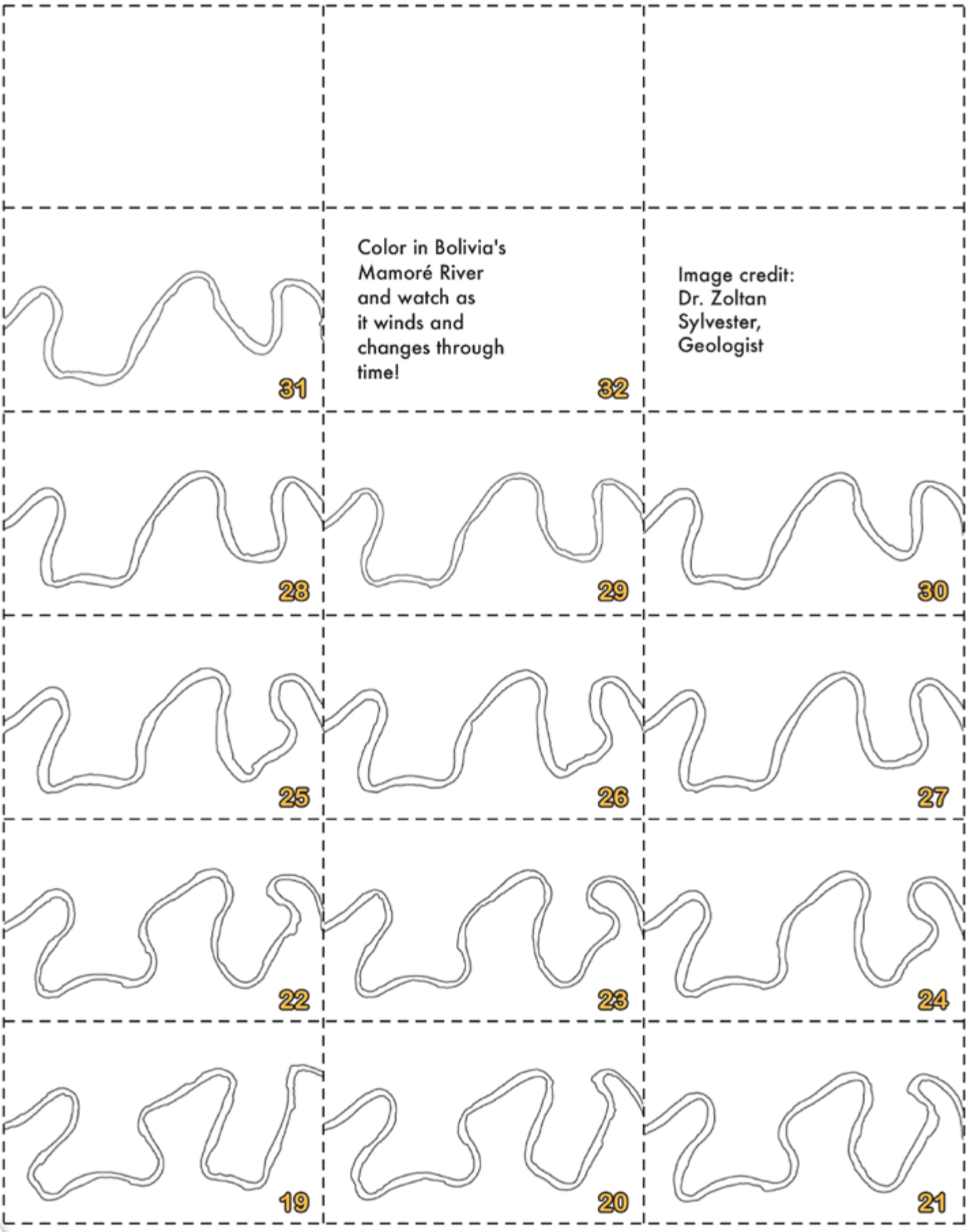
This Landsat time series show the Ucayali River meandering across Peru's landscape. Water movement causes erosion, wearing down the sides of the river. This eventually cuts off a section of the river, creating an oxbow lake.
3


Color in Bolivia's Mamoré River and watch as it winds and changes through time!
Image credit: Dr. Zoltan Sylvester, Geologist
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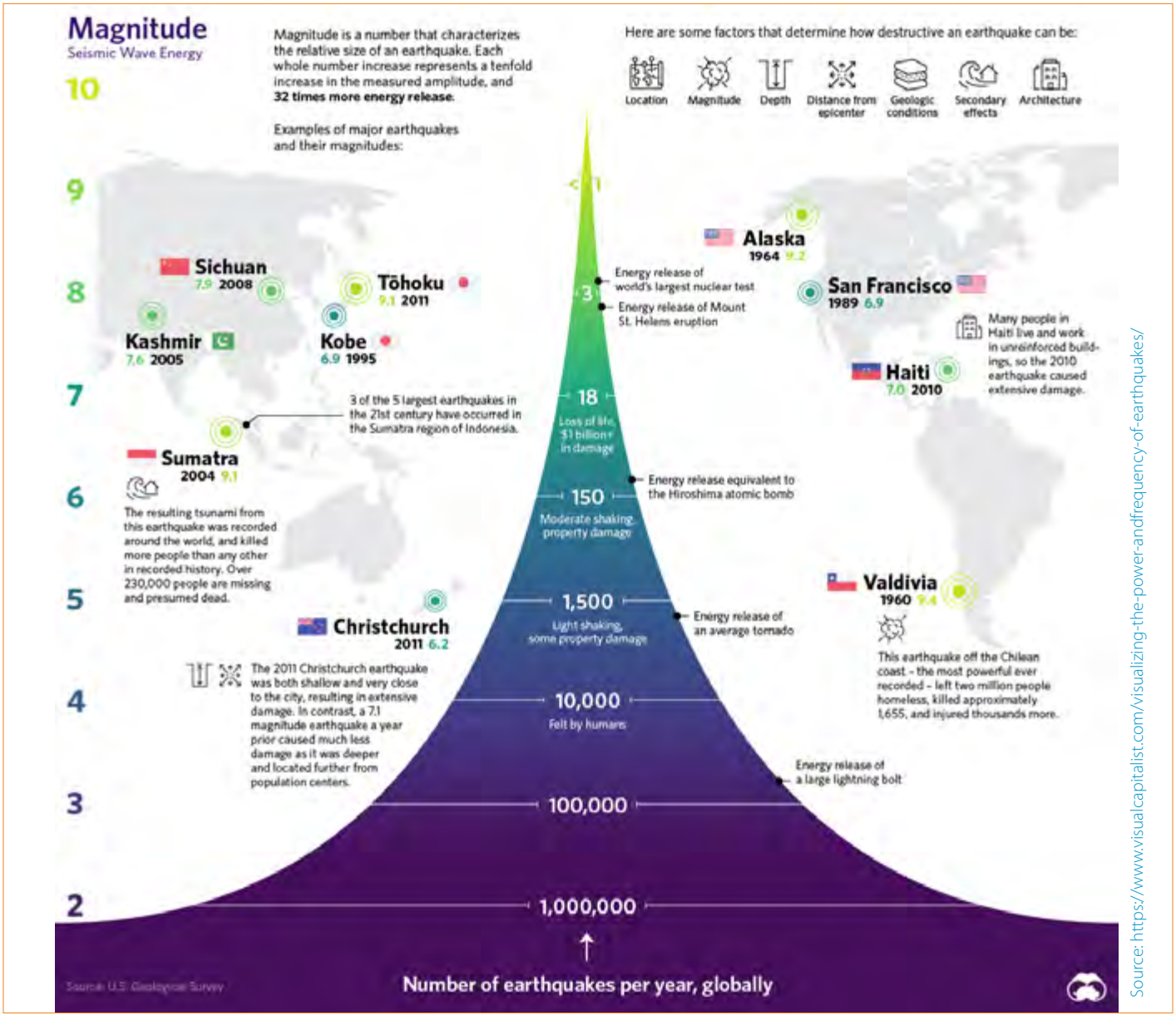
SNAPSHOT 4: Earthquakes

Visual Capitalist www.visualcapitalist.

Earthquakes occur because the crust of the Earth is made up of several plates. The boundaries of these plates create faults. Earthquakes describe both the mechanism that causes a sudden stress release along plate boundaries and ground shaking. They occur when stress builds up along a tectonic fault. This stress causes the two surfaces of the fault, which had previously been stuck together due to friction, to suddenly move, or slide, releasing energy in the form of seismic waves

Diagram: Earthquake magnitude



Magnitude and intensity

Magnitude is a number most commonly associated with the Richter scale, describing the size of an Earthquake on a scale from 0 to 10. Each increase by one on the scale represents a tenfold increase in the amplitude. Another way to measure the size of an earthquake is by how much energy it releases. The amount of energy radiated by an earthquake is a measure of the potential for damage to man-made structures.

Intensity describes the severity of an earthquake with a qualitative evaluation of its effects on the Earth's surface and on the built environment. An earthquake may have a high magnitude but if a city or landscape experiences little damage, it can be said that the intensity is low. **The Modified Mercalli Intensity Scale** measures this intensity.

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

Canada 1: Major landforms, geomorphic processes and geomorphic hazards

Lorraine Chaffer, Vice President GTA NSW & ACT

NOTE: this is a condensed and adapted version of an article published in the Geography Bulletin: Vol 47, No 4, 2015

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

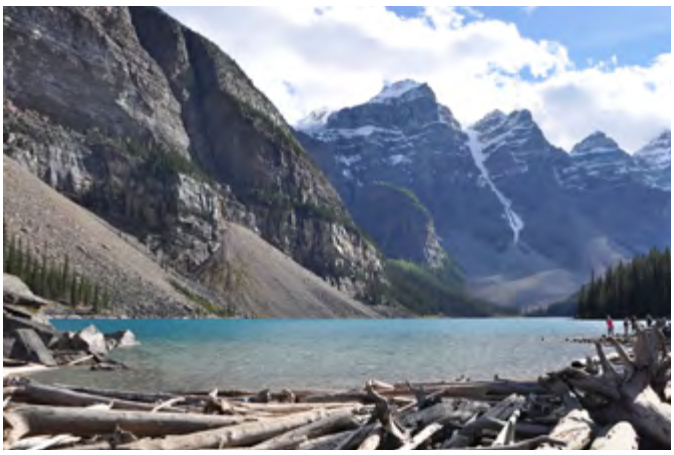
Landscape: An area created by a combination of geological, geomorphological, biological and cultural layers that have evolved over time eg riverine, coastal, urban.

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

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

Source A: Canada has a diversity of landscapes and landforms



Above: Moraine Lake Image: L Chaffer

Prairies of the interior plains in Sasckatchewan Image: Kjfmartin. Source: https://commons.wikimedia.org/w/index.php?curid=11278035

What do you know about Canada?
Take the Quiz in Student Activity 1

Source B: Major landform regions of Canada by elevation

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

CANADA: FACTS

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

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.

Source C: Major landform divisions of Canada

Source: https://s-media-cache-ak0.pinimg.com/originals/24/41/58/244158288c85fc9d493773cdd8ccda07.jpg

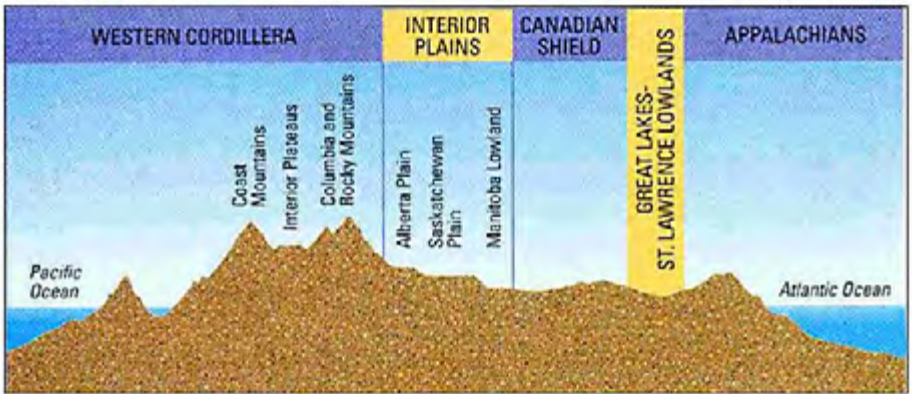
What do you know about global plate tectonics?
Check your understanding in Student Activities

CANADA'S MAJOR LANDFORM

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

Landforms and geomorphic processes

1. **Mountains and highlands** to the west, east and north vary in age and characteristics. They include:
   - **The Western 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. This landform region is covered by ***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.
   - **The Canadian Shield:** covers almost half of the country. The landscape consists of hills and plateaus 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. The Canadian Shield has vast minerals resources including emeralds, diamonds and copper but is mainly unsuited to farming.
2. **Lowlands and plains** formed by **glacial erosion** 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.
3. **The Canadian Arctic Archipelago** refers to the 36,000 islands such as Baffin and Ellesmere to the north and on the edge of the Arctic Ocean . Landforms include the Arctic and Hudson Bay tundra covered lowlands and permanently snow capped mountains



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). This plate movement created the coastal mountains 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 **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 British Columbia's (BC) 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 changed 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.

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 (Source J) and human activities are earthquake triggers and can contribute to tsunamis in coastal areas.

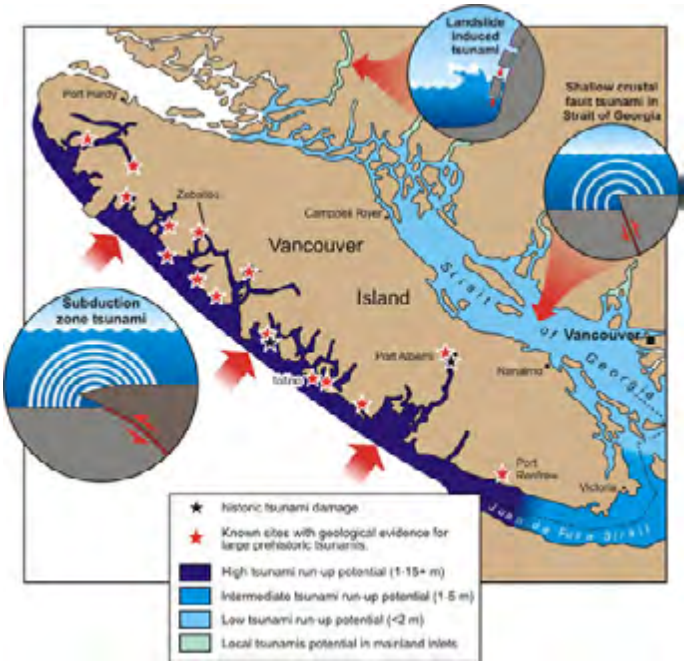
One contemporary geomorphic hazard including causes, impacts and responses

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

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

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

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

Image: L Chaffer

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

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

Canada 2: Unique landforms and geomorphic processes

Spirit Island in Maligne Lake, Jasper National Park, Alberta, Canada (Part of the Canada Parks World Heritage Area). Image: L. Chaffer

Lorraine Chaffer,
Vice President GTA NSW & ACT

NOTE: this is a condensed and adapted version of an article published in the Geography Bulletin: Vol 47, No 4, 2015

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

Glaciated landscape: shaped by the action of icesheets and glaciers

Fluvial landscape: shaped by the action of a stream or river

Volcanic landscape: shaped by tectonic forces in Earth's crust that cause volcanic eruptions

INTRODUCTION

The geomorphic processes of weathering, erosion and deposition by water and ice are responsible for the development iconic landscapes and their distinctive landforms in Canada, including the Columbia Icefields, the Great Lakes and Niagara Falls, Lake Louise and the Maligne and Fraser Canyons. These landscapes and landforms, along with the volcanic mountains, created by tectonic plate movements, hold important aesthetic, spiritual, cultural and economic value.

GLACIATED LANDSCAPES AND LANDFORMS

During the Pleistocene era the Laurentide Ice Sheet (Source A) covered most of Canada and northern USA. In parts of Central Canada the ice sheet was up to 3 km thick. Over time, the actions of the ice sheet and mountain glaciers left behind rugged mountain ranges, spectacular glaciated valleys and waterfalls, extensive plains and lake systems that making Canada **the most glaciated country in the world**. The last remains of the Laurentide Ice Sheet are the Barns Ice Cap and glaciers on Baffin Island in Canada's far north.

Can you name any unique landforms in the world created by glaciers, rivers and volcanic activity?

Source A: The extent of the ice sheet covering North America in the Pleistocene Era

Source: http://serc.carleton.edu/eslabs/climatedetectives/3.html

Icefields, glaciers, lakes and waterfalls

In western Canada**,** where the Rocky Mountains separate Canada's west coast from the interior plains thousands of glaciers and icefields are features of the mountain landscape. Melting snow and ice feed large river systems that cross the country and empty into oceans to the north, east and west. These rivers erode through mountains, plateaus and glacial sediments to create their own distinctive landform features.

The Columbian Icefield is one of Canada's most famous landscapes, covering an area of 325 square kilometres with ice to a depth of 100 to 365 metres. Up to 7 meters of snow falls here each year enhancing its aesthetic value. Millions of tourists visit the icefield and the spectacular landforms in Jasper National Park including:

- Glaciers e.g. Athabasca Glacier
- Mountain peaks, U shaped valleys, waterfalls, lakes and rivers fed by snow and glacial melt.
- Braided rivers – many channels as they erode through tonnes of glacial debris.

The Athabasca Glacier from the Icefields Parkway Visitors Centre. Image: L Chaffer

Tourists on the Athabasca Glacier. Image: L Chaffer

Values

Canada's spectacular glaciated landscapes and landforms attract millions of visitors each year for their aesthetic and spiritual value and are an economic asset because of the income they generate in states such and Alberta and British Columbia. Glaciers also have environmental value as indicators of environmental change and as water sources for many river systems. National Geographic ranks the Icefields Parkway and its landscapes among the top scenic drives in the world.

Lake Louise in Banff National Park was created when a natural dam of glacial debris trapped snow and glacial meltwater water to back up and form a lake. The lake feeds into the Bow River an important east flowing river and source of water on Canada's interior plains. Other glacial lakes are formed high in mountains where glaciers carved hollows, which later fill with water. These are known as **cirque lakes**.

Lake Louise is an iconic Canadian landform of glacial origin . Image: L Chaffer

Landslides also dammed rivers creating lakes such as Maligne Lake in Jasper National Park and Moraine Lake in Banff National Park.

The turquoise coloured water in Canada's mountain lakes and rivers is caused the presence of moraine flour deposited by snow and glacial melt. Over time glacial lakes will fill with debris currently being weathered and eroded by glaciers and water high in the mountains above.

Tourists flock to Lake Louise for the landscape and the adventure activities the landscape offers such as hiking, skiing, kayaking and photography.

The Great Lakes and Niagara Falls

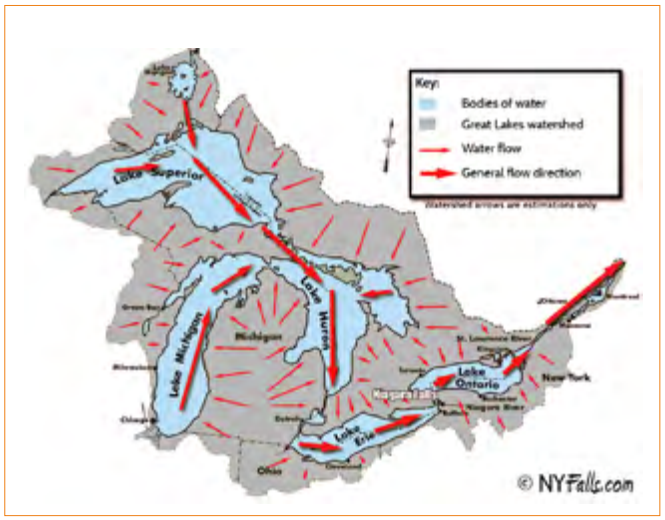
The Great Lakes, a series of five interconnected lakes (Superior, Michigan, Huron, Erie and Ontario) on the border of Canada and the USA, were formed by ***retreating ice sheets*** that carved large basins into the land that filled with glacial meltwater. Water from the lakes then eroded a passage through the Niagara escarpment where a resistant layer of rock created the three waterfalls (Horseshoe, American and Bridal Veil Falls) that combine to form **Niagara Falls**.

The lakes are the largest freshwater basin in the world with a fifth of Earth's freshwater, and two thirds of this water flows over Niagara Falls each year. From the falls, water travels to the Atlantic Ocean via Lake Ontario and the St Lawrence River. Water erosion continues to sculpt the falls causing them to change shape and move upstream. In 12,000 years the falls migrated approximately 11km upstream leaving a deep gorge below. Snow and ice remain an important influence on Great Lakes landscapes and landforms. (Source B)

Niagara Falls

Niagara Falls provides inspiration for travelers, creatives (artists, authors and filmmakers) and residents. The aesthetic and social values of the falls led to efforts to reduce threats from industrial and commercial exploitation like withdrawal of water for hydroelectricity. Laws have been used in the past to restrict the amount of water diverted from the falls and erosion control strategies such as strengthening the rocks at the top of the falls have been implemented to reduce erosion and ensure the safety of visitors.

Source B: The Great Lakes and Niagara Falls



Source: http://nyfalls.com/niagara-falls/faq/

Source C: NASA satellite image of The Great Lakes

Source: http://visibleearth.nasa.gov/view.php?id=54379

Source D: Niagara Falls

Source: http://www.niagarafallslive.com/images/pano2.jpg

Does Australia have any large waterfalls? If yes, where are they? Suggest possible reasons for differences between Australia and Canada.

FLUVIAL AND KARST LANDSCAPES AND LANDFORMS

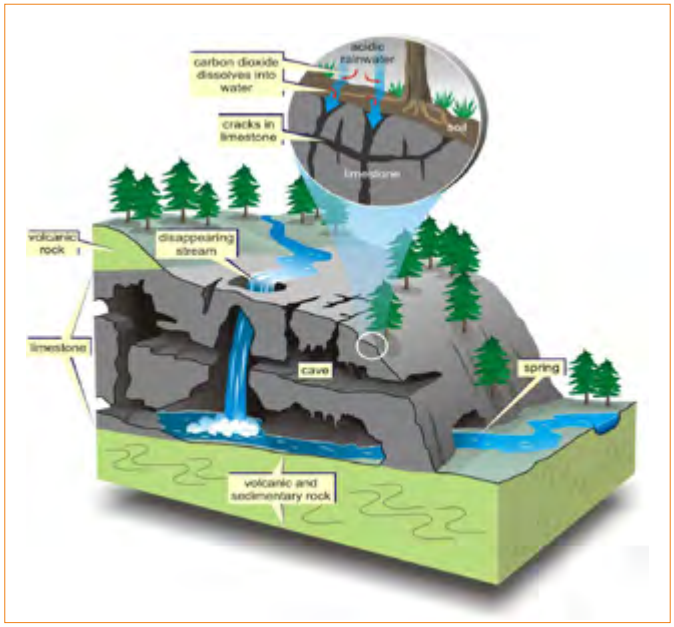
Water is the main agent of erosion and deposition responsible for the formation of landforms across much of modern day Canada including valleys, canyons, caves, waterfalls, lakes, floodplains and deltas. In places the erosion is influenced by past glaciation and tectonic activity as well as the type of rock present. Most of Canada's canyons are recent additions to the landscape formed since the departure of glaciers. As ice melted, large amounts of water with high erosive power was released creating deep narrow canyons. Karst landscapes and landforms resulted where carbonate rock such as limestone dissolved in water to leave caves, underground rivers and deep canyons (Source E).

The Fraser Canyon is an 84 km canyon formed by the **Fraser River** as it cut through the interior plateau and Coast Mountains on its journey from the Rocky Mountains to the sea. The past volcanic history of the landscape can be seen in lava flows present in cliffs along the canyon. The Fraser River emerges from the canyon slightly above sea level but over 100 km inland then winds its way to the Pacific coast near Vancouver depositing sediment on a large floodplain and delta.

Fraser Canyon in British Columbia

Does Australia have Karst landforms?

Source E: Karst landscapes and landform



Maligne River, Maligne Canyon and Medicine Lake

Maligne Canyon formed from a hanging glacial valley, when a smaller glacier melted to leave a valley high above the main floor of the retreating Athabasca Glacier. The Maligne River carved quickly downwards to reach the lower level of the main valley leaving a deep narrow canyon.

The Maligne River formed from meltwater from the surrounding mountains, flows into and out of Maligne Lake (a large glacial lake created by a natural moraine dam), enters ***Medicine Lake*** and then disappears underground for 14 km before reappearing in a 55 metre deep canyon.

The underlying limestone rock is easily dissolved in the rapidly flowing and swirling water creating caves, underground channels and large potholes. Marine fossils in the limestone provide evidence that these rocks formed when covered by ocean water before being lifted by tectonic activity.

Maligne Canyon is an example of a Karst landscape

Karst and cave experiences, such as caving, attract an increasing number of visitors to Canada each year. Vancouver Island attracts more than 55 000 visitors annually to its Horne Lakes Caves Provincial Park.

The Badlands, on the interior plains to the east of Calgary in Alberta, is one of the most interesting depositional and erosional landscapes in Canada. Unusual rock formations, known as Hoodoos, were created by river erosion and wind over 70,000 years ago. The layers of sedimentary rock formed millions of years before the hoodoos were created contain dinosaur fossils that still being uncovered by archeologists today. Specimens of every group of cretaceous dinosaurs have been found here including those of 35 species dating more than 75 Million years ago. The site is now a part of Dinosaur Provincial Park World Heritage Area.

Hoodoos in Canada's Badlands landscape

Source: http://interiorplains.weebly.com/location-and-landscape.html

Source F: Hoodoo Mountain (1,850 m) in British Columbia is a volcano that formed beneath a glacier but since exposed by retreating ice.

Source: http://www.bcmag.ca/British_Columbias_18_Sleeping_Volcanoes

VOLCANIC MOUNTAINS

Mountain landscapes in Canada been shaped by **volcanism**. Western Canada is on the **Ring of Fire zone** of earthquake and volcanic activity circling the Pacific Ocean. Over 100 volcanoes are located in western and northern Canada, mostly in remote locations, and are less active than those in other Pacific countries. Some volcanic mountains formed beneath glaciers and were exposed when ice retreated. Mount Garibaldi (2,678 m), just 66km north of Vancouver, is the youngest volcano in Canada and most likely to become active in the future. (Source G).

Source G: Volcanic mountains in British Columbia

Source: http://plate-tectonic.narod.ru/volcanoam10bphotoalbum.html

Are there volcanic landscapes in Australia? If yes, where are they and what do they look like?

Waterton Lakes National Park, Peace Park and Biosphere reserve is an region of stunning beauty and diversity. Source: https://en.wikipedia.org/wiki/Waterton_Lakes_National_Park#/media/File:Pano14.jpg

Canada 3: Landscape values and protection

Lorraine Chaffer,
Vice President GTA NSW & ACT

NOTE: this is a condensed and adapted version of an article published in the Geography Bulletin: Vol 47, No 4, 2015

LANDSCAPE VALUES AND PROTECTION

The aesthetic, spiritual, cultural and economic values of Canada's landscapes, landforms and biomes are evident in the images and example contained in this article. These values are managed and protected in a system of protected forty-four national parks and park reserves. Parks Canada's first priority is the protection the natural and cultural heritage. The parks system includes representative areas for key landscapes and biomes.

- **National Parks** – a system of 44 representative natural areas of significance in every province and territory. The parks are managed for public enjoyment without compromising the area for future generations, and include the management of wildlife and their habitats eg. Banff National Park. Park management recognises and incorporates indigenous knowledge and the unique relationship of First Nations people with the land.
- **World Heritage Listing** – that recognises sites of natural and cultural significance. For example the national parks of Banff, Jasper, Kootenay and Yoho and three provincial parks are listed as the ***Canadian Rocky Mountain Parks World Heritage Site*** for the following reasons.
  - Natural beauty and biological diversity including landscape features such as mountain peaks, glaciers, lakes, waterfalls, canyons and limestone caves
  - Representation of significant and on-going glacial processes.

How does Australia protect it's valued landscapes and landforms?

- **Wildlife protected areas** fall into two categories:
  - *National Wildlife areas* (46 Marine and terrestrial sites) to protect wildlife and wildlife habitat
  - *Migratory Bird Sanctuaries* (92 sites) to protect and conserve migratory birds and their nests.

There are146 sites protecting many of Canada's important wildlife habitats. Since 1990, the overall protected area in Canada has doubled to nearly 10% of land.

The ***Dinosaur Provincial Park*** is listed for its natural qualities including the unique badlands landscape and fossil site. The park also protects the prairie grasslands on the site.

The unique ***Waterton-Glacier International Peace Park*** includes the ***Waterton Lakes National Park*** in Canada and the Glacier National Park in the United States. Both parks are declared Biosphere Reserves by UNESCO as a World Heritage Site to preserve the unique mountains, prairie, lakes and freshwater wetlands. Landscapes and habitats protected in the bio-sphere reserves include prairie grasslands, alpine tundra biosphere and forests.

Canada's National Parks

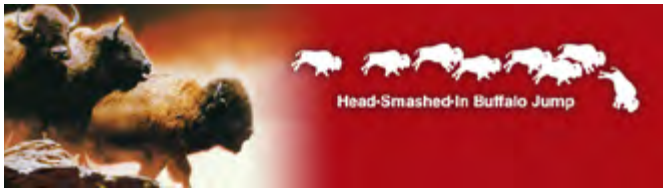
Source: http://www.cbc.ca/news2/interactives/map-canada-parks/

Canada's World Heritage Listed sites

Source: http://www.pc.gc.ca/eng/progs/spm-whs/sec02.aspx

The Canadian Rocky Mountain Parks World Heritage Site and *National Park Status* recognise the aesthetic, spiritual and environmental values of this mountain landscape above Lake Louise.

The aesthetic, spiritual and economic value of Canada's landscapes, landforms and biomes is reflected in the thousands tourists travelling Canada in RV's every year.



The ***Head Smashed In Buffalo Jump*** cultural listing recognises the cultural significance of a site where, for hundreds of years, Blackfoot hunters drove stampeding bison off the edge of a cliff and into the rocks below. This cultural listing is one of the world's oldest, largest, and best-preserved buffalo jumps where the foothills of Canada's Rocky Mountains meet interior plains. The site contains the cliff, the remains of butchering camps, buffalo trails and an accumulation of bones that recognises the understanding of topography and bison behaviour that enabled native people to hunt bison (buffalo).

The *Head Smashed in Buffalo Jump* World Heritage Listing recognises and protects the cultural values of this cliff landform, prairie landscape and cultural heritage

All photos L. Chaffer

SNAPSHOT: Concepts and connections

Lorraine Chaffer,
Vice President GTA NSW & ACT

THE ROLE OF WATER

Water is a link to every topic in Geography Stages 4–6 Water:

- is essential to life on Earth
- connects people, places and environments through the water cycle and water based activities activities such as trade, tourism and the production and consumption of goods and services
- is an agent in the geomorphic processes that shape landscapes and landforms
- influences the liveability of places
- contributes to human-well being and quality of life
- is a climatic factor that determines the distribution and productivity of Earth's biomes, and their capacity to produce food .
- is affected by climate change and human modifications to landscapes, biomes and environments.
- is a natural resource impacted by population growth and human activities
- causes political conflict and population movements
- influences types and patterns of economic activities such as agriculture and tourism.
- has cultural, spiritual, economic, environmental and aesthetic values to people

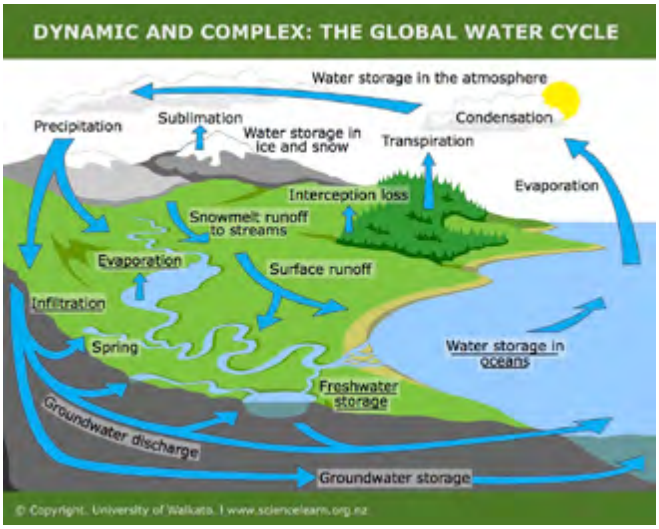
The hydrological (water) cycle

A catchment is an area where water is collected by the natural landscape. Water moves through a catchment via the processes of the water (hydrological) cycle. As it moves water connects people, places and environments. For example, in a catchment, water that falls as rain on higher land will travel through different environments such as forests, rivers and wetlands and be used by people for a range of activities such as agriculture and drinking water as it travels above and below the surface towards the ocean.

'The water cycle is one of the largest physical processes on earth, with the earth's water used over and over again'

Water NSW

SOURCE A: The Water Cycle



Source: https://en.wikipedia.org/wiki/Water_cycle#/media/File:Diagram_of_the_Water_Cycle.jpg

Water Cycle processes

The key processes changing the state and location of water are:

- evaporation
- condensation
- precipitation
- infiltration
- runoff

Understanding hydrological processes is essential to effective and sustainable management of places, environments and human activities.

Global water cycle

At a global scale the amount of water stays basically the same year after year and there is a balance between evaporation and precipitation. Evaporation and precipitation occur all over the earth, continuously and at the same time.

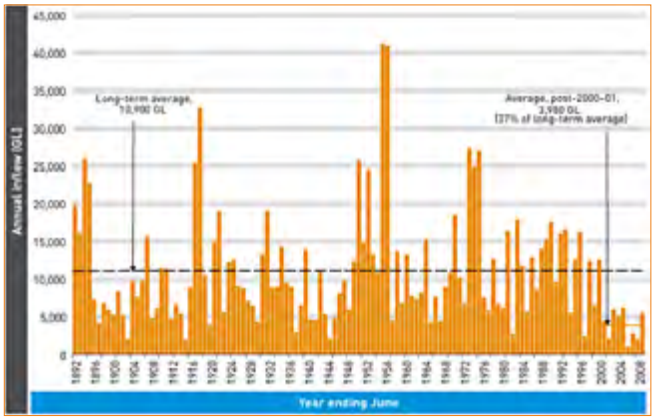
Water cycle in a catchment

The amount of water in a catchment (also known as a watershed or drainage basin) changes over time. Water is gained or lost via wind and clouds as water vapour and water droplets. People live in catchments and rely on the available water resources which could include rivers, wetlands and groundwater. Sometimes water needs to be transferred from other catchments by pipelines to satisfy demand. Natural environments in a catchment also rely on its water resources

SOURCE B: Features of a catchment

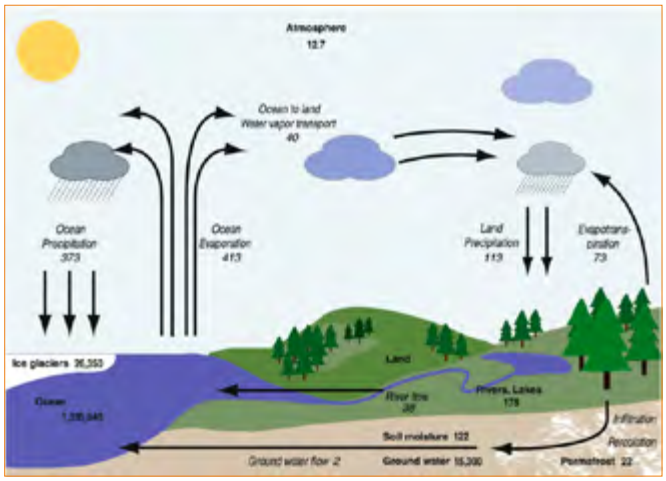
Rainfall variability refers to natural changes in annual precipitation. Australia has very high rainfall variability. Large variations can result in droughts and floods.

SOURCE C: Yearly rainfall variability in NSW



Source: https://www.mdba.gov.au/sites/default/files/archived/annualreports/2009-10/chapter3-2.html

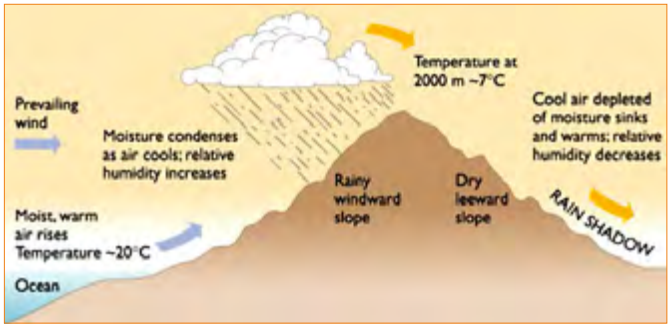
SOURCE D: The Global Water Cycle



Factors influencing how the water cycle works in a catchment particularly precipitation include:

- altitude and topography
- latitude and distance from the sea
- ocean currents and circulations
- air pressure and wind direction

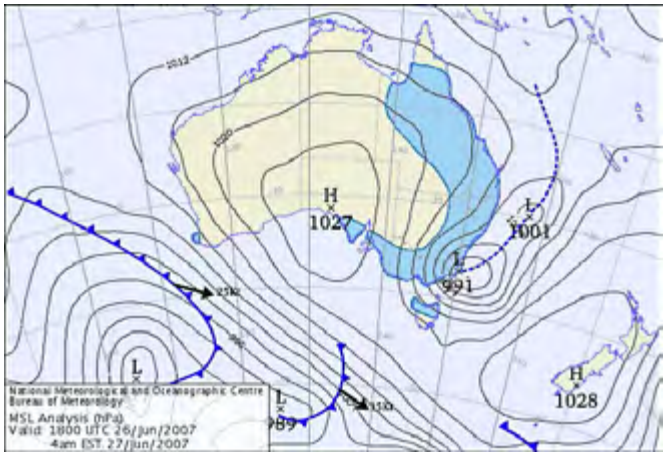
SOURCE E: Altitude, topography and rain



Source: https://studylib.net/catalog/Science

Orographic rainfall forms as air rises over mountains and a rainshadow tends to develop as air descends the other side.

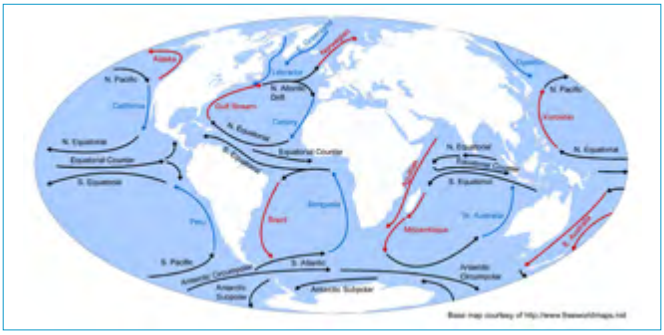
SOURCE F: Low air pressure and rain



Source: http://www.bom.gov.au/nsw/sevwx/facts/events/june-07-ecl/

Low pressure is associated with unstable (rising) air and creates the chance of precipitation occurring. As air rises it cools and water vapour condenses. This can result in result in precipitation. Each year, East Coast Lows bring heavy rain to the NSW coast. High pressure is associated with stable (sinking) air. When air sinks it becomes warmer and is less likely to form clouds and bring precipitation.

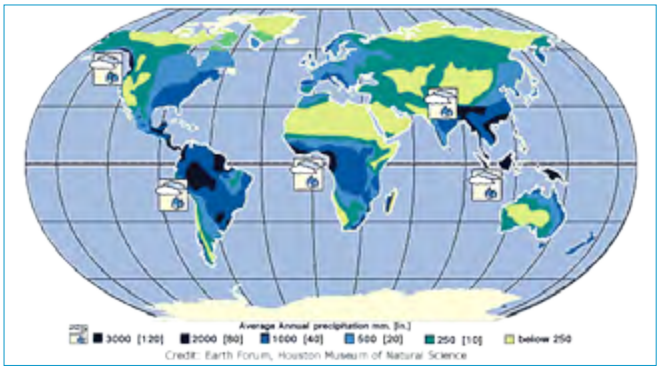
SOURCE G: Warm and cold ocean currents



Source: http://www.ecn.ac.uk/what-we-do/education/tutorialsweather-climate/climate/factors-affecting-climate

Ocean currents act like a conveyor belt, transporting warm water and precipitation from the equator toward the poles and cold water from the poles back to the tropics. Cold currents result in less rainfall due to less evaporation compared to warm currents.

SOURCE H: Latitude and distance from the sea



Source: https://www.usgs.gov/media/images/generalizedworld- precipitation-map

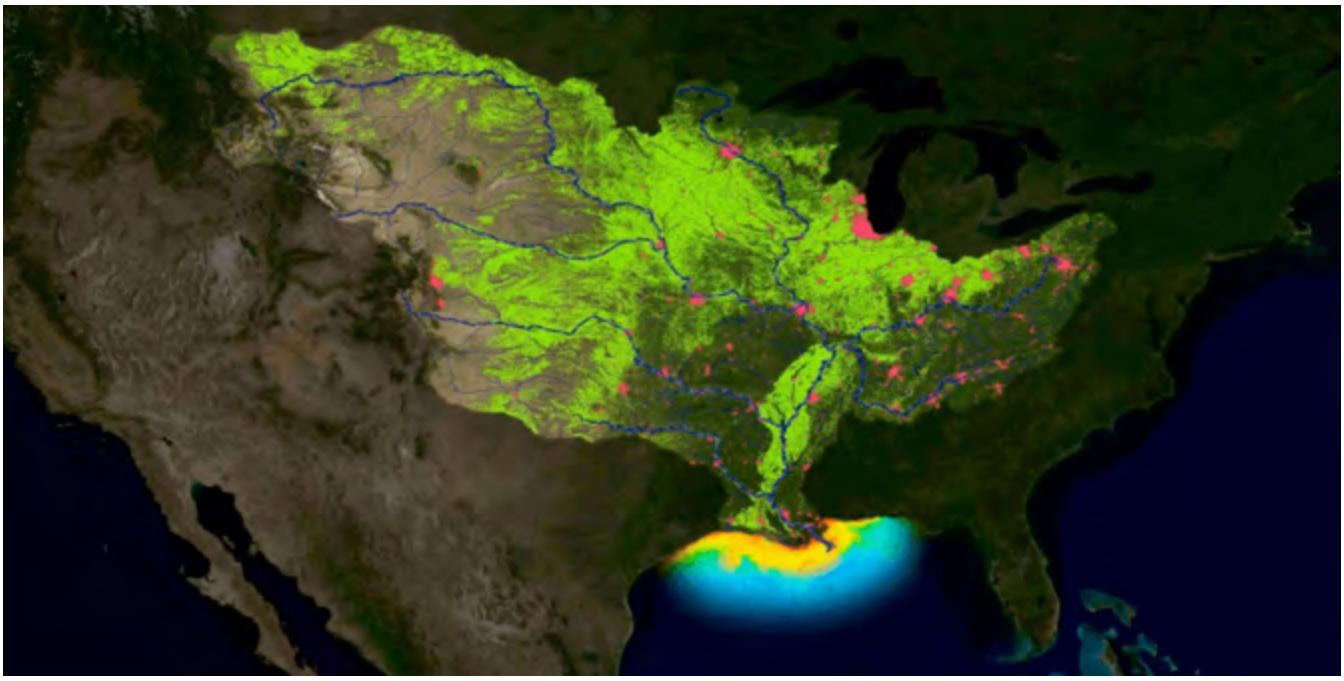
The wettest places on Earth are in the **low latitudes** (between the tropics) where hot, moist air brings heavy rainfall and along coastlines where moist winds carry moisture onto the coast. Other influences such as altitude and ocean currents impact on these patterns.

Catchment connections

Water connects people and places within a catchment and needs careful management. Activities in the upper catchment such as dam building, urban settlements and agriculture, will impact on users downstream. When water the quantity and quality are reduced there are consequences for people and environments.

Water connects environments within and outside of a catchment such as wetland, rivers and marine environments like coral reefs. Some species live in both land (terrestrial) and marine environments, moving from fresh to salt water during their life cycle. Corals rely on clear water. Activities in a catchment affect water availability and quality important for the health and survival of environments. Dead zones form in marine environments such as the Gulf of Mexico as a result of polluted freshwater discharged from catchments.

SOURCE I: Catchment connections



The Mississippi River catchment and the Gulf of Mexico Dead Zone Source: https://news.umich.edu/very-large-dead-zone-forecast-for-gulf-of-mexico/

Canada 4: Water resources and hazards

Lorraine Chaffer,
Vice President GTA NSW & ACT

Source: https://upload.wikimedia.org/wikipedia/commons/9/93/Niagara_Falls_386.jpg

A condensed and adapted version of an article published in the Geography Bulletin: Vol 48, No 1, 2016

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

Catchment area: The area drained by a river or water body. Also known as river basin.

Groundwater: water located beneath Earth's surface filling the spaces between grains of soil or rock.

Precipitation: Forms of water falling from the atmosphere to the Earth's surface

Spatial distribution: The location and arrangement of particular phenomena

Water cycle processes: physical changes to water that change its state and geographical location.

Climate change: A long-term change in regional or global climate patterns eg. annual precipitation, frequency of weather events

Atmospheric hazard: Hazard event originating in the atmosphere eg storms, tropical cyclones

Hydrologic hazard: event originating in the hydrosphere from changes to the water cycle eg floods and droughts

A FIRST NATIONS PERSPECTIVE

The First Nations people of Canada settled where water resources were plentiful such as along rivers and lakes. Water is a living thing in First Nations culture: part of the biotic rather than the abiotic environment as viewed by scientists.

Many First Nations people take their name from water e.g. the Sto:lo of the Fraser Valley are the river people and the Dakelh of the central interior are people who go around by boat. In the state of British Colombia 203 communities are located on fish-bearing waterways.

Algonquin canoe – The birch bark canoe of the Algonquin peoples was ideal for travel by rivers and lakes separated by narrow watersheds or portages. From: ***Perspectives: Journal of ecosystems and management. "Water: A first Nations spiritual and ecological perspective"***

Source: http://forrex.org/sites/default/files/publications/jem_archive/ISS1/vol1_no1_art7.pdf

SOURCE A: First Nations value water as a living thing

"Water is a meditative medium, a purifier, a source of power, and most importantly it has a spirit. Water is alive – biotic.

The Elders believe that water has a strong spirit, which can be gentle or powerful, forgiving or angry'. 'If you don't make offerings to the water, sometimes it can take you'.

The water is shown respect and appeased through offerings in the form of gifts of food or coins, and through prayer.

'The water is the biggest part of all our lives; without it we'd never survive. So when you go to the water and you talk to that water, that water helps you. If you go to the water early in the morning and get into it before anybody's up or around, that water will strengthen you because your spirit cries for that water"

From: Perspectives: Journal of ecosystems and management. "Water: A first Nations spiritual and ecological perspective" http:// forrex.org/sites/default/files/publications/jem_archive/ISS1/ vol1_no1_art7.pdf

CANADA'S WATER RESOURCES

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. With a large latitudinal and longitudinal extent (from 42° to 83° N and 52° to 141° W) annual precipitation varies greatly from north to south and coast to inland.

Considered as one of the world's water rich countries with an estimated 20% of the world's freshwater resources much of which is highly visible as glaciers, icefields, wetlands, rivers and lakes. Fresh water covers around 9% of Canada's total area (or 891 163 square kilometres).

Visible water resources

- Canada has over **2 million lakes,** 563 of which are over 100 square kilometres in area, more than any other country
- The Great Lakes (shared with the USA) is the **largest area of freshwater in the world** storing 18% of global surface freshwater resources
- **Average annual precipitation** varies across the country with the greatest concentrations on the Atlantic and Pacific coasts, reducing inland and to the north.
- About 2% of the country is covered by frozen freshwater in the form of **snow, glaciers and ice fields.**
- On average 36% of annual precipitation falls as snow but variations occur from north to south and from the coast to the inland. (North, 50%; Prairies, 25%; coasts as low as 5%).
- High precipitation levels and the melting of winter snow contributes to river flow and an average discharge of freshwater from Canadian rivers into the sea totaling nearly 9% of the world's freshwater supplies.
- The Mackenzie River (4,241 km) is Canada's longest river.
- **Wetlands** are found in every province and cover 14% of the country's total land area.

SOURCE B: Visible water resources

Examples of visible water resources in Alberta and British Colombia, from the top Lake Louise, Fraser River, Athabasca Glacier. (Photos: L Chaffer)

Does Australia have the same visible water resources as Canada?

Can you state ONE difference between water resources in Canada and Australia?

INVISIBLE WATER RESOURCES

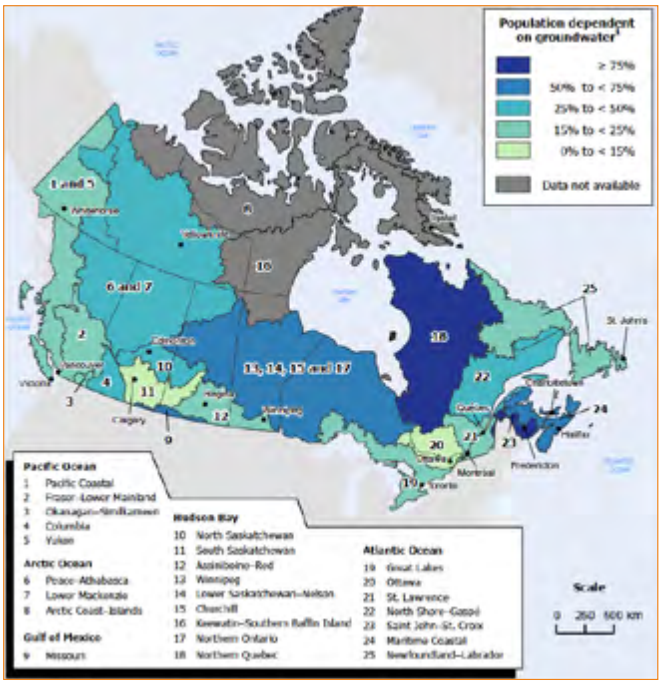
Groundwater is an important resource for inland, rural regions and more remote provinces of Canada with an estimated 25–30% of the population relying on groundwater for domestic and agricultural use. Many rural communities use wells to provide a reliable, less expensive water supply than obtainable from nearby lakes, rivers and streams. In some places groundwater is the primary source of water. Spatial variations on groundwater dependence can be seen in Source C.

Many ecosystems are also dependent on groundwater. **Wetlands,** such as the Vermillion Lakes wetlands on the Bow River, support millions of Canadian ducks and waterfowl and other iconic Canadian species such as Caribou, are recharged from groundwater flows. Wetlands also store floodwater, filter nutrients to keep rivers cleaner and recharge rivers in times of drought as in other parts of the world. The contamination of invisible groundwater resources in Canada has become a major concern in recent years.

SOURCE D: The Vermillion Lakes wetlands

Source: http://www.canadiangeographic.ca/atlas/themes.aspx?id=watershedawareness&lang=En

SOURCE C: Variations in groundwater



From: Human activity and the environment: Freshwater supply and demand in Canada. Source: http://www.statcan.gc.ca/pub/16-201-x/16-201-x2010000-eng.pdf

How important is groundwater as a water source in Australia?

Are there variations in the use of groundwater across Australia?

VALUES OF WATER RESOURCES

Aesthetic, spiritual, cultural and social values

"Water not only slakes thirst and gives Canadians a sense of identity but supports healthy aquatic and terrestrial organisms, provides a myriad of ecological services and is the backbone for a competitive economy"

Source: http://www.canadiangeographic.ca/atlas/themes.aspx?id=watershedawareness&lang=En

Canada's glaciers, lakes, rivers, wetlands and waterfalls add beauty to the environment and are enjoyed by millions of tourists and Canadians every year. The snow covered mountain peaks, glaciers, lakes eg Lake Louise and rivers of Banff National Park attracts 3–4 million visitors a year. Other examples include the Athabasca glacier, the Fraser River Valley, Vermillion Lakes wetlands (Source D), Waterton Lakes and Niagara Falls. The Great Lakes alone provide drinking water to 8.5 million Canadians.

Economic value

Rivers and groundwater are the lifeblood of Canadian agricultural production, urban settlement, industrial production, hydroelectric generation, transportation and trade across Canada. The Great Lakes are a vital trade highway connecting inland Canada with the USA, coast and overseas markets through the St Lawrence Seaway.

Water's annual measurable contribution to the Canadian economy is estimated to be between $7.5 billion and $23 billion, and by some estimates, 60 percent of the country's GDP is directly dependent on water.

THE WATER CYCLE

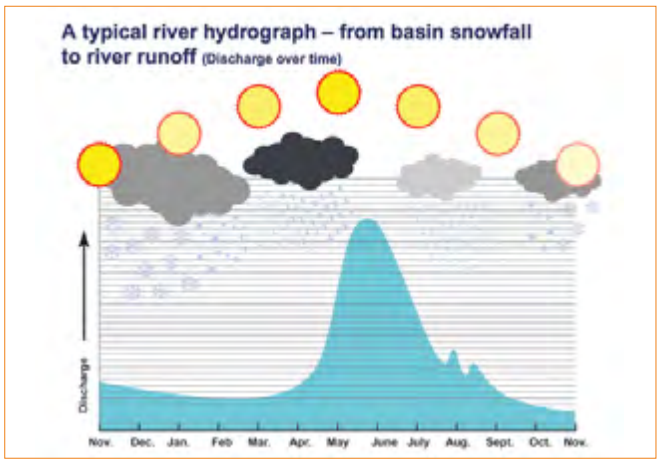
Precipitation and runoff

High annual precipitation (renewable water resources) results in large amounts of runoff, although runoff also varies due to slope, soils, vegetation cover and human landuses.

Precipitation, in a catchment becomes runoff, infiltrates into the soil or evaporates. **Runoff** flows in streams flowing to the ocean. In Canada catchments empty into the Pacific Ocean, Atlantic Ocean, Arctic Ocean, Hudson Bay, The Great Lakes and Labrador Sea. It is said that 50 – 60% of the total flow of Canadian rivers drains northward into the Arctic Ocean or into Hudson and James bays, often thousands of kilometres from the water source while most of the population (85%) lives within 300 kilometres of the border with the USA.

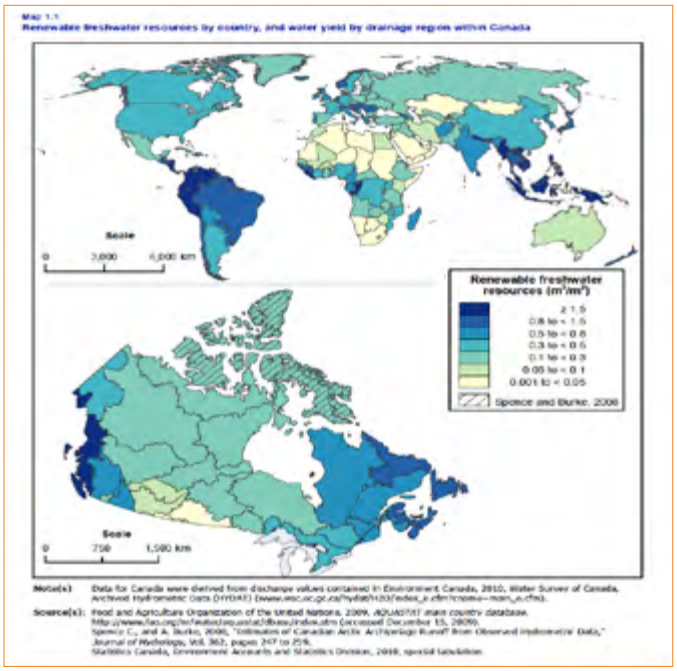
The Bow River Drainage Basin, begins in the Rocky Mountains west of Calgary and the water discharges into Hudson Bay. Some southern catchments drain into The Great Lakes or cross the border into the USA. To make use of its surface water resources about 850 dams have been built on Canadian rivers and streams storing water for urban use rural uses.

SOURCE E: The contribution of snowmelt to river flow in Canada



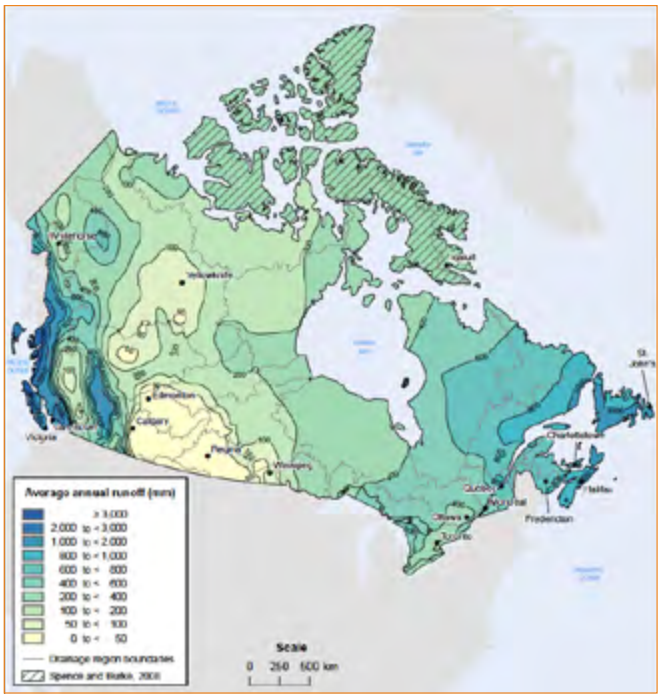
Source: https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=B98C0EB3-1

SOURCE F: Canada's water by drainage basin



From: Human activity and the environment: Freshwater supply and demand in Canada – http://www.statcan.gc.ca/pub/16-201-x/16-201-x2010000-eng.pdf

SOURCE G: Spatial variations in runoff



From: Human activity and the environment: Freshwater supply and demand in Canada – http://www.statcan.gc.ca/pub/16-201-x/16-201-x2010000-eng.pdf

Where does snow contribute to river runoff in Australia?

CANADA'S HYDROLOGIC AND ATMOSPHERIC HAZARDS

Winter storms and blizzards consist of heavy snowfall, cold temperatures, high winds and whiteouts. A blizzard occurs when winds are over 40 km/h and visibility is reduced to below about 400 metres because of snow falling and / or blowing for at least four hours.

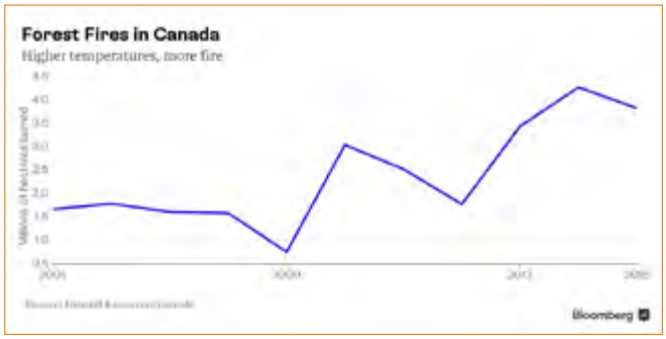
Cold arctic air from the north brings blizzard conditions, which could last for days.

Floods are the most frequent natural hazard in Canada caused by heave winter precipitation (snow, sleet and hail) and the spring thaw. Rapid melting of ice and snow accompanied by heavy rain has historically caused serious flooding. Heavy rain also causes flash floods, especially during the hurricane season in the eastern provinces or on the steep slopes of the Canadian Rockies. The growth of urban areas such as Calgary exacerbates the extent of flooding along rivers and lakes. The worst flood in Canada's recent history occurred in Alberta in June 2013.

Tornadoes in the summer months consist of rotating columns of wind that cause a path of destruction in inland provinces such Ontario and the Prairies in southern Canada. Canada gets more tornadoes than any other country with the exception of the United States.

Drought and wildfires. Drought is less common but in 2015 record-breaking high temperatures and low rainfall brought drought western Canada, devastating agricultural production and causing widespread bushfires. For parts of Alberta conditions meant the lowest rainfall in 50 years. Climate change is increasing the risk of wildfires such as those in 2019 when 803,393.32 hectares was burned by Sam Jones, a figure over 3.5 times greater than the average land area burned over five years.

SOURCE H: Forest fires associated with drought conditions in 2015

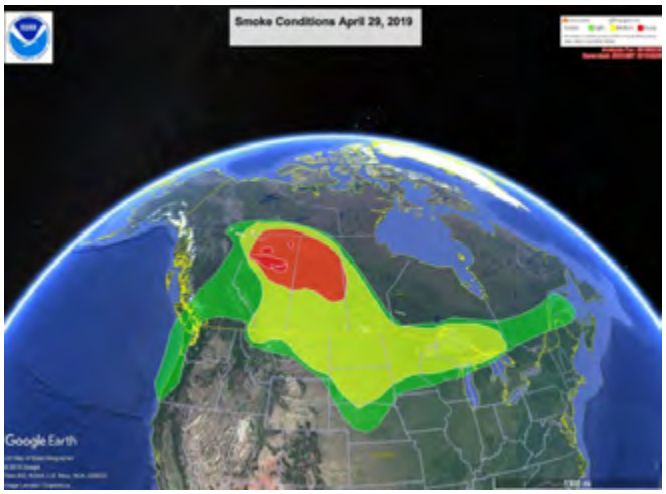


http://www.bloomberg.com/news/articles/2015-08-26/snowy-canada-suffers-drought-heat-fires-as-earth-gets-warmer

SOURCE I: Examples of hazards impacting Canada

F5 tornado, near Elie, Manitoba, Canada in 2007. Source: Wikipedia

The Chuckegg Creek fire captured by satellite on May, 26, 2019
Source: https://www.discovermagazine.com/environment/striking-satelliteimagery-reveals-multiple-wildfires-blazing-across



Smoke from bushfires impacted most of Canada in 2019.

Source: https://www.discovermagazine.com/environment/striking-satellite-imageryreveals-multiple-wildfires-blazing-across

Source: https://images.ctfassets.net/cnu0m8re1exe/4DEZ4RfcPiMTcvdLsyhQXq/71c22ee1176806bdb4d32b2aad470686/Smoke-Conditions.jpg?w=650

SOURCE J: Case study – 2013 Calgary flood event

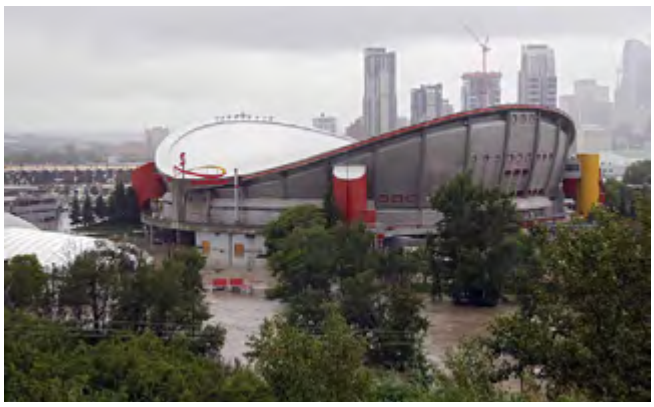
On June 20, a large weather system moved in from the southwest, dropping nearly 100 mm of rain in just over a day in some areas. The river systems and ground were unable to handle the massive amount of precipitation and rivers crested creating flooding across much of southern Alberta. The rain persisted creating devastating conditions in and around Calgary, including High River and Red Deer. Homes were washed away, people struggled to save their homes and cars, but many were forced out of their homes. At least four people died. Many people were unable to return to their homes or businesses.

The Insurance Bureau of Canada estimated that the flooding was the costliest in Canadian history, topping off at $1.7 billion.

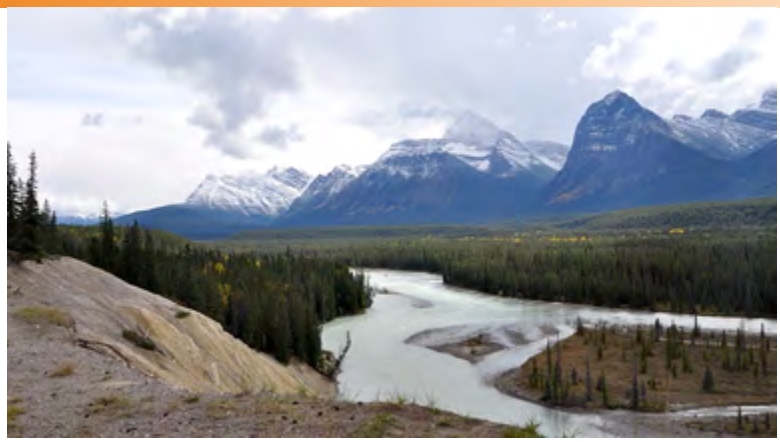
- 100,000 Albertans displaced
- Closure of part of the Trans-Canada Highway
- 4,000 businesses impacted in Calgary alone
- Closure of Calgary Zoo
- Rainfall averaged 75 to 150 mm in under three days
- Almost 500,000 people across southern Ontario were left without power due to the storm.

Left and above: Aerial view of the flooded Calgary Stampede stadium,Calgary, June 2013.

Debris and water pours down suburban streets and across the Trans-Canada Highway



Source: http://globalnews.ca/news/1046844/worst-natural-disasters-in-canadian-history and http://globalnews.ca/news/1012584/2013-weather-year-in-review/



The Bow River on its journey from the Rocky Mountains to the sea. Photo: L Chaffer

Canada 5: The Bow River

Lorraine Chaffer,
Vice President GTA NSW & ACT

NOTE: this is a condensed and adapted version of an article published in the Geography Bulletin: Vol 47, No 4, 2015

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

Catchment area: The area drained by a river or water body. Also known as river basin.

Groundwater: water located beneath Earth's surface filling the spaces between grains of soil or rock.

Precipitation: Forms of water falling from the atmosphere to the Earth's surface

Spatial distribution: The location and arrangement of particular phenomena

Water cycle processes: physical changes to water that change its state and geographical location.

Climate change: A long-term change in regional or global climate patterns eg. annual precipitation, frequency of weather events

Bow Lake at the headwaters of the Bow River. Photo: L Chaffer

Bow River at Banff. Source: http://www.theglobeandmail.com/news/national/protecting-the-health-of-albertas-bow-river/article26767720/

GEOGRAPHICAL INQUIRY

1: Independent inquiry

Analyse SOURCES to answer an inquiry question about the challenges to water security in the Bow River catchment.

2: Guided inquiry

Answer sets of questions to discuss an inquiry focus question about water resources in the Bow River catchment.

3. Class inquiry

A class group interpret and discuss visual sources to draw conclusions about water resources in the Bow River catchment and create a visual presentation.

The Bow River flowing through the city of Calgary Photo: L Chaffer

SOURCE A: Location of Calgary within Canada

SOURCE B: Location of the Bow River within the Saskatchewan River Catchment

Image source: https://en.wikipedia.org/wiki/Bow_River#/media/File:Saskatchewanrivermap.png

What catchment do you live in?

Can you visualise your own catchment on a map?

What is the main river in your catchment and where does this river begin and end.

SOURCE C: Journey of the Bow River

Image source: http://www.theglobeandmail.com/news/national/protecting-the-health-of-albertas-bow-river/article26767720/

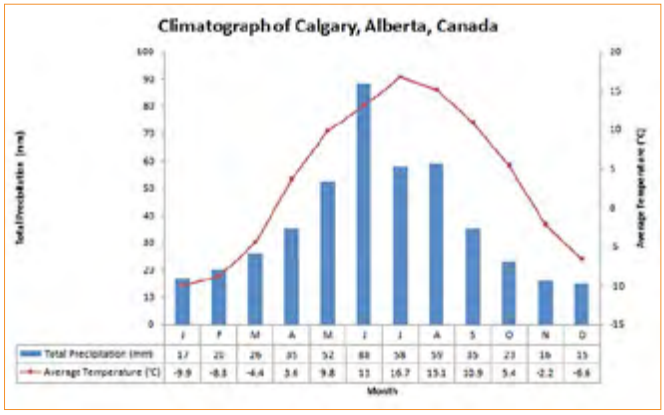
SOURCE D: Facts and statistics

a. Basic facts

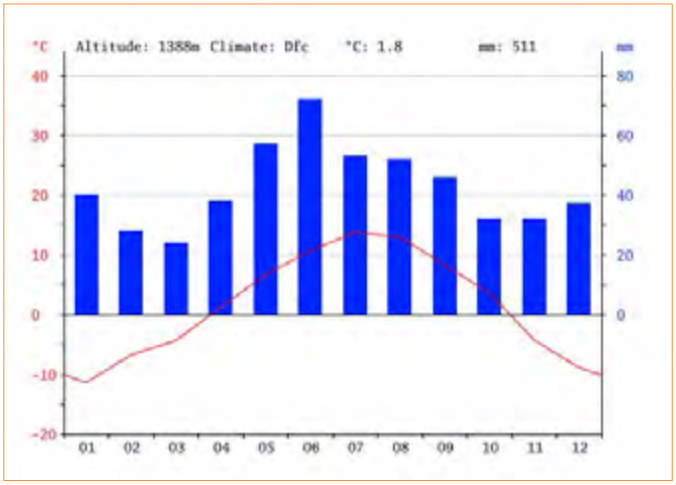
FEATURE	FACTS
Country	Canada
Province	Alberta
Source	Bow Glacier (Altitude 1,960 metres)
Mouth	South Saskatchewan River (Altitude 700 metres)
Length	587 kilometres
Catchment	26,200 square kilometres
Discharge	129 cubic metres per second (Average)
	1,640 m3/s maximum discharge
	3 m3/s minimum discharge

Source: http://geogratis.gc.ca/api/en/nrcan-rncan/ess-sst/d8fb41f0-8893-11e0-92bb-6cf049291510#distribution

b. Climate graphs for Calgary and Banff



Calgary: https://ecozoneexperts.wikispaces.com/file/view/Calgary_Climate.png/125443907/Calgary_Climate.png



Banff: http://en.climate-data.org/location/9245/

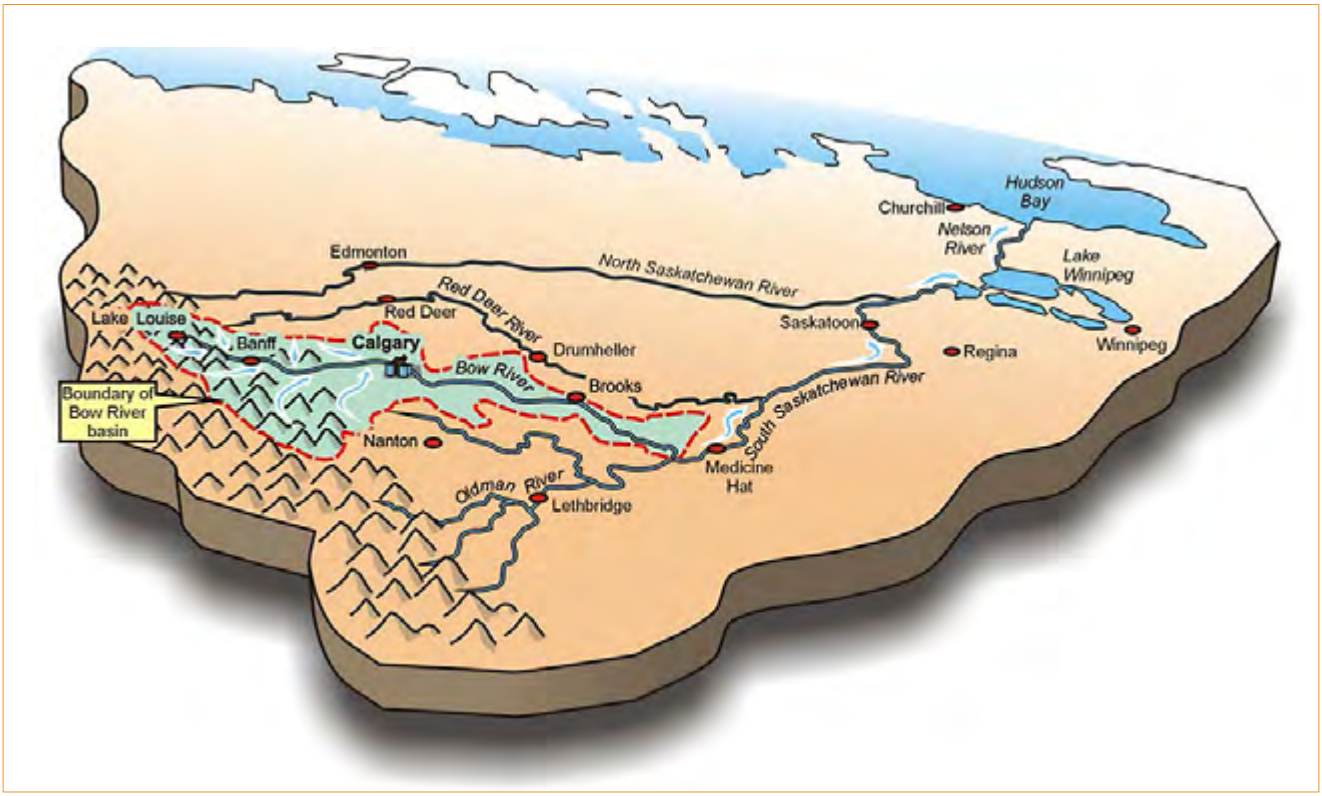
SOURCE E: Topography of the Bow River catchment (Drainage Basin)

Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

Bow River Valley

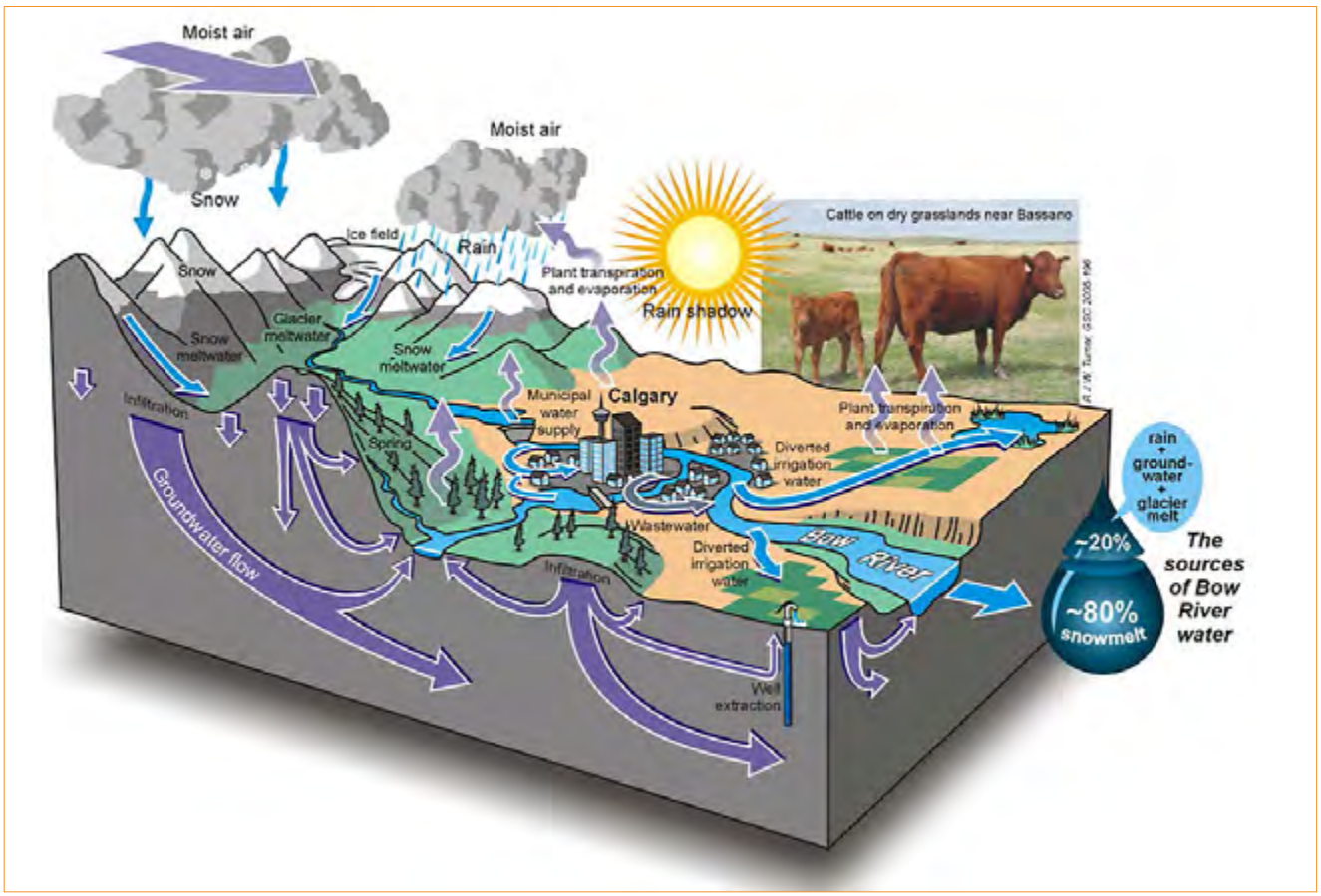
Source: https://upload.wikimedia.org/wikipedia/commons/6/63/View_over_Bow_River_Valley_from_Sulphur_Mountain_Summit_-_Banff_-_Alberta_-_Canada.jpg

SOURCE F: Journeyof the Bow River



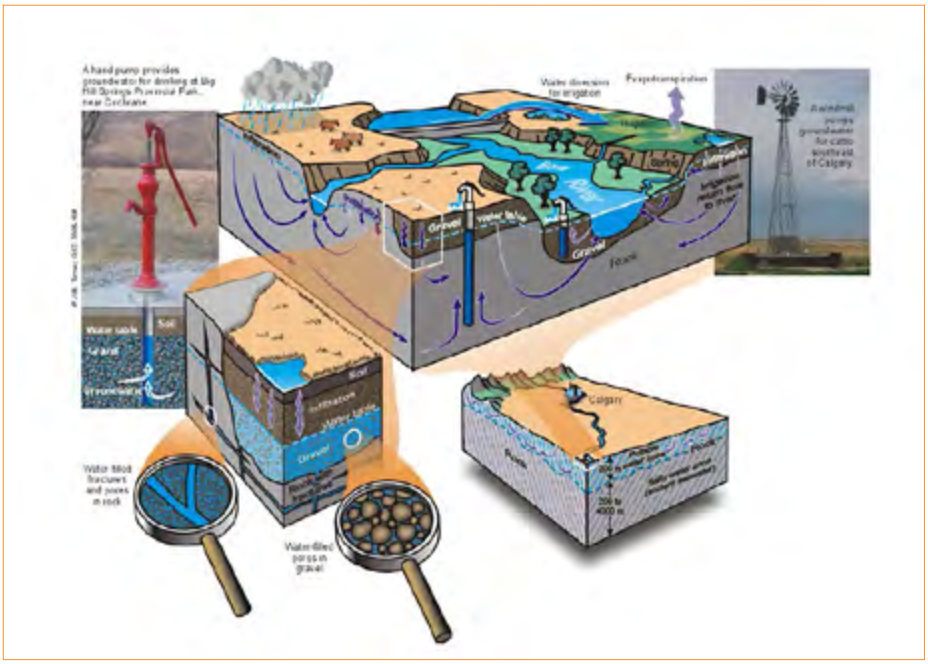
Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

SOURCE G: Bow River Catchment water cycle



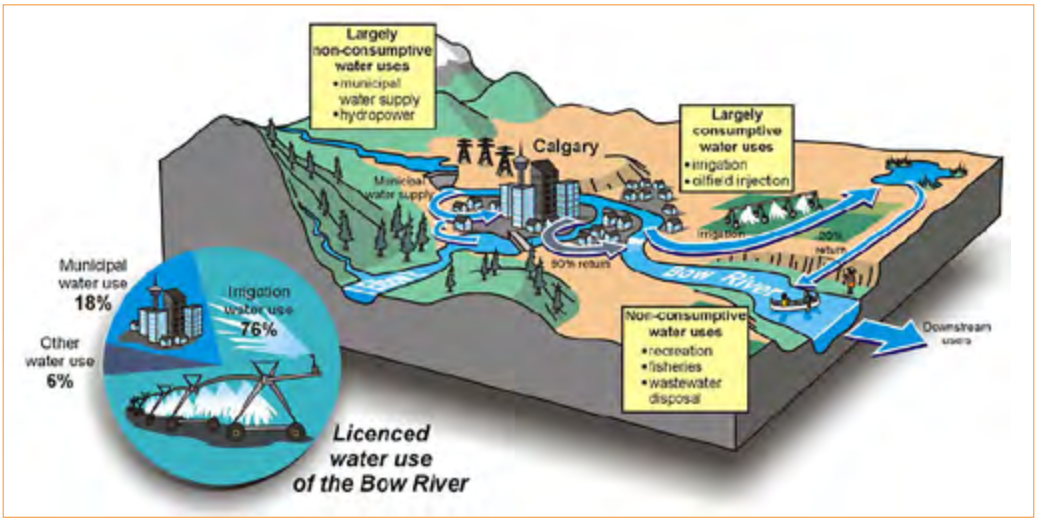
Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

SOURCE H: Groundwater resources



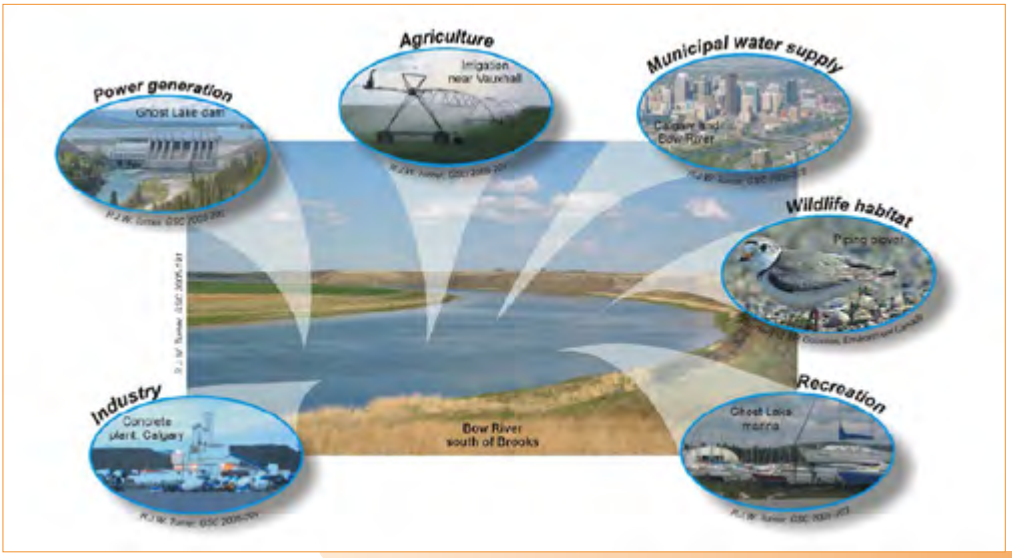
Source: http://www.cgenarchive.org/bow-river-clean.html

SOURCE I: Water use



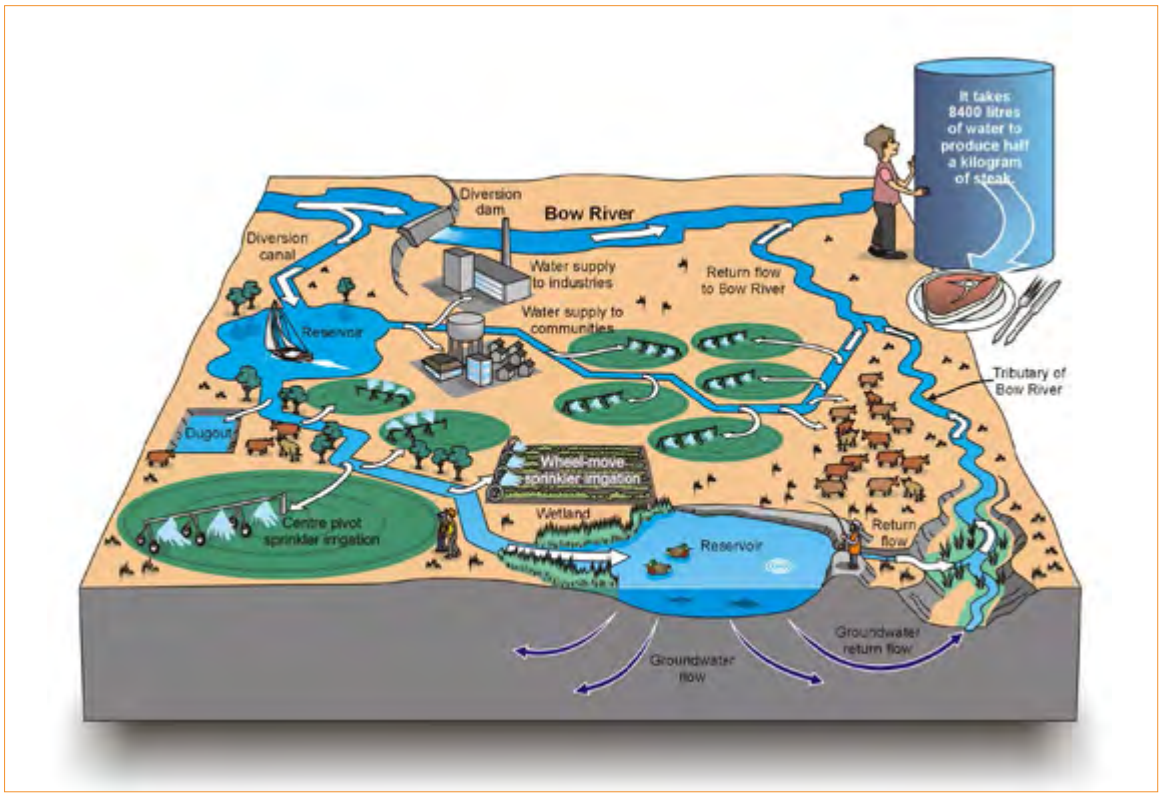
Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

SOURCE J: Competing water uses



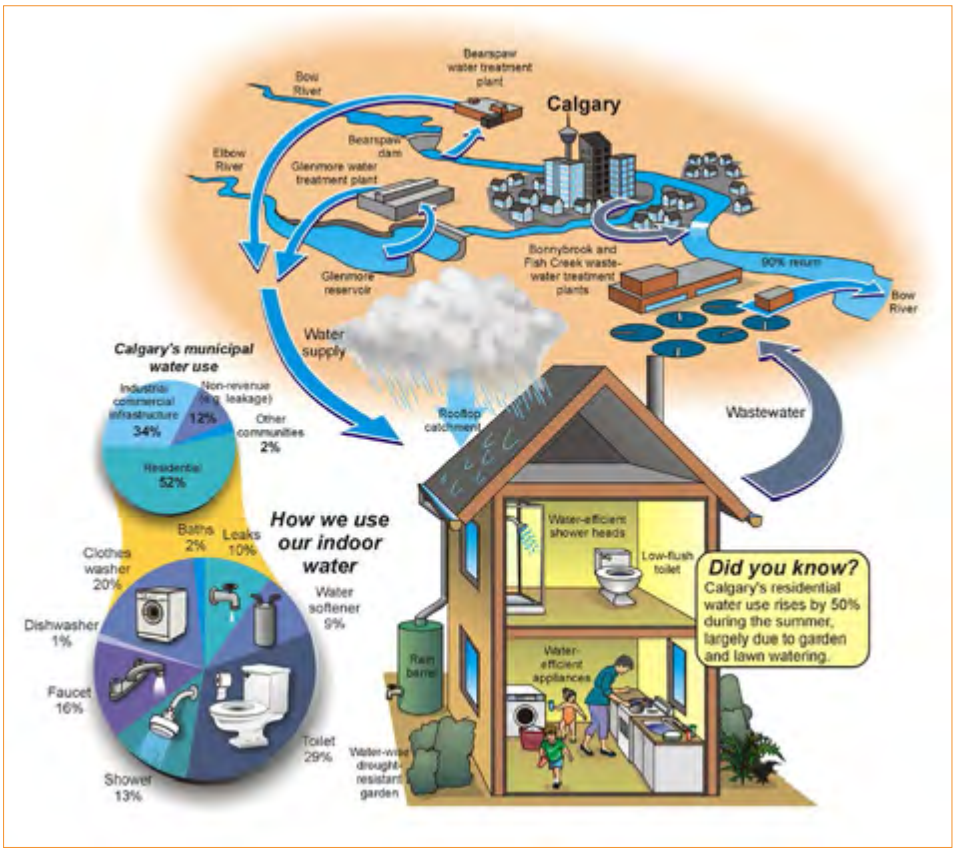
Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

SOURCE K: Making water available for human use



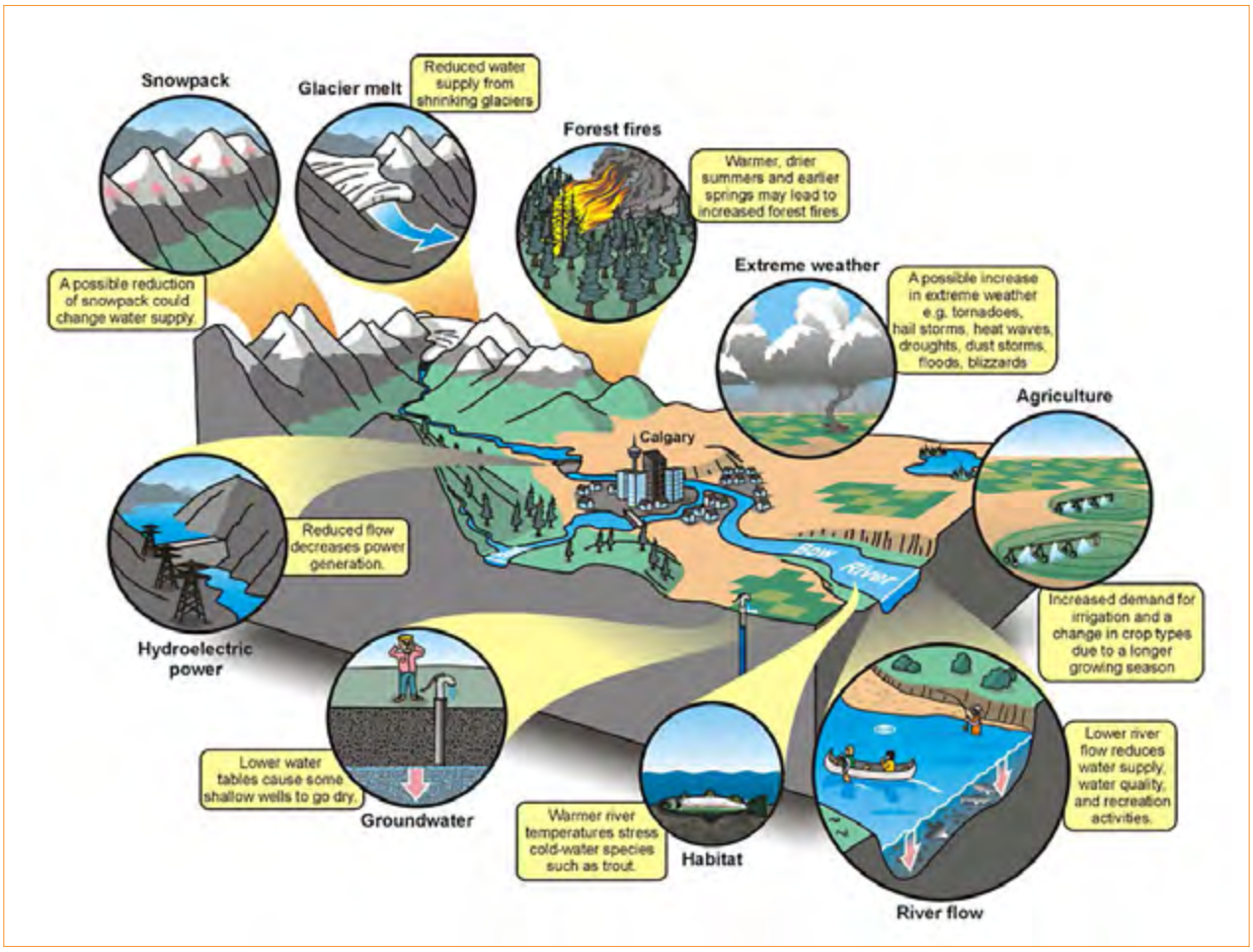
Source: http://www.cgenarchive.org/bow-river-clean.html

SOURCE L: Urban water use



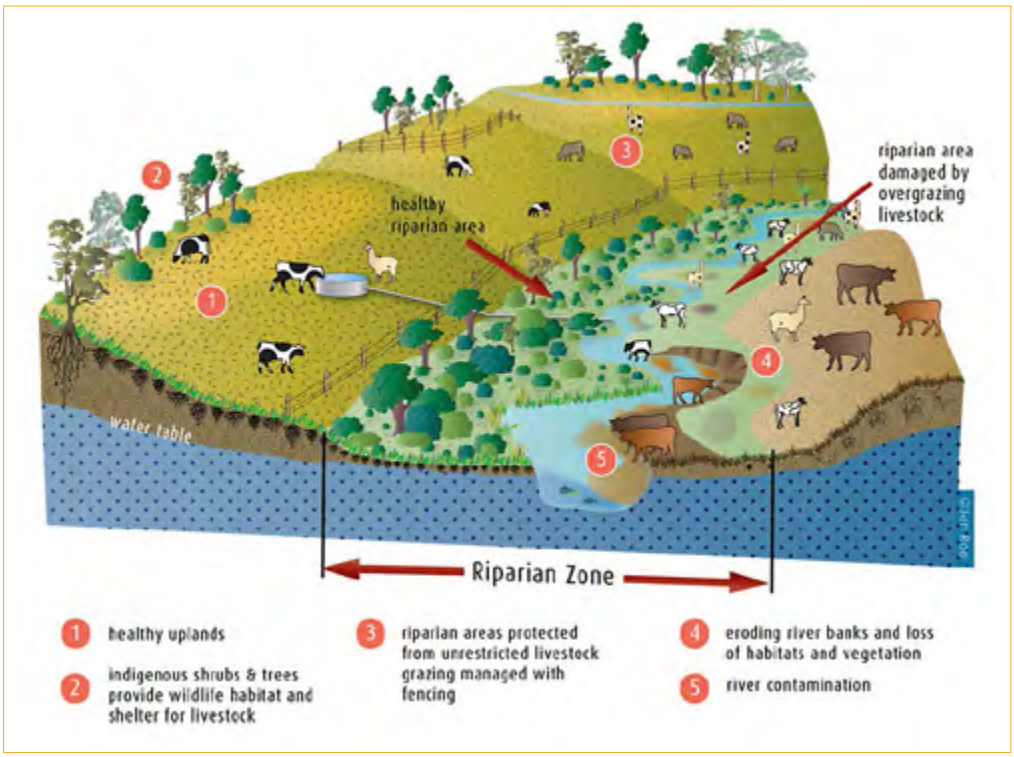
Source: http://www.cgenarchive.org/bow-river-clean.html

SOURCE M: Climate change threats



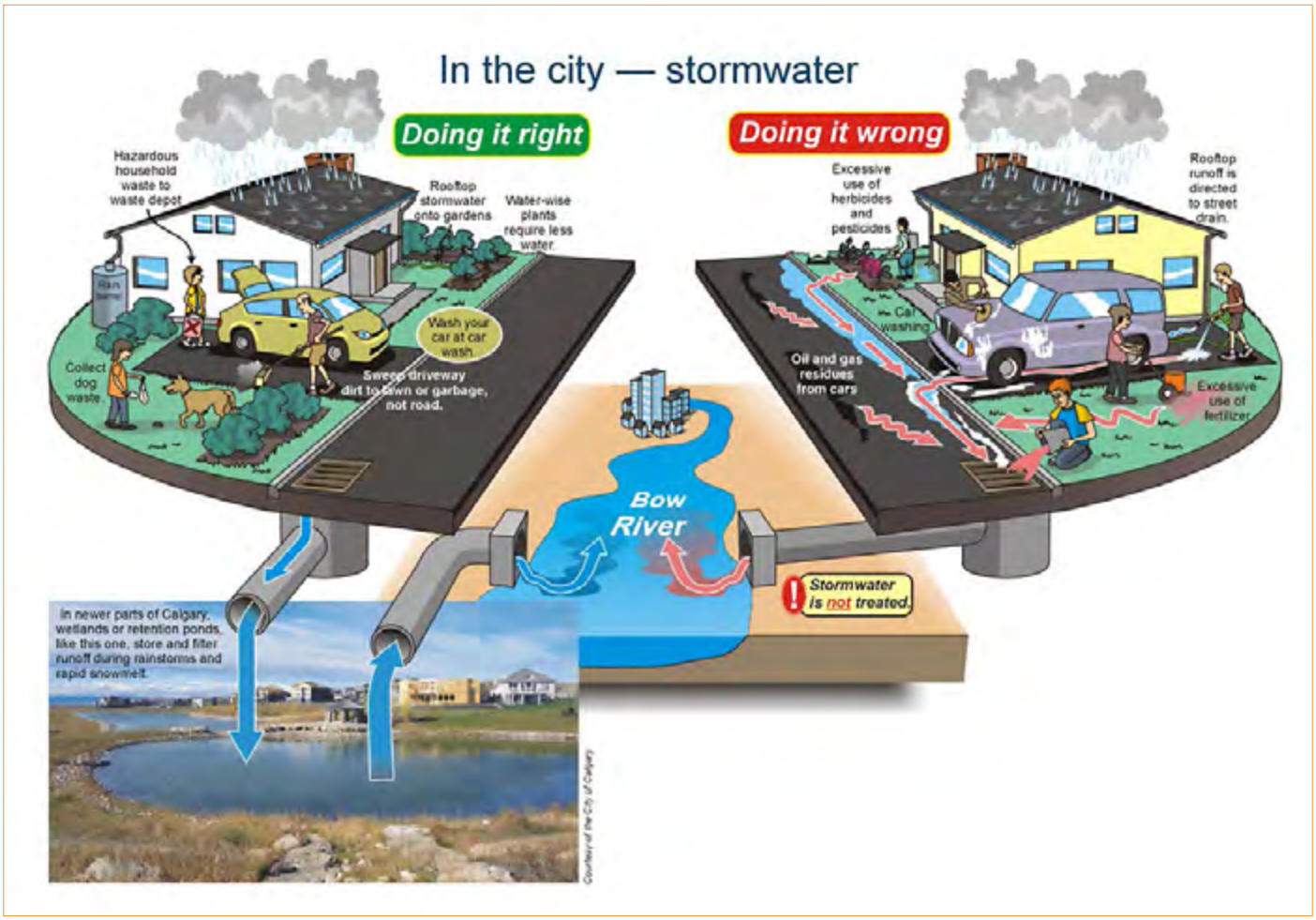
Source: http://www.thebowriver.com/bow_river_basin_waterscape.htm

SOURCE N: Rural water management



Source: http://theriparianproject.com.au/about and http://www.cgenarchive.org/bow-river-clean.html

SOURCE N: Urban water management



Source: https://www.cgenarchive.org/bow-river-clean.html

Ice skating on frozen River in Calgary Bowness Park (Sluice Gate, an arm of the Bow River.

Source: https://upload.wikimedia.org/wikipedia/commons/f/ff/Dilmaghanian00711.JPG

How does your catchment compare to the Bow River catchment in water resources, water uses and water management issues?

Will climate change impact your catchment?

STAGE 4: VIRTUAL FIELDWORK

NSW Environmental and Zoo Education Centres (EZECs) have created virtual fieldwork experiences for teachers and students currently unable to participate in real world fieldwork during 2020.

Collated by Lorraine Chaffer
Geography Bulletin Editor
Vice President GTANSW & ACT

LANDSCAPES and LANDFORMS

Rumbalara Environmental Education Centre (Gosford) has developed a virtual fieldwork experience to assist with the investigation of the diverse features and characteristics of a forest and coastal landscape at Bouddi National Park, Killcare. Students will consider the different values of the landscape and investigate ways people manage and use the landscape

The virtual fieldwork will allow students to experience simulated investigations such as:

- using geographical tools such as maps and compasses,
- undertaking a field sketch using photos from the site,
- observing the geological features and landforms,
- identifying plants and animals,
- measuring abiotic factors such as wind, temperature, humidity, light and canopy cover,
- assessing human impact and management of Bouddi National Park.

Link to site and student worksheets: https://sites.google.com/ education.nsw.gov.au/ rumbalara-eec-landscapes/ home

Royal National Park Environmental Education Centre facilitates a range of fieldwork programs in and around the Royal National Park. To assist teachers and students while excursions are on hold, we have created a number of resources to support virtual fieldwork and fieldwork on school grounds.

Landscapes and landforms at Wattamolla is one of our popular excursions for Stage 4 Geography. The stunning coastline and range of features around Wattamolla lends itself to the topic. On excursion, we view examples and evidence that support the learning of theory in the classroom. Our Online resource aims to provide an alternative to the fieldwork experience. The activities include: videos, Google Tours, field sketches, slideshows, a Kahoot!, Google quizzes, and more. We look forward t excursions resuming, at which time we will adapt the resource to provide in-depth pre and post excursion activities.

Online resource: https://sites.google.com/ education.nsw.gov.au/wattamolla-landscapes/about- wattamolla

STAGE 4: VIRTUAL FIELDWORK

Developed by **Gibberagong Environmental Education Centre**, the virtual fieldwork resource, Landscapes and Landforms: West Head, enables students to study the Landscapes and Landforms content area from the spectacular West Head lookout in The Ku-ring-gai Chase National Park.

The resource commences with a series of activities for students to observe and identify coastal landforms from an immersive 360 image. The interactive google map and topographic map of the area provide a further opportunity to develop their skills to identify the geographical features of the area.

Students then use a variety of source material to learn more about the geomorphic processes that shaped the Palm Beach coastline, including the well know Palm Beach tombolo. Students will use what they have learnt, and the instructional videos, to create annotated field sketches of this area.

A comprehensive web page of fieldwork equipment provides students with the information and instructional videos to develop their knowledge and skills on using geographical tools. In the fieldwork task, students will utilise this knowledge to analyse and compare the data from two forest areas in West Head.

Students will hear from Aboriginal teachers as they speak about the importance of Aboriginal connection to country and the importance of the landforms of this special area. Finally students will visit an Aboriginal cultural site in a 360 tour to learn more about this special connection and how these sites are currently managed.

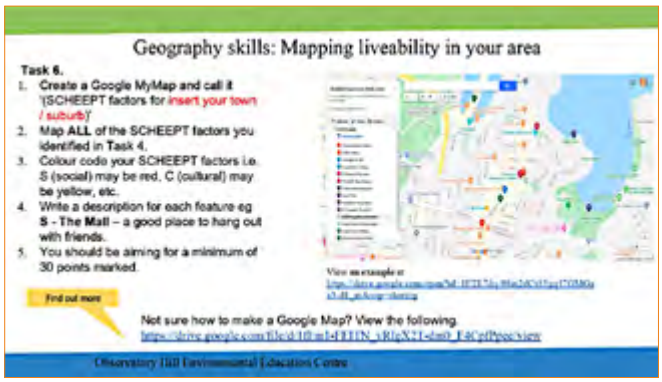
A student booklet and google form accompany this resource and both can be adapted by the teacher to suit the learning needs of their students.

The resource can be accessed at https:// sites.google.com/education.nsw.gov.au/landscapes- andlandforms/home

Observatory Hill Environmental Education Centre runs a variety of urban geography K–12 fieldwork programs in and around Sydney's CBD. These now include a number of virtual fieldwork programs. For Stage 4 'Place and liveability', students investigate liveability in their own suburb or town and then compare two inner city precincts at Harold Park and White Bay. The students use their learning about liveability to answer a fieldwork question "Is Harold Park a liveable place, and how can the White Bay Power Station precinct be transformed into a more liveable place?"

The students complete the unit of work by working as a town planner and drawing up plans for the White Bay precinct to turn it into a more liveable place. The unit of work incorporates geography skills in mapping and addresses the cross curriculum priority of Sustainability, as well as a number of general capabilities including Work and Enterprise.

A preliminary presentation guides learning, and a support website, containing a virtual google tour, allows students to explore the topic further. Teachers have the option to book a 45–60min lesson on Harold Park and the White Bay Precinct, led by EEC geography teachers, to further familiarise students with the area under investigation.



Find out more at https://sites.google.com/education.nsw.gov.au/obhill-place-and-liveability/home or, ring the Centre on 9247 7321.

Teaching from home or at school?

At Taronga we are committed to connecting with schools through our engaging digital programs. We have launched some new initiatives to help you and your students through this period - find out about the newly launched Taronga TV, our virtual tours, webcasts and make sure you follow us on Facebook for all the latest Education updates from Taronga!

Through accessible user-friendly technology, staying connected with Taronga Education programs is easier than ever before!

Our digital programs are suitable for all school ages and offer great opportunities to add depth to a unit of work, or as unique, stand-alone learning experiences.

Visit our Digital Programs and Online Resources webpage to find out more.

What we offer

Webcasts
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Google Expeditions
Agents of Discovery

Competitions
Wild snaps

Curriculum learning resources
Schools for the wild
Maths at Taronga Zoo
Working Scientifically Videos

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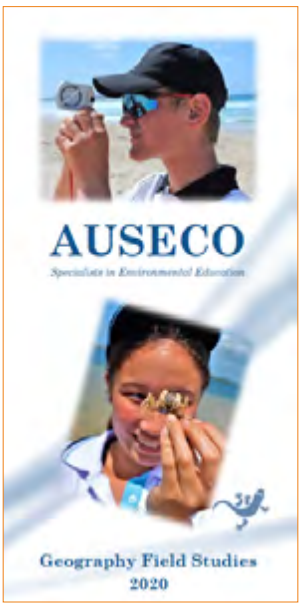
Facebook: @TarongaEducation

NSW Education | Sydney Catholic Schools | Catholic Education Diocese of Parramatta

TARONGA CONSERVATION SOCIETY AUSTRALIA
For the Wild



Auseco's Virtual Fieldwork

Auseco has virtual excursions ready for Stage 4, 5 & 6 Geography students. These include Landscapes & Landforms, Environmental Change & Management and Biophysical Interactions.

Our all-inclusive virtual platform allows students to easily navigate through the work following the order of the Auseco worksheets that are normally completed in the field. Teachers have full flexibility on how to deliver the work. Some teachers have organised an intensive day for the entire cohort in the school gymnasium whilst others have run the program over a week, allowing students to complete it at a slower pace.

The online platform that is used to present the work is Prezi. It contains everything required to complete the worksheets, including instructional videos of the site and equipment, photos of all results taken directly from field equipment (e.g. anemometers and clinometers) and copies of secondary sources (e.g. aerial photos and topographic maps). Answer sheets are also supplied to teachers for assistance with marking.

The cost is $10 per student +GST. Short preview videos are available at www.auseco.com.au under Virtual Excursions Geography. Auseco is also offering interested teachers full access to the Prezi platform to explore the content and see what's on offer before purchase. Simply request this when you complete a booking form from the website.

More are on the way! **Stage 4 Place & Liveability, Stage 5 Sustainable Biomes, Stage 5 Changing Places** and **Stage 6 Urban Study** are currently in production.

Stage 4 Landscapes & Landforms Mt Keira, Wollongong

Students will investigate the **Illawarra Escarpment at Mt Keira** and examine the geological and human history of the area. Students will measure physical characteristics such as foliage cover (using a coverscope), tree height (using a laser rangefinder) and soil moisture (using a soil moisture meter) in two landscapes - open forest (at the top of the escarpment) and rainforest (at the bottom of the escarpment). Students will observe evidence of mass movements as an example of a local geomorphic hazard, and will use hand lenses to observe the geology of rockfalls up close.

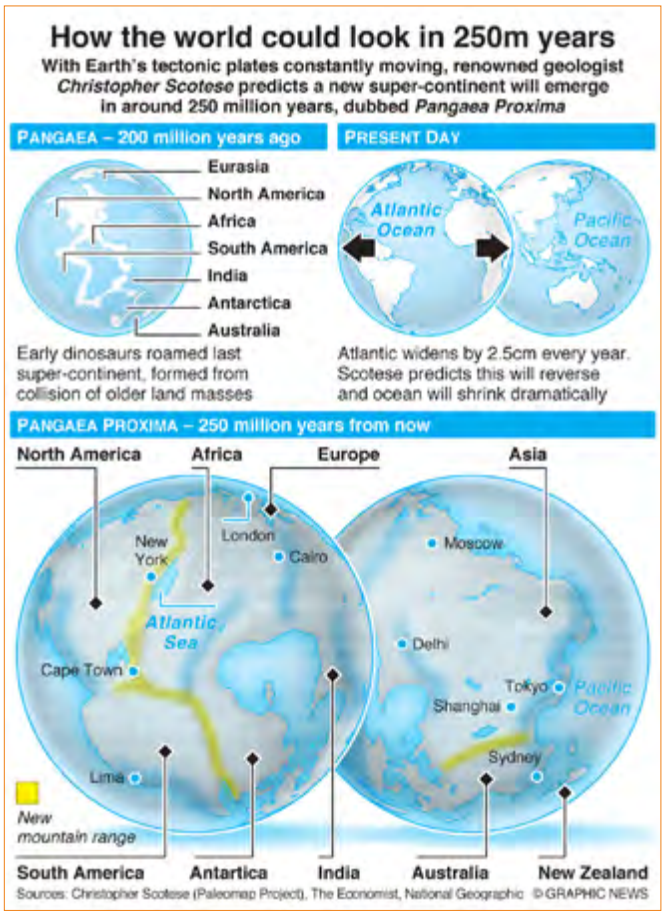
Stage 5 Environmental Change & Management, Cronulla

Students will investigate coastal processes by measuring and studying elements of a **natural/re-established sand dune**, such as size and shape, vegetation type and cover and wind speed. Identification of landforms and examination of land use in the surrounding areas will be undertaken using aerial photographs or cadastral maps. Historical photographs will be used to examine the effects of human development and storm erosion processes on the sand dunes. Detailed investigation of past and present management strategies will also be undertaken.

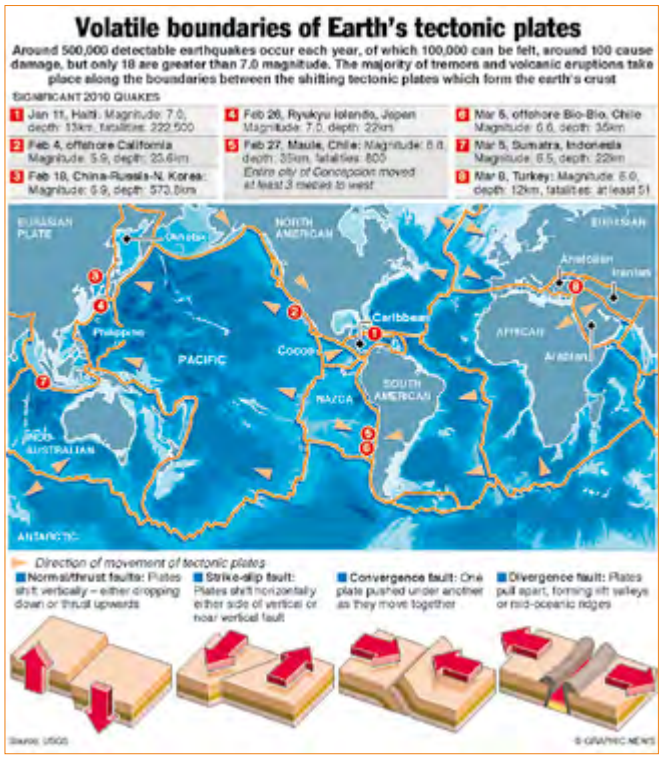
Top: Screen captures from the AUSECO website.Centre: Mt Kiera Ring Track signage from Wikimedia Commons. Above: Cronulla and Cronulla Beach screen capture from Google Earth

STAGE 4: SKILLS STIMULUS

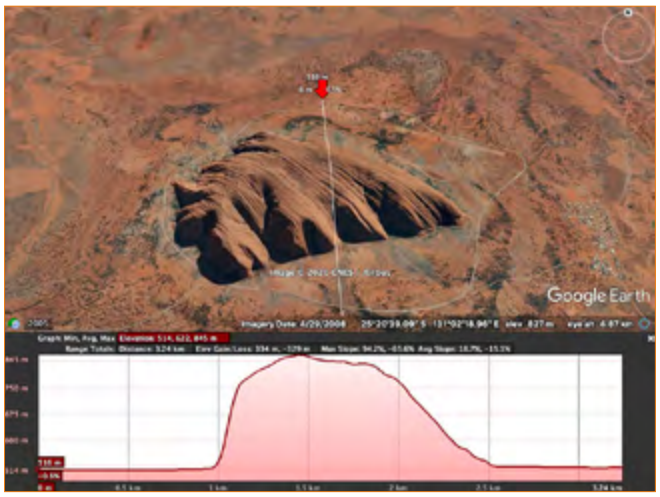
SOURCE A: How the world could look



SOURCE B: Earth's volatile boundaries

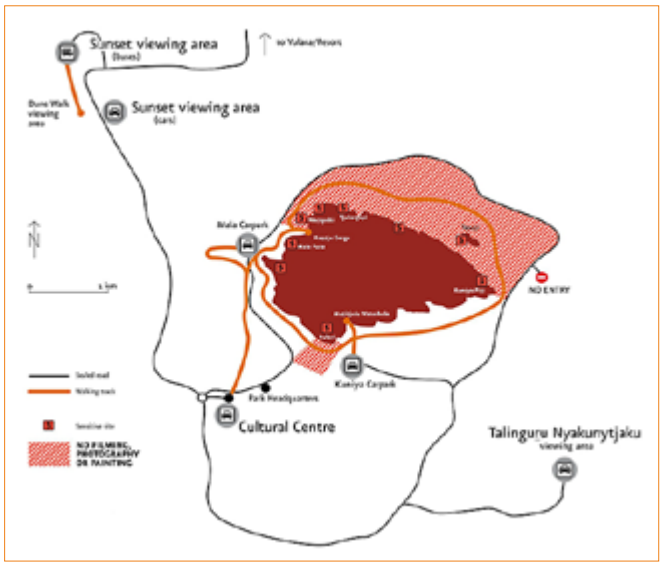


SOURCE C: Uluru – satellite image and elevation profile (cross section)



Source: Google EarthPro

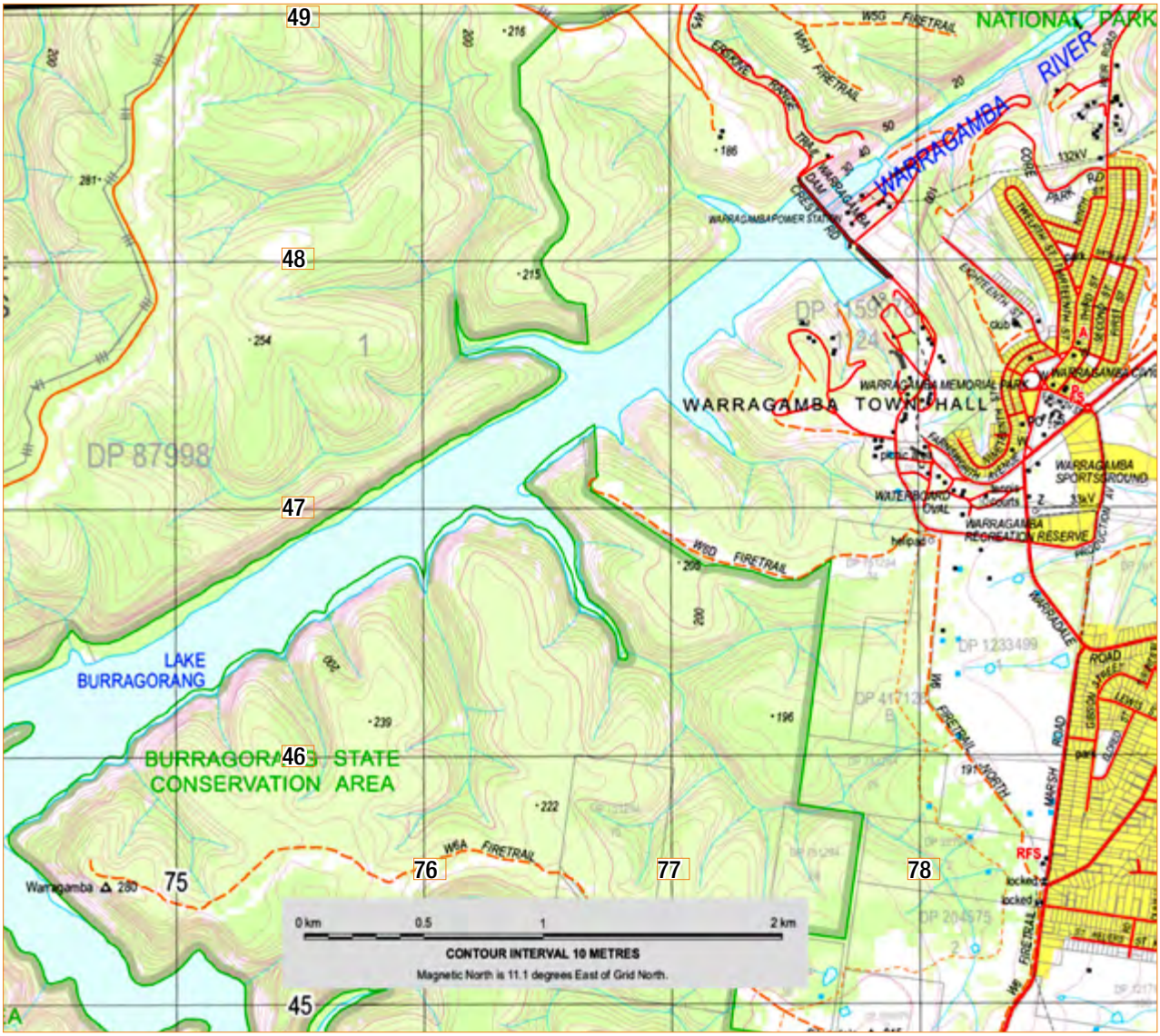
SOURCE D: Uluru visitor map



SOURCE E: Uluru during rain

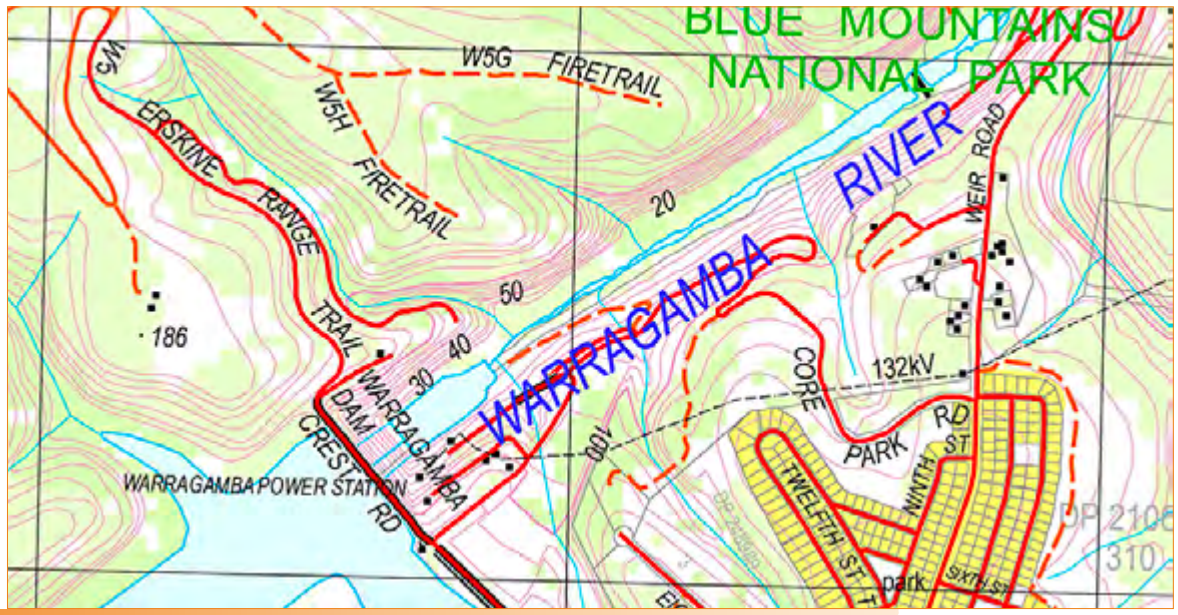
Uluru-Kata Tjuta National Park is listed with UNESCO World Heritage sites for its natural and cultural landscape.

SOURCE F: Warragamba Dam – landscapes, landforms and water resources



SOURCE G: Warragamba Dam

Do not use the topographic map scale with the enlarged map section below



NOTE: Only use the scale on the Source F: Warragamba map on P. 59 to calculate distance and area.

Lake Burragorang from the Lookout, May 14 2020

Warragamba River below Warragamba Dam

Warragamba Dam and Lake Burragorang

Images sourced from https://www.thefifthestate.com.au/articles/nsw-can-have-water-or-fossil-fuels-but-not-both/

Warragamba Topographic map legend

Source: https://sydneyuncovered.com/warragamba-dam-and-lake-burragorang-lookout/

SOURCE H: Access to water

One in 10 people without safe water

Over 650 million people, equal to almost one in 10 of the world's population, are living without access to safe drinking water, putting them at risk of ill-health or premature death, according to international charity WaterAid

Top 10 countries with greatest percentage of people living without access to safe water

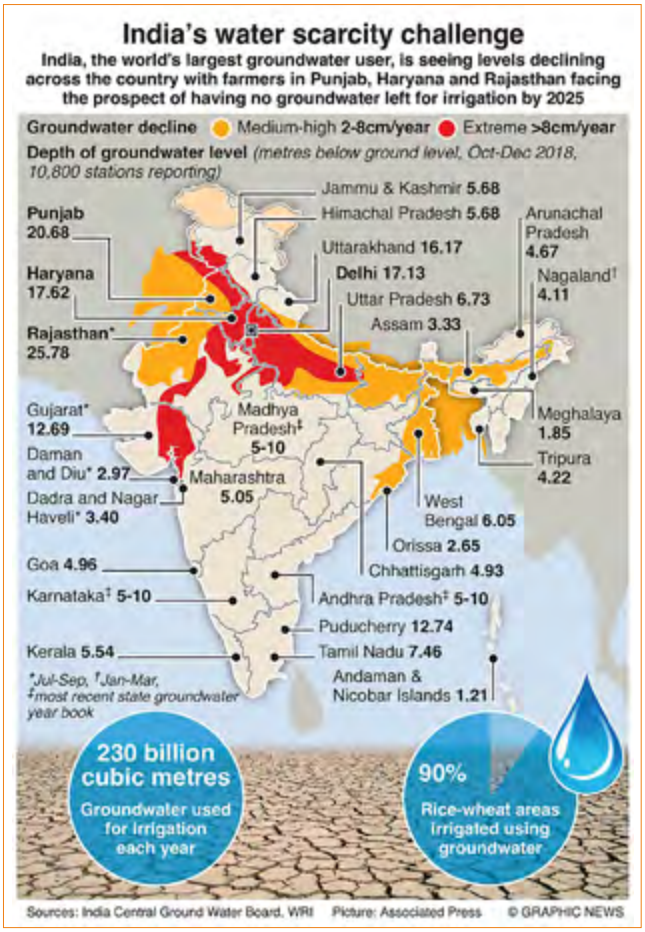
Rank	country	Percentage
1	Papua New Guinea	60
2	Equatorial Guinea	52
3	Angola	51
4	Chad	49
5	Mozambique	49
6	Madagascar	48
7	Democratic Rep. of Congo	47
8	Afghanistan	45
9	Tanzania	44
10	Ethiopia	43

Top 10 countries with greatest numbers of people living without access to safe water

Rank	country	Numbers (millions)
1	India	75.8
2	China	63.2
3	Nigeria	57.8
4	Ethiopia	42.3
5	Democratic Rep. of Congo	33.9
6	Indonesia	32.3
7	Tanzania	23.2
8	Bangladesh	21.1
9	Kenya	17.2
10	Pakistan	16.1

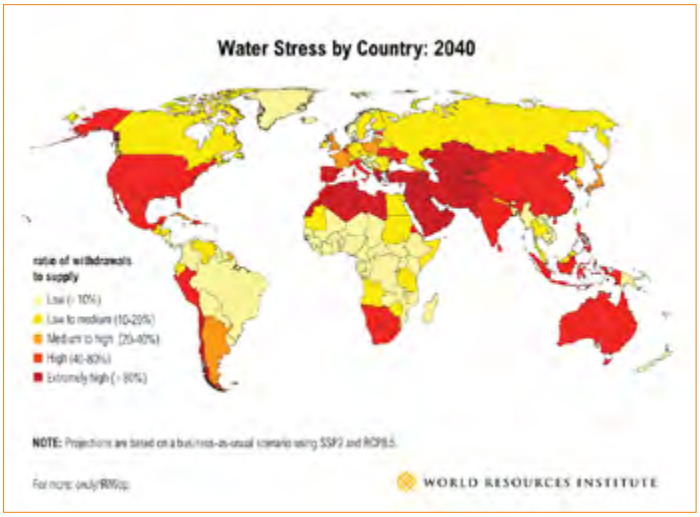
Source: WaterAid Picture: Newscom © GRAPHIC NEWS

SOURCE I: Water scarcity



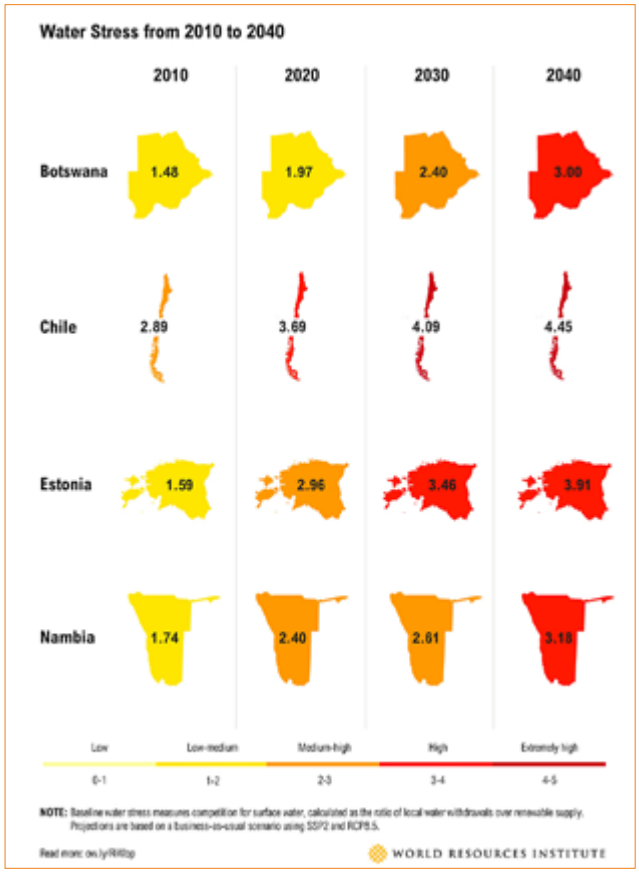
Water scarcity can mean scarcity in availability due to physical shortage, or scarcity in access due to the failure of institutions to ensure a regular supply or due to a lack of adequate infrastructure.

SOURCE J: Global water stress



World Resources Institute blog Source: https://www.wri.org/blog/2015/08/ranking-world-s-most-water-stressedcountries-2040

SOURCE K: Water stress by country

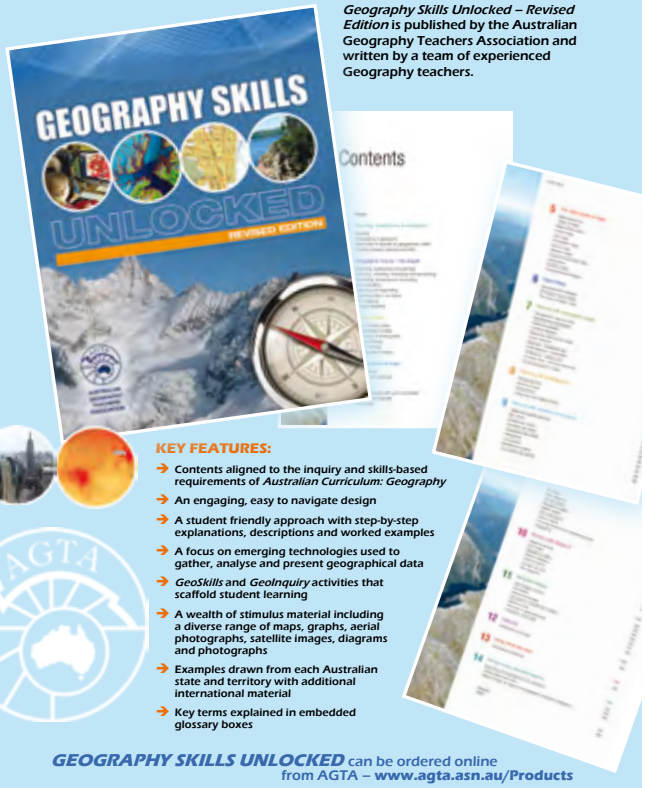


RESOURCES

AGTA ANNOUNCES A REVISED EDITION OF THIS POPULAR BOOK

GEOGRAPHY SKILLS UNLOCKED, the essential skills book for Australian secondary schools

Geography Skills Unlocked – Revised Edition is published by the Australian Geography Teachers Association and written by a team of experienced Geography teachers.



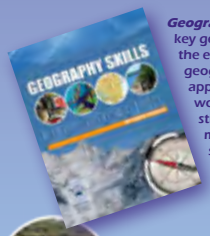
KEY FEATURES:

- Contents aligned to the inquiry and skills-based requirements of *Australian Curriculum: Geography*
- An engaging, easy to navigate design
- A student friendly approach with step-by-step explanations, descriptions and worked examples
- A focus on emerging technologies used to gather, analyse and present geographical data
- *GeoSkills* and *GeoInquiry* activities that scaffold student learning
- A wealth of stimulus material including a diverse range of maps, graphs, aerial photographs, satellite images, diagrams and photographs
- Examples drawn from each Australian state and territory with additional international material
- Key terms explained in embedded glossary boxes

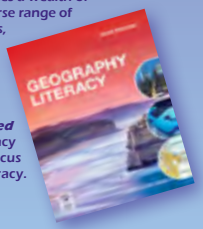
GEOGRAPHY SKILLS UNLOCKED can be ordered online from AGTA – **www.agta.asn.au/Products**

PRE-SERVICE GEOGRAPHY TEACHER STARTER PACK

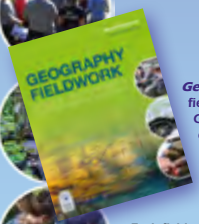
The Australian Geography Teachers Association (AGTA) offers pre-service Geography teachers the opportunity to access three essential teaching resources at a considerable discount on their recommended retail price. All three resources are available for the heavily discounted price $115.00.



Geography Skills Unlocked a comprehensive coverage of the key geographical skills including those related to the focus on the emerging technologies used to gather, analyse and present geographical data. It provides the user with a student-friendly approach with step-by-step explanations, descriptions and worked examples. The book includes a wealth of stimulus material including a diverse range of maps, graphs, aerial photographs, satellite images, diagrams and photographs.



Geography Literacy Unlocked focuses on developing the literacy skills of students. It includes a focus on written, visual and oral literacy.



Geography Fieldwork Unlocked features 33 inquiry-based fieldwork activities developed by a team of experienced Geography educators. The book introduces the reader to concept of inquiry-based fieldwork. It also provides guidance in developing fieldwork action plans, research methodologies, and data collection tools and approaches. It also provides guidance on the presentation and communication of fieldwork findings.

Each fieldwork activity is framed by one or more inquiry questions. They also feature: a statement of expected learning; a list of the equipment needed to successfully complete each fieldwork activity; a short introduction; background information that contextualises student learning; pre-fieldwork activities; and detailed step-by-step instructions on how to complete each fieldwork task.

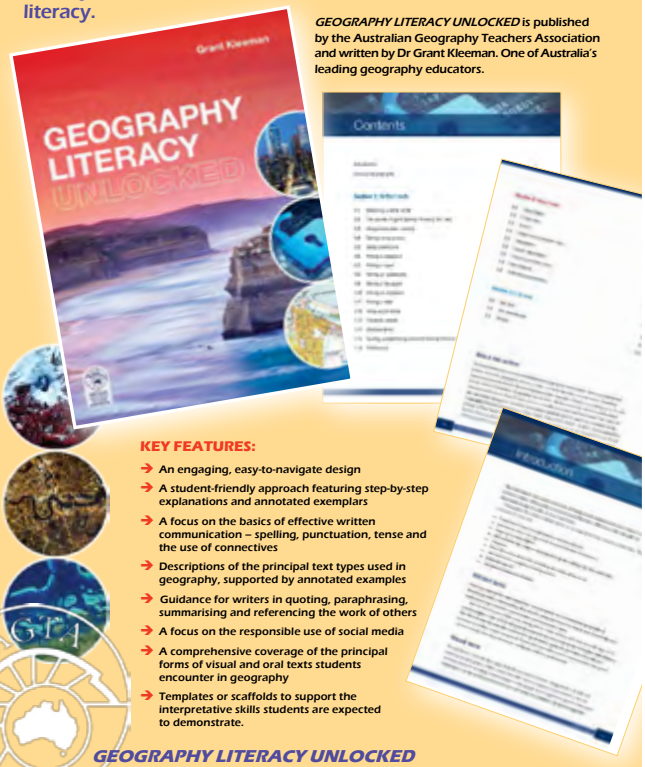
TO ORDER – Email: gta.admin@ptc.nsw.edu.au or Phone: 02 9716 0378

Find out about the AGTA Geography Unlocked series – www.agta.asn.au/Products

AGTA ANNOUNCES AN ESSENTIAL NEW GEOGRAPHY RESOURCE

GEOGRAPHY LITERACY UNLOCKED has been written for secondary geography students seeking to improve their literacy skills. It includes a focus on written, visual and oral literacy.

GEOGRAPHY LITERACY UNLOCKED is published by the Australian Geography Teachers Association and written by Dr Grant Kleeman. One of Australia's leading geography educators.



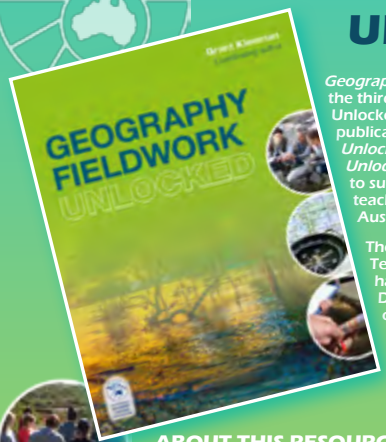
KEY FEATURES:

- An engaging, easy-to-navigate design
- A student-friendly approach featuring step-by-step explanations and annotated exemplars
- A focus on the basics of effective written communication – spelling, punctuation, tense and the use of connectives
- Descriptions of the principal text types used in geography, supported by annotated examples
- Guidance for writers in quoting, paraphrasing, summarising and referencing the work of others
- A focus on the responsible use of social media
- A comprehensive coverage of the principal forms of visual and oral texts students encounter in geography
- Templates or scaffolds to support the interpretative skills students are expected to demonstrate.

GEOGRAPHY LITERACY UNLOCKED is available for purchase from the GTANSW website: **www.gtansw.org.au**

NEW TO THE AGTA GEOGRAPHY UNLOCKED SERIES

GEOGRAPHY FIELDWORK UNLOCKED



Geography Fieldwork Unlocked is the third book in the Geography Unlocked series. Like companion publications – *Geography Skills Unlocked* and *Geography Literacy Unlocked* – the resource seeks to support and enhance the teaching of Geography in Australian Schools.

The Australian Geography Teachers Association (AGTA) has published the book with Dr Grant Kleeman, one of Australia's leading Geography educators, acting as coordinating author.

→ **NOW AVAILABLE**

ABOUT THIS RESOURCE

Geography Fieldwork Unlocked features 34 inquiry-based fieldwork activities developed by a team of experienced Geography educators

Section 1 of the book introduces the reader to inquiry-based fieldwork. It also provides guidance in developing fieldwork action plans, research methodologies, and data collection tools and approaches. It also provides guidance on the presentation and communication of fieldwork findings.

Section 2 features nine fieldwork activities for primary students (Years F/K–6). Each of these activities has been designed to develop students' conceptual understanding and the skills associated with inquiry-based learning.

Section 3 showcases 25 fieldwork activities aligned to the topics studied by students in Years 7–10.

Each fieldwork activity is framed by one or more inquiry questions. They also feature: a statement of expected learning; a list of the equipment needed to successfully complete each fieldwork activity; a short introduction; background information that contextualises student learning; pre-fieldwork activities; and detailed step-by-step instructions on how to complete each fieldwork task.


Source: http://www.fao.org/sustainability/frameworks-approaches/en/

Teacher guide to using these resources

Lorraine Chaffer, Vice President GTA NSW & ACT

The focus of these resources and activities is the important biophysical processes, cycles and concepts linked to **Sustainable Biomes and Environmental Change and Management topics**.

Use the resources and student activities:

- to check student knowledge and understanding of content covered online or in class. Students complete activities before or after examining Snapshots provided for each topic.
- as a topic starter to cover key concepts and content focus
- to apply knowledge and understanding to a 'place' for example
- for independent learning OR guided classroom use
- as a stimulus for further inquiry of a landscape or case study

SUSTAINABLE BIOMES

- ✓ Snapshot: Biomes and their productivity
- ✓ Snapshot: Pollinators, bees and food
- ✓ Case study: Grasslands biomes

ENVIRONMENTAL CHANGE

- ✓ Case Study: Tundra
- ✓ Case Study: Sydney Harbour
- ✓ Virtual Fieldwork
- ✓ Stage 5: Skills Stimulus

SNAPSHOT: Biomes and their productivity

Lorraine Chaffer,
Vice President GTA NSW & ACT

Sahara Desert, Morocco. Photo: L Chaffer

GLOSSARY

Biomes – Earth's major vegetation (plant) communities
Climatic zones – areas of the Earth that have similar temperatures. Climate zones are linked latitude and altitude
Spatial distribution – The location and arrangement of biomes across the surface of the Earth.
Arable– land cultivated to grow crops
Biome productivity – refers to the amount of biomass or living plant material produced through photosynthesis.
Tropical – refers to places that are between the tropics and have warm winters and hot summers
Temperate – refers to places with mild to warm summers and cool to cold winters
Polar – refers to places with cool summers and very cold winters.

Characteristics that differentiate the world's biomes

Earth's major biomes have distinctly different features of vegetation and animal life due to differences in climate (temperature and precipitation). Earth's biomes generally correspond to the different climate zones. The same biome can occur in different places with similar climates, for example tundra can occur in areas near the Arctic Circle as well as high up mountain ranges where the climate is too cold for trees to grow and precipitation occurs as snow in winter.

Other factors such as relief, gradient, aspect and soil quality also influence the features of different biomes.

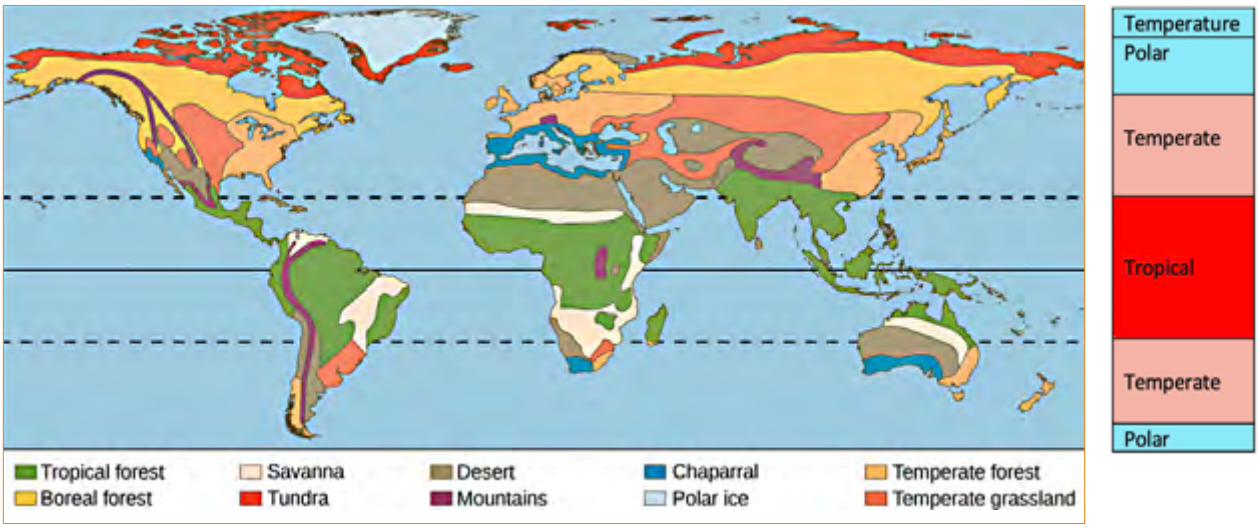
Comparing biomes

Comparing biomes is one way to understand reasons for differences between them.

Examining the **climatic graphs** of places located in different biomes will reveal key characteristics such as temperature, temperature range, annual precipitation, types of precipitation and seasonal variations in temperatures and precipitation.

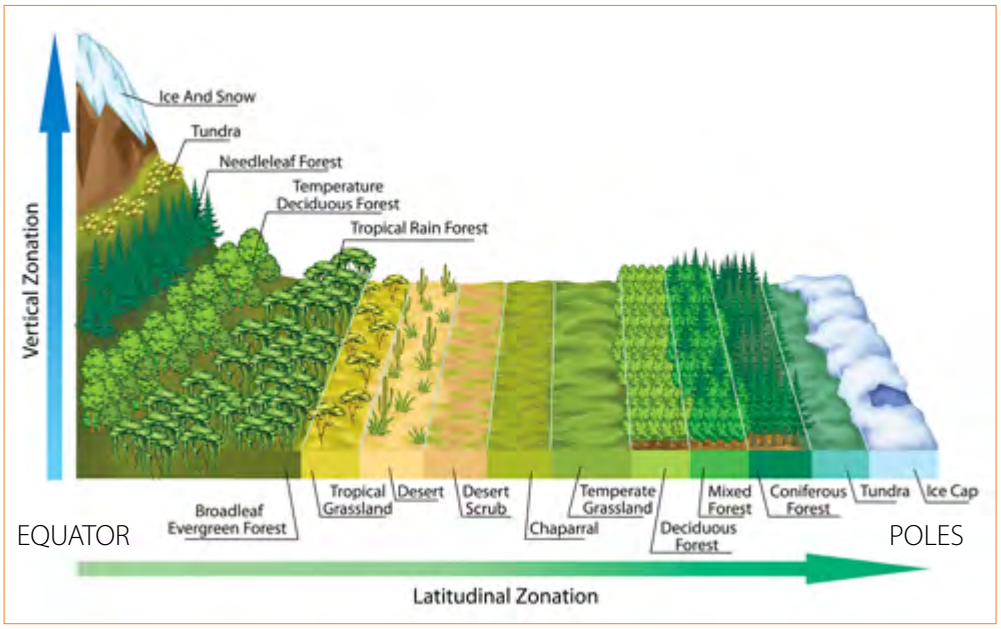
Useful resources for comparing biomes include:
Biome Viewer https://media.hhmi.org/biointeractive/biomeviewer_web/index.html
Earth Observatory Mission Biome at: https://earthobservatory.nasa.gov/experiments/biome

SOURCE A: Distribution of Earth's biomes



Source: https://openoregon.pressbooks.pub/envirobiology/chapter/3-3-terrestrial-biomes

SOURCE B: Earth's biomes by latitude and altitude



Source: Shutterstock

See the Bulletin Supplement activity for "Biomes and their productivity" to demonstrate your understanding of the links between biomes and climate

Biome productivity

Primary productivity refers to the amount of biomass or living plant material produced through photosynthesis. High productivity can support large numbers of consumer species through food chains and food webs and can be understood by examining **food pyramids** and **food webs**.

The least productive biomes are those with extreme climates like deserts and tundra where temperatures are hot or cold and precipitation low, resulting in limited plant growth. The most productive biomes typically have higher temperatures, plenty of water and lots of available soil nitrogen.

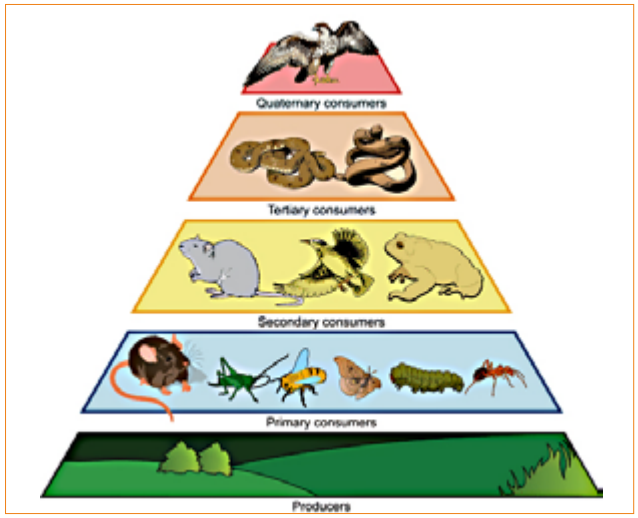
Biome productivity and capacity to produce food

The most productive biomes generally have the best capacity to produce food, because they have the climatic conditions that plants need to grow ... and can produce crops for human consumption or pasture and feed for livestock.

Biomes are used for food, fibre and industrial products production in many ways:

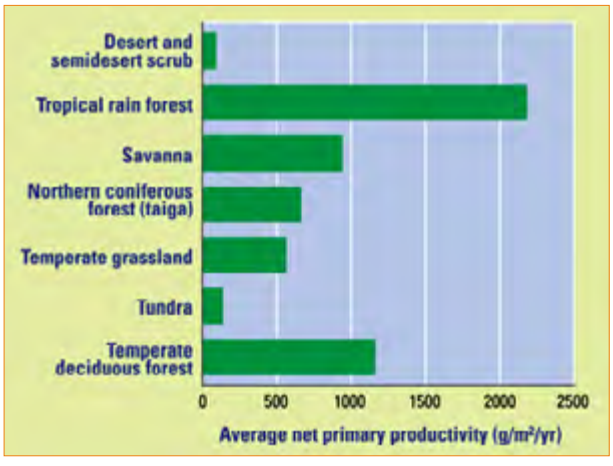
- harvesting biome resources such as nuts, fruits, seeds, wildlife and timber in forest biomes
- managing the natural resources of the biome for food production such as grazing animals on native pastures in grassland and tundra biomes.
- replacing the natural biome with introduced species of plants and animals such as rice, wheat and cotton and improving pastures with exotic species.
- modifying the characteristics of natural biomes such as using irrigation to supplement natural rainfall, terracing land to grow crops, fertilising soils and building wind breaks.

SOURCE C: Food pyramid



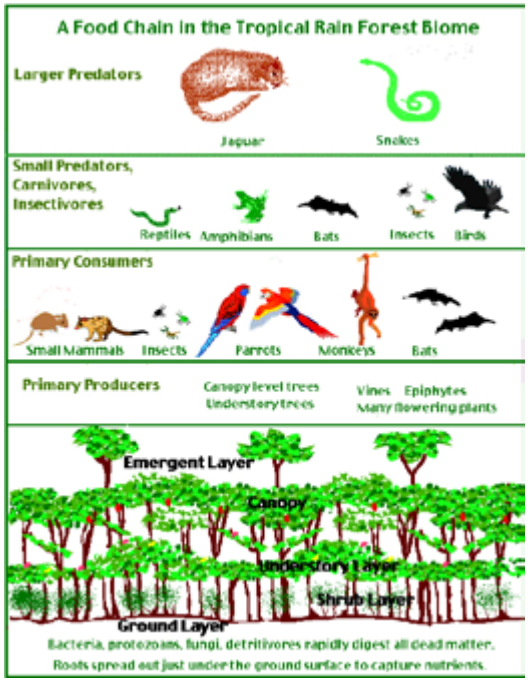
Primary producers create biomass (plant material) used as food by consumers. Plants are the base of food pyramids.

SOURCE D: Biomes productivity

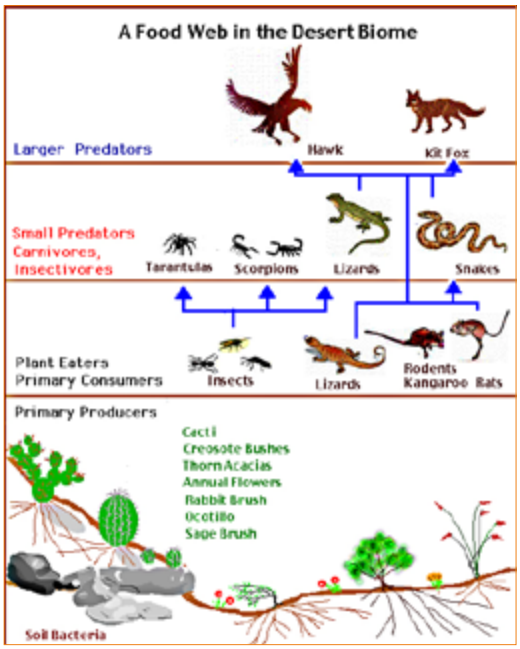


Net primary productivity is the biomass left after producers meet their survival needs. It is available for plant growth.

SOURCE E: Food Pyramids



Source: https://www.world-builders.org/lessons/less/biomes/rainforest/tropi_rain/rainweb.html



Source: https://www.world-builders.org/lessons/less/biomes/desert/hot-desert-chain.html

Global satellite monitoring

Satellites are used to monitor biome productivity by showing how "green" different parts of the planet are and how that greenness changes over time. These observations help scientists understand the influence of natural cycles, seasons and drought on vegetation.

On this global map dark greens show land areas with plenty of leafy green vegetation, such as the Amazon Rainforest. Beige to white areas have little or no vegetation, including deserts and Arctic tundra areas. Areas with moderate amounts vegetation such as grasslands are pale green. Water appears blue and 'no data' areas appear as grey.

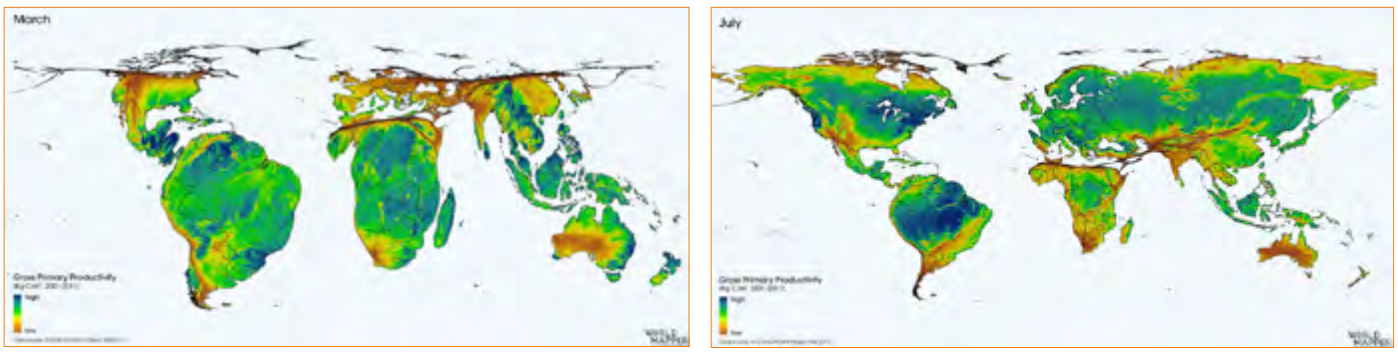
SOURCE F: Seasonal biome productivity

Productivity changes with the seasons

Visualisations showing changing productivity through the seasons can be found at these locations:

- A NASA visualisation shows 20 years of continuous observations of plant life on land and at the ocean's surface, from 1997 to 2017 at https://www.nasa.gov/feature/goddard/2017/thechanging-colors-of-our-living-planet
- Worldmapper 'Heartbeat of natures productivity' is a fascinating cartogram visualisation in which countries are resized by their productivity. Watch the visualisation and read more at https://www.visualcapitalist.com/animation-theheartbeat- of-natures-productivity

SOURCE G: Earth's Heartbeat



Source: WORLDMAPPER 'Heartbeat of natures productivity' at https://www.visualcapitalist.com/animation-the-heartbeat-of-natures-productivity/

Climate change and biome productivity

Potential impacts of climate change on biomes include:

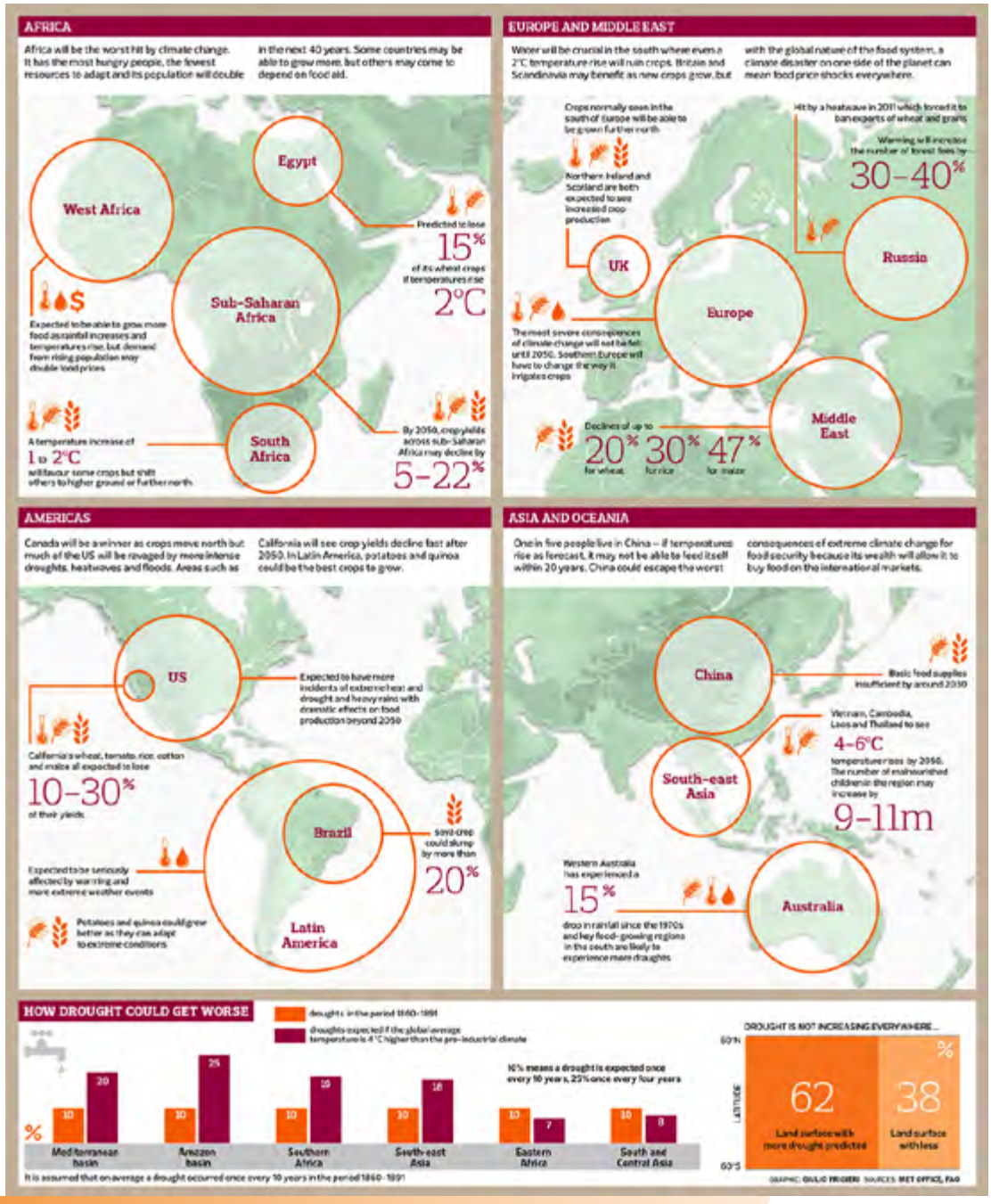
- higher temperatures favouring some plant species. Trees may grow in areas where it is now too cold.
- increasing rainfall increasing biome productivity
- decreasing rainfall reducing productivity and may turn grasslands into deserts
- more extreme weather events such as drought, flood, bushfire and storm stressing the capacity of ecosystems such as forests to survive
- sea level rise submerging coastal biomes or reducing plant growth because of salinity
- species migration and changing food webs

Climate change and food production

Hotter, wetter, drier climates will impact on the suitability of some biomes to produce food.

- desertification will reduce the capacity of farmers to graze cattle on grasslands
- grain growing regions may become too wet for wheat but more suited to rice.
- grazing land could be used to grow crops without irrigation.
- irrigation may be needed to keep crops growing where the climate becomes dryer
- crop losses from pests and diseases may increase

SOURCE G: Climate change and food production



The GUARDIAN: Climate change: how a warming world is a threat to our food supplies (2013) https://www.theguardian.com/environment/2013/apr/13/climate-change-threat-food-supplies

A honeybee pollinates a flower (Creative Commons). Source: https://en.wikipedia.org/wiki/Honey_bee#/media/File:Pollinationn.jpg

POLLINATORS, BEES and FOOD

Lorraine Chaffer,
Vice President GTA NSW & ACT

NOTE: this is a condensed and adapted version of an article published in the Geography Bulletin: Vol 51, No 1, 2019

POLLINATORS

Pollinators include bees, insects, birds, and other animals that move pollen from one flower to another, fertilising plants and allowing them to reproduce. Native pollinators are species native to a specific region. Although bees are the most common pollinators, other insects and animals, including wasps, butterflies, flies, beetles, bats, and birds are also important. The wind plays role in pollination while some plants are also self pollinating.

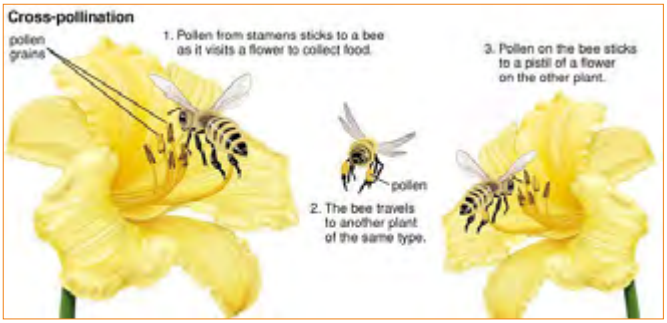
Bees, food and biomes

A large proportion of global food production and food security depends on the bees and insects which pollinate fruit, vegetable and pasture crops. Opportunities to increase the size and quality of crop harvests for up to 70 per cent of the world's main crops depends on continued honeybee pollination. In many biomes the biodiversity of plant species also depends on pollinators.

Approximately 30 percent of global food and fibre crops depend upon pollinators for reproduction. The fruits and seeds from these crops provide 15 to 30 percent of food and beverages consumed by people.

The role of bees in food production

Podcast: The power of pollinators Food and Agriculture Organization of the United Nations – http://www.fao.org/news/podcast/tzh-06-the-powerof-pollinators-why-more-bees-means-better-food/en



"In Australia, two-thirds of all horticultural and agricultural crops need honeybees for optimal pollination. Many fruits, such as apples, raspberries and peaches, are more productive, produce better, more attractive fruit and even store better and for longer when they are serviced by honeybees. Lucerne, which is an important crop for feeding livestock such as cattle, is also much more productive when sufficient numbers of honeybees are available to promote pollination. Almond blossoms rely completely on honeybees for pollination—so, no bees, no almonds. It has been estimated that the value of honeybee-reliant agriculture in Australia is AUD $4–6 billion per year and rising"

From: AustralianAcademy of Science: Getting the buzz on the value of bees – https://www.science.org.au/curious/everything-else/bees

Threats and challenges

Pollinator species are in decline along with global biodiversity. Since the 90's, the worldwide bee population has declined rapidly. There are many possible reasons for this decline including the usage of pesticides, habitat destruction and climate change. The challenge to future food production is maintaining honeybee numbers along with other pollinator species and halting the decline in global biodiversity.

World Bee Day

World Bee Day was an initiative launched in Slovenia on 2014 to increase global awareness about the need to protect bees due to the serious decline in bee populations worldwide. In December 2017, the UN, supported by all UN states, declared May 20th to be World Bee Day. As awareness increases opportunities to restore bee health and bee numbers also increases.

Opportunities

Australian universities and research organisations such as the CSIRO have researchers working on understanding be behaviours, the threats to honeybee populations and ways to combat their decline. Thousands of honey bees have been fitted with tiny sensors as part of a world-first research program to monitor the insects' movements. Understanding bee behaviour while they travel through farm crops will help scientists trouble shoot immediate threats to their survival.

"CSIRO is also involved in bee research initiatives, leading the Global Initiative for Honeybee Health. This includes a project where 5000 bees have been fitted out with tiny sensors, then let loose into the environment. When the bees pass certain checkpoints, the sensors are detected, allowing the researchers to create a map of the bees' movements and better understand how they move through the landscape"

Australian Academy of Science – https://www.science.org.au/curious/everything-else/bees

Bee with a backpack… of the sensor variety

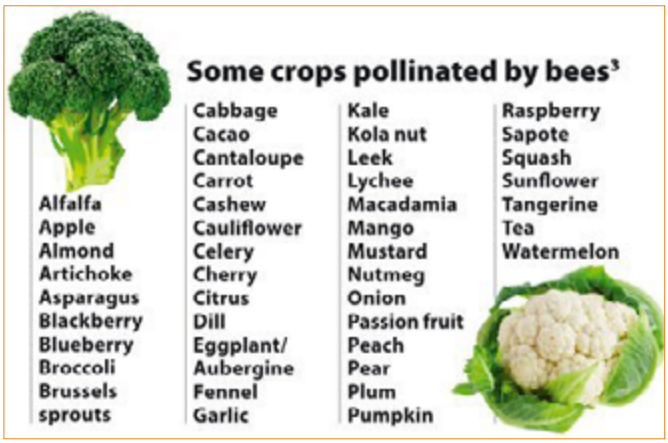
Source: Photo CSIRO – www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology/Swarm-sensing

Growing demand for bee services

Although the process of pollination occurs naturally, there is a growing demand in Australia for bee services where professional beekeepers help with the process as a business operation. These honey bee pollinators are estimated to add around $6 billion a Australia's economy each year.

Native species such of bees and insects as well as wind assist in the pollination process and there are differences between the requirements of different crops. In 2018, 53 crops grown in Australia were found to depend on bees for pollination and the same study estimated that honey bees contributed $14.2 billion to the Australian economy.

SOURCE A: Crops pollinated by bees



Source: https://www.scienceabc.com/nature/bee-extinction-means-endhumanity.html

Australia needs more service bees

In 2019, 240,000 honey bee hives were used for pollination by the almond industry. This was over half the number of managed honey bee hives in Australia at the time. Over a six week period beekeepers from as far away as Queensland and northern New South Wales relocate their their hives to the Murray River almond-growing region in Victoria where 68% of the Australia's almond trees are found. Pollination broker Trevor Monson says that this year, for the first time, the almond trees "almost ran short of bees to pollinate them."

Future demand for these bees is expected to increase to 300,000 hives. There is competing demand for bee services from avocado, macadamia and blueberries producers in northern NSW and Queensland in particular. Avocados and blueberries flower at the same time as almonds. There is growing pressure for Australia t have a pollinator policy to ensure future food security.

Drought and bushfires have impacterd on Australia's capacity to increase the number of honeybee hives for agricultural use.

Aussie Agriculture future needs to bee secure. Source: https://www.nationalgeographic.com.au/australia/aussieagriculture-future-needs-to-bee-secure.aspx

Mongolia's Grassland Biomes

Dr Susan Bliss
Educational Consultant
Condensed and adaprted from Bulletin 48, No 1, 2016

Grassland, Northern Mongolia. Source: Shutterstock

Grasslands can appear as desolate landscapes with kilometres of endless grass containing a few scattered trees. Instead they are home to a rich biodiversity of species and are a primary source of food for both wildlife and humans. In Mongolia traditional life is closely connected to the environment.

What are grasslands?

Grasslands are:

- not the same across the world but vary according to climate, altitude, landform and soil.
- referred to as 'savannas' in Africa; 'steppes' in Asia; 'prairies' in North America; 'pampas' in South America and 'rangelands' or 'savannas' in Australia.

Where are grasslands located?

Grasslands:

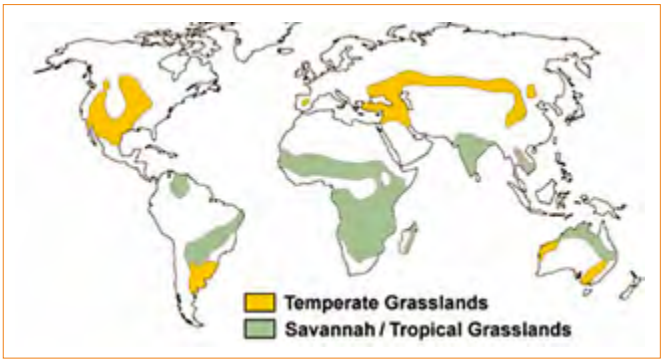
- cover 30% of the Earth's land.
- occur primarily in the interiors of continents and have large seasonal temperature variations, with hot summers and cold winters
- encompass 50% of the land area in Africa, 33% in South America and 75% in Australia and Kenya.
- are generally located between forests (wetter environments) and deserts (drier).but are also found at different altitudes from sea level to high plateaus.
- Central Asia's vast grassland area is known as the Eurasian Steppe. This area extends into Mongolia, a land-locked county bordering Russia and China.

Characteristics

Grasslands have developed in response to natural fire, periodic drought, and wildlife grazing as well as climatic conditions that prevent shrubs and trees growing.

Grasslands usually have very rich, dark topsoil that support deep root systems – often much of the grass is below the ground.

SOURCE A: Grassland regions of the world



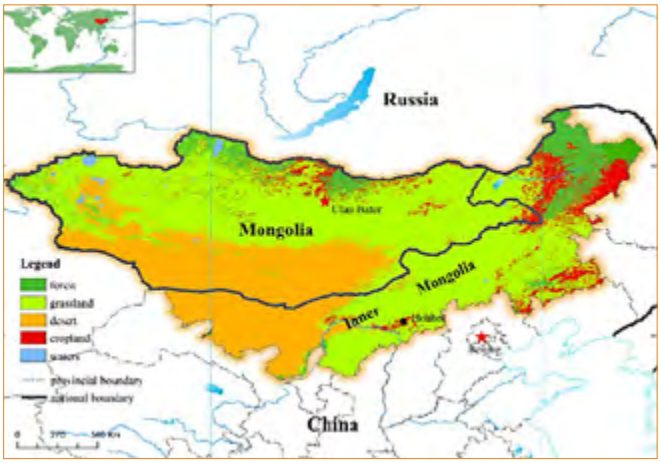
Grassland productivity?

The productivity of grasslands, depends on climate and soil quality. Higher precipitation leads to tall grasses with a high biodiversity of grasses and high productivity. Lower precipitation leads to short grass prairies and arid grasslands.

The productivity of grasslands makes them suitable for grazing and crop growing. All the major food grains corn, wheat, oats, barley, millet, rye and sorghum are produced in grasslands. Grazing grasslands eg sheep and cattle also produces food including meat and milk. Fibres such as wool and cotton are produced in grassland biomes.

Deep, fertile soils are highly productive in wetter grassland biomes. Source: https://grasslandscience10.weebly.com/temperate-grassland.html

SOURCE B: Mongolia's biomes



Source: http://www.mdpi.com/remotesensing/remotesensing-05-05193/article_deploy/html/images/remotesensing-05-05193f1-1024.png

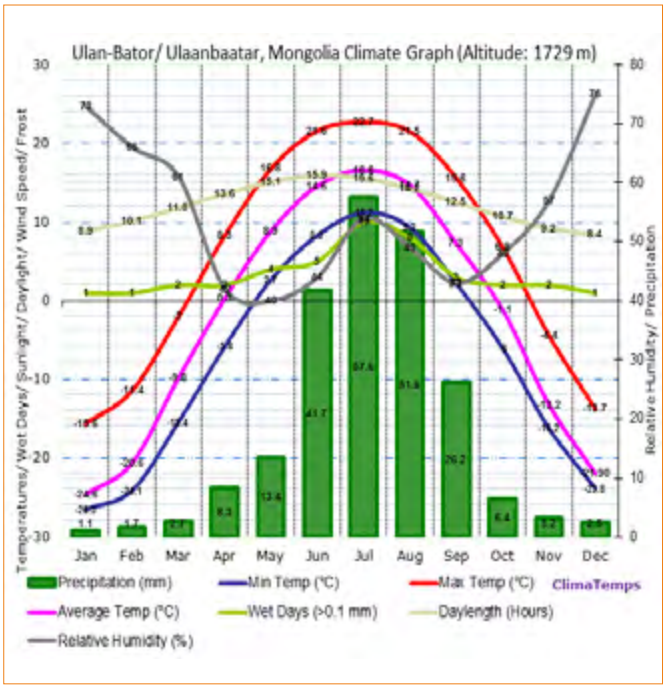
Mongolia's grasslands

Mongolia contains expansive grasslands that remain sparsely populated, dominated by agriculture, and support relatively isolated human communities dependent on its natural resources.

The Mongolian-Manchurian grasslands cover an area of nearly 900,00km^2. The biome is classified as a temperate grassland for the following reasons:

- **Climate:** The Mongolian climate varies from arid to semi-arid with warm to hot short summers and long cold winters. Temperatures range from –45°C in winter to over 40°C in summer. The country is called the 'Land of the Eternal Blue Sky' as it enjoys over 250 sunny days a year. Few clouds results in little precipitation that averages 400mmpa in the east, declining to 150mmpa in the west.
- **Plants:** The grasslands consist of medium to tall grasslands, dominated by feather grass.

SOURCE C: Climate graph of Ulaanbaatar



Source: http://www.ulaanbaatar.climatemps.com/graph.php

The grasses have evolved over 65 million years ago and are connected to changes in temperature and precipitation.

- **Animals:** The biome supports a variety of animals such as gazelles, wolves, foxes, antelopes and pheasants. The grass is crucial for semi-nomadic herders who graze horses, goats, cattle, yaks and camels. The growth in the cashmere trade has fuelled economic pastoralism and growth in exports.
- **Net Primary Productivity (NPP)** is low for grasslands located in dry or cold regions, but is higher after precipitation.

Grasslands span 80 percent of Mongolia and generate livelihoods for 200,000 families.

Yurt village and herds, Mongolia. Source: Shutterstock

Grassland agriculture

Extensive grazing occupies 80% of Mongolia's land, mostly on the grasslands. Only 1% of Mongolia is arable land used to grow crops and 5% urban.

Nomadic herders placed very little stress on the grasslands and never seriously threatened the biodiversity (plants and animals). A low population density and small settlements that migrate with the seasons helps to maintain the natural environment. Livestock grazing consists of goats, horses, donkeys, cattle, yaks, and Bactrian camels. Most pastoral households maintain multiple-species herds with at three to five types of livestock.

Cashmere goats produce quality wool, making it the most profitable source of income for Mongolian herders. More recently, overgrazing of these goats has caused land degradation and desertification.

Threats and challenges

Grasslands provide essential goods and services to Mongolians but recently their nomadic lifestyle is threatened by increased livestock numbers, the growth of settlements, mining and climate change. Trophy hunting and the illegal trade in rare animal species has reduced biodiversity.

As a result of a decline in nomadic pastoralism, many Mongolians have changed from living in gers or yurts, designed for easy movement a few times a year, to living in small brick homes in villages or high rise apartments in the capital city Ulaanbaatar.

Land degradation from overgrazing and mining has led to environmental degradation, as well as social changes for traditional herders.

Over the past 30 years, climate change and land degradation have resulted in serious desertification, and the drying out of 850 lakes and 2,000 rivers. If this persists, the Mongolian tradition of nomadic herding on the grasslands and the cultural customs of these people could completely disappear.

Sustainable management of grasslands?

Grasslands are one of the most endangered biomes on Earth as they are constantly altered by human activities. Where soils are rich, and the land is flat and treeless, areas have been turned into farms to grow crops or graze animals. Modified biomes, referred to as anthropogenic biomes or anthromes, now cover more of the Earth's land surface than so called 'wild' or 'natural' ecosystems. The sustainability of biomes is essential to human survival and wellbeing. The biomes need be protected to meet the needs of the present without compromising the ability of future generations to meet their own needs (Bruntland Report 1992).

What are the government strategies?

The Government of Mongolia has established nature reserves and national parks to limit people's access to grassland biomes. The government has introduced an environmental policy to:

- create a 'green economy'
- implement sustainable land management principles
- halt environmental pollution and land degradation (e.g. tree planting campaigns to reduce soil erosion and desertification)
- create water reserves and prevent water depletion
- ensure sustainable development of animal husbandry, crop farming and the food production sector
- promote ecotourism
- implement the 'one hundred thousand solar light' program
- expansion of specially protected areas
- abatement of air pollution in Ulaanbaatar
- introduce environmentally sound technologies in mines

The Mongolian National Council for Sustainable Development aims to combat poverty, reverse environmental degradation and improve human wellbeing.

Eastern Gobi desert steppe, watering point for goats

Mongolian horse riders on the grassland plains

Umnugovi Province, Two Wells watering point.
Photos: J Bliss

TUNDRA INVESTIGATIVE STUDY

Louise Swanson, GTA NSW & ACT

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

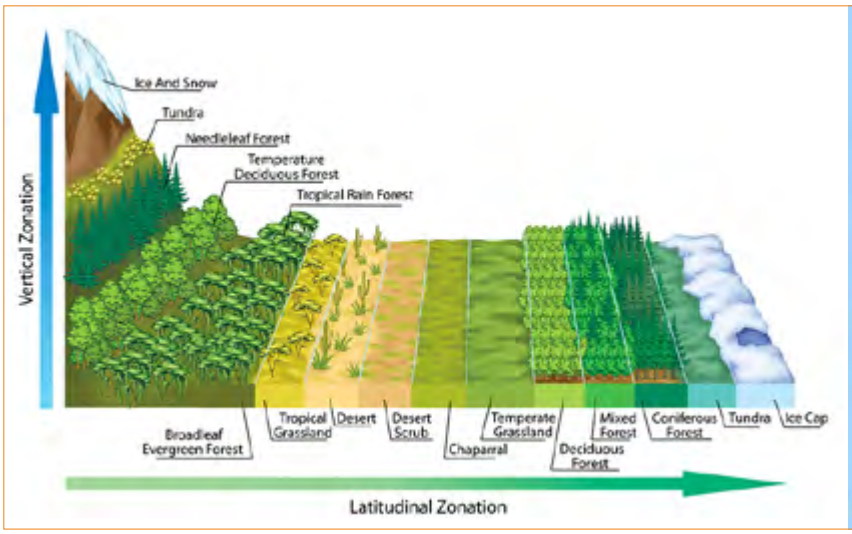
SOURCE A: Comparative locations

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 places are located in the Northern Hemisphere which is just south of the Arctic Circle.

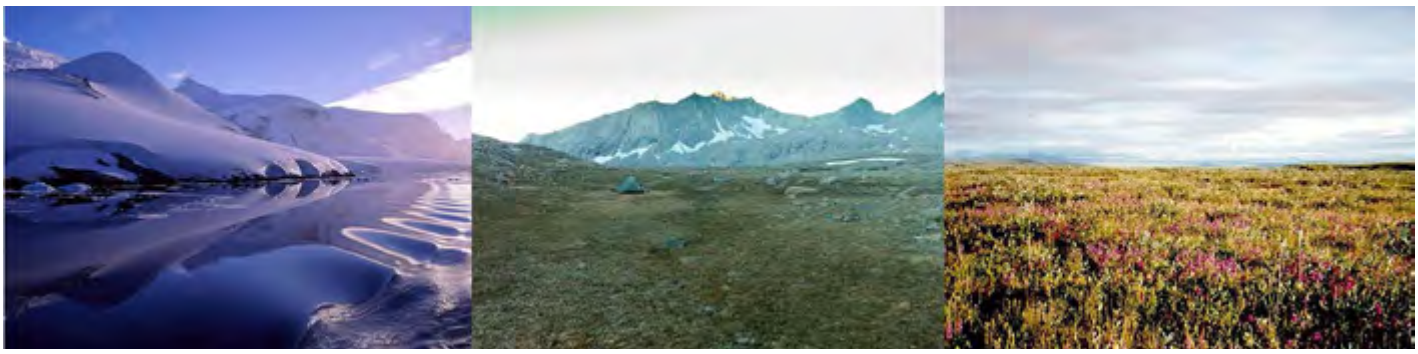
SOURCE B: Zone of transition – diagram and map



Source: Shutterstock

Canadian tundra. Source: 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

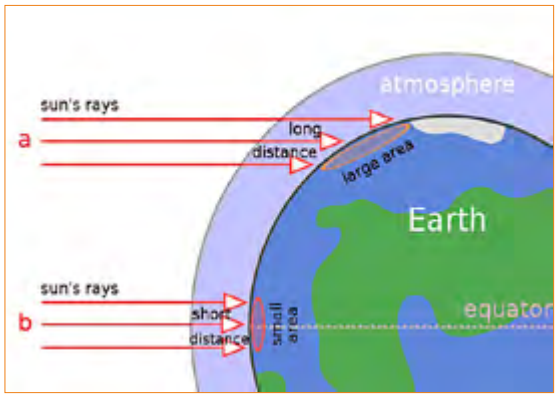
SOURCE D: A cold, dry climate

Metric Units

Statistic	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

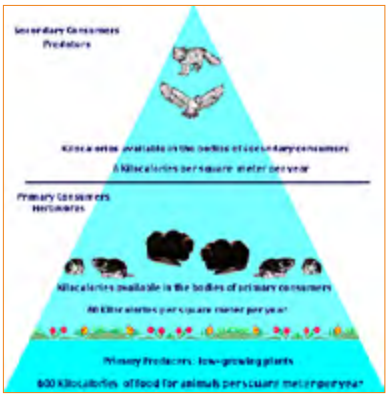
Climate statistics for Churchill ,Canada. Source: https://www.climate-charts.com/Locations/c/CN71913.html

Source E: Cold climate



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

Source F: Low productivity



Source G: Low biodiversity

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

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 isinfluenced 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.

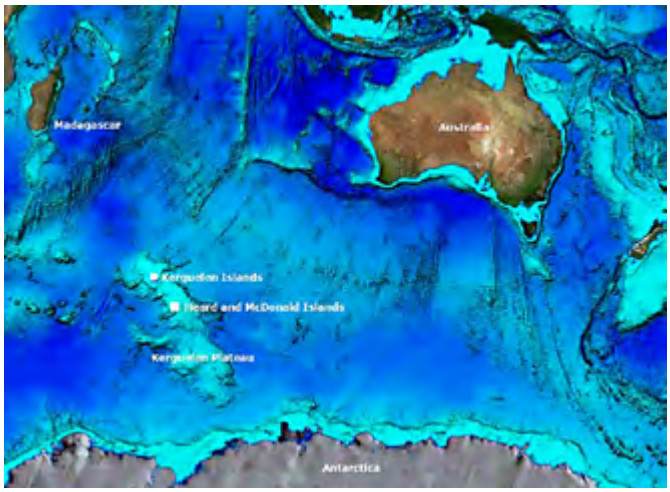
Water cycle

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 is 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^2 of Heard Island. Plant communities on Heard Island include open cushion carpet, mossy feldmark, wet mixed herbfi eld, 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 plants 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 Sheathbill, 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 aff ected 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 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

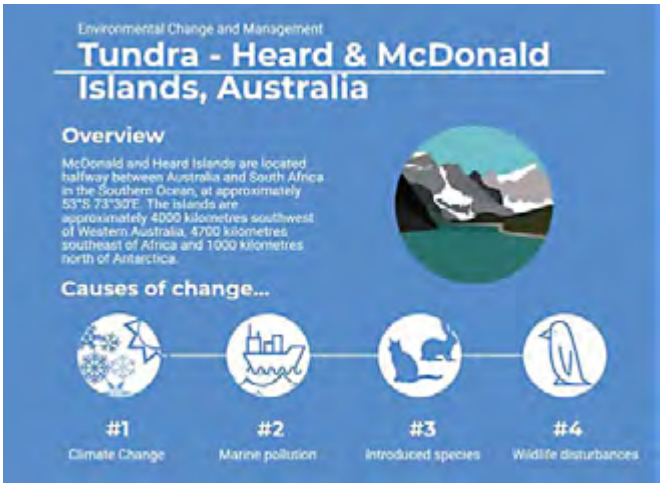
Since the first recorded visit in 1855, there have only been about 240 shore-based visits, and only two lists to McDonald Islands. The purpose of visits include sealing (in the past), research and management, private expeditions and surveillance. Visitors must apply to the Australian Antarctic Division 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 show 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 form 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.

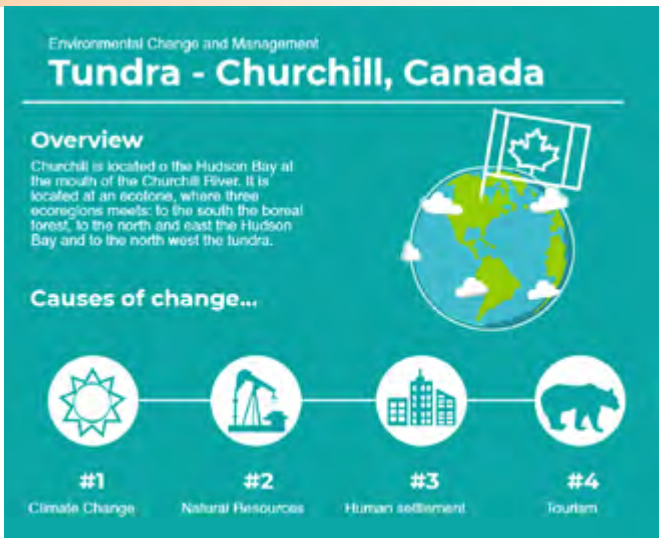
Ice on the Hudson Bay is forming more slowly and melting more quickly, and as a result polar bears are struggling to hunt for food. Polar bears generally hunt seals on the pack ice, and the last of ice is resulting in some bears starving or being underfed, and the survival rates of cubs declining.

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 microbiotic activity and release of greenhouse gases like carbon dioxide and methane.

SOURCE L: Climate change impact

Source: Shutterstock



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.

I n 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

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.

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.

Source: L. Swanson

Source: L. Swanson

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

Albedo	The fraction of solar radiation that is reflected back into space.
Antarctic Circle	The parallel of 66.5 degrees south latitude.
Arctic Circle	The parallel of 66.5 degrees north latitude.
Atmosphere	The gaseous envelope surrounding Earth.
Biosphere	The living organisms of Earth
Boreal forest (taiga)	A needle-leaf forest in sub-arctic regions of Eurasia and North America.
Carrying capacity	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.
Climate	Weather conditions of a long period of time.
Evaporation	When liquid water is converted to gaseous water vapour.
Glacier	A large natural accumulation of land ice that flows downhill, or outwards from the point of accumulation.
Hydrosphere	All water on Earth, including lakes, rivers, oceans, groundwater, etc.
Ice Sheet	A blanket of ice that completely covers the underlying terrain.
Lithosphere	The solid, inorganic portion of the Earth's surface.
Polar High	A high pressure system over either polar region.
Subpolar Low	A zone of low pressure situated at about 50–60 degrees latitude (either North or South). Also known as a polar front.
Taiga	See boreal forest.
Tundra	A treeless region, where low growing plants such as moss, heath and lichens grow and where subsoil is permafrost or permanently frozen soil.
Permafrost	Permanently frozen, impermeable ground (upper layers may thaw during summer). It results when ground surface temperatures remain below freezing point for long periods.
Weather	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/

SYDNEY HARBOUR ESTUARY

Lorraine Chaffer, Vice President GTA NSW & ACT

NOTE: This is a condensed and adapted version of the original article in Vol 50, No 4, 2018. For information on environmental management see the original article.

SYDNEY HARBOUR: AN ESTUARY AND A MARINE ENVIRONMENT

ENVIRONMENTAL SNAPSHOT: ESTUARIES

'Estuaries are partially enclosed bodies of water along coastlines where fresh water and salt water meet and mix. They act as a transition zone between oceans and continents. An estuary has a free connection with the ocean. Fresh water input from land sources (usually rivers) dilutes the estuary's salt content' (1).

Environmental processes

Most estuaries were formed around 12,000 years ago when rising sea levels flooded river valleys while others formed due to glacial erosion or tectonic forces.

Rivers carry sand, silt and plant matter downstream where it is deposited in estuaries to create a nutrient rich environment. Daily tides, **rainfall and runoff** result in a mix of saltwater and freshwater – salinity decreases moving upstream in the estuary. The **landscape and topography** of an estuary will determine its unique characteristics.

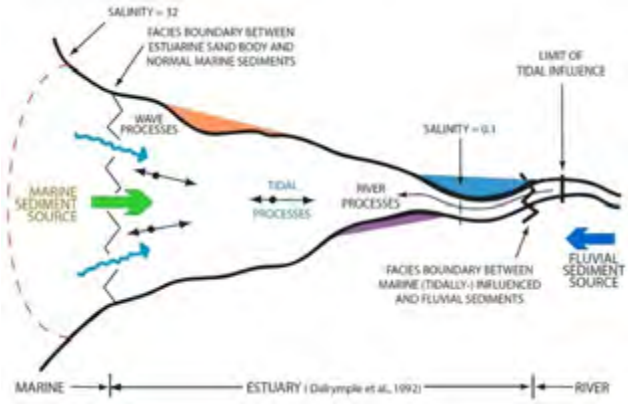
'It's the transport of nutrients and biological matter washed from land to sea and back that makes an estuary productive' (2)

'A healthy estuary produces between four and ten times as much organic matter as a cornfield of the same size"

Sources

1. Estuarine Science http://omp.gso.uri.edu/ompweb/doee/ science/ descript/whats.htm
2. How do estuaries work? https://www.howitworksdaily.com/how-do-estuaries-work/
3. Estuarine Science http://omp.gso.uri.edu/ompweb/doee/science/ descript/whats.htm
4. Estuaries: Where the river meets the sea https://www.nature.com/scitable/knowledge/library/estuarieswhere-the-river-meets-the-sea-102734157

SOURCE A: Estuarine Processes (4)



Estuarine processes result in the mixing of salt and fresh water and the supply of sand (marine) and silt (river sediment).

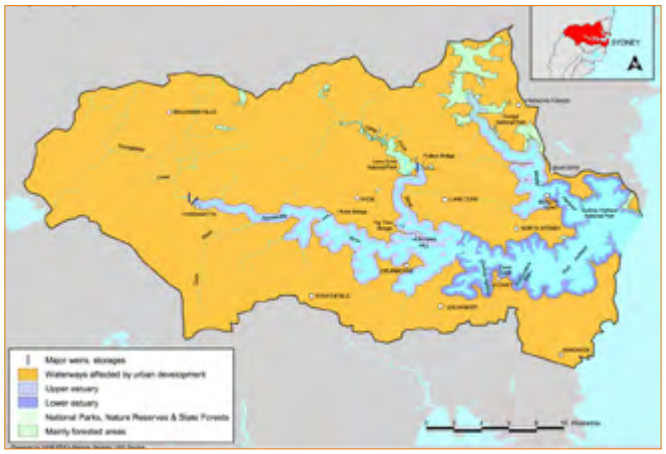
The importance of estuaries

1. **Habitats** for a diversity of marine species that thrive in a protected environment with abundant food. The life cycle of many commercial fish species is linked to estuaries while birds and mammals, rely on them for food and nesting or nurseries sites.
2. **Environmental services** of such as mangroves, salt marshes and oysters reefs
   - filter sediment and pollutants from the water as it moves from land to sea
   - act as buffers against storms and tidal surges.
3. **Economic importance**. Coastal activities, commercial and recreational fishing, boating, and tourism provide 28 million jobs and generate over 20 billion dollars of income each year.
4. **Recreation** at ocean and bay beaches and marinas.
5. **Cultural significance**. People have always used estuaries for food and transportation. For indigenous communities there is a cultural link to the land and sea within and around estuaries.

SYDNEY HARBOUR ESTUARY

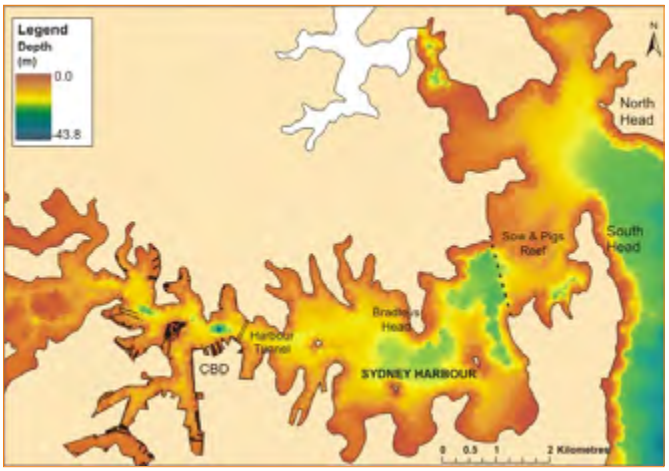
Sydney Harbour, one of the largest estuaries in the world, is a drowned river valley with a wide, open mouth, and many bays and inlets. The structure of the harbour creates a wide variety of habitats that support a high level of biodiversity compared to comparable estuaries around the world. Until the 1950's very little was known about what was below the surface of Sydney Harbour, but today that is changing as research scientists investigate the marine environment to better understand its features, functioning and threats.

SOURCE B: Sydney Harbour Estuary and catchment



Source: Environment NSW https://www.environment.nsw.gov.au/ieo/SydneyHarbour/maplg.htm

SOURC C: Natural bathymetry of Sydney Harbour



Source: Ozcoasts http://www.ozcoasts.gov.au/geom_geol/case_studies/sydney_final_report.jsp

For map showing submarine contours visit the Port Authority of NSW website https://www.portauthoritynsw.com.au/sydney-harbour/pilotage-navigation/pilotage-harbour-masters-directions/port-passage-plan/

GEOGRAPHICAL FACTS

- Extent – 30 km west to Parramatta
- Surface area approx. 50 km^2 with a total catchment of 500 km^2
- 3 km wide at the heads – up to 30 m deep
- Major components
  - Port Jackson (Sydney Harbour)
  - Middle Harbour
  - Parramatta and Lane Cove Rivers (main tributaries)
- The natural beauty attributed to the complex shoreline and topography
- 90% of the catchment is urbanised or industrialised
- 50% of the foreshore is armoured
- The surrounding population is 5 million people
- The seabed is heavily contaminated from Sydney's industrial past

Source: Sydney Institute of Marine Science http://sims.org.au

ENVIRONMENTAL PROCESSES AND FUNCTIONING

A number of related processes create physical conditions for a diversity of habitats and species within the harbour. These include:

Tides

Sydney Harbour is a tide-dominated estuary that extends inland to the Parramatta weir where the tidal influence ends. The tidal range is considered to be small at 2.1 metres. Before the river valley drowned as the sea level rose, the coastline was 3 to 5 km east of where it is today. The flooding of the river valley was followed by sedimentation, erosion, deposition that created a complex marine environment.

Relief and landforms

The underwater relief (bathymetry) of the harbour has an average depth of 13 metres, with deep channels and shallow areas from 3 to 5 metres deep. Some channels used for shipping are 28 to 45 metres. There are large, shallow bays between headlands and intertidal zones exposed at low tide and submerged at high tide.

Water flows

Salt and fresh water flows into the estuary supply a mix of sand (marine) and silt / mud (river) that settles on the floor and shoreline creating different habitats.

Salinity

Saltiness varies with the inflow of freshwater and saltwater – this is determined by precipitation, runoff and evaporation in the catchment, daily tides, prevailing winds and extreme weather events such as East Coast Lows.

Freshwater catchments

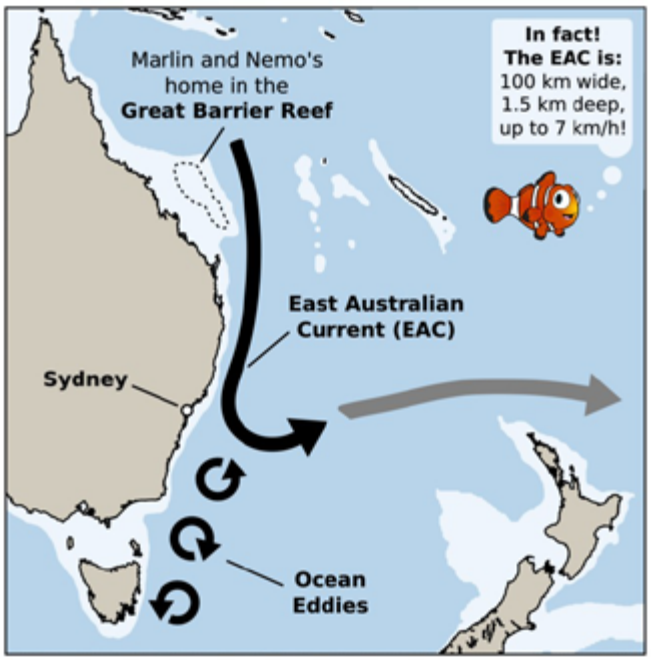
The Sydney Harbour catchment has been described as dry with periodic high precipitation events, a feature that limits freshwater flushing in many bays and inlets leaving saltier habitat conditions. The main Sydney Harbour catchments are Parramatta, Lane Cove and Middle Harbour, however runoff also comes from small creeks and stormwater outlets.

The East Australian Current

This current brings warm nutrient poor water down the east coast of Australia. Current speeds off Sydney can be up to 1.5 m/s. Over time, this current has strengthened making Sydney and eastern Australia climate change "hotspots " and impacting on the marine environment and its habitats and species. An increasing number of tropical species are being found within the estuary, some now 'wintering', meaning they can survive further south all year round.

The story of NEMO is a reality in Sydney Harbour.

SOURCE D: The East Coast Current



Source: https://blog.csiro.au/things-warm-up-as-the-east-australian-current-heads-south/

The EAC starts at the Great Barrier Reef and travels south to Sydney before turning eastward to New Zealand.

Variation and diversity

Variations in the natural environment within Sydney Harbour have created a diversity of habitats that support a large number of species. These habitats have distinct characteristics, yet are interconnected through the movement of water, nutrients, sediments and organisms within the entire estuary. A change in one place can influence the entire marine environment.

The importance of understanding the Sydney harbour environment

With over 3000 marine species, Sydney Harbour is a biodiverse waterway because of the variety of habitats, varying types of sediment, water depth, and vegetation. Aquatic organisms require different light, salinity, temperature, air exposure conditions. Changing conditions such as the East Coast Current can impact on biodiversity. Understanding these environmental limits is important for environmental management.

Threats to Estuaries

Urban development, agriculture and aquatic Industries, over-fishing, habitat loss, boating, structures, erosion, sedimentation and pollution, dams and power stations, litter.

SOURCE E: Threats to estuaries

Source: Integration and Application Network (IAN)

Parramatta River, Parramatta. Source: https://commons.wikimedia.org/wiki/

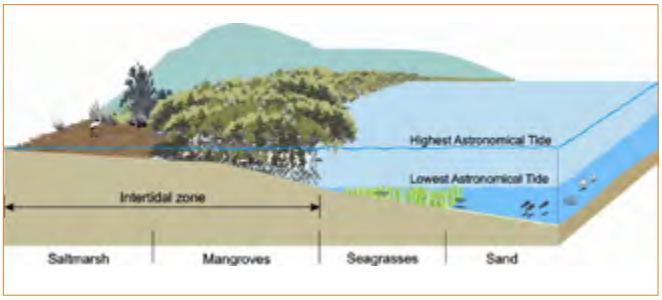
THE NATURAL HABITATS OF SYDNEY HARBOUR

Subtidal rocky reefs occur where the harbour bottom dips from the shoreline to deep channels such as Dobroyd Head and Middle Head. In this habitat native kelp beds support high levels of biodiversity including sea-urchins, sponges, algae, seahorses and fishes. There are 45 species of wrasses, 32 species of gobies and 26 species of damselfishes as well as endemic species such as the Sydney Scorpionfish. Compared to other urban estuaries such as Melbourne's Port Phillip Bay, Sydney Harbour rocky reefs have high levels of fish biodiversity at 25–25 species per 500 m2.

Rocky intertidal shores include fragmented areas of natural shoreline ranging from flat or gently sloping sandstone shelves to vertical walls. Habitat forming species such as oysters and algal beds are found in patches that support high levels of biodiversity. Much of this habitat in Sydney Harbour has been replaced by human structures such as seawalls.

Soft bottoms and beaches support seagrass, mangrove and saltmarsh vegetation communities. Mangroves (mainly Grey Mangrove and River Mangrove) are the basis for detritus-based (decaying plant matter) food webs that support a variety of species including algae, barnacles, molluscs and fish. Saltmarsh found landward of the mangroves, and seagrasses (submerged plants), which once dominated places with soft sediment, have largely been cleared. Estimates state that seagrasses now occupy less than half the area (51.7 ha) they did in 1943 while mangroves have increased in that time.

SOURCE I: Soft harbour bottoms and beaches



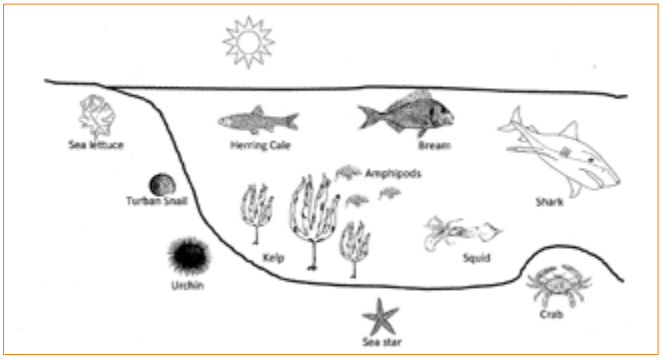
Source: https://www.ces.vic.gov.au/sotb/chapter/mangroves-saltmarsh

Source F: Rocky reef and intertidal shore habitats

Source: https://www.localliving.com.au/manly/beaches-off-the-beatentrack/reef-beach/

SOURCE G : Rocky reef species in Sydney Harbour

Kelp is the main habitat forming organism rocky reefs.



Source: Sydney institute of marine science

SOURCE H : Species zoning

Source: The Marine Biological Association http://www.mba.ac.uk/factsheet-rocky-shore

Open waters support plankton-based food webs. Deeper water transports material from upstream to other habitats and supports the migration of fishes and mammals between the estuary and the ocean, including annual migrations of Humpback and Southern whales and the Little Penguin that nests between Manly and North Head.

SOURCE J: Little Penguin timeline in Sydney Harbour

Source https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/little-penguin/manlys-little-penguins/where-can-i-see-them

HABITAT FORMING ORGANISMS

Some species within the different habitat types of the harbour have important values including filtering water, stabilising and protecting shorelines and supporting high levels of terrestrial and aquatic biodiversity through food chains and food webs. These species iprovide food and shelter to many animals. They include:

- Mangroves and saltmarshes
- Oysters
- Kelp

Human activities in and around the harbour have severely reduced populations of these organisms and in doing so impacted on water quality and biodiversity in the estuary. Habitat restoration efforts to restore some of these habitats have increased in recent years.

SIGNIFICANCE FOR ABORIGINAL AUSTRALIANS

The first peoples

It is estimated that over 1500 Aboriginal people from several different clans lived around the Sydney Harbour Estuary before 1788. These clans included the Gadigal, Wangal, Wallumedegal, Boromedegal, Gamaragal, Borogegal, Birrabirragal and Gayamaygal. Archaeological evidence from rock engravings, shell middens and artefacts as well as historical artworks show that fish were an important source of food for groups living around Port Jackson and Parramatta and Georges Rivers.

***** Shell middens are the location of campsites and 'dinner-time' camps, and the shells are principally the remains of past meals

Aboriginal people using bark canoes, spear-fishing, diving, swimming, and returning to shore

Detail from Lycett, Joseph: Fishing [Port Jackson], 1817.National Library of Australia Source: http://nla.gov.au/nla.pic-an2962715-s17

SOURCE K : Mangroves, oysters and kelp

Benefits of oysters. Source:http://theleadsouthaustralia.com.au/environment/surprising-benefits-oysters-no-not-thinking. Kelp forest. Source: johnwturnbull/14545258891/. Mangroves: UNESCO. Source: https://es.unesco.org/node/293694

SOURCE L : Living on the harbour

'People lived on the south-eastern edge of Australia well before the sea started rising around 11,000 ago. Humans witnessed the inundation, albeit over generations, and adapted to the changing environments. Ultimately, they retreated to occupy the foreshores that were created when the waters finally stopped rising some 6,000 years ago. By then what had been a river valley was a complex harbour of many coves, headlands and points, with three estuarine arms to the immediate north, north-west and west.

At some time before or after the water stabilized, these people established territories around the waterway based upon family groups. By the 1700s, there were at least eight clans occupying specific parts of the harbour foreshores. These were 'saltwater people' who gathered much of their food from the waterway and for whom the meaning of place was all-important. The land, shore, and probably the harbour itself, were imbued with social and spiritual significance. Headlands, points and coves were named from Boree (North Head) along to Parramatta, at the end of the Harbour's western estuary, and back around to Tar-ral-be (South Head).

The local sandstone was ideal for engraving, so on rock platforms along the waterway, the harbour's first people carved images of the animals they saw and hunted and to which they may have attached totemic significance.

Source: https://dictionaryofsydney.org/entry/sydney_harbour_a_cultural_landscape. Information on the site based on the following publication.– Val Attenbrow, *Sydney's Aboriginal Past: Investigating the Historical Records*, second edition, University of NSW Press, Sydney, 2010

ENVIRONMENTAL CHANGE

Artificial structures and shoreline modification

Sydney Harbour is one of the most modified harbours in the world. While under water impacts are invisible to most people, the extent of urban development and modifications to the shoreline are the most dominant and visible change. Today, 90% of the catchment is urbanised or industrialised and 50% of the foreshore armoured.

Structures include seawalls, marinas, jetties and pontoons. Reasons for structures:

- Reclamation
- Protection
- Recreation
- Economy (trade, tourism)
- Community

Nature of change

1. Nutrients, microplastics and litter have increased.
2. Intertidal habitats have been modified by artificial structures.
3. The water cycle has changed – water diversion and hard urban surfaces have altered freshwater runoff, sediment and nutrient flows.
4. Aquatic species have been overexploited or reduced by habitat destruction through land reclamation and building seawalls to replace the natural shoreline.
5. Industry has caused high concentrations of contaminants in harbour sediments and water.
6. Introduced species are altering habitats and food webs, threatening native species, and reducing commercially important species.
7. Climate change is impacting on habitats and biodiversity.

Circular Quay seawall. Source: L Chaffer

'The City of Sydney', drawn by M.S. Hill in 1888, shows an aerial view of the city

Source: City of Sydney Archives. https://historycouncilnsw.org.au/new-home-dictionary-of-sydney/

What's wrong with Sydney Harbour today?

'A common perception is that cities, and their associated ecological impacts end at the waterline. However, coastal cities such as Sydney are also highly modified underwater. Below the waterline in Sydney Harbour there is a dense network of coastal infrastructure, the sediments hold a legacy of chemical contamination and shipping activities contribute further stress through antifouling biocides and invasive species.'

Source: Sydney Marine Science – http://engonet-sims.azurewebsites.net/directory/59/putting-sydney-harbour-into-marine-rehab&sa=D&ust=1542237211549000&usg=AFQjCNEOZbXhspCDsBdLKwWUnfXbObSWdQ

Circular Quay Sydney. Source: L Chaffer

Photographs show Sydney Harbour today where a heavily armoured shoreline has replaced natural habitats

CUMULATIVE IMPACTS

Pollution in the harbour is caused by poor waste management, Sydney's industrial past industry and stormwater runoff. Although industrial waste disposal to Sydney Harbour is now regulated, past pollutants remain in the sediments on the harbour floor where they can be injested by organisms and enter food chains. Warnings about eating fish caught west of the Sydney Harbour bridge are evidence of this pollution.

Plastic and microplastic pollution

More recently, plastics (including microplastics) and cosmetic products (microbeads) have become issues in relation to water quality. Plastic container deposit schemes, plastic bag and microbead bans and education programs about microplastics are recent efforts to reduce these pollutants.

Stormwater runoff adds to water pollution preventing habitats such as oysters from recovering to a level where they can improve sediment and water quality through natural filtering. Restoration projects include creating oyster reefs and tiling seawalls to attract habitat forming species with water filtration powers. Living seawalls are now seen as the 'rooftop gardens' of the harbour.

Nutrients including nitrogen, phosphorus and carbon are recycled through harbour food chains and keep habitats functioning healthily. Excess nutrients from human sources such as fertilisers and sewage can cause problems such as eutrophication (where excess nutrients lead to the growth of algae that increase turbidity). This in turn interrupts food chains by reducing the sunlight available for photosynthesis by aquatic plants such as Kelp and seagrasses.

Education and effort to intercept and treat stormwater runoff to remove nutrients are ways of addressing this issue.

Ships, boating and fishing

Recreational boats, ferries and cruise ships along with fishing activities and infrastructure such as moorings and marinas have multiple impacts including:

- removing large fish from aquatic food webs
- causing propeller damage, wash, noise and pollution from antifouling paints and oil spills.
- Reducing biodiversity through animal strikes, sediment resuspension, anchor drag, and transporting introduced species that can compete with native species for food and habitat

Establishing marine parks and designing and building fish friendly moorings, piers and jetties are efforts to manage these issues.

SOURCE M: Microplastic pollution

Source: http://www.waterkeeper.ca/cases-microplastics

'Harbour-dwellers that thrive in the crevices of pilings and pontoons are often invasive species hostile to Sydney's natural ecosystem and include sea squirts and bristle worms which spread across habitats, driving indigenous marine life away.'

Marine ecologist Dr Katherine Dafforn. Source: https://www.smh.com.au/national/its-war-down-there-sydney-harbour-a-marine-battleground-between-invasive-and-local-species-20140807-101dt1.html

'In Sydney Harbour, recreational boat density has increased at approximately 2 per cent per year. Moorings affect the seabed when their attached chains scour the sediment, disturbing seagrasses. Seagrass-friendly moorings have been installed at some locations...'

State of the environment Report 2016. https://soe.environment.gov.au/theme/coasts/topic/2016/coastal-waters

Climate change is a growing concern. Rising temperatures are causing changes to water temperatures and impacting on the distribution of aquatic species, their growth and reproduction. Tropical fish are now commonly found in Sydney Harbour, with some surviving through winter. The impact on of tropical grazing fish on sea grasses and kelp beds is already being seen off the coast. Predicted sea levels rises will impact on intertidal habitats.

'By 2050 sea levels are predicted to rise by up to 40cm from 1990 levels, and by 90cm by 2100... a one centimetre sea level rise could potentially result in one metre of erosion.

Rising sea levels will eat away habitats, particularly in low-lying areas like mangroves or marshes.

Source Cool Australia https://www.coolaustralia.org/sydney-harbour-secondary/

STAGE 5: VIRTUAL FIELDWORK

Aerial view of Sydney Harbour. Source: Shutterstock

NSW Environmental and Zoo Education Centres (EZEC) have created virtual fieldwork experiences for teachers and students unable to participate in real world fieldwork in 2020.

Collated for NSW EZECs by Lorraine Chaffer, Editor and Vice President GTANSW & ACT

ENVIRONMENTAL CHANGE and MANAGEMENT

Rumbalara Environmental Education Centre (Gosford) has developed a virtual fieldwork experience to assist with the investigation of the issues related to managing coastal environments and erosion at Wamberal Beach and estuary and water quality management at Terrigal Lagoon.

The virtual excursion will allow students to experience simulated investigations such as:

- using geographical tools such as maps and compasses,
- measuring beach characteristics and abiotic factors at 'The Ruins' Wamberal (beach profile, vegetation transect, sand sizing, wind, waves)
- investigating the management of coastal erosion at 'The Ruins' Wamberal and the perspectives of different stakeholders
- observing human impact on the remnant wetland at Terrigal and learning how to construct a vegetation profile
- assessing water quality related to the Terrigal lagoon catchment
- observing change at 'The Haven' Terrigal though historical photo analysis and investigating current pressures and changes with an emphasis on the current 'Plan of Management' for 'The Haven'
- observing erosion and management of erosion at 'The Skillion' Terrigal.

Link to site and student worksheets https://sites.google.com/education.nsw.gov.au/stage-5-environmental-change-m/home.

Left: Wamberal Beach.

Wetlands Environmental Education Centre (located at Newcastle) has a virtual fieldwork program to support the topic Enviromental Change and Management. Students will investigate significant changes impacting coastal environments, and explore strategies to manage these changes. A case study of Stockton Beach at Newcastle forms the focus of investigation for this virtual leaning activity. This location is significantly impacted by coastal erosion due to interruption to the coastal processes.

Students will examine elements of the biophysical environment, impacts of human activity along with current and potential management of these issues.

The package includes pre-learning materials to support the virtual excursion.

The virtual learning includes a 60minute lesson in the field at Stockton Beach led by Environmental Education Centre teachers, to further familiarise students with the area under investigation and allow interaction with the teachers in the field. All presentations come with a student worksheet and follow up support materials.

Find out more: https://docs.google.com/document/ d/1oMHQH2SOGxQIEChSvnxVVYztAHTll_Ech6e1DL4u ij4/edit?usp=sharing

Call WEEC (02 4955 8673) to make a booking https://wetlands-e.schools.nsw.gov.au/

Above: Stockton Beach

Observatory Hill Environmental Education Centre has a virtual fieldwork program to support the topic Environmental Change and Management. Students investigate significant changes impacting global marine environments, and strategies to manage these changes. They then examine Sydney Harbour as an example of a marine environment and changes affecting it, especially microplastic pollution, impacts of seawalls on biodiversity, historical dioxin contamination and global warming.

Their website includes resources to support student's learning including a google tour around Sydney Harbour highlighting some of the most important environmental impacts.

Teachers have the option to book a 45–60min lesson on environmental change and management of Sydney Harbour, led by EEC geography teachers, to further familiarise students with the area under investigation. All presentations come with a student worksheet, and a follow up support site with extra resources and a copy and recording of the presentation.

Find out more at: https://sites.google.com/ education.nsw.gov.au/obhill-env-chng-mgmt/ home

Or, contact the Centre on 9247 7321.

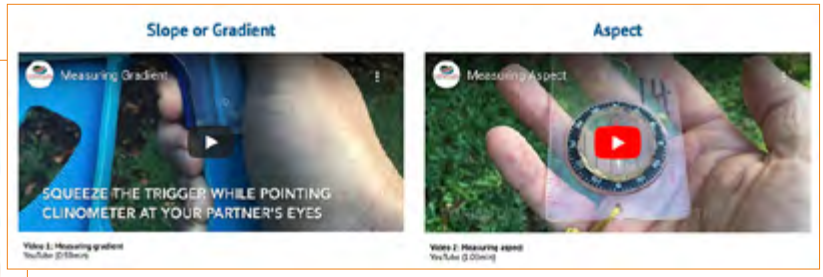
FIELDWORK EQUIPMENT AND HOW TO USE IT

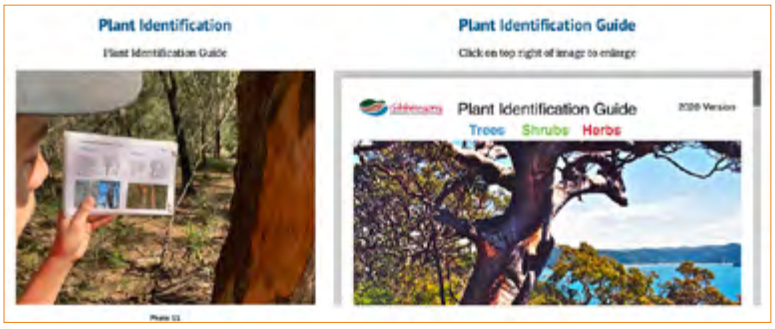
From the editor

While virtual fieldwork will never replace real fieldwork in which students make observations, gather their own data, use fieldwork equipment and answer inquiry questions about a place or issue to complete a geographical inquiry, 2020 has created a need to complete fieldwork using virtual tools. These excellent resources provided by NSW EZECs fill that gap until schools and fieldwork opportunities return to normal.

For teachers lacking confidence with fieldwork methodologies, the virtual experiences are an opportunity to learn about and understand the tools and techniques of data collection, particularly for collecting biotic and abiotic data for the topics with a natural world focus such as Landscapes and Landforms, Water in the World, Sustainable Biomes and Environmental Change and Management.

Several EECs have provided instructional videos as a part of their virtual fieldwork materials. While directed at students, these videos are excellent for teachers unfamiliar with fieldwork, fieldwork equipment and fieldwork techniques.

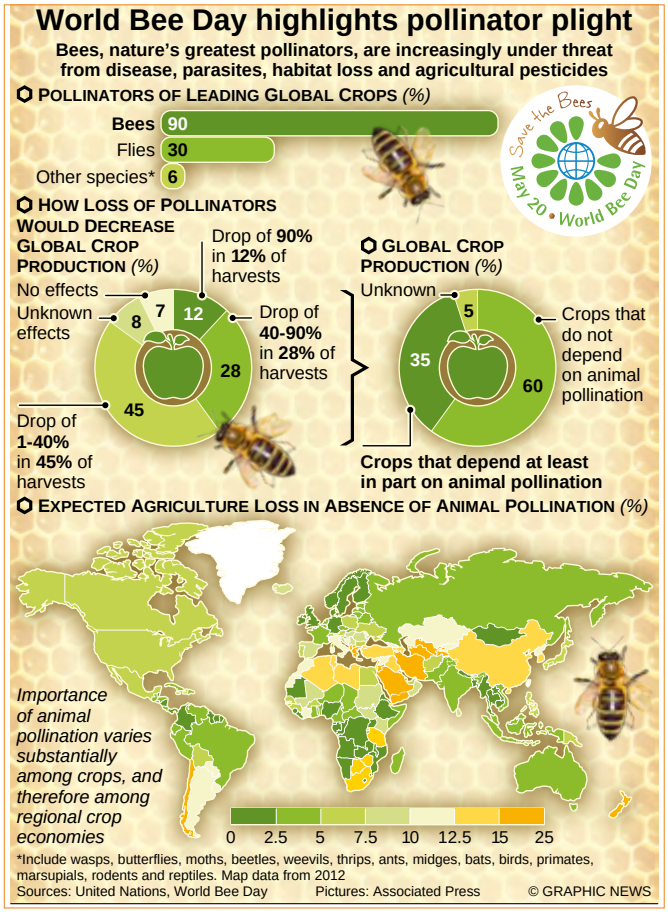




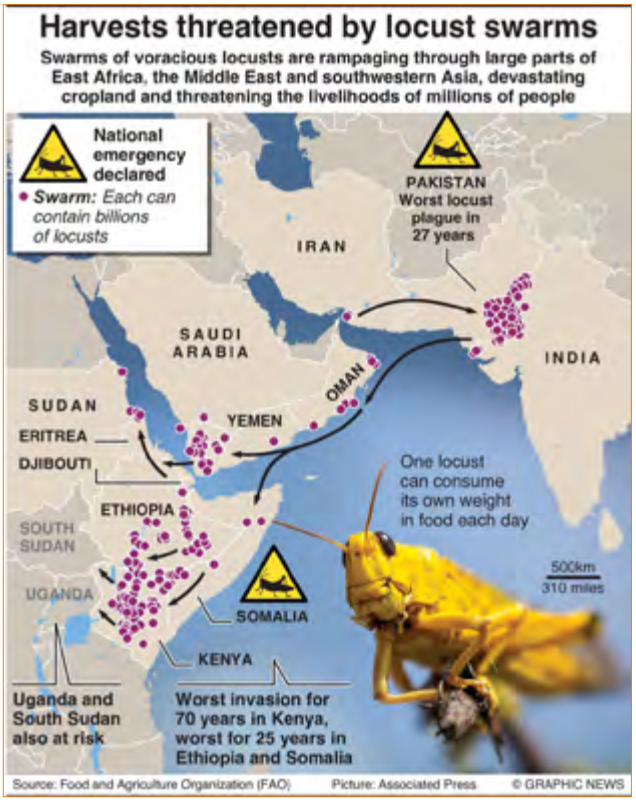
Images from from Rumbalara, Gibberagong, Royal National Park and Observatory Hill EEC resources in this edition of the Geography Bulletin

STAGE 5: SKILLS STIMULUS

SOURCE A: Pollinators



SOURCE B: Locusts



SOURCE C: Climate and topography

Farming under glass in climate controlled greenhouses enable the Netherlands to be a global leader in tomato exports..

This tiny country feeds the world. Source: https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/

Photographs: Shutterstock

The Netherlands is a small, densely populated country lacking the natural environments thought necessary for large-scale agriculture . Despite this, it ranks second highest in exports of food (by value), behind the United States, which is 270 times larger. The Dutch are the top exporters of potatoes and onions and second largest exporter of vegetables overall. More than a 30% of all global trade in vegetable seeds originates in the Netherlands.

Green circles in the desert usually indicate tracts of agriculture supported by center-pivot irrigation. Egypt's Western Desert is dry and receives just centimeters of rainfall per year – often described as "hyperarid." Greenery has been appearing in the area in recent decades. On February 26, 2017, Landsat 8 captured these natural-color images of one of Egypt's land reclamation projects aimed at making some desert areas suitable for agriculture.

NASA Source: https://earthobservatory.nasa.gov/images/89820/cultivating-egypts-desert

AMAZON BASIN BIOMES AND ENVIRONMENTAL CHANGE

'What we see in the Amazon over the past four decades is extraordinary change. We see major losses in both humid and dry forests; incredible expansions of pasture and agriculture; and clears shifts in land use driven by economic forces and the way land is managed. There is really nowhere else in the world that compares to the Amazon for the scale and scope of change.'

Matthew Hansen, University of Maryland (a remote sensing scientist specialising in mapping land cover and land use change)

SOURCE D: Amazon Basin land cover

These Landsat mosaic images give a view of the Amazon Basin's land surfaces.

The **darkest green** areas is forest, mostly tropical rainforest that is not severely changed or degraded by human activity.

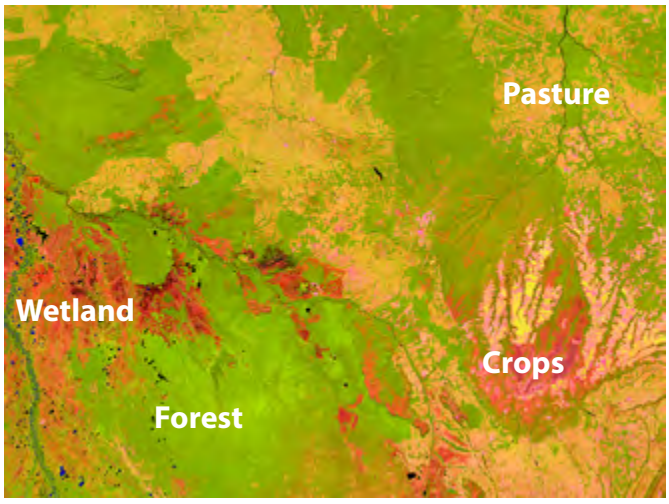
Lighter green areas are mainly tropical savanna. These woodland-grassland regions may have widely spaced trees without a closed canopy .

Areas affected by human activity also stand out.

- Forest areas converted to pasture generally appear **yellow**.
- Savanna converted to cropland is generally **pink**, especially if fields are fallow or have exposed soil.

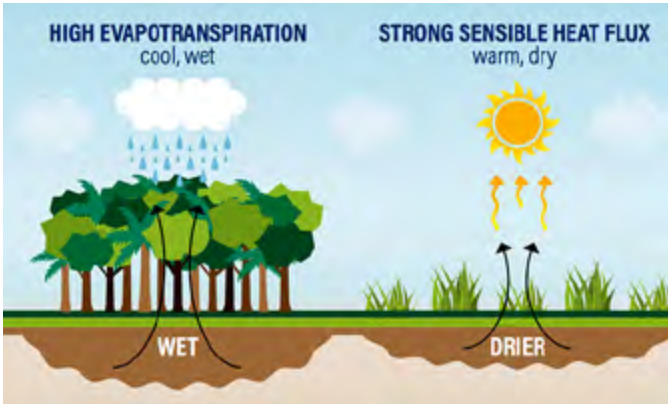
Deforestation threatens biodiversity, reduces atmospheric carbon absorption, increases damage from natural disasters such as fire, and disrupts the functioning of the water cycle.

SOURCE E: Landuse investigation



'A growing body of evidence indicates that the continuing destruction of tropical forests is disrupting the movement of water in the atmosphere, causing major shifts in precipitation that could lead to drought in key agricultural areas'

SOURCE F: Water Cycle



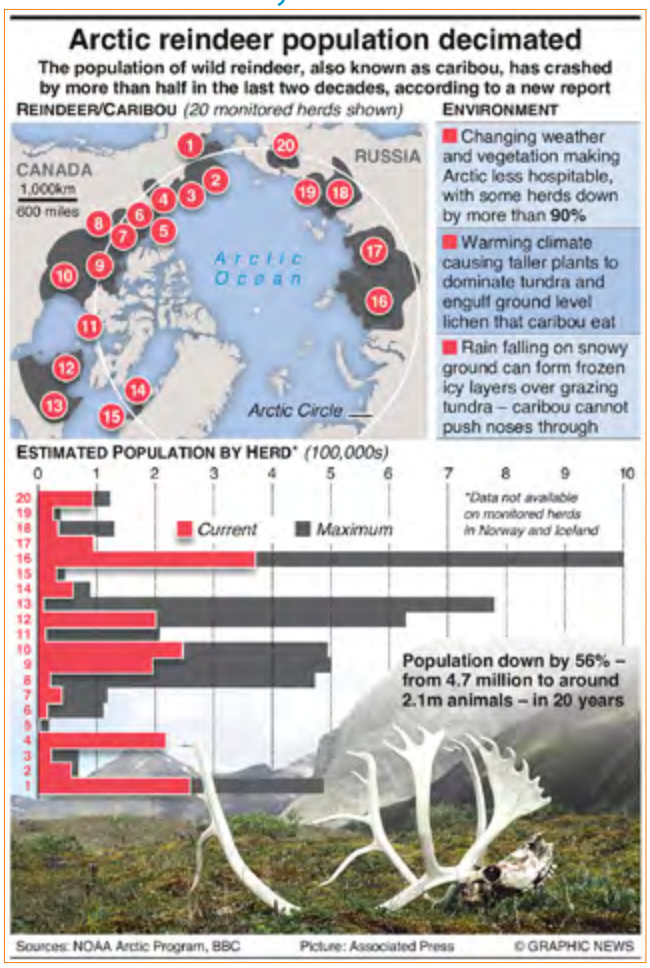
Trees draw water from the ground and release water vapor through their leaves, creating atmospheric 'rivers of moisture'.

SOURCES OF INFORMATION, SATELLITE IMAGES and ILLUSTRATION

1. Earth Observatory NASA https://earthobservatory.nasa.gov/images/145649/mapping-the-amazon

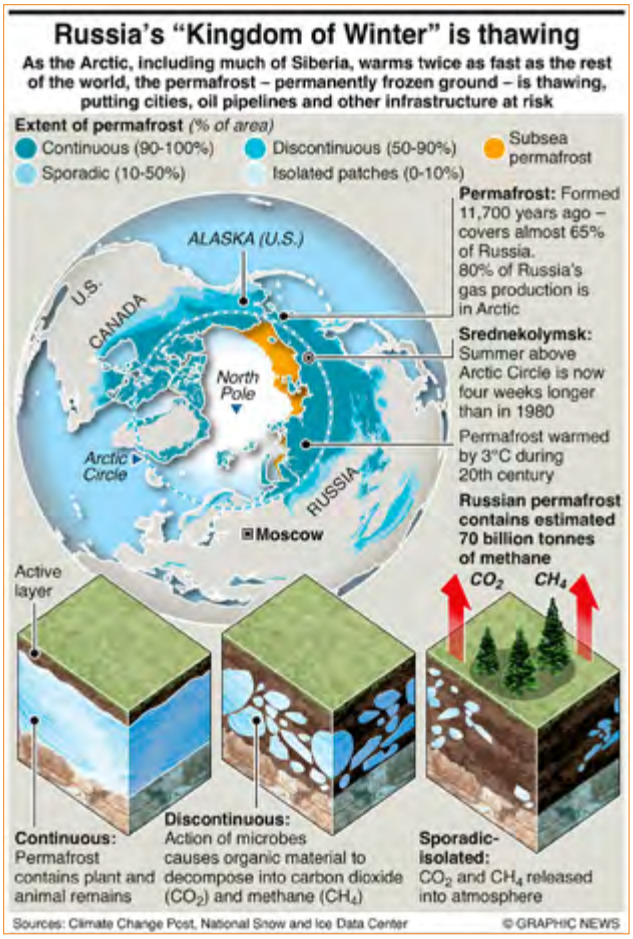
2. e360 Yale Edu: https://e360.yale.edu/features/how-deforestation-affecting-global-water-cycles-climate-change

SOURCE F: Biodiversity loss

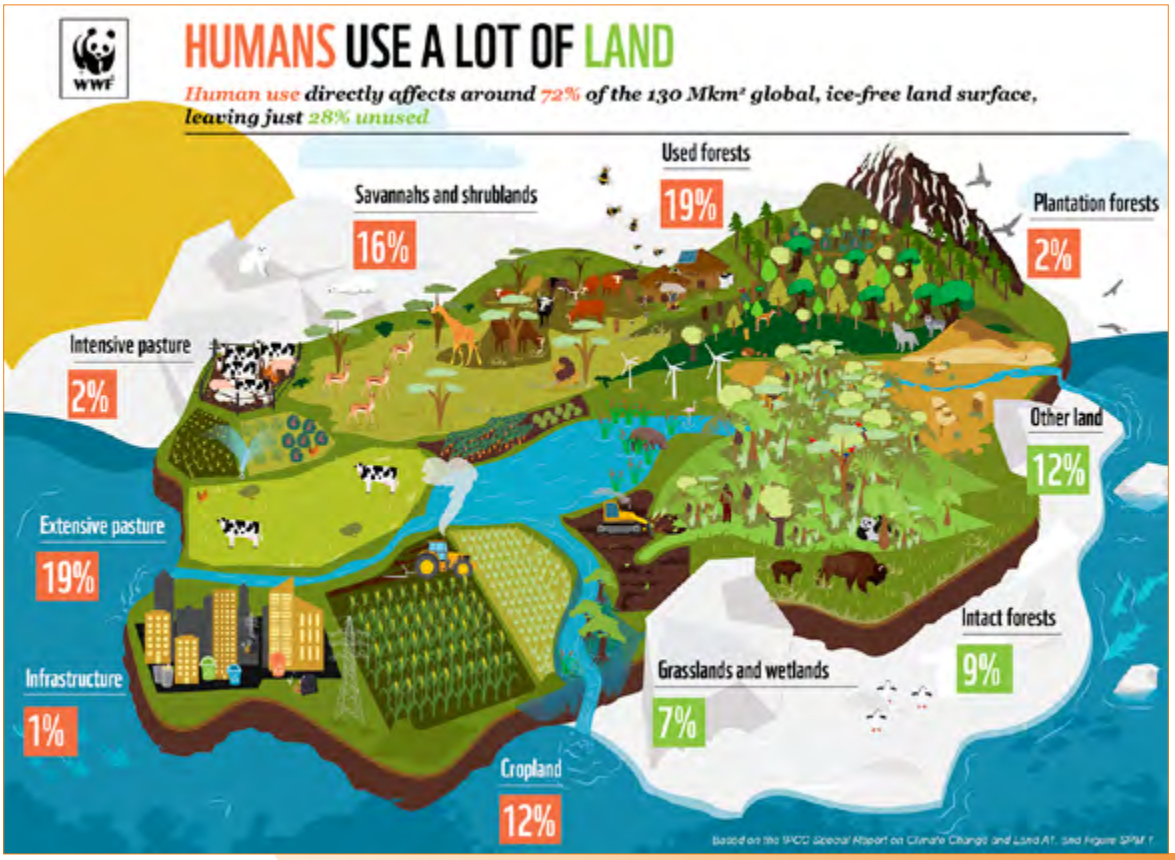


SOURCE: Graphic News https://www.graphicnews.com

SOURCE G: Thawing soils



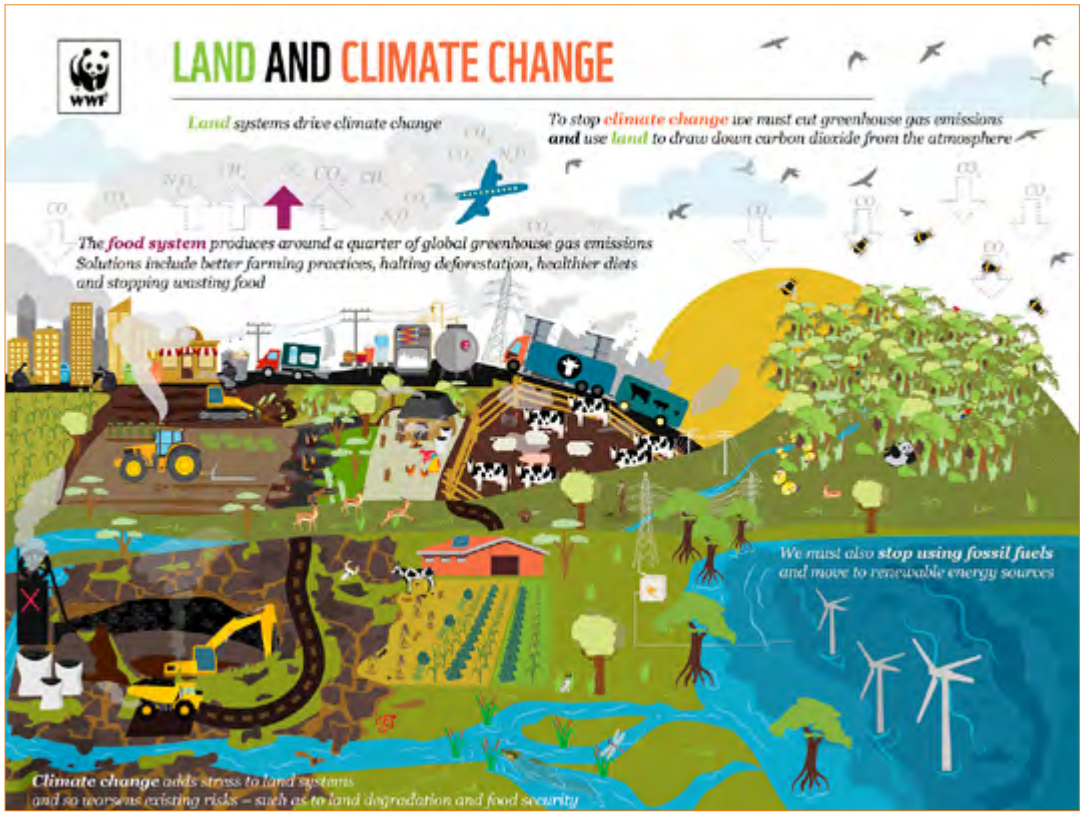
SOURCE H: Human use of Earth's biomes and environments



Source: https://wwf.panda.org/our_work/climate_and_energy/ipcc_land/

INTERCONNECTIONS: FOOD, BIOME USE and ENVIRONMENTAL CHANGE

SOURCE J: Sustainable land management



SOURCE I: Landuse and climate change

SOURCE: https://wwf.panda.org/our_work/climate_and_energy/ipcc_land/
You can also find a link to the IPCC Land and Climate Change report here using this link

Introduction to careers with geography

Lorraine Chaffer, Vice President GTA NSW & ACT

There is an increasing range of resources that focus on careers in geography.

The two posters on page 97 are:

- Get kids into survey – https://www.getkidsintosurvey.com/resources/
- Geoscience for the future – http://rses.anu.edu.au/files/geoscience-for-future-jobs.pdf

These posters make ideal classroom displays and can be used as stimulus for career discussions and integrated into topics such as Environmental Change and Management, Urban places and liveability. The student activities in the supplement can be used to generate interest careers linked to the study of geography.

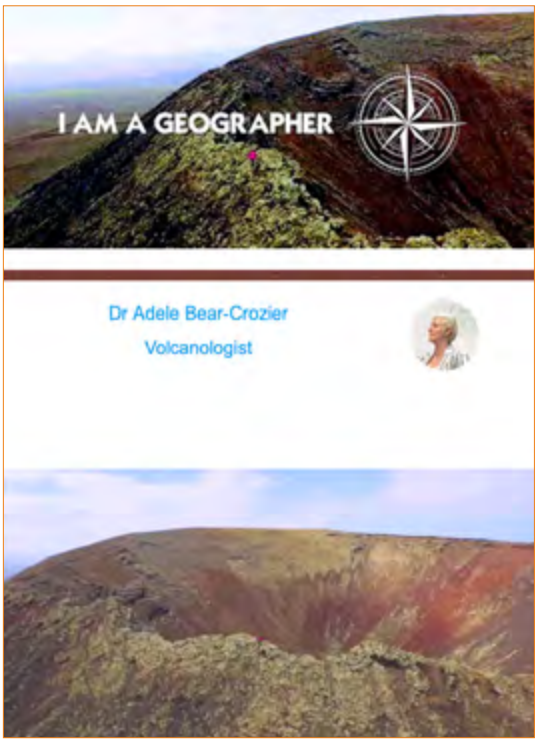
GTANSW & ACT
Pathways to careers in Geography shows the courses offered at different universities across Australia that contain a component of Geography. These posters can be purchased from the GTA NSW & ACT website for display in classrooms, the library and careers rooms in your school.

Order here https://www.gtansw.org.au/product/new-pathways-with-geography-10-posters/

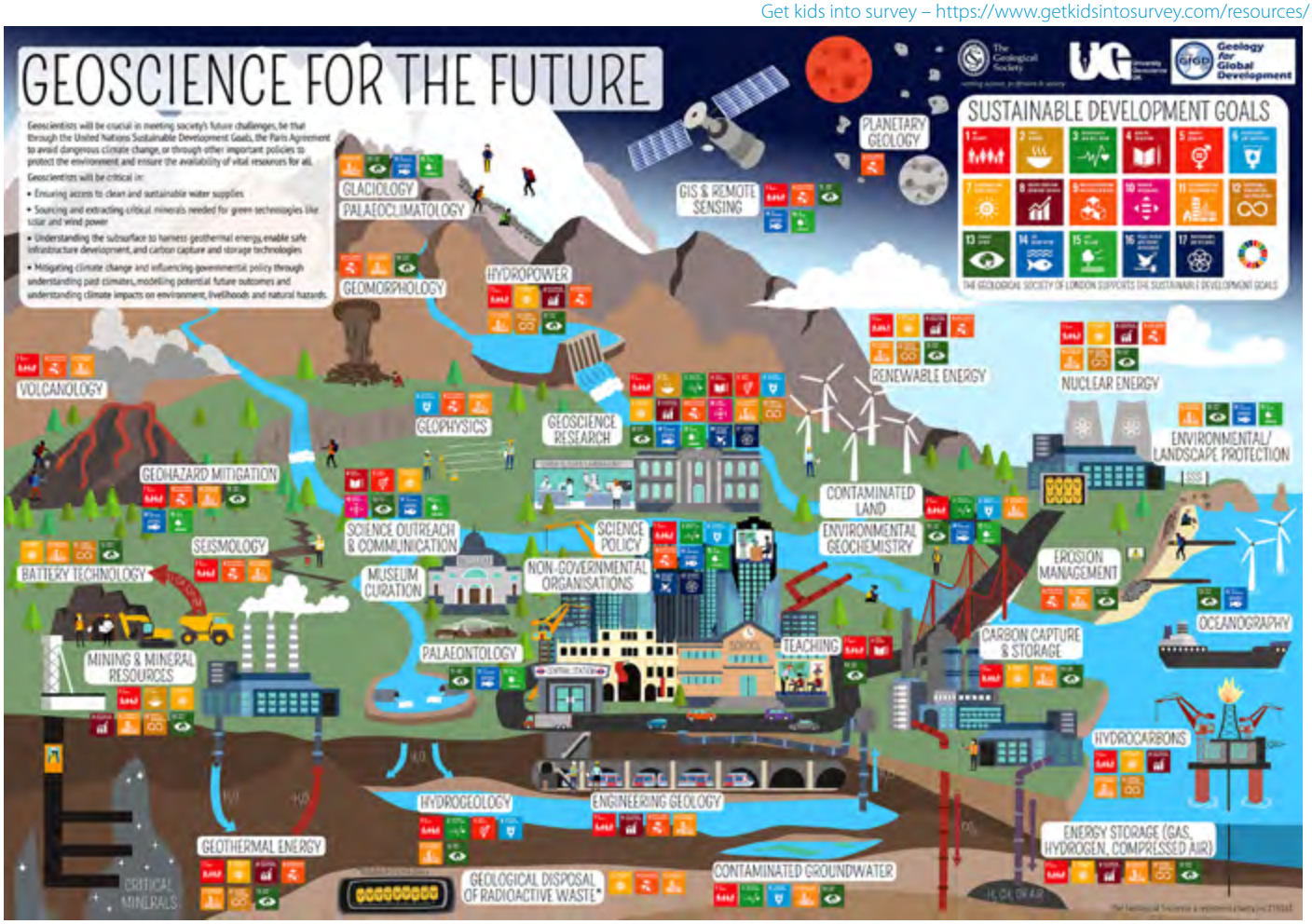
GTAV is producing a video series titled *'I am a Geographer'*. These provide a short overview of real people in jobs in Australia who studied geography. GTA NSW is funding two more of these excellent career snapshots.
See https://www.gtav.asn.au/careers-in-geography/video-profiles

Other resources

- Careers in surveying GTA NSW & ACT Bulletin 1 2020 "Getting students excited about geography's real-world applications" https://www.gtansw.org.au/wp-content/uploads/2020/03/GTA-Bulletin_Issue-1_2020-3-84-58-59.pdf
- Career options http://www.hi.com.au/careers/geography/index.htm
- Careers in spatial technologies https://www.geospatialscience.com.au
- Geographers making a difference https://www.youtube.com/watch?v=qdPnNkspWE0
- Geographers make most employable university graduates https://news.rgs.org/post/153564709243/geographers-remain-among-the-most-employable



Get kids into survey – https://www.getkidsintosurvey.com/resources/



Geoscience for the future – http://rses.anu.edu.au/files/geoscience-for-future-jobs.pdf

The Geography Teachers' Association of NSW & ACT

2019 ARTHUR PHILLIP FIELDWORK COMPETITION

Full competition results by award category

The Geography Teachers' Association of NSW & ACT

2019 ARTHUR PHILLIP FIELDWORK COMPETITION RESULTS

The Geographical Fieldwork and Research Award – Stage 4 Category

Equal First Place

Catherine Park

SCEGGS Darlinghurst
How does your local area rate in regards to liveability?

Hannah Guest

SCEGGS Darlinghurst
Local area liveability study of Woolwich

Second Place

Eliana Watters-Cowan

Hunter School of Performing Arts
Place and Liveability – Number One Sportsground

Third Place

April Foster

Wollondilly Anglican College
How liveable is my local area?

Highly Commended

Jade Wainwright

Hunter School of Performing Arts
Place and Liveability – Cardiff Train Station

The Geographical Fieldwork and Research Award – Stage 5 Category

Equal First Place

Isabella Fung

Hunter School of Performing Arts
Pollution in Throsby Creek

Chloe Linstrom

Hunter School of Performing Arts
Erosion at Stockton Beach

Second Place

Ada Pascoe

Hunter School of Performing Arts
The Impact of Climate Change in the Wine Industry

Equal Third Place

Hugh Gelder

Hunter Valley Grammar School
The Changing Place of Maitland

Leila Anderberg

Hunter Valley Grammar School
The Changing Place of Maitland

The Geographical Fieldwork and Research Award – Stage 6 Category

First Place

Archie Hyles

Cranbrook School
To what extent has drought effected the mental wellbeing of people living in and around the rural community of Jugiong

Second Place

Ned Hendersen

Cranbrook School
A comparative study between physical and human impacts of varying levels of light pollution in the Sydney CBD and rural areas

Third Place

Ruby McGinty

Tara Anglican School for Girls
The impacts of pollution on the Hawkesbury-Nepean River

Highly Commended

Cassie O'Carroll

Bomaderry High School
Evaluation of Kellet Creek's land title and ecological significance

The Brock Rowe Senior Geography Fieldwork Award

Equal First Place

Jasmine Locke

St Mary Star of the Sea, Wollongong
Brackish water in the Minnamurra River and how it affects the flora and fish species

Olivia Tingay

Roseville College
A study of the social impact the dominance of young families has on South Turramurra

Second Place

Jessica Young

St Mary Star of the Sea, Wollongong
Comparison between protected and non-protected marine areas

Third Place

Camille O'Loughlin

Roseville College
The impact of equestrian facilities surrounding Ku-Ring-Gai Chase National Park

The Geography Teachers' Association of NSW & ACT

2019 ARTHUR PHILLIP FIELDWORK COMPETITION RESULTS

Highly Commended

Edward Sutherland

Hunter Valley Grammar School
Soils Ability to Combat Climate Change

The Dr Susan Bliss Cross-Curricular Priority Awards

Equal First Place

Jessy Arnold

St Benedicts Catholic College
Soil Structure in Farming

Zachary Smith

Wollondilly Anglican College

Has the introduction of 'Return and Earn' improved the recycling habits of residents from a range of different towns across the Wollondilly Shire?

The Dr Maurine Goldston-Morris Civic and Citizenship Award

Nicola Bliss, Indiana Hardwick & Abby Nelson

Warners Bay High School
The Creativity and Sustainability Challenge – Proposing an Environmental Representative Council

The Dr Maurine Goldston-Morris Geography Teacher Award

Adam Everatt

St Mary Star of the Sea, Wollongong

Adam has inspired his students to a high level of geographical understanding through research in the field and through secondary sources. His students have discovered aspects of Geography through the studies of a wide variety of issues, employing a variety of ICT methodologies. Adam is commended on the quality of his students' research and breadth of presentations of topics. He has consistently inspired his students to learn about the ever-changing world.

About the Geographers

Admiral Arthur Phillip (1738–1814) joined the Royal Navy at fifteen and worked his way up the ranks to be appointed captain of HMS Sirius in 1786. Phillip was appointed Governor of New South Wales, the first British colony on the Australian continent. He was also the founder of the city of Sydney. As an experienced sea captain he had an excellent knowledge of the geography of the world.

Brock Rowe was a founder of GTA NSW and he became a Fellow of the association in 1982. In honour of his role in the association and his contribution to Geography over many years, the original fieldwork competition for individual senior geography projects was given his name.

Dr Susan Bliss joined GTANSW in 1961 as a student at Sydney University and became a GTANSW Councillor in 1981, giving continuous service until her retirement in 2013.
Award entries demonstrate significant achievement or development of understanding in any of the three Australian K–10 Geography Curriculum cross curricular priority areas; Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia or Sustainability.

Dr Maurine Goldston-Morris OAM devoted herself to the life and achievements of Arthur Phillip, she was the Founding President of the Arthur Phillip Society. Author of the book *The life of Admiral Arthur Phillip R.N. : 1738 –1814* / transcripts by Maurine Goldston-Morris

Two awards, for Civic and Citizenship and for Geography teachers honour her achievements.

GTA NSW & ACT would like to congratulate all the winners and also commend the students and teachers who have participated in this year's competition.

ADVICE TO CONTRIBUTORS

Geography Bulletin guidelines

1. ***Objective:*** The Geography Bulletin is the quarterly journal of The Geography Teachers' Association of NSW & ACT Inc. The role of the Geography Bulletin is to disseminate up-to-date geographical information and to widen access to new geographic teaching ideas, methods and content. Articles of interest to teachers and students of geography in both secondary and tertiary institutions are invited, and contributions of factually correct, informed analyses, and case studies suitable for use in secondary schools are particularly welcomed.

2. ***Content:*** Articles, not normally exceeding 5000 words, should be submitted to the GTA NSW & ACT Office by email gta.admin@ptc.nsw.edu.au

   Submissions can also be sent directly to the editors: Lorraine Chaffer (lchaffer@tpg.com.au)

   Articles are welcomed from tertiary and secondary teachers, students, business and government representatives. Articles may also be solicited from time to time. Articles submitted will be evaluated according to their ability to meet the objectives outlined above.

3. ***Format:*** Digital submission in Word format.

- Tables should be on separate pages, one per page, and figures should be clearly drawn, one per page, in black on opaque coloured background, suitable for reproduction.
- Photographs should be in high resolution digital format. An indication should be given in the text of approximate location of tables, figures and photographs.
- Every illustration needs a caption.
- Photographs, tables and illustrations sourced from the internet must acknowledge the source and have a URL link to the original context.

Note: Please try to limit the number of images per page to facilitate ease of reproduction by teachers.

Diagrams created using templates should be saved as an image for ease of incorporation into the bulletin.

All assessment or skills tasks should have an introduction explaining links to syllabus content and outcomes. A Marking Guideline for this type of article is encouraged.

4. ***Title:*** The title should be short, yet clear and descriptive. The author's name should appear in full, together with a full title of position held and location of employment.

5. ***Covering Letter:*** As email with submitted articles. If the manuscript has been submitted to another journal, this should be stated clearly.

6. ***Photo of Contributor:*** Contributors may enclose a passport-type photograph and a brief biographical statement as part of their article.

7. ***References:*** References should follow the conventional author-date format:

   Abbott, B. K. (1980) ***The Historical and Geographical Development of Muswellbrook*** Newcastle: Hunter Valley Press.

   Harrison, T. L. (1973a) ***Railway to Jugiong*** Adelaide: The Rosebud Press. ***(2nd Ed.)***

Refereeing

All suitable manuscripts submitted to the Geography Bulletin are subject to the process of review. The authors and contributors alone are responsible for the opinions expressed in their articles and while reasonable checks are made to ensure the accuracy of all statements, neither the editor nor the Geography Teachers' Association of NSW & ACT Inc accepts responsibility for statements or opinions expressed herein.

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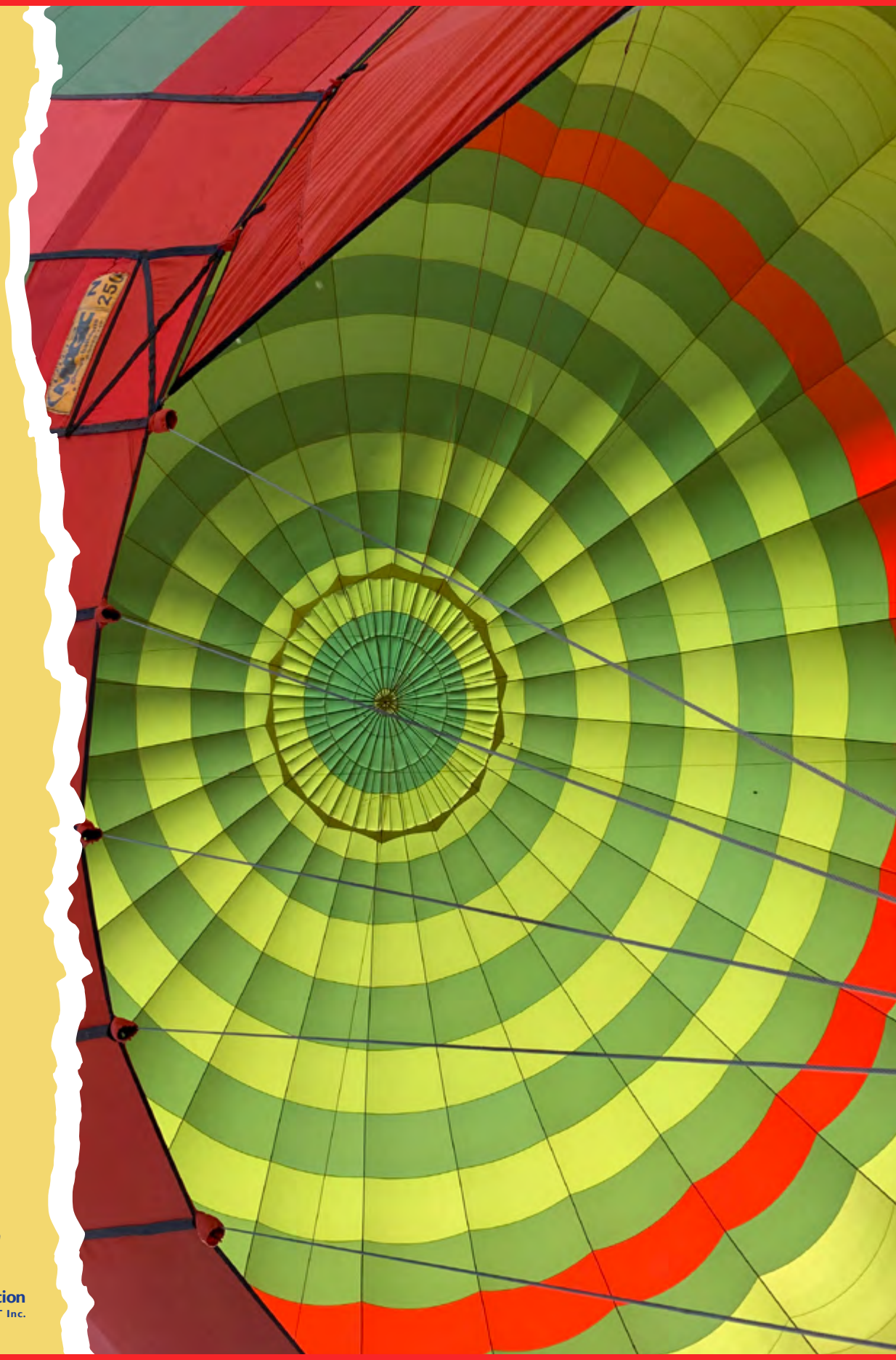

The
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of NSW & ACT Inc.