GEOGRAPHY BULLETIN

SPECIAL STAGE 6 EDITION

The Geography Teachers Association of NSW & ACT Inc.

Vol 53 Special Edition
2021

IN THIS ISSUE:

2020 HSC
- EXAMINATION FEEDBACK – HOW TO GET THE ANSWER
- 2020 GEOGRAPHY HSC AND SCALING

STAGE 6 SKILLS
- SELECTED HSC MAP SKILLS FOR YEAR 11

PROFESSIONAL READING
- DIGITAL VOLUNTEERISM: MISSING MAPS

PROFESSIONAL LEARNING
- GTA NSW & ACT WEBINARS IN 2021

BIOPHYSICAL INTERACTIONS
- UNDERSTANDING THE CARBON CYCLE
- CARBON CYCLE POSTER ACTIVITIES
- THE CARBON CYCLE GAME
- GUIDED READING ACTIVITY
- MADDEN JULIAN OSCILLATION (MJO)

ECOSYSTEMS AT RISK
- GOING GLOBAL WITH CASE STUDIES: TROPICAL RAINFOREST HERITAGE OF SUMATRA
- KAKADU WETLANDS

VISUAL LITERACY
- CONNECTING TOPICS: DEFORESTATION AND NATURAL CYCLES

PROJECTS • REPORTS • RESOURCES • ARTICLES • REVIEWS

EXECUTIVE 2021

GEOGRAPHY BULLETIN

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The Geography Bulletin is a quarterly journal of The Geography Teachers' Association of NSW & ACT Inc. 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' at the back of this issue.

GEOGRAPHY BULLETIN

Volume 53, Special Edition 2021
EDITOR: Lorraine Chaffer

Editorial 2

2020 HSC
- Examination Feedback – How to get the answer 5
- 2020 Geography HSC and Scaling 6

STAGE 6 SKILLS
- Selected HSC map skills for Year 11 10

PROFESSIONAL READING
- Digital Volunteerism: Missing Maps 19

PROFESSIONAL LEARNING
- GTA NSW & ACT Webinars in 2021 Program 22

BIOPHYSICAL INTERACTIONS
- Understanding the Carbon Cycle 25
- Carbon Cycle Poster activities 27
- The Carbon Cycle Game 30
- Guided Reading Activity 40
- Madden Julian Oscillation (MJO) 43

ECOSYSTEMS AT RISK
- Going Global with case studies: Tropical Rainforest Heritage of Sumatra 59
- Kakadu Wetlands 65

VISUAL LITERACY

Connecting topics: Deforestation and Natural Cycles 81

Advice to contributors 87

EDITORIAL

EDITORIAL

Welcome to the first Stage 6 Geography Case Studies Special Edition for 2021.

Many thanks to the authors who have generously shared case studies and teaching resources.

This edition has a focus on the connected topics Biophysical Interactions (Year 11) and Ecosystems at Risk (Year 12).

Some exciting news for 2021 is the new Young Geographer Awards – replacing the old Arthur Phillip Awards (APA) for students. Use the link in the following flyer to learn more about the new awards and register your students for FREE.

There are three articles that relate to the HSC Examination.

- In ***How to get the answer: Section 1 – 2020 HSC Exam*** a team of GTA teachers led by John Lewis have provided answers to the 20 multiple choice questions with short explanations for how answers were determined.
- ***Selected HSC Map skills for Year 11*** is an overview of some examinable mapping skills that year 11 should be able to master. Integrating these skills across all topics through Year 11 is an important teaching strategy.
- In ***Geography HSC and Scaling 2020*** Graham Wright has analysed the contribution of HSIE subjects, including Geography to student ATAR scores. According to Graham,

  'For students with high aspirations when it comes to their HSC studies, Geography is a good option for students with an interest in its content.'

Under **Professional Reading** is an interesting article on "digital volunteerism', that links to topics across years 11 and 12 including Global Challenges (Development, Population) and Urban Places (Megacities).

- ***Missing Maps*** by Jeana Kriewaldt and Shu Jun Lee

Experienced HSC teachers know that the Year 11 Biophysical Interactions topic is foundational learning for Ecosystems at Risk in Year 12. It is important that students understand, and can explain, processes in the biophysical environment that make up Earth's complex natural systems and the impacts of human change.

I have provided three linked resources relating to the Carbon Cycle.

- ***Understanding the Carbon Cycle*** by Lorraine Chaffer consists of student activities using the GTANSW & ACT Carbon Cycle Poster Pack 1
- ***The Carbon Cycle Game,*** a game modified and shared by Jennifer Ceven, from the USA.
- ***Guided Reading: The Carbon Cycle*** is a literacy focused activity most suited to students where differentiation is required. This was sourced from the twitter account of @MrHand_.

Note: These resources could also be used in Year 10 for Environmental Change and Management and in Year 12 for HSC Exam preparation.

Lorraine Chaffer, Editor

Dr Susan Bliss explains a little-known phenomenon that influences global weather and climate. The article is a good summary of the phenomenon and is accompanied by student activities and a resource list.

- ***Madden-Julian Oscillation (MJO) Pulse Circles Globe***

The following detailed case studies have been generously shared by Stage 6 teachers for Year 12 Ecosystems at Risk.

NOTE: The biophysical interaction components and human impacts on these ecosystem case studies could be used in Year 11 for a study of an issue in the biosphere…. deforestation – Sumatra rainforest and introduced species – Kakadu wetlands.

- ***Going Global with Case Studies: Tropical Rainforest Heritage of Sumatra*** by David Latimer
- *Kakadu Wetlands* by Kate Watson

Note: Two appendices providing stimulus material and student activities for the Kakadu Wetlands will be on the GTA website with this edition of the Geography Bulletin.

To end this edition, I have created several activities for building Visual Literacy. The activities in ***Deforestation and Natural Cycles*** are linked to the Biophysical Interactions and Ecosystems at Risk material in this edition but can be used independently of those and for Stage 5 where appropriate.

COMING SOON

- **PROFESSIONAL LEARNING PACKAGE**

  A digital Professional Learning resource containing recordings of selected sessions from the 2021 Annual Conference will be available to participants after the conference and will be on sale to schools unable to attend. Some of these presentations will relate to Stage 6.

- **HSC STUDENT EXAM PREPARATION PACKAGE**

  The package will contain:

  a. Recorded advice on each topic from the 2020 package

  b. New material prepared for 2021.

  Schools can purchase the entire package (a plus b) OR only the 2021 additional material.

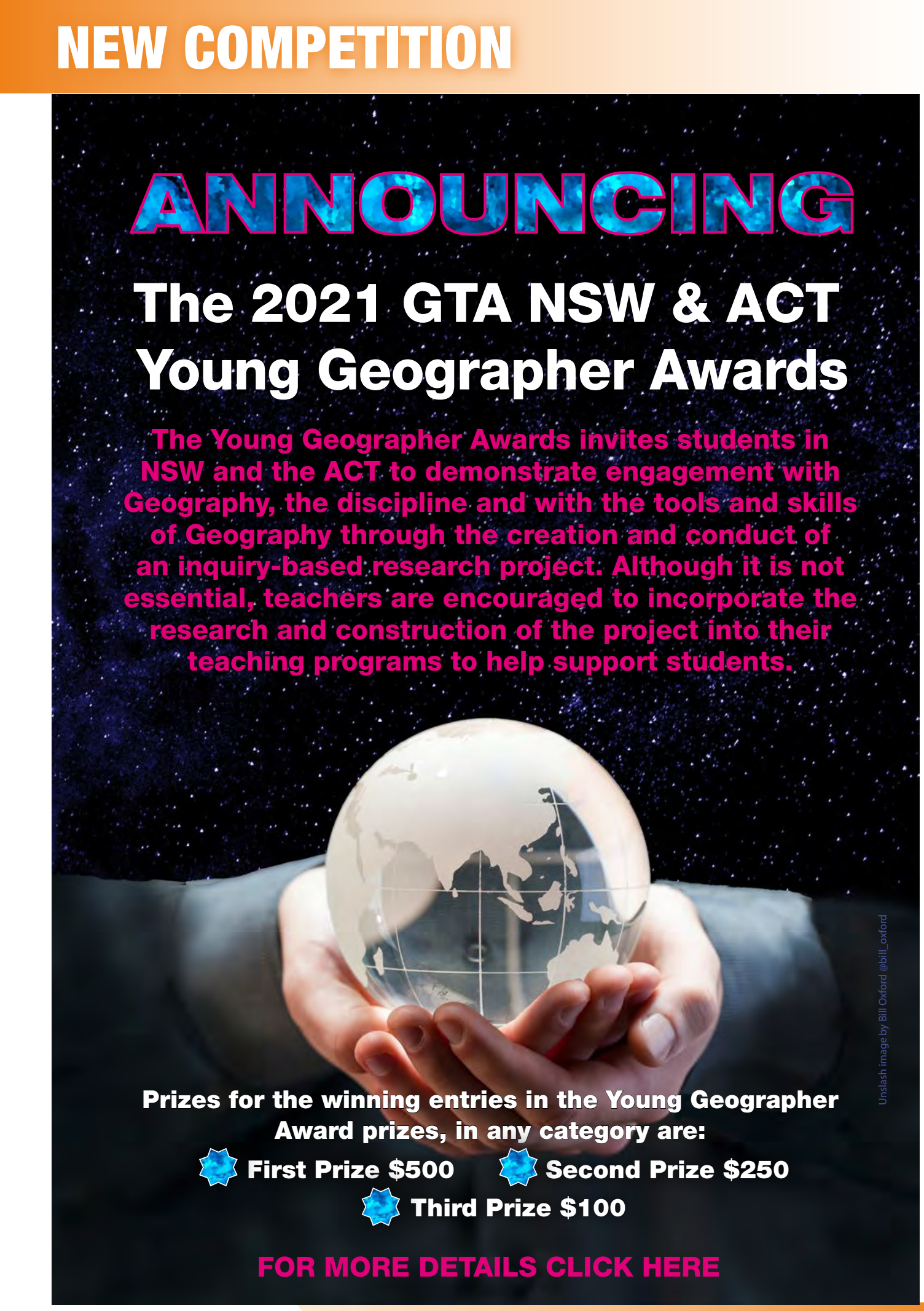
  A flyer will be sent to member schools soon.

  The package will be available for viewing from June to October 2021.

ANNOUNCING

The 2021 GTA NSW & ACT Young Geographer Awards

The Young Geographer Awards invites students in NSW and the ACT to demonstrate engagement with Geography, the discipline and with the tools and skills of Geography through the creation and conduct of an inquiry-based research project. Although it is not essential, teachers are encouraged to incorporate the research and construction of the project into their teaching programs to help support students.



Unslash image by Bill Oxford @bill_oxford

Prizes for the winning entries in the Young Geographer Award prizes, in any category are:

- **First Prize $500**
- **Second Prize $250**
- **Third Prize $100**

FOR MORE DETAILS CLICK HERE

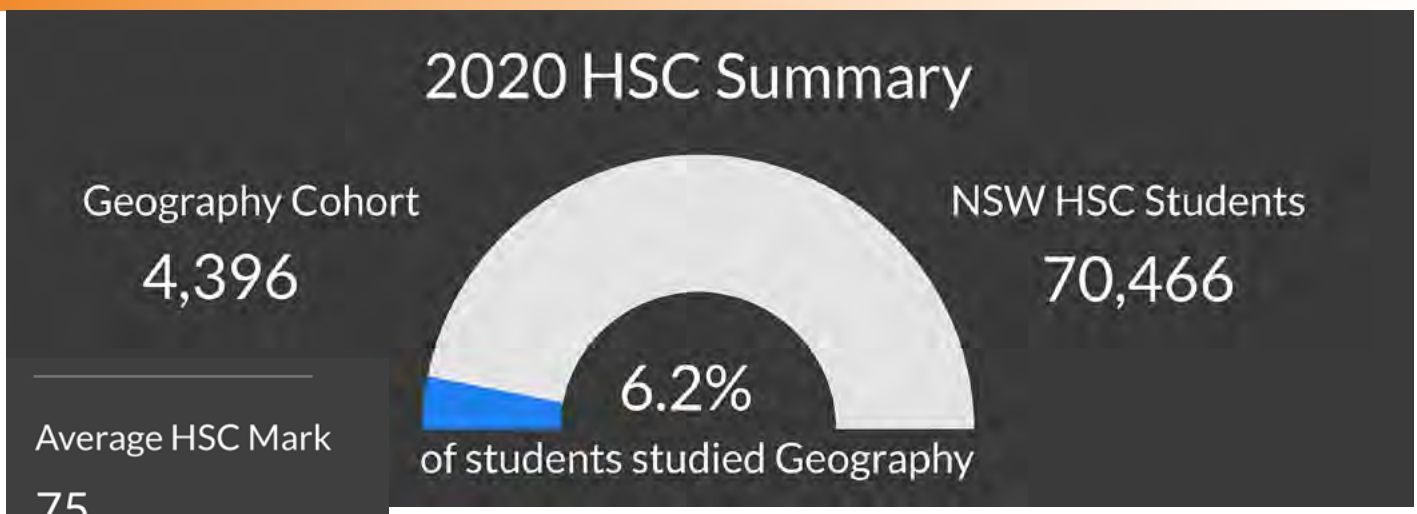
"How to get the answer"

Section I – 2020 HSC Geography Exam

Produced by the GTA NSW & ACT, led by John Lewis

1	A	Latitude is a spatial measurement.
2	B	Decentralisation is the movement of activities specifically out from central urban places.
3	A	Suburbs are expanding.
4	C	Southern Hemisphere (as warmer in ...) D, J & F → add rainfall columns (right axis).
5	D	Bilby is a nationally vulnerable mammal, so reduce predators.
6	C	Change over time, so taking photographs of that (direct measurement – not indirect survey).
7	D	Spatial relationships shown graphically.
8	D	Primary consumer eats a producer (plant).
9	A	1569 – 622 km is total distance travelled, divided by 11 hrs .... 86km/h.
10	B	Eastern hemisphere, so above 120° E.
11	B	Larger scale shows more detail.
12	D	Measure using a protractor to go all the way around to 330 degrees.
13	B	Measure line from watercourse "entry" into AR to "exit" from AR.
14	C	1 : run / rise
15	D	No contours block between 825m and 728m spot heights. All others are blocked.
16	B	Photo faces N, waterfall is 500m to right, ie. east, so GR 299232.
17	A	Line slants down from tertiary industry axis to point R.
18	C	Large tertiary sector indicating developed country.
19	C	(1 200 000 + 400 000) x 110%
20	A	Winter, southern hemisphere, midday. Sun is in the north, shadows are to the right, so the photographer is facing East.

GEOGRAPHY HSC AND SCALING

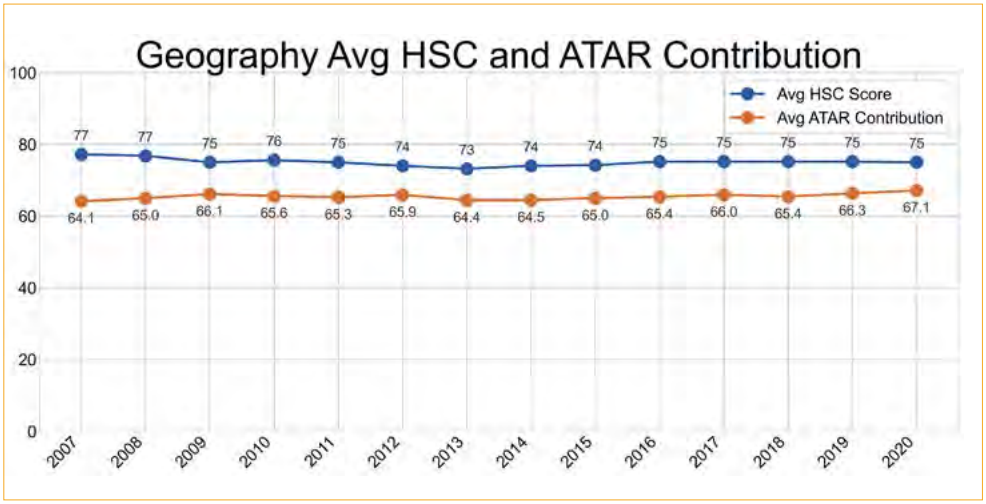


Graham Wright, Education consultant

Cohorts and Averages over time

The number of students studying Geography since 2007 has remained relatively constant, as have average HSC scores over the same period.

Since 2015 the average ATAR contribution from Geography scores has had a slight upward trend despite little change to HSC score averages. Because of the way scaling works, this means that the relative performance of Geography students in all other subjects has been slightly increasing, implying that the academic performance in Geography has been slightly increasing also.



ATAR Contributions

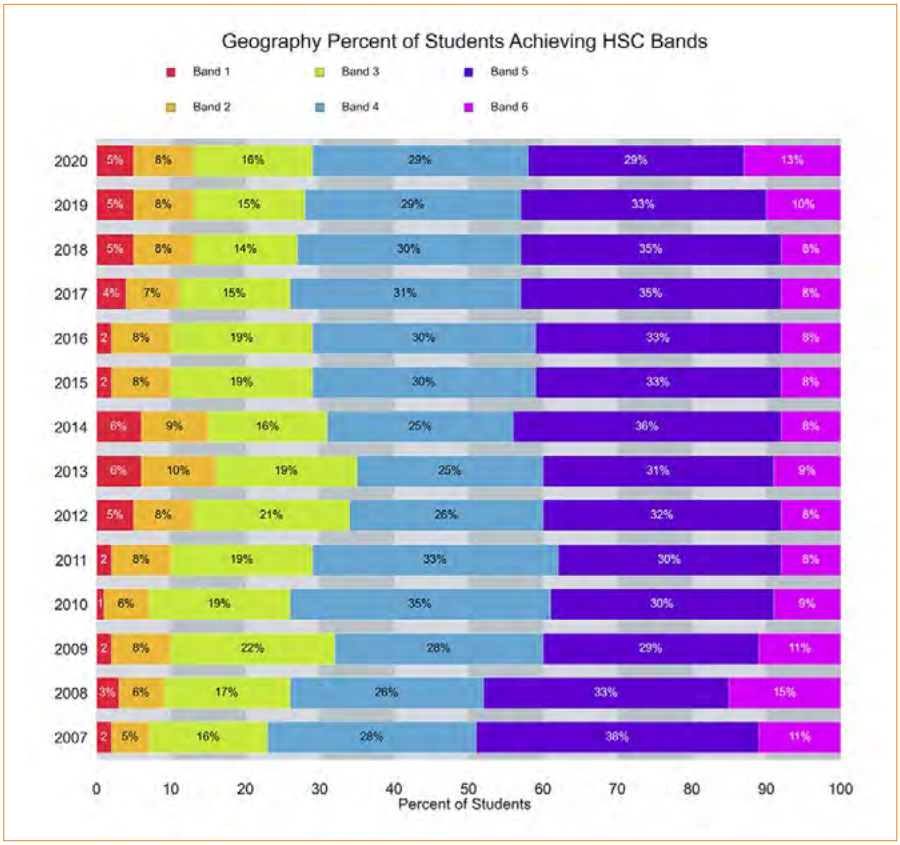
Because every subject has its own scale for the purposes of HSC marks, comparing performance from one subject to another using HSC marks won't provide a reliable measure.

'ATAR Contributions' are an attempt to provide a fair means of comparing student performance from one subject to another. It is an attempt to answer the question 'What would a student's ATAR be if they were allowed to study only one subject in their HSC?'

So in 2020 the average HSC mark in Geography was around 75. If a student was allowed to study just Geography and scored 75 for their HSC mark, then their ATAR would be around 67.1.

The ATAR contribution is indicative of what a student's ATAR would be if they performed at the same academic level for all of their subjects.

Band Attainment and Scaling



Band Attainment

The chart on the left shows the percentage of students who have achieved different Bands 1-6 in Geography since 2007.

Although the average HSC scores achieved in Geography in the last ten years and more have remained quite constant, the same isn't always true of the percentage of students achieving at individual bands.

2020 saw the highest percentage of Geography students achieving at Band 6 level since 2008. The combined percentage of students achieving a Band 5 or 6 in 2020, however, is slightly lower than the three preceding years.

The increase in the percentage of students attaining Band 6 scores in recent years has been coupled with an increase in the percentages of students achieving at Bands 1-3.

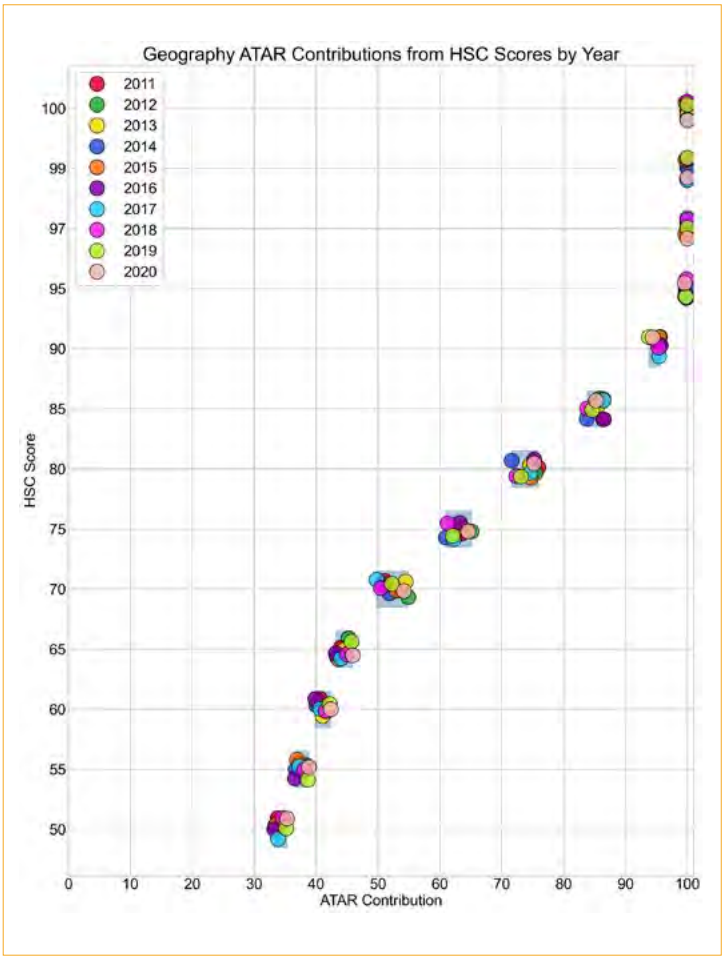
Scaling Consistency

Understanding the significance of what changes in the percentages of students achieving at different bands mean needs to be coupled with a look at the changes in scaling of certain marks in the HSC.

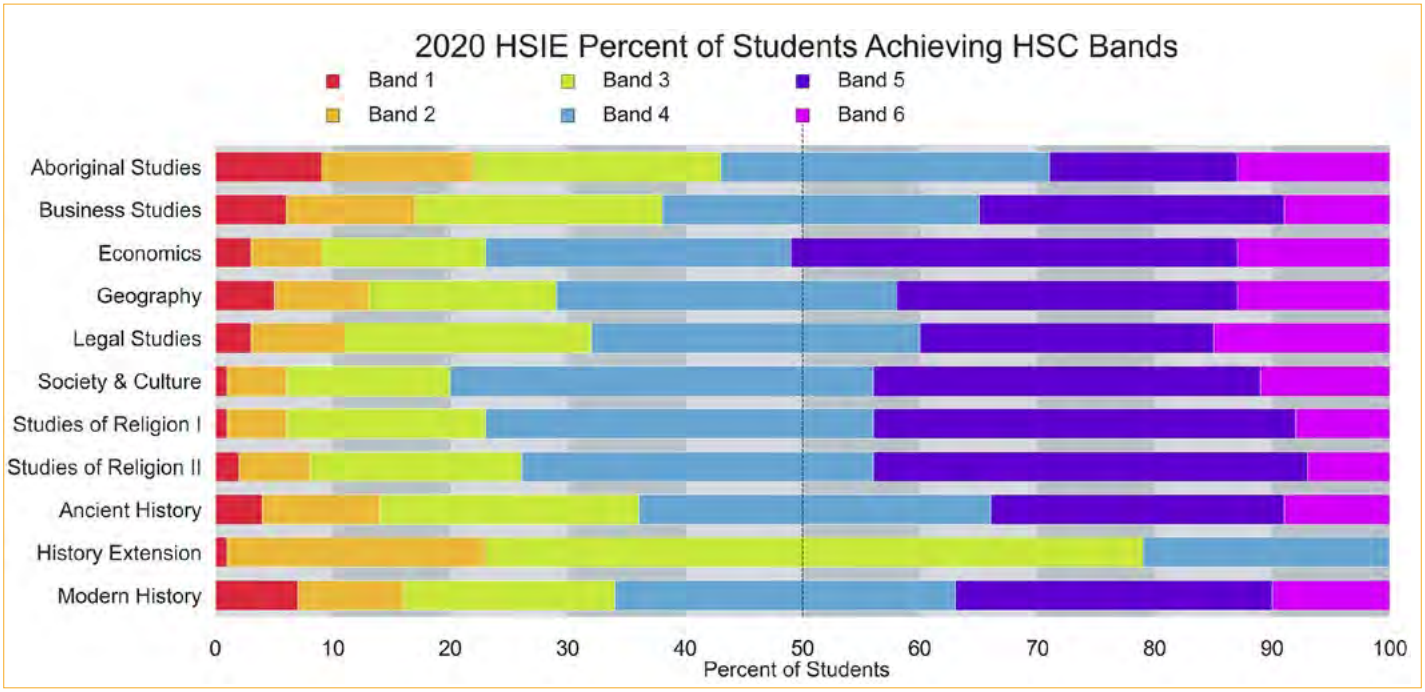
The chart on the right shows the ATAR contributions(x axis) of certain HSC milestone scores (y axis).

HSC scores of 95 plus have scaled very consistently and very highly over the last ten years. An HSC score of 95 or more in Geography consistently contributes toward an ATAR of 99 or more. The implications of this, in terms of scaling, are that it is expected that only the top 1,000 or so students in the entire state would be capable of achieving a score of 95 in Geography and that would be if every single student in the state was studying Geography.

It is important to note the change in scaling in 2019 and 2020 for HSC scores of 90, though. Where there has been an increase in the percentage of students achieving a Band 6 in Geography, there's also been a slight decrease in how a low Band 6 score scales. This indicates that rather than a significant number of students achieving at a higher level, the bar for Band 6 has been lowered slightly, resulting in more students jumping over it. The scaling system is designed to absorb these kinds of changes, and that's what has happened.



Geography and Other HSIE Subjects



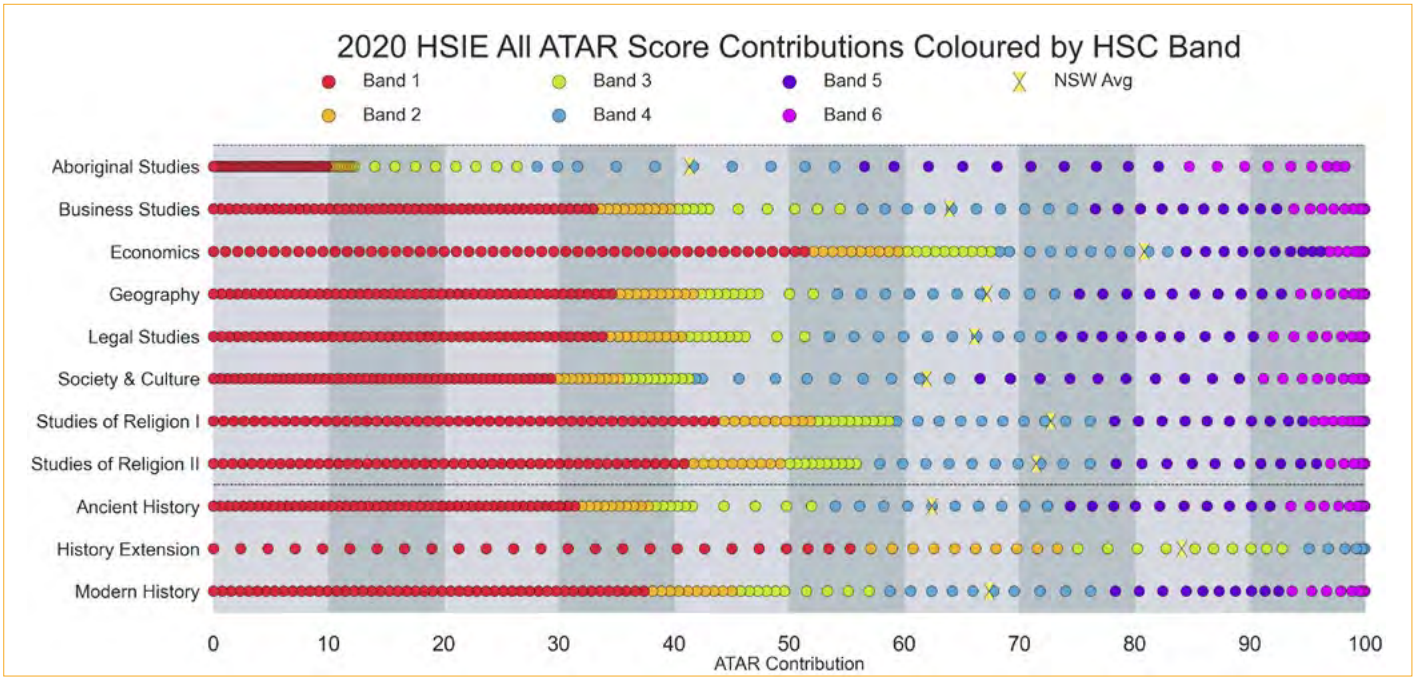
Band achievement in Geography is not particularly remarkable compared to other subjects in HSIE.

Scaling patterns in Geography (see chart below) are most similar to those in Legal Studies.

The chart below shows my estimations of scaling for all HSC scores in all HSIE subjects. Each dot is a possible HSC score, coloured by band. Band 1 scores are red, Band 6 scores are purple and all the other bands in between. In all HSC subjects, Aboriginal Studies has the lowest average ATAR contribution and corresponding HSC marks in Aboriginal Studies tend to scale significantly lower than all other HSIE subjects. Economics is the highest scaling 2 Unit subject in HSIE and, apart from History Extension, has the highest average ATAR contribution.

Geography is a subject which affords students the opportunity to excel in their HSC. The maximum scaled mark in Geography in 2020 was 50, which is the maximum mark that can be awarded in any subject. At least 15% of students in Geography (possibly up to 20%) achieved an ATAR contribution of 90 or more.

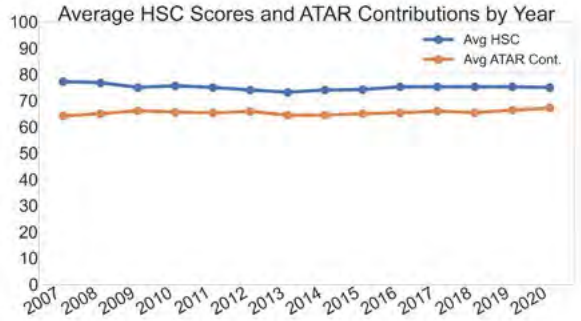
For students with high aspirations when it comes to their HSC studies, Geography is a good option for students with an interest in its content.

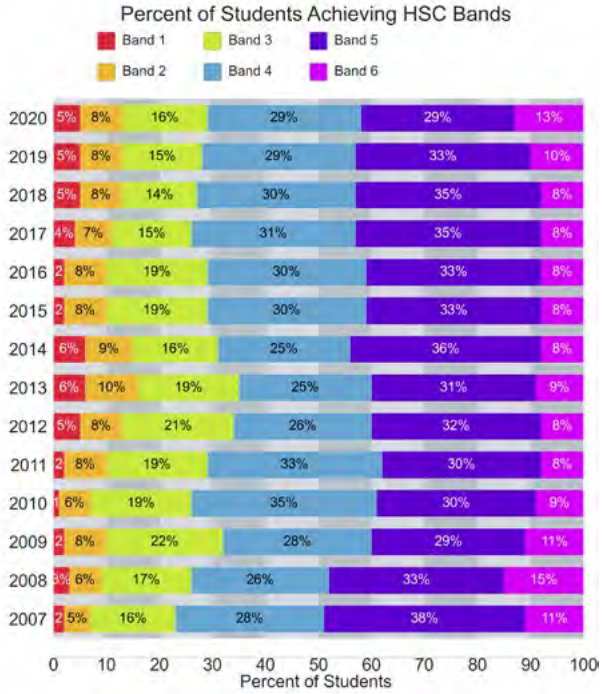


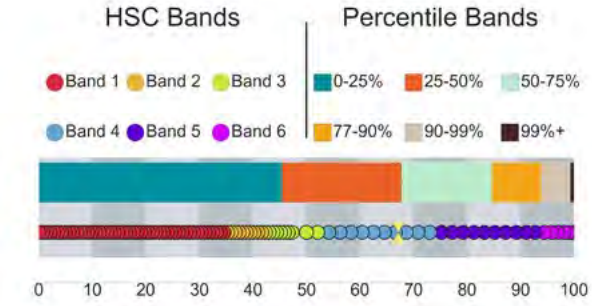
Geography ATAR Summary

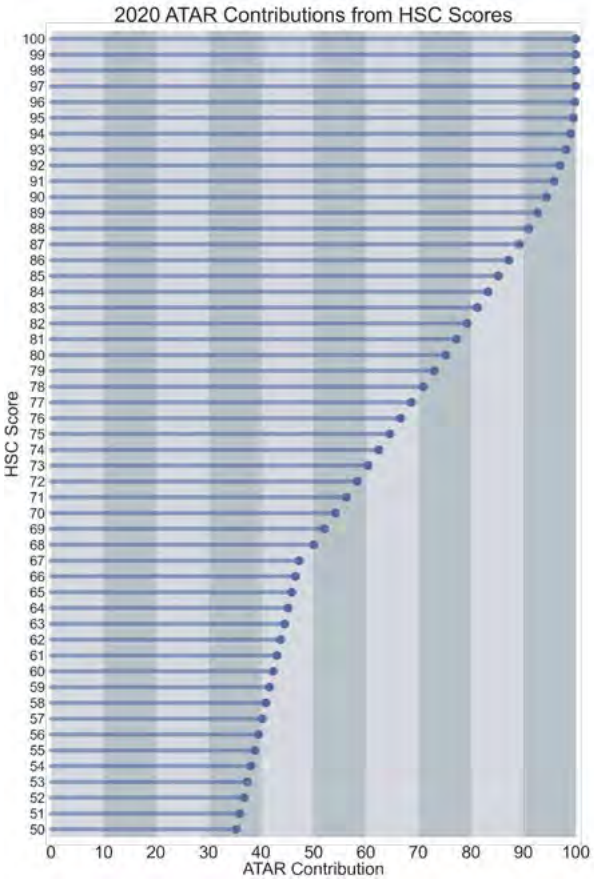
Average		Maximum	
HSC	ATAR	HSC	ATAR
75.0	67.14	98.0	99.95

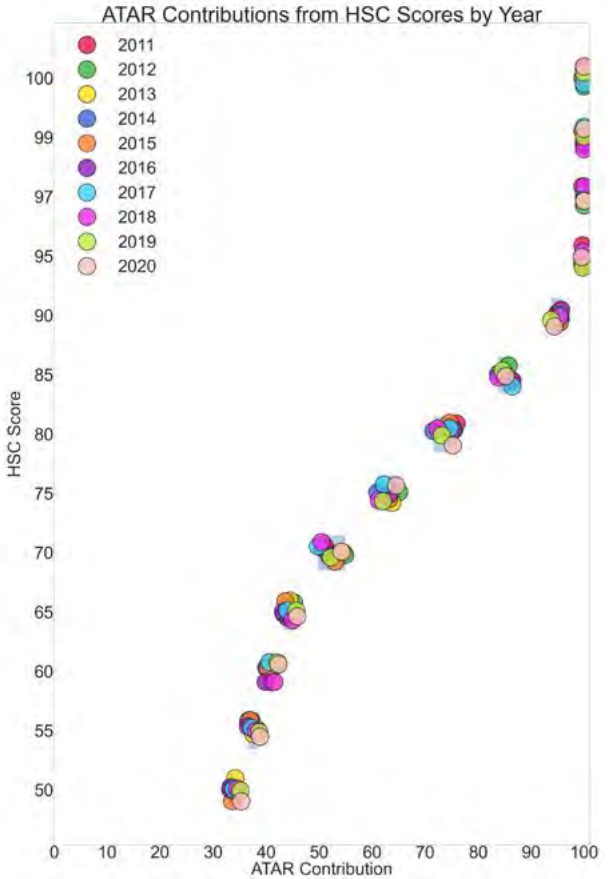
NSW Candidature: 4396











SELECTED HSC MAP SKILLS FOR YEAR 11

Image source: Shutterstock

Lorraine Chaffer, Geography Educator

SKILLS

- Locate features using degrees and minutes of **latitude and longitude**
- **Scale*** and direction
- Distinguish between **large-scale and small-scale maps***
- Calculate the **area*** of a feature
- Calculate the **density*** of a feature
- Calculate **local relief ***
- Calculate the **gradient*** of a slope as a ratio
- Determining **sight lines*** between two points
- Identify the **aspect*** of a slope
- Calculating the **vertical exaggeration*** of a cross-section

NOTE: The most problematic skills are those requiring calculations and multiple sources.

Images sourced from:

- AGTA Geography Skills Unlocked Text
- Macmillan Australia GeoWorld NSW Series 7 – 10 Texts
- Grant Kleeman GTA NSW & ACT PPT for Skills workshops
- *2007 HSC Stimulus Booklet*. A PDF of the Stimulus Booklet can be found in the GTA Stage 6 Google Drive Folder for the Teachers of HSC Geography Facebook Group.
- Suggested answers are provided.

1. LATITUDE & LONGITUDE

- Latitude is written first and must ALWAYS include N (north) or S (south)
- Longitude is written next and must ALWAYS include E (east) or W (west)
  EXAMPLE: 31° N 145° E
- Laugh Lots / LA before LO (Alphabet rule)
- Degrees are ALWAYS expressed as WHOLE NUMBERS
- Each degree is split into 60 minutes. Each minute is split into 60 seconds

2. SCALE

The scale indicates the level of detail in different maps and images.

Remember that scale is a ratio or a fraction, and 1/100 is a bigger number than 1/500,000. The larger the second number, the denominator, the smaller the scale of the map.

Do you want 1/100 of a million dollars or 1/20. You want the larger portion – 1/20.

Large scale maps show small areas in large detail (ZOOM IN to see details) – 1:25,000

Large detail e.g., minor roads and tracks; small features e.g., suburb, buildings

Small scale maps (ZOOM OUT to see a larger area) - 1: 250,000

Small detail e.g., only major roads; large features e.g., countries

The **SAD** acronym may help you to remember the information above:

For large scale maps: e.g. 1:25 000	**SAD**	**For small scale maps:** e.g. 1: 1,000,000
Large scale	**SCALE**	Small scale
Small area	**AREA** covered	Large area
Large detail	Amount of **DETAIL**	Small detail

Note: The scale of maps can be compared visually by looking at the level of detail.

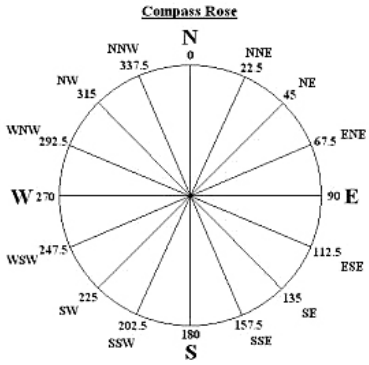
TRY THIS

a. Which of the maps above has the smallest scale, Collaroy OR Japan?

b. Which of the following represents the largest scale? 1:100,000 OR 1/ 50,000 OR 1cm represents 25 km

3. DIRECTION

- Know up to 16 cardinal (compass) points.
- Know the corresponding bearings (degrees from North)
- When giving direction, always place yourself at the location direction is being determined FROM.
- Use a 360° protractor to avoid making errors with bearings. Start with 0° at the North position and measure going clockwise.



4. TOPOGRAPHIC MAPS

a. Area and Grid References (AR and GR)

- Use the *Alphabet Rule* (Eastings - before Northings)
- Think *CAPITAL L* – to give an AR of a grid square. Bottom left-hand corner.
- When writing a capital L, you draw the down line first – this is the Eastings.

b. Scale, distance and area

On a topographic map, scale is shown in 3 ways. HSC students need to understand ratios.

TRY THIS

1: 100,000 means .....

1: 250,000 means .....

1:50,000 means .....

Convert the following scales to ratios:

1centimetre represents 3,000 metres .....

1 centimetre represents 200 metres .....

To calculate the AREA of a feature

1. For a regular shaped feature (square or rectangle), use the scale to measure the dimensions and calculate the area using Length x Breadth in km. Follow rules for circles and triangles.
2. Use the scale to determine the area of 1 grid square. Count how well the feature fills one or more grid squares.
3. For larger areas calculate the number of completely filled grid squares PLUS the number of incomplete grid squares divided by two.
4. Make conversions to different units of measurements for area as needed

*$1km^2 = 100ha$ 1 hectare(ha) = $10,000m^2$ (100m×100m)

c. Area and Density

Density = the number of features per 1 km^2

(1 grid square on a 1:100,000 map with grid squares of 1cm x 1cm is $1km^2$)

(1 grid square on a 1:25,000 map with grid squares 2 sm x 2 cm is 1 km^2)

TRY THIS

*** Use the Vancouver topographic map from the 2007 HSC on page 18**

What is the scale of the map? .....

What does this mean in metres and km? .....

If the area of a grid square is 1 km^2, what is the approximate area of Stanley Park north of the 60 Northing .....

d. Topography, relief and landforms

- Topography is the shape of the land.
- Relief is the differences in the height of land shown on a topographic map by contour lines and spot heights.

Be able to…

- *Recognise common landform features*
- Determine the ***direction a river flows.*** (This direction is named by where the river is flowing to)
- Calculate differences in height between places
- Calculate ***local relief***
- Explain how local relief impacts on sight lines and human activities
- Calculate ***gradient***
- Explain how gradient impacts on human activities

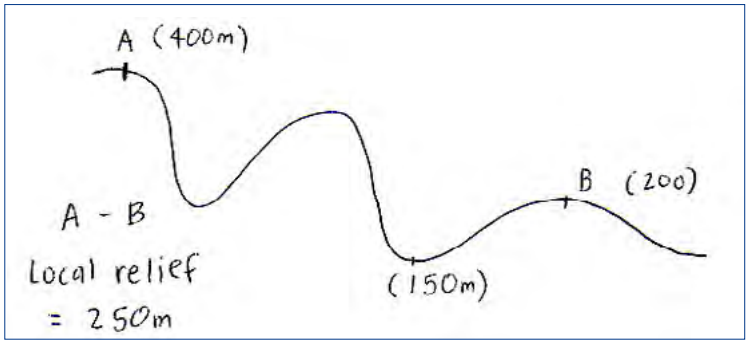
- ***Local relief***

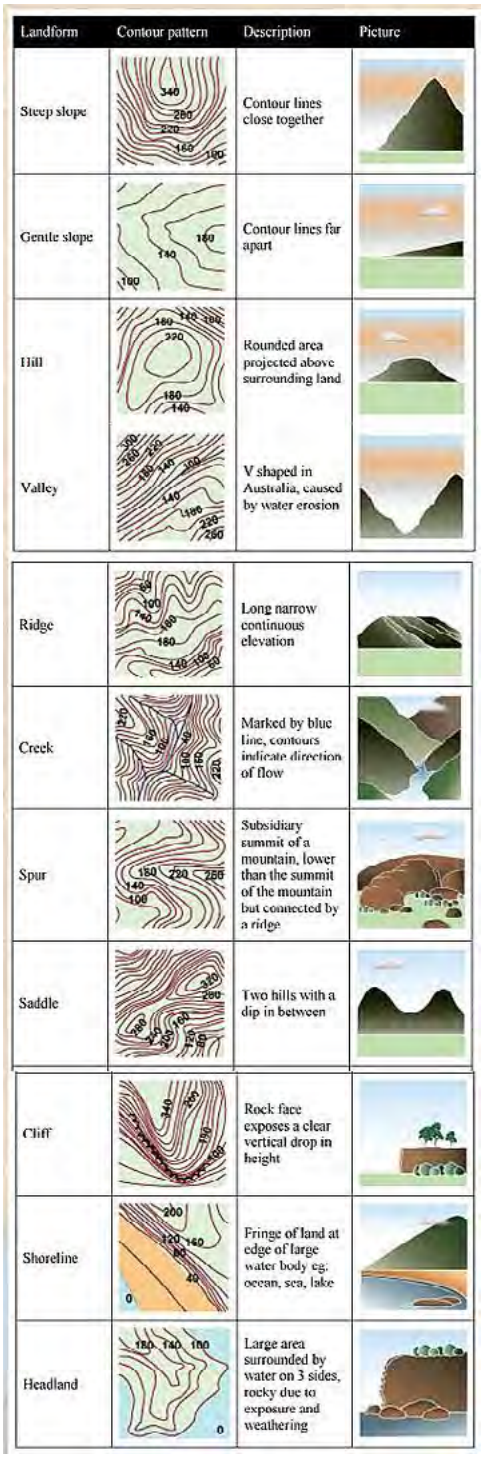
  Local relief is the difference between the highest and lowest points along a transect. (Look for higher or lower points between the start and finish of a transect)

- ***Sight lines***

  A sight line is the ability to see one location from another.
  This is often referred to as intervisibility
  Often the local relief means a higher point between two places stops a person seeing one place from another.

  Examples:





G Kleeman GTA Skills PPT

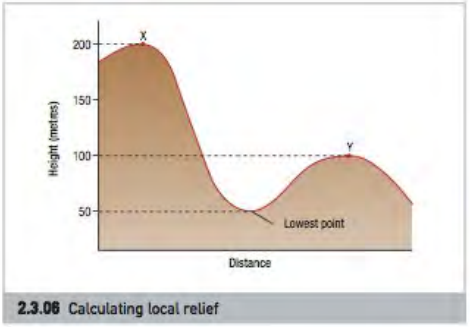
TRY THIS

Can a person standing at A see place B?

What is the local relief between X and Y?

Why would understanding local relief be important for:

- a farmer
- a town planner



2.3.06 Calculating local relief

- ***Gradient***

  Gradient is the slope of the landform between two given points.

  Gradient (GR) = Change in height (VR) divided by land distance (HR)

  GR = VR (Vertical rise) – use contours
  HR (Horizontal run) – use map scale to calculate

  e.g. The gradient of a slope that rises 200m between two places 6.4 km apart

  VR = 200 m (RISE). **Make sure the units of measurement are the same top and bottom
  HR 6400 m (RUN)

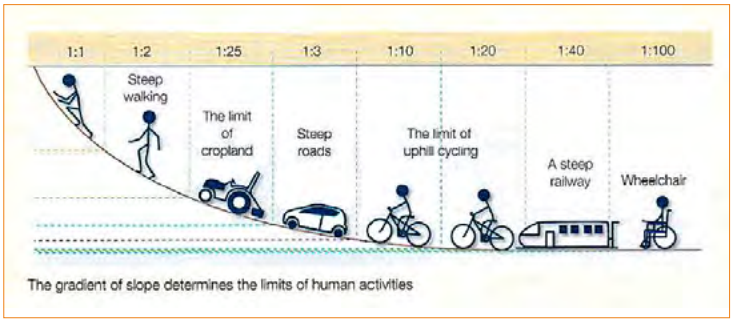
  = 1/32

  This means that for or every 32 metres travelled horizontally you rise by 1metre.

Why is gradient important?

Gradient influences many human activities eg agriculture, location of infrastructure such a rail lines, and physical events such as landslides and runoff – linked to erosion.

What vocations would this be useful for?
Town planning; Infrastructure planning; farming; bushfire management.



The gradient of slope determines the limits of human activities

- ***Aspect***

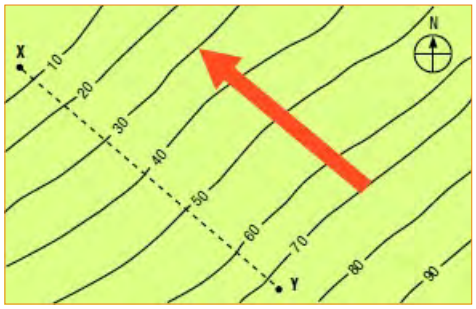
  The direction a slope is facing.
  Example:
  What is the aspect of the slope in the diagram?

  ……..

  Why is this useful knowledge?

  ……..

  ……



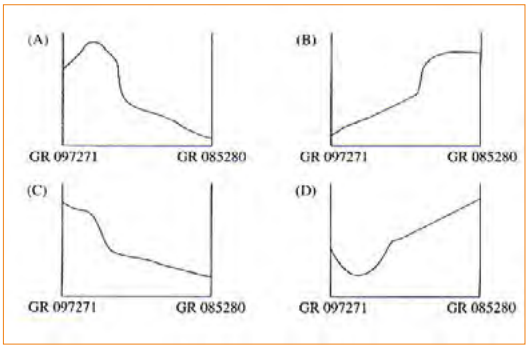
Source: G Kleeman GTA Skills PPT

- ***Cross section***

  Height is graphed to show the shape of the land

  You need to be able to…

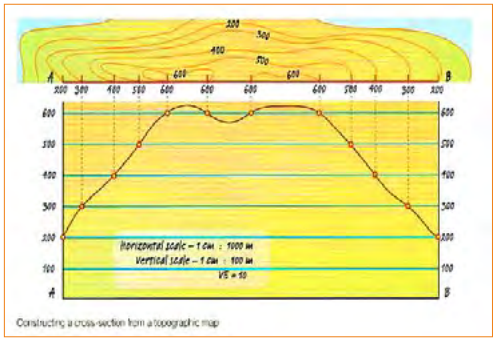
  – ***Draw or complete a cross section***
  – Recognise a cross section that matches pattern of contour lines on a map.
  – Calculate the ***vertical exaggeration*** of a cross section
  – Explain why vertical exaggeration is used.



- ***Vertical exaggeration***

The vertical scale is increased to exaggerate changes in the shape of the land unable to be seen when the vertical (VS) and horizontal (HS) scales are the same (as they are in the real world).

VE = VS (the scale from the graph)
HS (the scale from the map)



Example:

VS = 1 cm represents 20m

HS = 1 cm represents 100000 i.e. 1000m

VE = 1 / 1
20 / 1000

= 1000
20 = 50

A VE between 8 and 10 gives a reasonable indication of the shape of the land.

TRY THIS

Calculate the vertical exaggeration for a cross section with a VS of 1 cm represents 250 metres and a HS scale of 1:200,000

What would be the advantage of changing the vertical exaggeration of a cross section from 5 to 20?

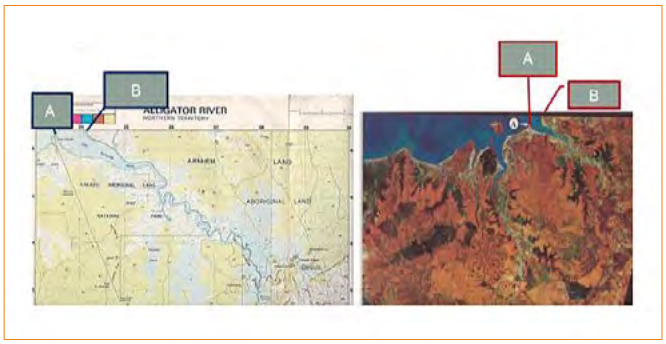
- ***Estimating the scale of a photograph using a map***

Often there will a map and photograph of the same area. Photographs usually do not come with a scale like the map. You can use the map to create a scale for the photograph.

Steps

There are a few numbers to determine:

- The distance between two points on a map in km
- The distance between the same two points on the photograph in cm



- On the map find two points that also appear on the photograph. (See A and B above)
- Measure the land distance between A and B using the scale of the map. (km)
- Now measure the distance between the same two points on the photograph (in cm).
- This answer gives you a scale for the photograph 1cm represents the land distance.

Example:

On a map with a scale of 1:50000. The distance between two headlands is 4cm. The real distance is 2km (2000m and 200 000cm). On the photograph the distance between the two headlands is 2cm. On the photograph 2cm represents 2km (2000m or 200000cm) or 1cm represents 1km. As a ratio – this is 1: 100000

TRY THIS

a. Calculate the scale of the Vancouver photograph 2007 HSC Stimulus

b. Use the scale to calculate the area covered by the photograph.

5. SYNOPTIC CHARTS
(Weather at a point in time OR predicted atmospheric conditions)

Weather maps or synoptic charts show atmospheric conditions. Make links to topics.

a. Remember these connections

AIR PRESSURE
(shown by contour lines in hectopascals hPa)
(Linked to global circulations / summer & winter)

Determines

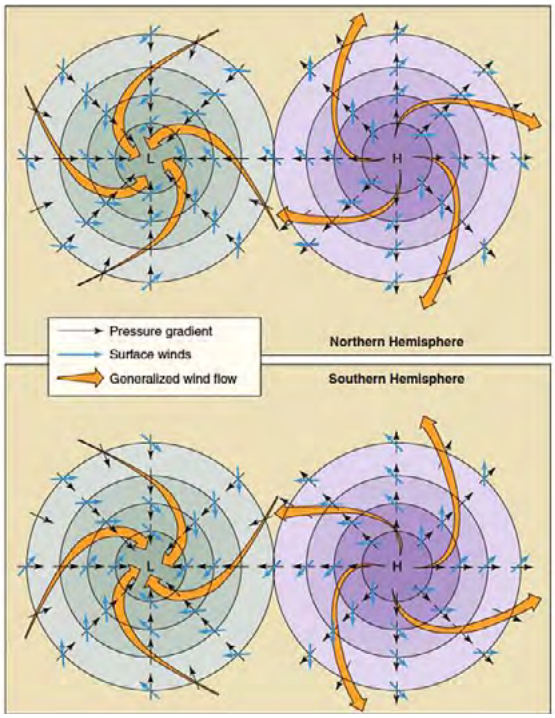
WIND DIRECTION
(Australia: Clockwise into a Low,
Anticlockwise away from a High)

Determines

AIR MASSES
(Equatorial, Tropical Maritime, Southern Maritime,
Tropical Continental)

Determine

WEATHER
(temperature, humidity, wind, likelihood of rain)



Use the letter S to assist in remembering **wind circulation patterns around high, and low**, pressure cells in the Southern hemisphere.

High (Top of S is drawn going anticlockwise)

Low **S** **outhern**

(Bottom of the S is drawn going clockwise)

b. Know how the atmosphere changes with the passing of a front (especially a cold front)

These will include air pressure (give before & after hPa readings), wind direction (from _____ to _____) wind strength (use wind arrows or closeness of isobars), temperature and humidity (what air mass is affecting the weather before and after the front), possible cloud cover (more, less, possible type of cloud) and likelihood of rain.

*Be specific in your answer by reading data eg direction, air pressure from stimulus provided

c. Know about East Coast Lows that impact on coastal weather conditions in NSW.

d. Know that winds affect sea conditions – waves and swell.

Onshore winds create swell and waves and bring atmospheric moisture onshore that increases the likelihood of precipitation (orographic or convectional)

Offshore winds e.g., Westerlies on the East Coast of NSW flatten the sea

e. Types of precipitation eg orographic, frontal and convectional.

These terms may be relevant to questions about precipitation.

SUGGESTED ANSWERS

TRY THIS

a. Which of the maps above has the smallest scale, Collaroy OR Japan? Japan

b. Which of the following represents the largest scale?
1:100,000 OR 1/ 50,000 OR 1cm represents 25 km

TRY THIS

1: 100,000 means 1cm represents 1 km or 1000 metres

1: 250,000 means 1 cm represents 2.5 km or 2,500 cm

1:50,000 means 1 cm represents ½ or 0.5 km or 500 metres

Convert the following scales to ratios:

1centimetre represents 3,000 metres 1:300,000

1 centimetre represents 200 metres 1:20,000

TRY THIS

*** Use the Vancouver topographic map from the 2007 HSC on page**

What is the scale of the map? 1: 50,000

What does this mean in metres and km? 1cm represents 0.5 km or 500 metres

If the area of a grid square is 1 km^2, what is the approximate area of Stanley Park north of the 60 Northing 3.5 km^2

TRY THIS

Can a person standing at A see place B? No

What is the local relief between X and Y? 250 m

Why would understanding local relief be important for:

- a farmer: needs to see distant places for livestock or fire threats, rain, planning activities
- a town planner: planning land use, roads, communications

TRY THIS

Calculate the vertical exaggeration for a cross section with a VS of 1 cm represents 250 metres and a HS scale of 1:200,000

$$\frac{VS}{HS} \quad \frac{1/250}{1/2000} \quad \frac{2000}{250} = 8$$

What would be the advantage of changing the vertical exaggeration of a cross section from 5 to 20? To see the shape of the land more clearly

TRY THIS

a. Calculate the scale of the Vancouver photograph 2007 HSC Stimulus
1: 35,000 (1 cm represents 350 metres)

b. Use the scale to calculate the area covered by the photograph.
9.3 $km^{2.}$ (3.33 km x 2.8 km)

Source E – Vancouver topographic map (1986)

Dual highway
Road, hard surface, more than 2 lanes
Road, hard surface, 2 lanes
Road, hard surface, less than 2 lanes
Road, loose or stabilised surface
Trail
Railway, single track; multiple track
Railway station; bridge
House; large building
Church; school
Post office; telegraph office
Elevator; tower
Cemetery; historic site
Power transmission line
Campsite; picnic site
Retaining wall: small

Source G – Vancouver

NSW Board of Studies *2007 HSC Examination Stimulus* Page 18

DIGITAL VOLUNTEERISM

Putting the World's Vulnerable People on the Map

Missing Maps: Crowd sourcing to support humanitarian responses for a better future

Jeana Kriewaldt and Shu Jun Lee
Melbourne Graduate School of Education

Screen capture from http://www.missingmaps.org/

As geography teachers who teach about spatial inequalities in human development and welfare around the world, we wonder if there was more we could do, or inspire our students to do, to help address these issues?

Missing Maps might be just the right project for us and our students to apply our geographical mapping skills to help improve the well-being of vulnerable populations around the world. Before disasters including flood, cyclone or pandemic strike, our student-volunteers along with volunteers around the world can swing into action mapping buildings, waterways and roads to generate accurate base maps. This is a powerful way to build the knowledge and empathy into curricula and co-curricular activities.

What is *Missing Maps*?

Missing Maps (http://www.missingmaps.org/) is a humanitarian project that aims to create detailed maps of unmapped regions of the world to support international and local NGOs, and individuals, in their responses to crises affecting vulnerable populations. Founded in 2014 by the American and British Red Cross, the Humanitarian Open Street Map Team, and Doctors Without Borders / Médecins Sans Frontières (MSF), Missing Maps now consists of 18 member organisations and has over 110,000 mappers around the world supporting its efforts.

Many humanitarian organisations like Médecins Sans Frontières (MSF) are hindered when they work in areas that are 'missing' from digital maps. These organisations identify and prioritise unmapped regions according to current and projected humanitarian needs. ***Missing Maps*** then employs a three-stage process (Figure 1) that starts with remote volunteers identifying structures, usually buildings and roads, and marking them on satellite imagery. The second stage involves local community volunteers verifying these markings and adding details that cannot be derived from remote imagery. The third stage sees GIS professionals creating detailed maps using the crowd-sourced data (Schwerdtle & Herfort, 2018). The products can then be used by any humanitarian organisation to "plan risk reduction and disaster response activities that save lives" (MissingMaps, n.d.).

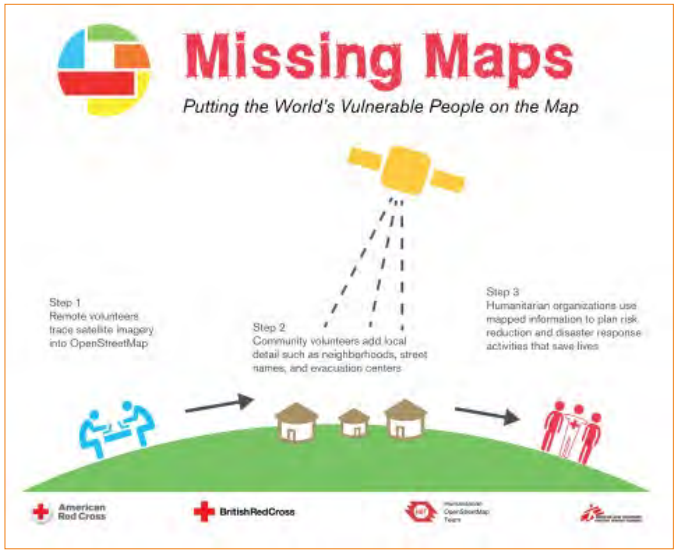


Figure 1. Missing Maps' three-stage process of producing maps (MissingMaps, n.d.)

Digital volunteerism

Missing Maps enables anyone – young and older, with or without digital mapping skills – to become a digital volunteer contributing to citizen science and humanitarian efforts. The platform enables volunteers to work remotely and simultaneously on an overall area, using OpenStreetMap (OSM), a free and editable digital map of the world. To begin mapping, simply sign up for an OSM account. New OSM users go through a tutorial to learn the tools on the platform. Then they choose their first project. They can search for projects according to their mapping expertise (e.g. 'Beginner Mapper'), priority level of projects (e.g. 'Urgent'), or even by location. Once volunteers have selected a project, they can begin mapping! (Figure 2)

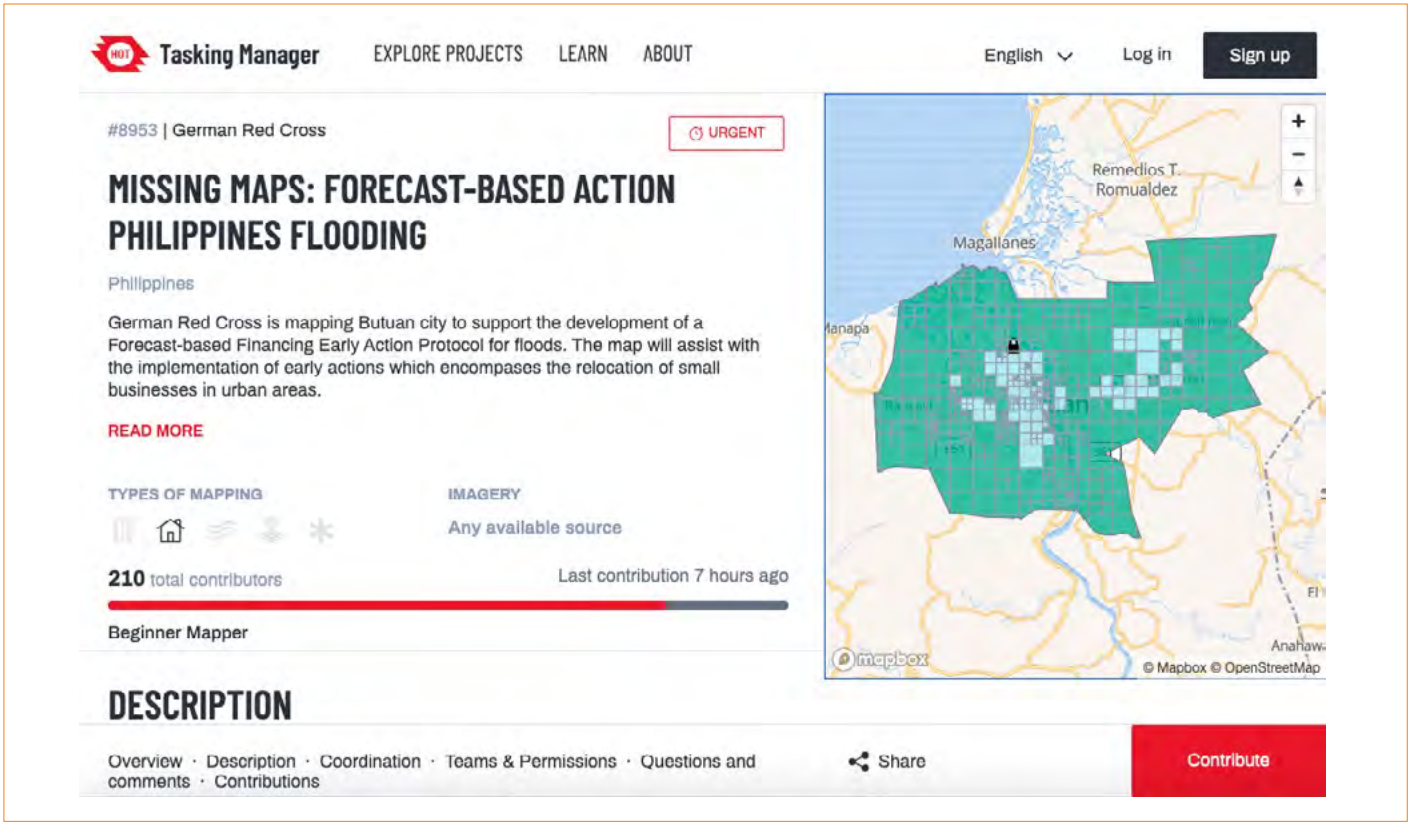


Figure 2. Screenshot of a mapping project for Butuan City, Philippines, to assist with the implementation of early responses to floods. The project is suitable for beginner mappers and marked as 'urgent'.

The three-stage process employed by Missing Maps ensures data is validated by experienced remote mappers and local volunteers on the ground. The quality of data is also improved over time as knowledge transfer takes place between novice and experienced contributors when they connect through mapping events/parties called mapathons. Universities, schools, mapping clubs and individuals around the world regularly organise mapathons, which help to achieve rapid results and is a great way to build community. The Missing Maps website provides helpful information on planning and hosting such events. School groups do mapathons.

Linking to curriculum

Teachers and student groups including the Student Representative Councils (SRC) can organise mapathons as team building opportunities and so that students can experience the impact of collective action and can make links to geography curriculum at a range of levels. There are several neat curriculum links, for example in the Geographical Concepts and Skills strand at year 9 and 10, students are asked to "collect and record relevant geographical data and information, using ethical protocols, from reliable and useful primary and secondary sources" (VCGGC130). In VCE Geography this activity links to Unit 1: Hazards and Disasters and builds knowledge of the use of spatial technologies (VCAA, n.d.).

Benefits and cautions

Missing Maps offers many learning opportunities for our geography students. Becoming a remote mapper provides them the opportunity to use and apply their GIS skills. The location-specific projects can help

increase their knowledge about places, enriching their geography knowledge. Deepening their understanding of the issues plaguing these vulnerable places and regions raise ethical questions, which can help students develop informed values and attitudes, and become more aware of their own roles and responsibilities locally and globally. In sum, using ***Missing Maps*** is an excellent example of the practical applications of the knowledge and skills of our discipline, and of how geographical understanding can help us create a better world.

As educators however, we need to remember that ***Missing Maps*** is designed as a practical tool and not for the purpose of education. To fully harness the benefits of the tool for education, we should take care to plan our lessons so the tool is not used as an end, but more as a means, to deliver our curriculum objectives. In a review of a Mapathon conducted by Monash University, the organisers found that student feedback was "overwhelmingly positive", with many appreciating the opportunity to act on international health inequity rather than just passively reading about it (Schwerdtle & Herfort, 2018, p.2). However, a small number of students failed to link the event with the learning objectives. This reveals the importance of ensuring that the lesson/Mapathon design makes explicit links to the learning intention. Frustrations with technology and the volume of information can also make it demotivating for students, who are mostly novice mappers. Care must be taken to provide sufficient time and space for students to learn how to the tool.

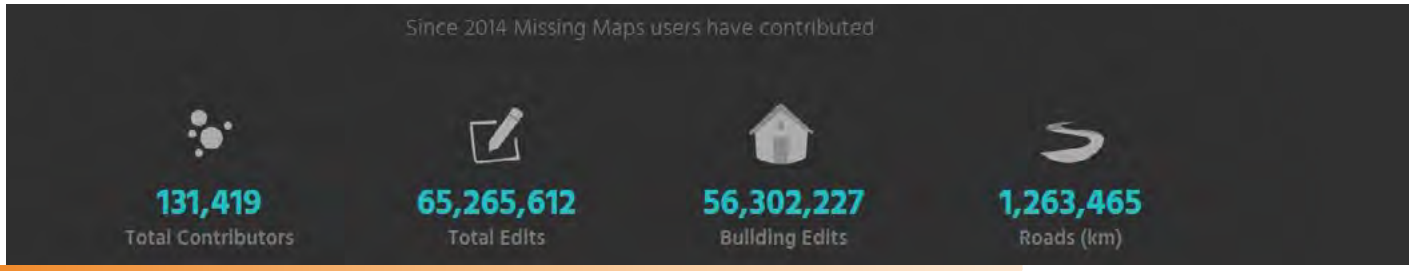
If you or your colleagues have used ***Missing Maps*** in your geography lessons, or have organised a mapathon, we are keen to hear your insights and we can be contacted at shulee@student.unimelb.edu.au

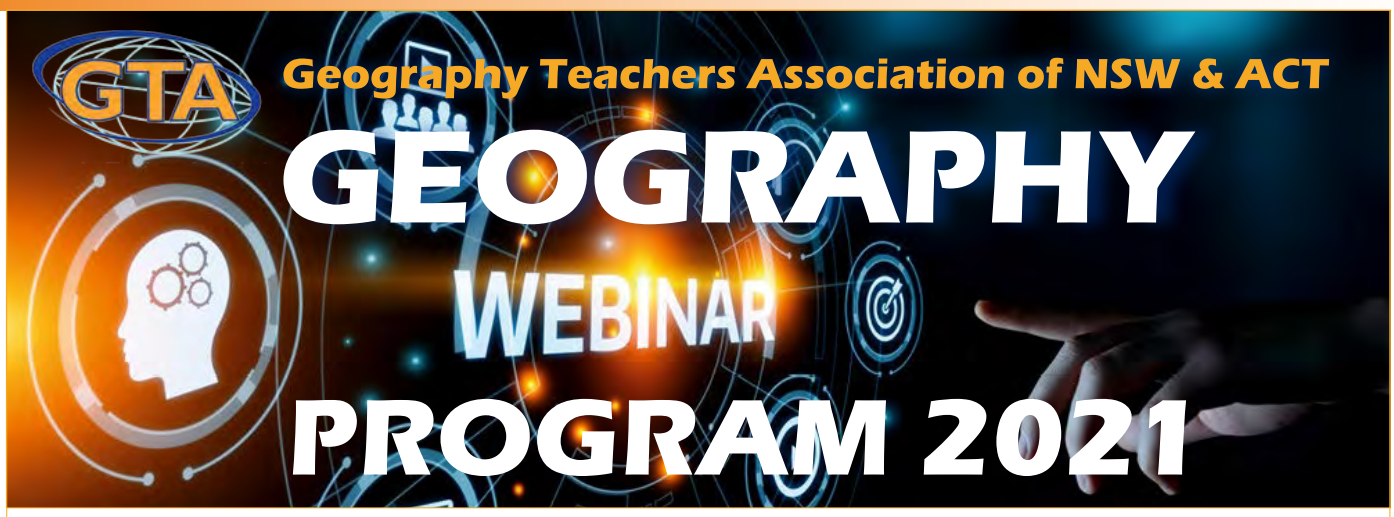
References

MissingMaps. (n.d.). Retrieved September 21, 2020, from https://www.missingmaps.org/

Schwerdtle, P., & Herfort, B. (2018). Teaching global health using crowd-sourcing with Missing Maps. ***Nurse Education Today***, ***60***.

VCAA. (n.d.). Victorian Curriculum Foundation-10: Geography Content Description VCGGC130. Retrieved September 21, 2020, from https://victoriancurriculum.vcaa.vic.edu.au/Curriculum/ContentDescription/VCGGC130





In 2021 the webinars will be co-ordinated by Susan Caldis, David Latimer, Alex Pentz and Beck Sutcliffe. Webinars will operate in Terms 2, 3 and 4, between 4.30pm – 5.30pm and cost $20 per session (members and non-members).

Due to recent changes in accreditation processes, the webinars will be available as 'Elective PD' to complete as part of your ongoing professional learning. As greater clarity and certainty emerges about accreditation of professional learning, the webinar team will take steps to ensure accreditation of the program is possible.

The webinar team are excited to announce two concurrent themes to the webinar program:

- **'From the Academy', where Geographers from universities around Australia will present their research, with pre-reading, in alignment with a syllabus focus; and**
- **'From the Classroom', where Geography teachers (and perhaps their students!) will share their practice, spark curiosity, and prompt dialogue amongst practitioners.**

Term 2: From the Academy

Date: Thursday 22 April 2021 Time: 4.30pm – 5.30pm
Presenters and webinar focus:

Professor Sue Jackson and Dr Lana Hartwig, from the Australian Rivers Institute, Griffith University, QLD will share their research findings about Indigenous water cultures, water value, and water governance and management in south-eastern Australia. Syllabus focus will attend to Water in the World, outcomes GE4-2, GE4-3, GE4-5

Cost: $20 members and non-members or $30 if registering for both of the advertised webinars

Term 2: From the Classroom

Date: Wednesday 26 May 2021 Time: 4.30pm – 5.30pm
Presenter:

Chris Betcher, Program Manager, Google for Education will present about Google's Geo tools. Syllabus focus broadly attends to the Stage 4 and 5 use and application of geographical tools, and also using Google's Geo tools to assist with acquiring, processing and communicating geographical information.

Cost: $20 non-members and non-members or $30 if registering for both of the advertised webinars

More webinars for Term 2 and beyond are in the process of organisation. Further information will be available shortly.

CLICK HERE TO REGISTER FOR 2021 GEOGRAPHY WEBINARS

GEOGRAPHY WEBINAR PROGRAM 2021

From the Academy: information about the presenters, syllabus alignment and registration

'From the Academy' aligns with a recommendation from Geography: Shaping Australia's Future (National Committee for Geographical Sciences, 2018) – to explore ways to increase collaboration between school and university geographers [and] improve the visibility and integrity of the discipline (pp. 87, 95). Geographers from universities around Australia will present their research in alignment with a syllabus focus. The purpose is to enable a connection to occur between discipline academics and school-based Geography educators. In so doing, it becomes possible to explore connections between current research and Geography syllabus content descriptions across Stages 4 – 6. Pre-reading will be available, and questions from those who attend the webinar will be encouraged.

Presenter information

Professor Sue Jackson is a geographer with 30 years' experience researching the social dimensions of natural resource management. She has an Honours degree in Applied Economic Geography (UNSW) (gentrification in Pyrmont-Ultimo) and specialised in cultural geography for her PhD on native title and planning (at Macquarie University). She has research interests in the social and cultural values associated with water, customary Indigenous resource rights, systems of resource governance, and capacity building for improved public participation in natural resource management and planning. She was awarded an Australian Research Council Future Fellowship in 2014.

Dr Lana Hartwig is an Adjunct Research Fellow at the Australian Rivers Institute at Griffith University in Queensland, and a Project Officer for the Murray Lower Darling Rivers Indigenous Nations, a confederation of First Nations in the southern Murray-Darling Basin. Lana has close to a decade of experience researching First Nations' land and water injustices particularly in NSW, as well as five years' experience teaching geography and planning university students about public engagement and human-environment interactions. Lana completed her Honours degree in Environmental Sustainability and her PhD in Aboriginal water rights and self-determination at Griffith University.

Syllabus alignment – Water in the World

The webinar presentation about Indigenous water cultures, water value, water scarcity, and water management and governance will be targeted towards Water in the World (Stage 4). However, relevant links can also be made with Environmental Management and Change (Stage 5), Biophysical Interactions (Stage 6) and Ecosystems At Risk (Stage 6).

Aspects of each key inquiry question from the syllabus will be addressed, together with coverage of content related to outcomes GE4-2, GE4-3 and GE4-5. The most relevant content descriptions from Water in the World include:

- Investigate the nature of water scarcity and water management and ways of overcoming it.
- Investigate the economic, cultural, spiritual, and aesthetic values of water for people, including Aboriginal and Torres Strait Islander Peoples and/or people of the Asia region.

Registration and pre-reading

Pre-reading and/or listening is recommended prior to the webinar. Upon registration, there will be access to further academic reading (such as peer-reviewed journal articles and/or book chapters). The readings are authored by the webinar presenters about Indigenous water cultures and management in Australia.

As an introduction to the work of Professor Jackson and Dr Hartwig, you are encouraged to read the article or listen to the podcast before the webinar.

- Hartwig, L.D., & Moggridge, B. (3 August 2020). Australia's legacy of denying water rights to Aboriginal Australians – audio file, 18 minutes, on ABC Late Night Live https://www.abc.net.au/radionational/programs/latenightlive/dr-lana-hartwig/12519894
- Jackson, S., Markham, F., Hooper, F., Rigney, G., Hartwig, L.D., Woods, R. (17 February 2021). Water injustice runs deep in Australia, fixing it means handing control to First Nations. The Conversation https://theconversation.com/water-injustice-runs-deep-in-australia-fixing-it-means-handing-control-to-first-nations-155286

Find out more about the webinars...

GEOGRAPHY WEBINAR PROGRAM 2021

From the Classroom: information about the presenter, syllabus alignment and registration

'From the Classroom' enables Geography teachers (and perhaps their students!) to share their practice, spark curiosity, and prompt dialogue amongst practitioners. A call for presenters was issued recently via social media. If you are a Geography teacher who would like to contribute to the webinar program please contact David Latimer via gta.admin@ptc.nsw.edu.au

Presenter information

Prior to joining Google, **Chris Betcher** spent almost 30 years in the classroom where he was always fascinated by the many ways in which digital technologies were able to positively impact teaching and learning. He has been an active contributor to numerous online educational communities for many years, and in 2013 he was recognised by the Australian Council for Computers in Education as the Australian ICT Educator of the Year. Chris is currently a Program Manager with the Google for Education team, based in Sydney.

Webinar focus and syllabus alignment

Google's Geo tools for Geo Teachers

Google creates a lot of amazing geo-based tools, and while not all have been created specifically for classroom use, nearly all have powerful applications for any geography class. From Maps to MyMaps, Earth to Earth Engine, Streetview to Arts and Culture, the collection of tools for teachers of geography is an absolute treasure trove of learning opportunities. In this workshop you'll learn about the powerful possibilities afforded by Google geo tools. Bring a computer so you can explore them yourself!

Please note this webinar will be hosted on the Google Meet platform. The focus of this webinar broadly aligns with the use and application of Google geo tools to assist with acquiring, processing and communicating geographical information across Stages 4 and 5. It will be up to you as the teacher to decide the syllabus unit and case study.

UNDERSTANDING THE CARBON CYCLE

Lorraine Chaffer
Geography Educator

Shutterstock

REFLECTION

Understanding the Carbon Cycle is key to understanding Climate Change, impacts of climate change and strategies to address climate change. Climate Change can be integrated into all NSW Senior Geography physical and human Geography topics including biophysical interactions; global challenges such as natural resource use, population, development and political geography; and all HSC topics - urban places, ecosystems and economic activity.

Before the Year 11 Geography Course it is worth asking your students this question.

> '*After 10 years of schooling including studies of Science and Geography, do you understand the Carbon Cycle and Climate Change?*'

The Quick Quiz will help you assess student knowledge and understanding so gaps can be filled, and misconceptions overcome early in the senior course. The following Poster Pack activities are designed to deepen student knowledge and understanding.

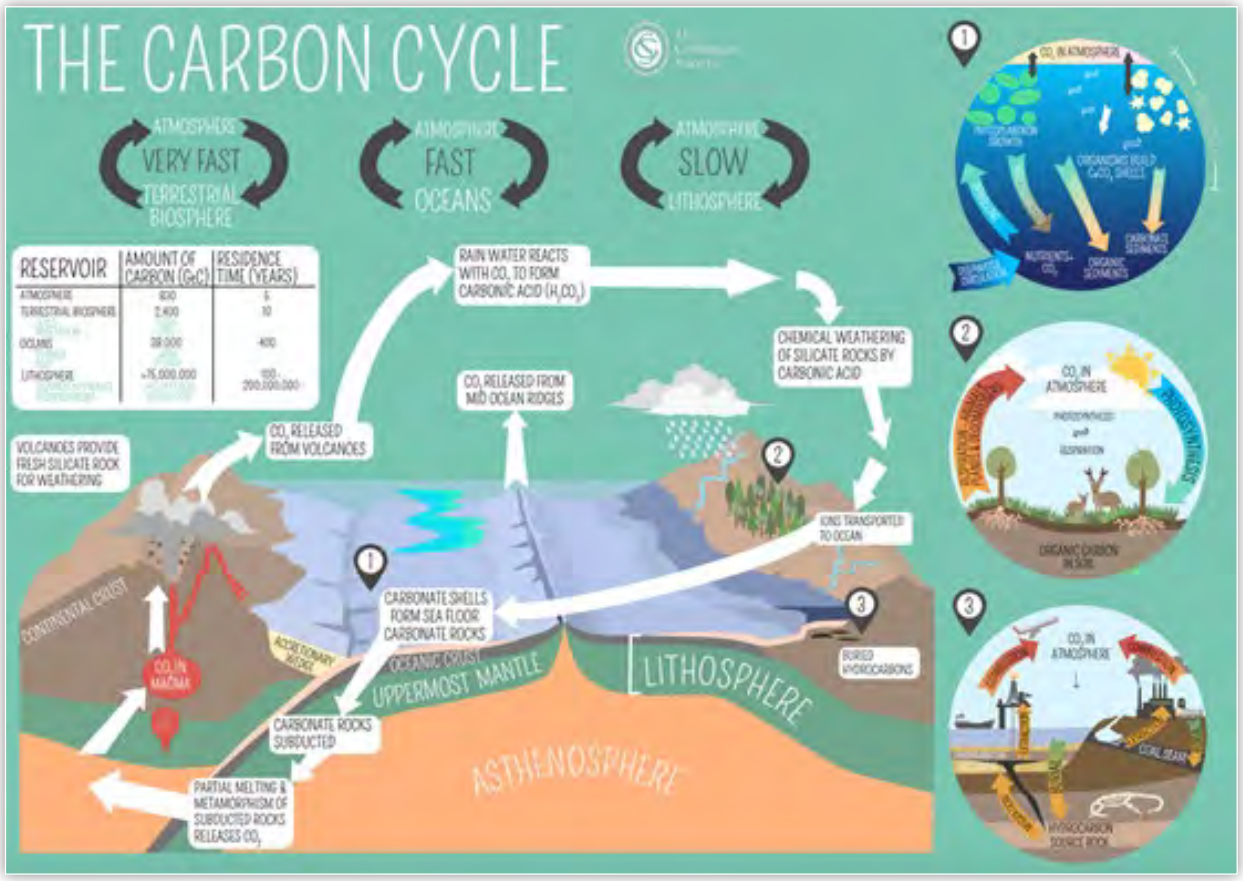
THE CARBON CYCLE and CLIMATE CHANGE

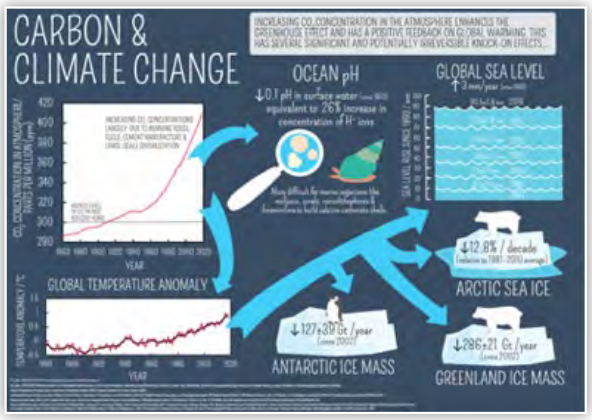
A. True or False. Justify each answer in the space provided on the worksheet.

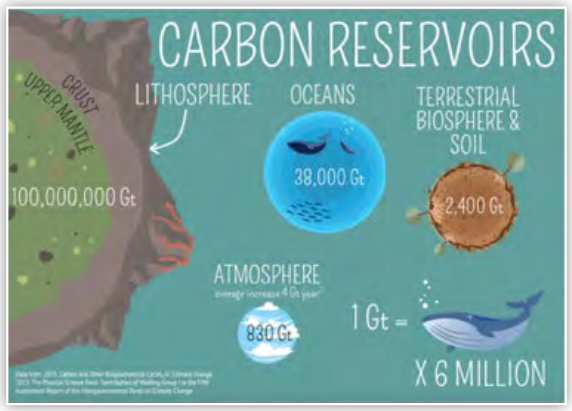
1. Without carbon life in Earth would not exist.
2. The amount of Carbon on Earth is infinite – more carbon is created over time.
3. Most carbon is stored in Earth's biosphere (plants and animals).
4. Oceans are a carbon sink – they absorb carbon.
5. Carbon dioxide is a greenhouse gas.
6. Erosion and volcanoes release carbon into the atmosphere.
7. Carbon is naturally stored as hydrocarbons in the lithosphere.
8. Earth's natural systems effectively remove carbon from the atmosphere.
9. Carbon reduction technology is an experimental solution to removing carbon from the atmosphere.
10. I can draw a simple diagram of the Carbon Cycle without supporting resources.

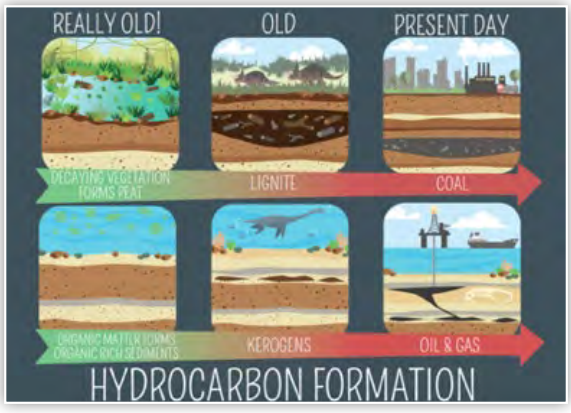
All activities are included in a STUDENT WORKSHEET on the GTANSW & ACT website. Some Suggested Answers are also provided.

Figure 1: GTA NSW & ACT POSTER PACK









Posters printed with permission from the Geological Society UK by GTANSW & ACT for Geography Education in Australian schools.

B. Poster Pack Activities

Use a classroom poster display to challenge students, get them moving and thinking.

The following activities refer to the GTANSW & ACT Carbon Cycle Posters Pack. For these activities set up stations around the room to facilitate visits by small teams of students.

Teamwork: After discussing the correct T & F answers, divide students into small groups to complete the following activities.

1. Write an agreed definition for each term below.
   phytoplankton, photosynthesis, respiration, hydrocarbon, combustion, calcium carbonate, carbonic acid, chemical weathering, subduction (crustal), gigaton, reservoir, pH, anomaly
2. Draw a diagram of the natural carbon cycle without using any resources. Label each sphere on the diagram – atmosphere, lithosphere, biosphere and lithosphere. (Provide an A3 sized sheet of paper)
3. Each team member in turn will visit the large carbon cycle poster and return to the team with additional information to ADD TO or CORRECT the team diagram. Discuss each addition before adding content to you diagram. Continue until the diagram mimics or improves on the wall poster.

Refer to your Carbon Cycle Diagram:

- Describe how the rate of carbon exchange between spheres varies. Suggest reasons for this variation.
- Explain ONE pathway in which carbon cycles between the atmosphere and the lithosphere and back to the atmosphere.
- Describe how carbon moves to and from deep ocean storage.
- How is buried hydrocarbon released into the atmosphere?

Visit each of the small carbon posters to complete the next worksheet questions.

Refer to the **Carbon Reservoirs** poster:

- List the global storages of carbon from highest to lowest stores.
- Calculate the total weight of global carbon (in Gt)
- Calculate the % of global carbon in each reservoir and represent in a PIE GRAPH (Sector Graph)
- Identify two sources of carbon in the biosphere.
- Calculate the total amount of atmospheric carbon in 50 years.
- Explain potential sources of this additional carbon.

Refer to the **Hydrocarbon Formation** poster:

- Describe steps in the formation of coal over time
- Describe steps in the formation of oil and gas over time
- Explain what is happening to hydrocarbon storages in the 'present day'
- Make a judgement about the rate of change for the 'Really old" and 'Present Day' stages of hydrocarbon formation.
- Suggest the implications of present-day human activities for global carbon distribution.

Refer to the **Carbon and the Greenhouse Effect** poster:

- Identify four Greenhouse gases
- What feature of Greenhouse Gases is most important for life on Earth?
- What happens to solar radiation (light) when it reaches Earth?
- What happens to the infrared radiation emitted from earth and its atmosphere?
- State two differences between solar radiation and infrared radiation.
- Explain how an increase in Greenhouse gases changes the natural process known as the Greenhouse Effect.

Refer to the **Carbon and Climate Change** poster:

- Calculate the change in Atmospheric CO2 concentrations between 1860 and 2020.
- Describe the trend in Global Atmospheric CO2 Concentrations since 1940.
- Explain the link between CO2 concentrations and Ocean pH (acidity). Explain the impact of changing Ocean pH?
- Describe the anomaly shown in the Global Temperature Anomaly Graph.
- What the connection between CO2 concentration and the Global Temperature Anomaly?
- Why is the relationship between Atmospheric Carbon Concentrations and the Global Temperature Anomaly called a 'positive feedback'.
- List FOUR 'knock on effects' of the Global Temperature Anomaly.
- Differentiate between Sea Ice AND an Ice Mass (Greenland and Antarctica).
- Where has Ice Mass loss been greatest? Use statistics in your answer.
- Assess the Validity AND Reliability of the information in this poster.

4. On your **Carbon Cycle diagram** show at least one human change to each sphere that interrupts the natural carbon cycle.
5. On completion of your Carbon Cycle diagrams and worksheet **compose an original paragraph** for your team to explain the Carbon Cycle and connections to Climate Change to Year 10 students. Allocate each team member something to say. Test your team explanation with another class group or a selected year 10 class. You can incorporate the posters into your presentation.

   Alternatively, students may use a digital program such as Explain Everything to present their team explanation.

Read the Abstract from National Geographic as a model of what students might include in their explanation.

Poster packs for sale HERE

https://www.gtansw.org.au/wp-content/uploads/2021/03/Posters-for-sale_amended-postage_11.03.21.pdf

Figure 2: A sample explanation

The Carbon Cycle. An abstract from National Geographic

https://www.nationalgeographic.org/encyclopedia/carbon-cycle/

'Carbon is in a constant state of movement from place to place. It is stored in what are known as reservoirs, and it moves between these reservoirs through a variety of processes, including photosynthesis, burning fossil fuels, and simply releasing breath from the lungs. The movement of carbon from reservoir to reservoir is known as the carbon cycle.

Carbon can be stored in a variety of reservoirs, including plants and animals, which is why they are considered carbon life forms. Carbon is used by plants to build leaves and stems, which are then digested by animals and used for cellular growth. In the atmosphere, carbon is stored in the form of gases, such as carbon dioxide. It is also stored in oceans, captured by many types of marine organisms. Some organisms, such as clams or coral, use the carbon to form shells and skeletons. Most of the carbon on the planet is contained within rocks, minerals, and other sediment buried beneath the surface of the planet.

Because Earth is a closed system, the amount of carbon on the planet never changes. However, the amount of carbon in a specific reservoir can change over time as carbon moves from one reservoir to another. For example, some carbon in the atmosphere might be captured by plants to make food during photosynthesis. This carbon can then be ingested and stored in animals that eat the plants. When the animals die, they decompose, and their remains become sediment, trapping the stored carbon in layers that eventually turn into rock or minerals. Some of this sediment might form fossil fuels, such as coal, oil, or natural gas, which release carbon back into the atmosphere when the fuel is burned.

The carbon cycle is vital to life on Earth. Nature tends to keep carbon levels balanced, meaning that the amount of carbon naturally released from reservoirs is equal to the amount that is naturally absorbed by reservoirs. Maintaining this carbon balance allows the planet to remain hospitable for life. Scientists believe that humans have upset this balance by burning fossil fuels, which has added more carbon to the atmosphere than usual and led to climate change and global warming.'

Web resources for the Carbon Cycle and Climate Change

- Climate change science. The carbon cycle and how we are changing it. https://publications.csiro.au/rpr/download?pid=csiro:EP128406&dsid=DS1
- National Geographic: The carbon cycle https://www.nationalgeographic.org/encyclopedia/carbon-cycle/
- What is the carbon cycle? https://oceanservice.noaa.gov/facts/carbon-cycle.html
- The Carbon Cycle https://www.noaa.gov/education/resource-collections/climate/carbon-cycle
- Climate and the Carbon Cycle https://serc.carleton.edu/eslabs/carbon/lab_overviews.html
- Carbon Cycle diagram with numbers https://scied.ucar.edu/image/carbon-cycle-diagram-doe-numbers

THE CARBON CYCLE GAME

Adapted by Jennifer Ceven from "The Incredible Journey," *Project Wet*

Source: https://climatechangelive.org/img/fck/file/carbon_cycle_game.pdf

Summary:

By rolling a die, students will simulate a molecule of carbon's movement throughout various locations within the carbon cycle.

Objective:

- Students will describe the movement of carbon within the carbon cycle.
- Students will evaluate the relative timing of movement through various locations in the carbon cycle.

Materials:

- 7 Dice
- 7 Station Signs
- 7 Station Movement Directions
- Data record sheets for each student

Background:

The movement of carbon through various aspects of the natural environment is the focus of much scientific research. Global warming and climate change can be attributed to the increased amount of heat-trapping gases, such as carbon dioxide. Students must develop an understanding of how carbon moves through the environment in order to appreciate the complexity of developing solutions to address problems associated with climate change. In addition, since anthropogenic influences impact how much carbon is reintroduced to the active carbon cycle, students should recognize that human actions negatively affect the environment.

Warm-Up:

- Review what carbon is (an element, the stuff of life)
- Discuss where carbon can be found on Earth.
- Discuss the role of carbon in each of the places identified.
- Review the processes that move carbon around in the carbon cycle
    1. Physical processes
        - Water currents
        - Settling to the ocean floor or to the ground
    2. Chemical and Biological processes
        - Respiration – Exchange of gases through breathing
        - Photosynthesis - The synthesis of complex organic materials, esp. carbohydrates, from carbon dioxide, water, and inorganic salts, using sunlight as the source of energy and with the aid of chlorophyll and associated pigments.
        - Combustion – The act or process of burning

- Dissolving gaseous carbon dioxide into water, where it takes the form of carbonic acid
- Coming out of solution of carbonic acid to become carbon dioxide in the air (same process that occurs when you open a soda)
- Death and Decomposition - breakdown or decay of organic matter

The Activity:

1. Tell students that they are going to be carbon atoms moving through the carbon cycle.
2. Categorize the places carbon can be found into these stations: Atmosphere, Plants, Animals, Soil, Ocean, Deep Ocean, and Fossil Fuels. Point out the areas of the room that are labeled with each station and contain the directions for movement from that station.
3. Assign students to each station randomly and evenly. Have students identify the different places carbon could go from that given station. Discuss the processes that allow for the transfer of carbon between stations. Students should make a line and roll the die individually to follow the directions for movement from (or retention at) each station. Remind them that they are representing atoms of carbon moving through the carbon cycle and that they should record their movements on the data sheet.
4. Students will realize the routine movements (or non-movements) in the carbon cycle.
5. Once the carbon atoms (students) have had a chance to roll the die ten times, have each student create a bar graph using the data they collected. The bar graph should represent the number of times the carbon atom (student) was at each station.
6. Using graph paper, create a large bar graph recording the number of carbon atoms (students) at each station.

Wrap-Up and Action Plan:

- Ask a few students to tell the story of how their carbon atom moved through the cycle.
- Discuss the results – using the bar graph have the students explain where the most/least amount of carbon was in the cycle?

Assessment:

- Rate students' understanding on their responses from class or group discussions.
- Assign a follow-up activity:
  - Role-play the motion of carbon throughout the carbon cycle.
  - Write a story about your carbon atom as it moved through the carbon cycle.

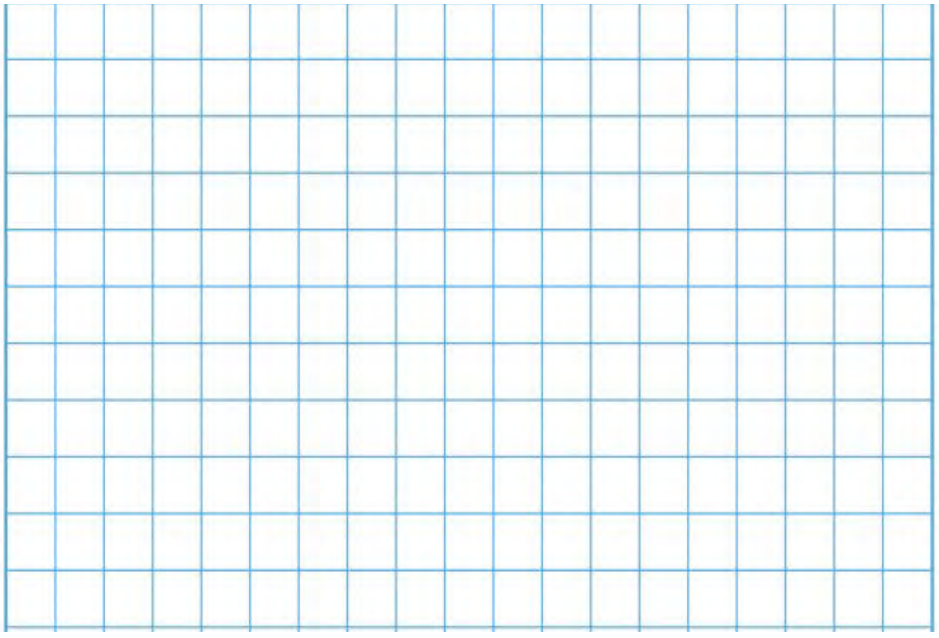
The Carbon Cycle

DATA RECORD SHEET

Record the places you have traveled as a carbon molecule.
Student's Name: _____

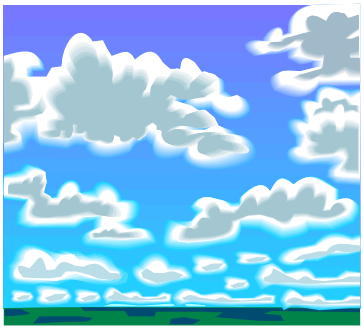
	Station Stop	What Happens	Destination
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

GRAPH



The Carbon Cycle

THE ATMOSPHERE



You are currently a molecule of carbon dioxide in the atmosphere.

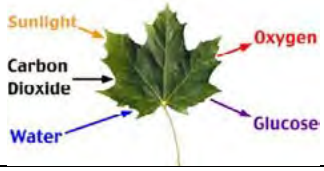
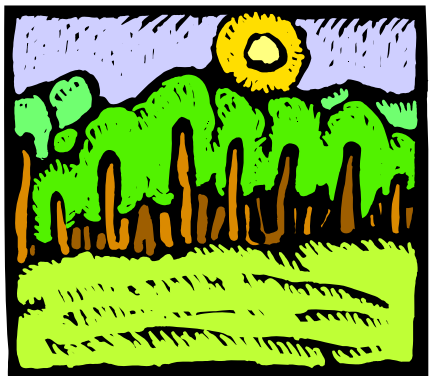
If you roll…	Then you …
1	Stay in the atmosphere. Much of the carbon dioxide in the atmosphere moves through the atmosphere.
2	Go to plant. You are used by a plant in photosynthesis. 
3	Stay in the atmosphere. Much of the carbon dioxide in the atmosphere moves through the atmosphere.
4	Stay in the atmosphere. Much of the carbon dioxide in the atmosphere circulates through the atmosphere.
5	Go to surface ocean.
6	Go to plant. You are used by a plant in photosynthesis.

Image source: Shutterstock

The Carbon Cycle
PLANTS

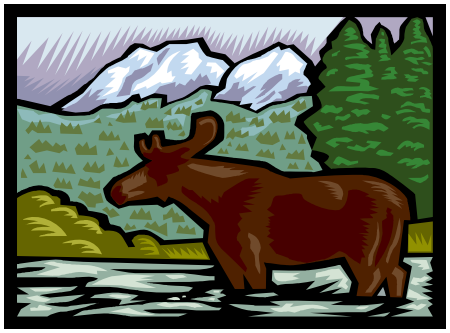


You are currently a carbon molecule in the structure of the plant.

If you roll…	Then you …
1	Go to soil. The tree shed its leaves. 
2	Stay in plant. You are a carbon molecule in the tree's trunk.
3	Go to animal. The leaves and berries that the plant produced contain your carbon molecule and were eaten. 
4	Stay in plant. You are a carbon molecule in the tree's roots.
5	Stay in plant. You are a carbon molecule in the tree's branches.
6	Stay in plant. You are a carbon molecule in the tree's trunk.

Image source: Shutterstock

The Carbon Cycle
ANIMALS



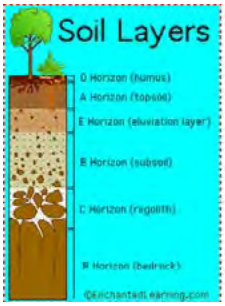
You are currently a molecule of carbon in an animal.

If you roll…	Then you …
1	Stay in animal. The carbon molecule is stored as fat in the animal.
2	Go to soil. The animal that consumed you died and your carbon molecule is returned to the soil. 
3	Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide.
4	Stay in animal. You are eaten by a predator. 
5	Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide.
6	Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide.

Image source: Shutterstock

The Carbon Cycle

SOIL



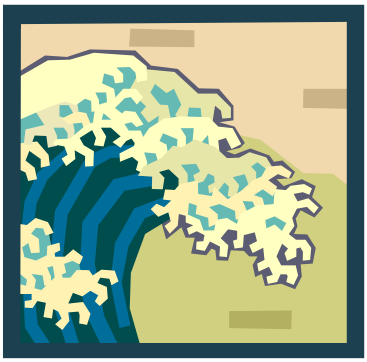
You are currently a molecule of carbon dioxide in the soil.

If you roll…	Then you …
1	Stay in the soil. Much of the carbon in the soil is stored there.
2	Go to plant. You are used by a plant in photosynthesis.
3	Go to fossil fuels. Your carbon molecule has been in the soil so long it turns into fossil fuels. 
4	Go to the atmosphere.
5	Stay in the soil.
6	Go to fossil fuels. Your carbon molecule has been in the soil so long that it turns into fossil fuels. 

Image source: Shutterstock

The Carbon Cycle

SURFACE OCEAN

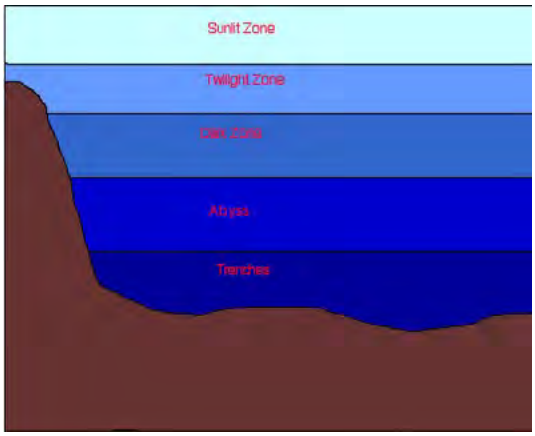


You are currently a molecule of carbon dioxide in the surface ocean.

If you roll…	Then you …
1	Go to deep ocean.
2	Stay in the surface ocean.
3	Go to deep ocean. Your carbon atom was part of an ocean organism that has died and has sunk to the bottom of the ocean. 
4	Stay in the surface ocean.
5	Go to the atmosphere.
6	Go to the atmosphere.

Photo by Leo Roomets on Unsplash

The Carbon Cycle
DEEP OCEAN

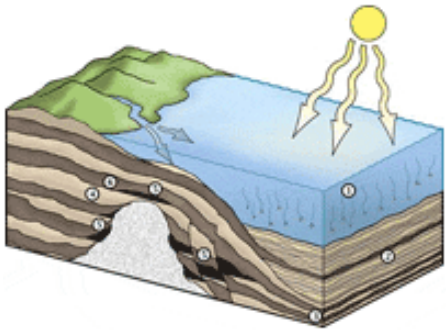


You are currently a molecule of carbon in the deep ocean.

If you roll…	Then you …
1	Stay in the deep ocean.
2	Stay in the deep ocean.
3	Go to surface ocean.
4	Go to surface ocean.
5	Go to surface ocean.
6	Go to animal. An organism in the water has taken you up as food in the deep ocean.

Image source: Shutterstock

The Carbon Cycle
FOSSIL FUELS



Fossil fuels are a rich source of energy that has been created from carbon that has been stored for many millions of years.

If you roll…	Then you …
1	Stay in the fossil fuels.
2	Stay in the fossil fuels.
3	Stay in the fossil fuels.
4	Stay in the fossil fuels.
5	Go to the atmosphere. Humans have pumped the fuel that you are part of out of the ground and have used it to power their cars.
6	Go to the atmosphere.

Image source: Shutterstock

YEAR 11 HOMEWORK 1.1

guided READING

THE CARBON STORY

https://www.bgs.ac.uk/discoveringGeology/climateChange/general/carbonStory.html

British Geological Survey

What is carbon and where does it come from?

'Weather' describes the combination of wind, rain, temperature and other natural atmospheric conditions we experience at a particular time and place.
Climate is the pattern of weather of an area averaged over many years.

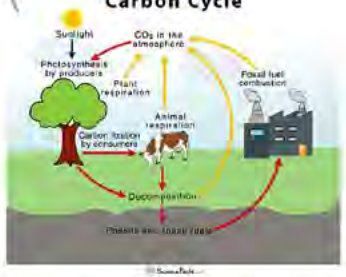
So, if we have extremes in weather conditions, such as a long summer drought or a very cold winter, it doesn't necessarily mean that the climate is changing.
We can only show whether or not climate change has occurred after decades of careful measurements and analysis.

The climate system has many components that can alter. For example, if the amount of solar energy absorbed on the Earth's surface were to increase, then the surface temperature would increase.
This, in turn, would lead to a decrease in the amount of snow cover. As snow reflects more solar energy than land, vegetation or water, a decrease in the amount of land covered by snow would allow more solar radiation to be absorbed. This is called positive feedback.

Carbon is a crucial element for all life on Earth. It is also present in plants and rocks, the atmosphere and the oceans.
Carbon therefore moves, or 'cycles', between each of these things and is redistributed between carbon dioxide 'sources' *(given off)* and 'sinks' *(stores)*.
Carbon is an interesting chemical because we don't always know where these sinks and sources are!

The carbon in the carbon cycle may be either 'organic' or 'inorganic '. Most inorganic carbon exists as carbon dioxide, carbonate and hydrogen carbonate.
Organic carbon is that found in living or dead organisms, fossil fuels, small deposits in rocks, dissolved in water or dispersed in the atmosphere.

Carbon Cycle



There is a continuous two-way flow of carbon between the organic and inorganic forms. Carbon can be released/ taken in as gas during respiration by both plants and animals to maintain their bodily functions. A

More than 99 per cent of the carbon in the carbon cycle is found in the Earth's crust . Carbon is added to, or removed from, this carbon 'reservoir' only slowly, so much of the carbon is essentially locked in the earth.

Most of the carbon in the crust has a biological origin, deposited on the ocean floor from the remains of the many marine organisms that use calcium carbonate in their skeletons. After consolidation, these deposits may be formed into limestone rocks.

Carbon dioxide levels in the atmosphere depend on a balance (equilibrium) between carbon dioxide sources and sinks: sources give out carbon dioxide and sinks absorb and store carbon.

Greenhouse gases are actually crucial to keeping our planet at a habitable temperature, without them, the Earth would be about -17°C.
Anthropogenic or human release of carbon dioxide contributes to the current enhanced greenhouse effect.

A greenhouse gas is so called because it absorbs infrared radiation emitted by the Earth's surface (this radiation originally came from solar radiation), in the form of heat, which is circulated in the atmosphere and eventually lost to space.
Greenhouse gases also increase the rate at which the atmosphere can absorb short-wave radiation from the sun, but this has a much weaker effect on global temperatures.
Greenhouse gases in our atmosphere are:

- carbon dioxide
- water vapour
- methane
- nitrous oxide
- ozone
- CFCs.

1 What is the difference between weather and climate?

2 What do we need to look at to be sure that the climate is changing?

3 Create a short flow diagram to show what would happen if the amount of heat absorbed by the sun increased.

4 What is the difference between a carbon source and a carbon sink?

5 Why is it difficult to measure how much carbon exists?

6 What types of activities lead to carbon being released as a gas?

7 Name one type of 'inorganic' carbon.

8 Name two types of 'organic' carbon.

9 What does equilibrium mean?

10 Why do you think this balance is so important?

11 What might happen if there were no greenhouse gases at all?

12 How might the world be different without them?

13 What does Anthropogenic mean?

14 What is absorbed by greenhouse gases?

15 Name 3 greenhouse gases. *(Find out their chemical symbols too)*

16 Do you think it is 'better' to have carbon stored in the ground or as a gas in the air? Explain your thinking.

See Appendix for a copy of this activity

The Geography Teachers' Association of NSW & ACT

GEOGRAPHY POSTERS FOR SALE

GTA NSW & ACT has printed a number of infographic posters for classroom use.

Posters are linked to topics studied in Geography K–12 for the Australian Curriculum and NSW Syllabuses.

- A **bank of questions** for individual and groupwork will be accessible via Google Drive to all schools /teachers purchasing posters.
- Posters can be purchased in **pre-packaged sets** or as **individual posters**.
- **New posters** will be added to the website throughout the year.

SOURCES AND PRICING

Posters have been sourced from organisations including the Geological Society (UK), Visual Capitalist and Graphic News. GTA NSW & ACT has also commissioned some posters.
Posters are being sold in sets of 4 or 5 to make postage viable. Affordability was a key consideration when determining pricing.
Administration, printing and distribution, licensing and design costs where relevant are incorporated into the cost of each pack.
Postage includes the cost of cylinders. A maximum of 5 posters will be packaged in any postage cylinder.

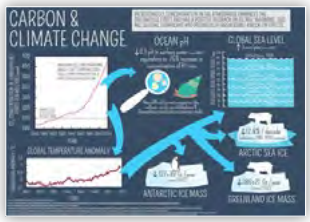
PACK 1: THE CARBON CYCLE – $70 includes p/h

Contents:

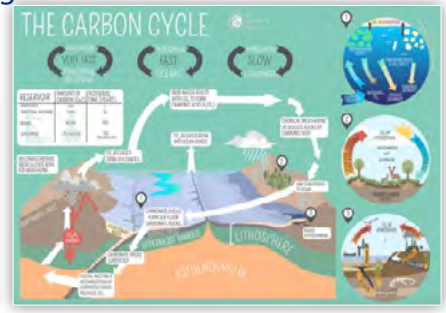
Click here to order Pack 1

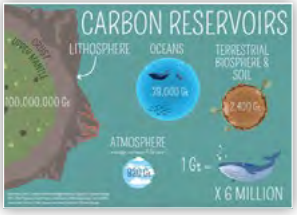
1 x A1 poster: **The Carbon Cycle**

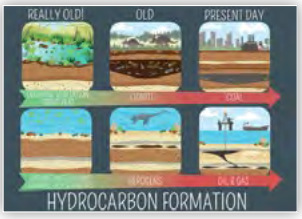
4 x A2 posters: **Carbon Set**



– Carbon & the Greenhouse Effect
– Carbon Reservoirs
– Hydrocarbon Formation
– Carbon & Climate Change







The Geography Teachers' Association of NSW & ACT

GEOGRAPHY POSTERS FOR SALE

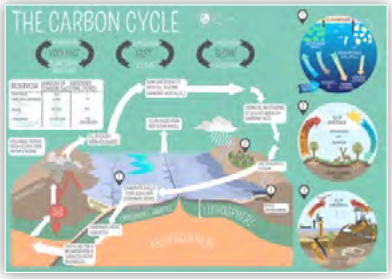
POSTERS POSTERS POSTERS POSTERS POSTERS POSTERS POSTERS POSTERS

PACK 2: GEOGRAPHY CONTENT – $81 includes p/h

Click here to order Pack 2

Contents: 4 x A1 posters

- Plate tectonics
- Minerals in a smartphone
- The Carbon Cycle
- On the Brink: The biggest threats to Earth's biodiversity



PACK 3: A2 CAREERS poster – 5 for $37.50 includes p/h

Pathways with Geography

Click here to order Pack 3

About the poster sizes –
A1 = 594mm X 841mm
A2 = 420mm X 594mm

INDIVIDUAL SELECTION: A1 sized posters @ $15 per poster (one type per order)

Up to 5 posters $15 postage (1 cylinder)
5 to 10 posters $30 postage (2 cylinders) etc

Choose from posters:

- Plate tectonics
- Minerals in a smartphone
- The Carbon Cycle

For more details and to order follow this LINK

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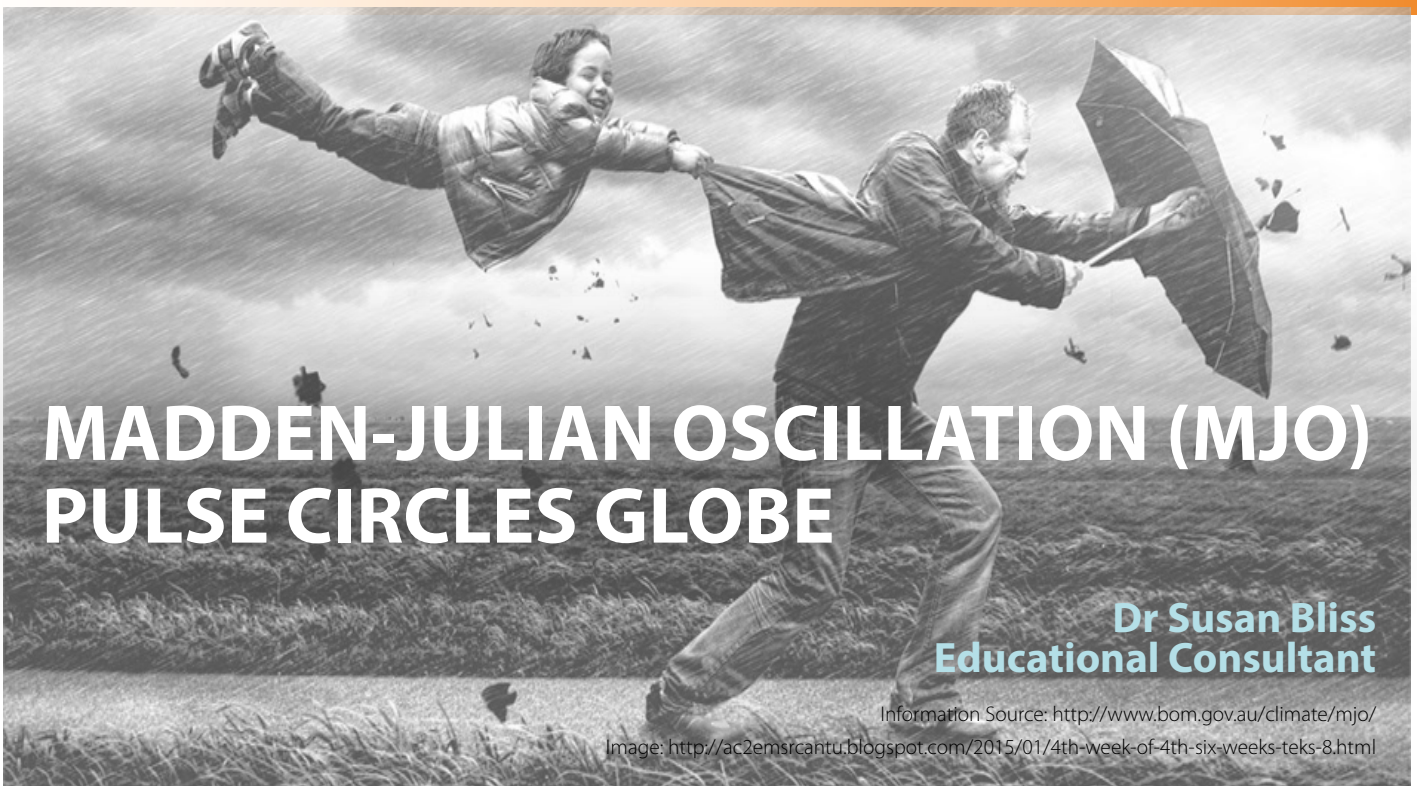


MADDEN-JULIAN OSCILLATION (MJO) PULSE CIRCLES GLOBE

Dr Susan Bliss
Educational Consultant

Information Source: http://www.bom.gov.au/climate/mjo/
Image: http://ac2emsrcantu.blogspot.com/2015/01/4th-week-of-4th-six-weeks-teks-8.html

CURRICULUM

- **Geographical Skills-**Weather Maps, Satellite Imagery, Diagrams, Graphs and photographs.
- **General Capabilities**-Literacy, Numeracy, Critical Thinking, Work and Enterprise, Information and Communications Technology.
- **Cross Curriculum:** Asia and Australia's Engagement with Asia

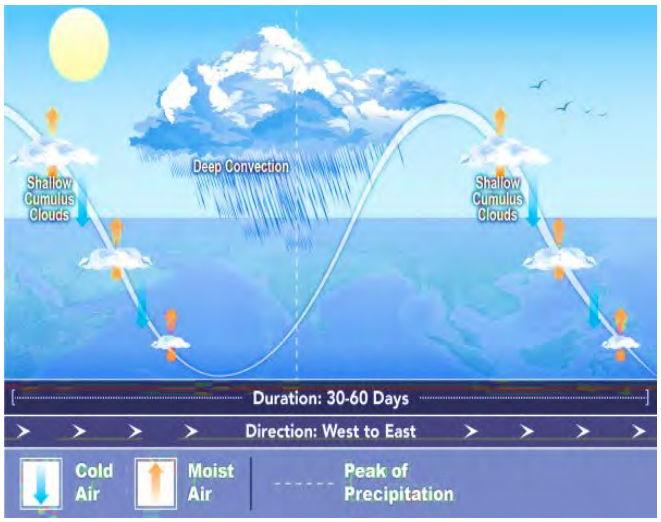
OVERVIEW

Australia's weather and climate varies over time and space. The island continent is affected by monsoons, tropical cyclones, blocking highs, El Nino, La Nina and the Indian Ocean Dipole. However, another important player is the lesser known **Madden-Julian Oscillation** or **MJO**. It is a naturally occurring **oceanic-atmospheric** phenomenon which affects weather across Earth ranging from **Asia, Australia, US** and the **Arctic.** The MJO is the dominant source used to forecast weather and climate in the **sub seasonal range** (3–4 weeks). In fact the **National Oceanic and Atmospheric Administration (NOAA)** produces a weekly update of MJO and a model forecasts MJO daily.

MJO is a **major fluctuation** in **tropical weather** affecting **Australia's northern climate**. It is characterised as an **eastward** moving 'pulse' of cloud and precipitation near the equator that circles Earth approximately every **30–60 days**. Historical weather observations together with the MJO index is used to manage Australia's northern grasslands such as 'best-bet' dates for fire management, weed control, moving stock and planting crops. Interestingly, it also has links with the mid-latitudes such as impacting on precipitation in the southern part of Australia such as NSW.

Recent observations and forecasts of the MJO are available from the Australian Bureau of Meteorology (BoM) website.

Diagram of The Madden-Julian Oscillation



The Madden-Julian Oscillation is a large complex of clouds and rain initiated over the Indian Ocean that slowly progresses around the world along the equator. The MJO has a large effect on tropical monsoons and cyclones, as well as other weather systems outside the tropics. https://www.pnnl.gov/science/highlights/highlight.asp?id=1032

BIOPHYSICAL INTERACTIONS: MJO

WHAT ARE THE TWO PHASES OF MJO?

The **Madden-Julian Oscillation (MJO)** also referred to as the 30–60 day oscillation/wave or intra seasonal oscillation, was discovered in the 1970s by Dr. Roland Madden and Dr. Paul Julian when studying tropical wind and pressure patterns.

Due to its slowly evolving nature, the MJO is monitored to assess its position and strength by **NOAA'S geo-stationary** and **orbiting satellites** and the **global radiosonde network.**

The MJO consists of two **phases** with periods of moderate-to-strong activity followed by periods of little or no activity:

1. **Enhanced rainfall phase** (or convective-active**).**
2. **Suppressed rainfall phase**.

The MJO brings precipitation in its active phase but suppresses rain before and after its arrival.

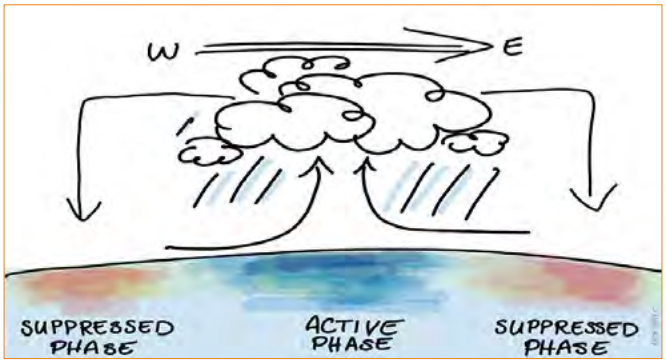
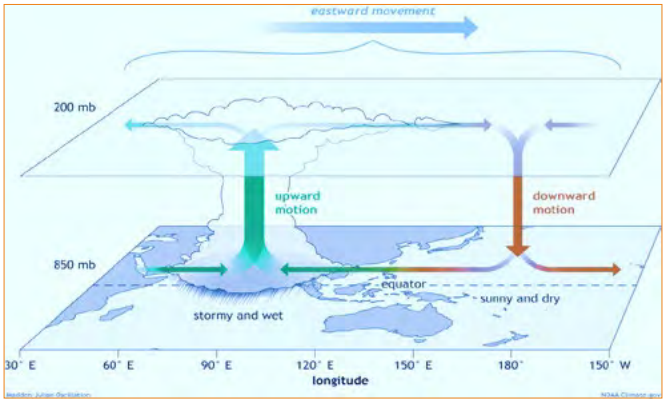


Image: ABC Weather: Kate Doyle https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346

Diagram of the movement of the MJO



Drawing by Fiona Martin. **Source:** https://www.climate.gov/sites/default/files/MJO_large.png

The surface and upper-atmosphere structure of the MJO is the **enhanced convective phase** (thunderstorm cloud) is centred across the Indian Ocean and the **suppressed convective phase** is centred over the west-central Pacific Ocean.

Horizontal arrows pointing left represent wind departures from average that are easterly, and arrows pointing right represent wind departures from average that are westerly. The entire system shifts eastward over time, eventually circling the globe and returning to its point of origin.

Source: https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

HOW IS MJO MEASURED?

Statistical methods such as RMM1 and RMM2 (Real-time Multivariate MJO Indexes) measure the strength and location of the MJO. The combination of **clouds** and **winds** at upper and lower levels of the atmosphere constitute the MJO index applied to any location.

WHAT ARE THE EIGHT GEOGRAPHICAL PHASES OF MJO CYCLE?

The MJO phases are grouped into geographically based stages **numbered 1–8**.

- 1 Africa
- 2/3 Indian Ocean e.g. India
- 4/5 Australia falls in the middle of the Maritime Continent
- 7/6 Pacific Ocean
- 8 America

The eight phases of the MJO cycle, move **east** from the Indian Ocean through the Pacific Ocean and into the Western Hemisphere.

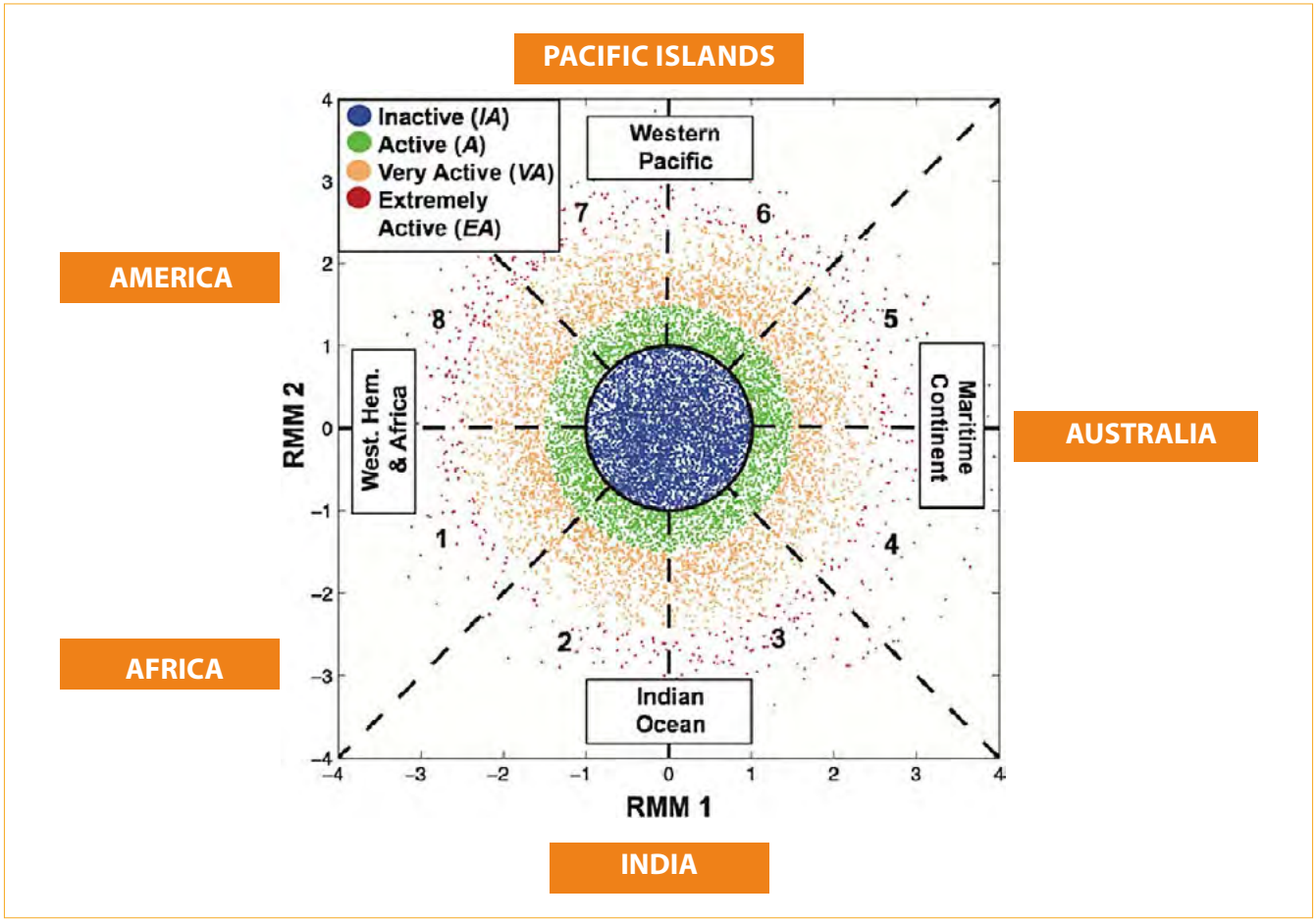
This region of enhanced rainfall travels at a speed of ~ 5 m/sec across the Indian Ocean, the Indonesian Archipelago (i.e., the Maritime Continent) and on into the western Pacific Ocean. However, once it reaches the central Pacific Ocean, it speeds up to ~ 15 m/sec and weakens as it moves out over the cooler ocean waters of the eastern Pacific.

https://tallbloke.wordpress.com/2018/11/20/ian-wilson-is-the-november-2018-madden-julian-oscillation-mjo-a-possible-trigger-for-an-el-nino/

Eight Phase Diagram

Travelling **anti-clockwise (eastward)** around the equator the diagram indicates that:

- The further the dot (MJO index) from the centre, the stronger the MJO. It is referred to as the **Active Phase.**
- When the dot (MJO index) is within the centre circle of the diagram, the MJO is considered weak. It is referred to as **Inactive/Suppressed Phase.**

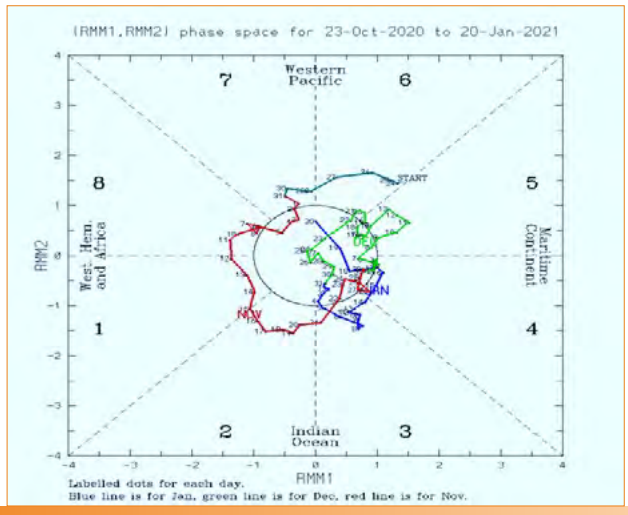


Source: https://www.researchgate.net/figure/Phase-space-diagram-of-the-RMM-index-WH04-showing-daily-phase-quadrant-and-magnitude_fig1_276474259

HOW CAN METEOROLOGISTS TRACK MJO?

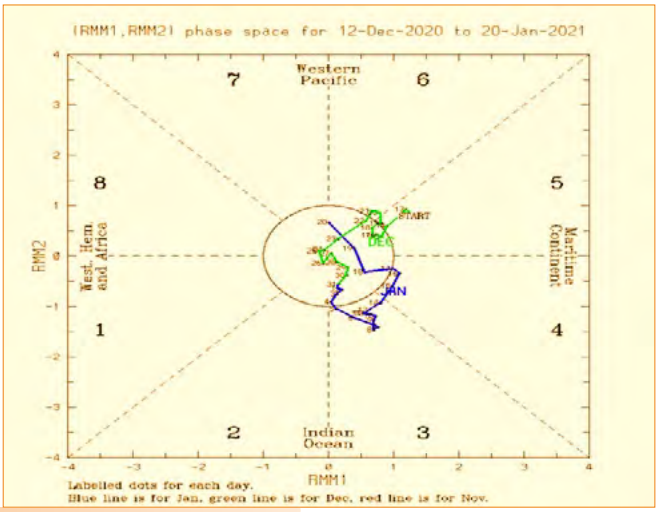
Meteorologists track the MJO using a phase diagram that marks the daily location and strength of the 'active MJO phase'. Update these diagrams at the **BoM site.**

MJO phase diagram:
Current phase 90 days 23 October 2020 to 20 January 2021



Source: http://www.bom.gov.au/climate/mjo/

MJO phase diagram:
Current phase 40 days 12 December 2020 to 20 January 2021



Source: http://www.bom.gov.au/climate/mjo/

BIOPHYSICAL INTERACTIONS: MJO

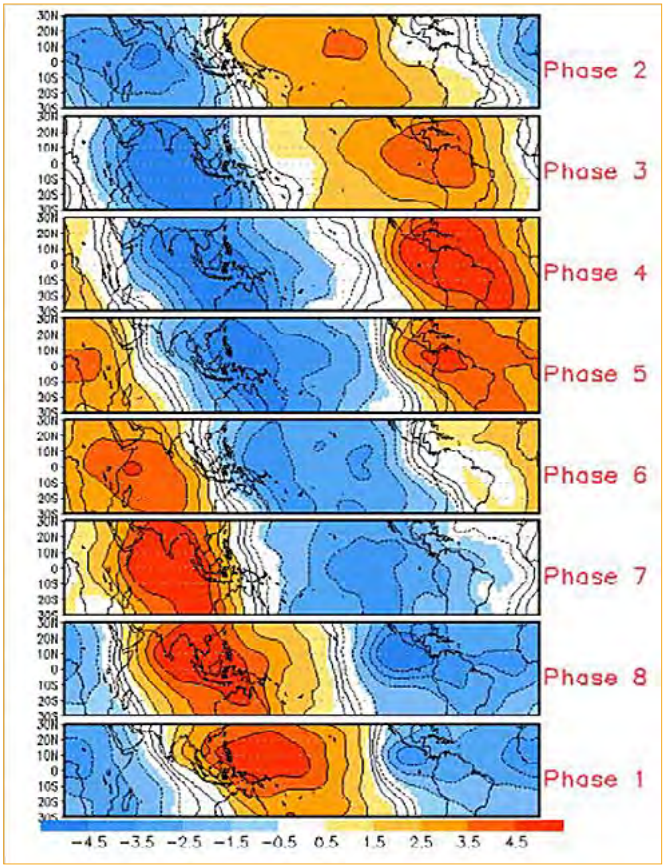
The active monsoon is expected to influence most of tropical Australia in the next fortnight, contributing to widespread heavy rainfall. Eastern parts of tropical Australia, the Coral Sea and the eastern Maritime Continent experience above-average rainfall with an MJO pulse over the western Pacific. During this period, there is an increased risk of a tropical low and cyclone formation over Australian waters.

Details on the MJO over Australia for these graphs are found at http://www.bom.gov.au/climate/mjo/#tabs=Weekly-note

HOW IS MJO MAPPED AS IT MOVES EAST?

Map: 200hPa May through September

Note the changes to Australia as MJO moves east



Source: https://www.daculaweather.com/4_mjo_phase_forecast.php

Mekong River, Don Dat Laos. Source: Wikimedia Commons

WHAT ARE THE IMPACTS ON WEATHER ASSOCIATED WITH MJO?

- Moderates the intensity of monsoon systems-timing (onset and end)
- Enhances the intensity and extent of the South Pacific Convergence Zone (Eastern Australia)
- Modulates tropical cyclone activity in the Indian Ocean, Pacific Ocean, Gulf of Mexico, and Atlantic Ocean
- Influences the ENSO cycle. It does not cause El Niño or La Niña, but is able to contribute to the speed of development and intensity of El Niño and La Niña episodes.
- Southern Oscillation, North Atlantic Oscillation and Indian Ocean Dipole affects the MJO.

SE Asia

The MJO is closely related to the **intra seasonal variability** of surface temperature in **East Asia.** Significant **cold surface temperature** anomalies are observed in East Asia during MJO phase 3.

Source: https://journals.ametsoc.org/view/journals/clim/33/20/jcliD200302.xml

USA

The MJO influences both **precipitation** and **surface temperature patterns** across **USA.**

The two most significant impacts over USA during the Northern Hemisphere winter are an increase in the frequency and intensity of:

- Heavy **precipitation** along west coast USA.
- **Cold air** outbreaks across eastern USA.

MJO is a major factor in forecasting hurricanes in USA.

Source: https://cbs12.com/news/local/atlantic-hurricane-season-likely-to-pick-up-due-to-mjo-but-what-is-that

Global

The MJO influences both the spatial distribution and the occurrence of **extreme weather events (ERE)** over **Southeast Asian regions**. Similarly, over the **East Asia** (Jeong *et al.*, 2008), **China** (Jia *et al.*, 2011), **South America** (Shimizu *et al.*, 2017) and **African regions** (Sossa *et al.*, 2017) as well as **globally** (Jones *et al.*, 2004). The impacts of the MJO on rainfall and ERE are evident.

Source: https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/met.1901

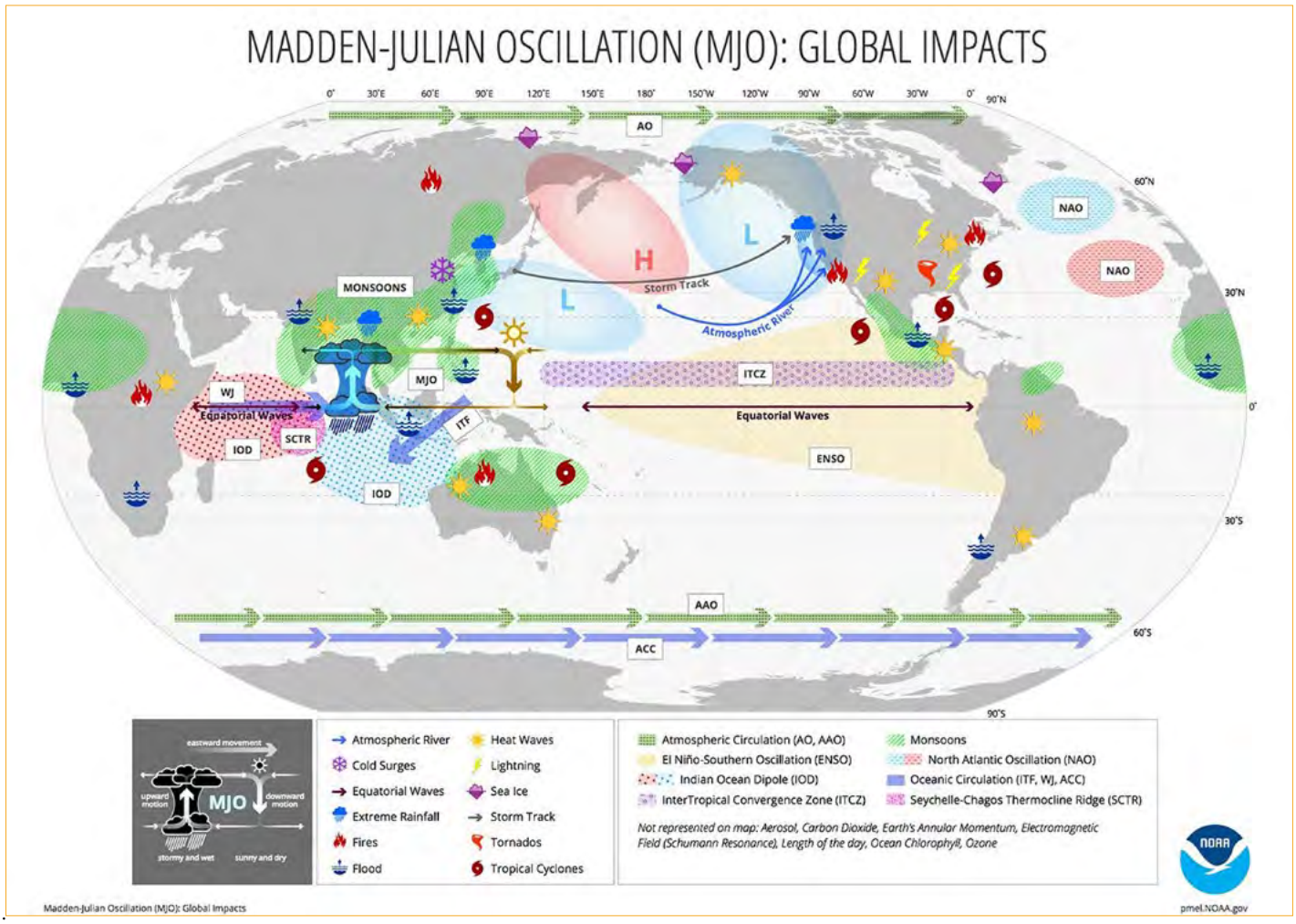
WHAT ARE THE GLOBAL IMPACTS OF MJO?

The MJO affects weather and climate globally-not only in tropical areas but also temperate zones and Polar Regions.

Additionally, the MJO influences the **physical** characteristics of the atmosphere and oceans, as well as **chemical** and **biological** processes on Earth (Zhang, 2013). For example, frequencies of tropical cyclones, tornados, floods, and heat waves can all change depending on whether the MJO is located over the Indian or Pacific Oceans.

sSource: https://eos.org/editors-vox/mysterious-engine-of-the-madden-julian-oscillation

Schematic illustration of global impacts of the MJO.
The locations of MJO-affected phenomena are not precise and complete

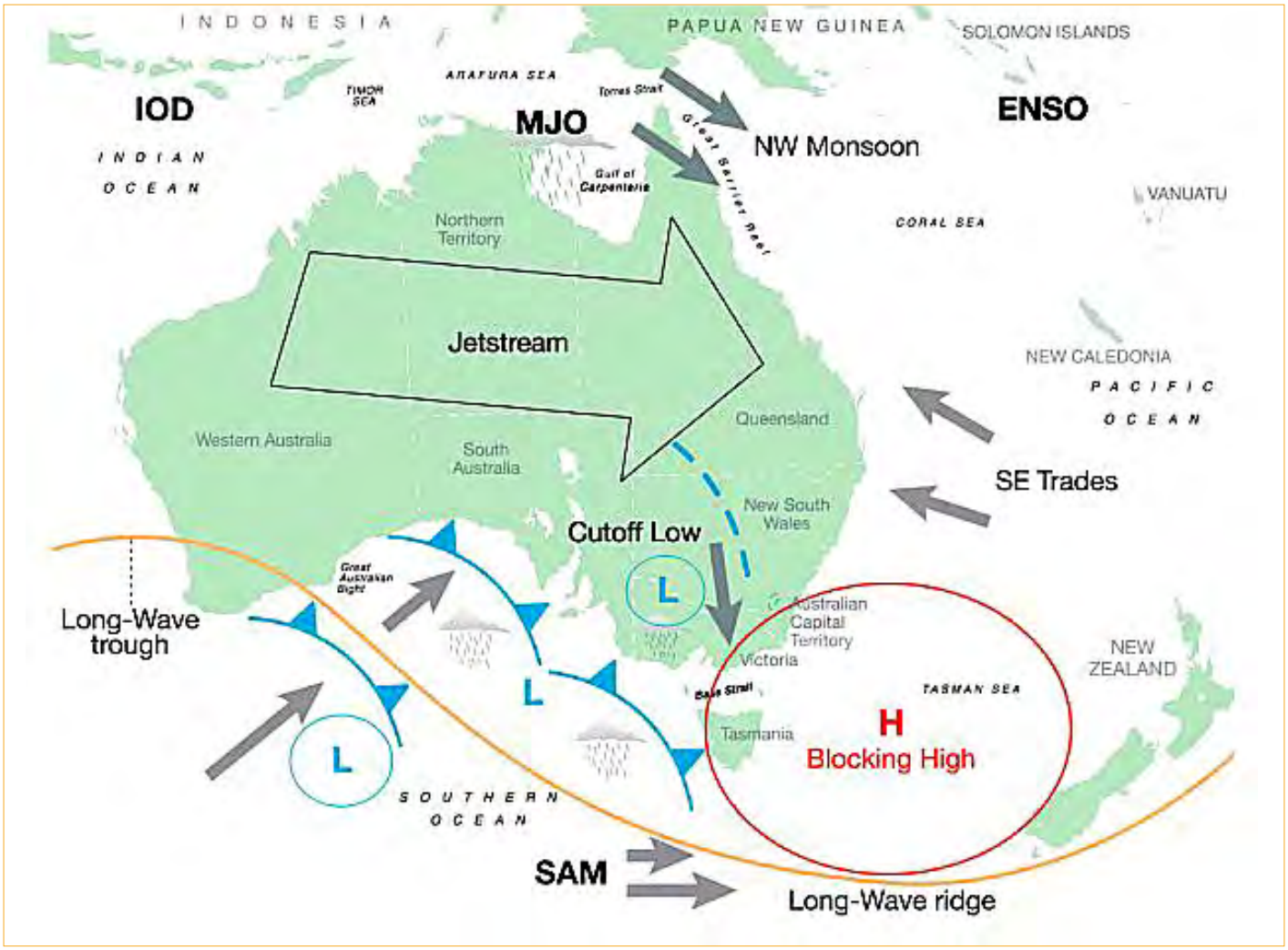


Source: Credit: Yoneyama and Zhang [2020], https://eos.org/editors-vox/mysterious-engine-of-the-madden-julian-oscillation

Citation: Zhang, C. (2020), Mysterious engine of the Madden- Julian Oscillation, Eos, 101, https://doi.org/10.1029/2020EO146334. Published on 06 July 2020. https://eos.org/editors-vox/mysterious-engine-of-the-madden-julian-oscillation

WHAT ARE THE WEATHER SYSTEMS THAT AFFECT AUSTRALIA?

Diagram: Schematic representation of the main drivers of rainfall variability in the Australian region. The dominant features are the Indian Ocean Dipole (IOD), Madden-Julian Oscillation (MJO), and El Niño-Southern Oscillation (ENSO), Southern Annular Mode (SAM), and blocking in the extra tropics.

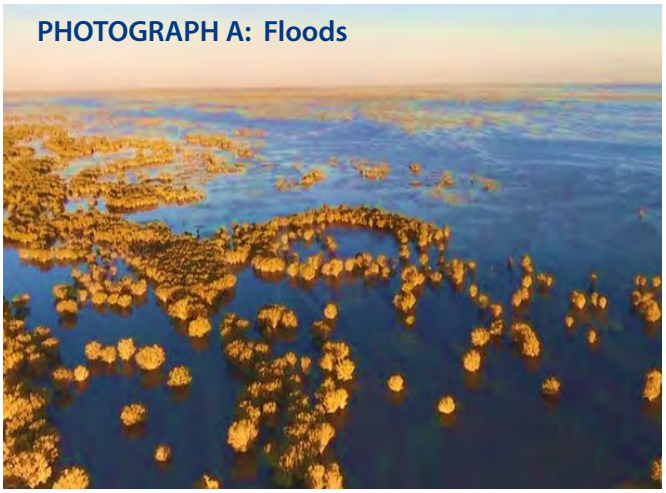


Source: Risbey et al 2008 https://www.climatechangeinaustralia.gov.au/en/overview/climate-system/australian-climate-influences/

MJO is one reason cyclones steered clear of Western Australia in 2019

There was a huge contrast in rainfall around Broome between 2018 photograph A (flooded) and 2019 photograph B (dry).

PHOTOGRAPH A: Floods

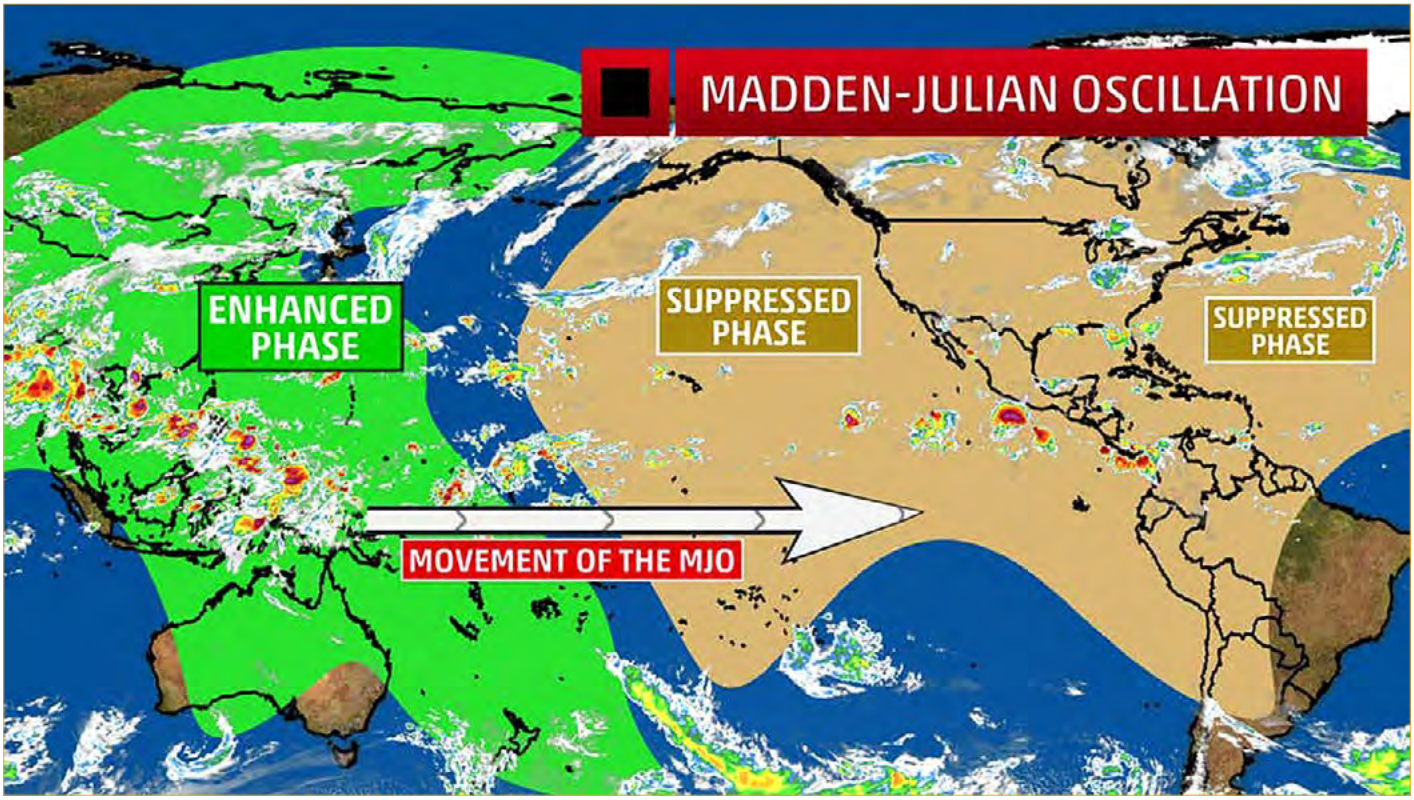


PHOTOGRAPH B: Dry

Images: https://www.abc.net.au/news/2019-03-03/madden-julian-oscillation-causing-wa-cyclones-to-vanish/10855032?nw=0

WHAT ARE THE IMPACTS OF MJO ON AUSTRALIA?

Diagram: Movement of MJO across Australia



Source: https://weather.com/storms/hurricane/news/2018-08-21-west-pacific-typhoon-atlantic-hurricane-relationship

IMPACTS OF MJO ON WEATHER IN AUSTRALIA

Wind

An active MJO generates a westerly wind pattern across Australia

Precipitation

MJO is able to increase or decrease precipitation depending on its location.

An active MJO generates a wetter summer season than normal across Australia (generally from October to April.)

Temperature

MJO can increase or decrease the average temperature depending on its location

Monsoon

MJO can drive surges and cessations in monsoon precipitation

El Niño

MJO is capable of triggering the MJO

WHAT ARE THE IMPACTS OF MJO ON AUSTRALIA DURING EIGHT PHASES?

The following maps show average weekly rainfall probabilities and expected 850hPa (approximately 1.5 km above sea level) wind anomalies for each of the eight MJO phases.

Colour:

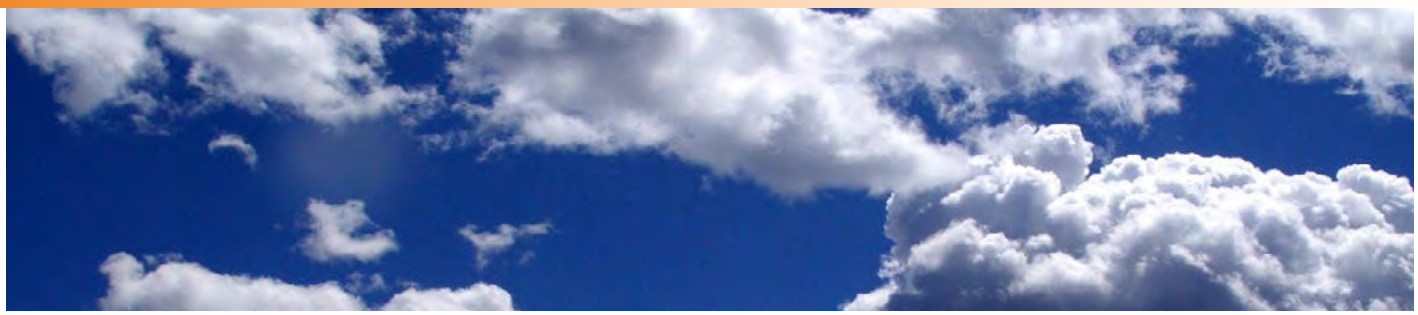
- **Green and blue** shading indicates higher than normal rainfall is expected.
- **Red and orange** shading indicates lower than normal rainfall is expected.

  The chance of weekly rainfall exceeding the median increases for northern Australia during Phase 5 and 6 of the MJO when it passes to the north of the continent.

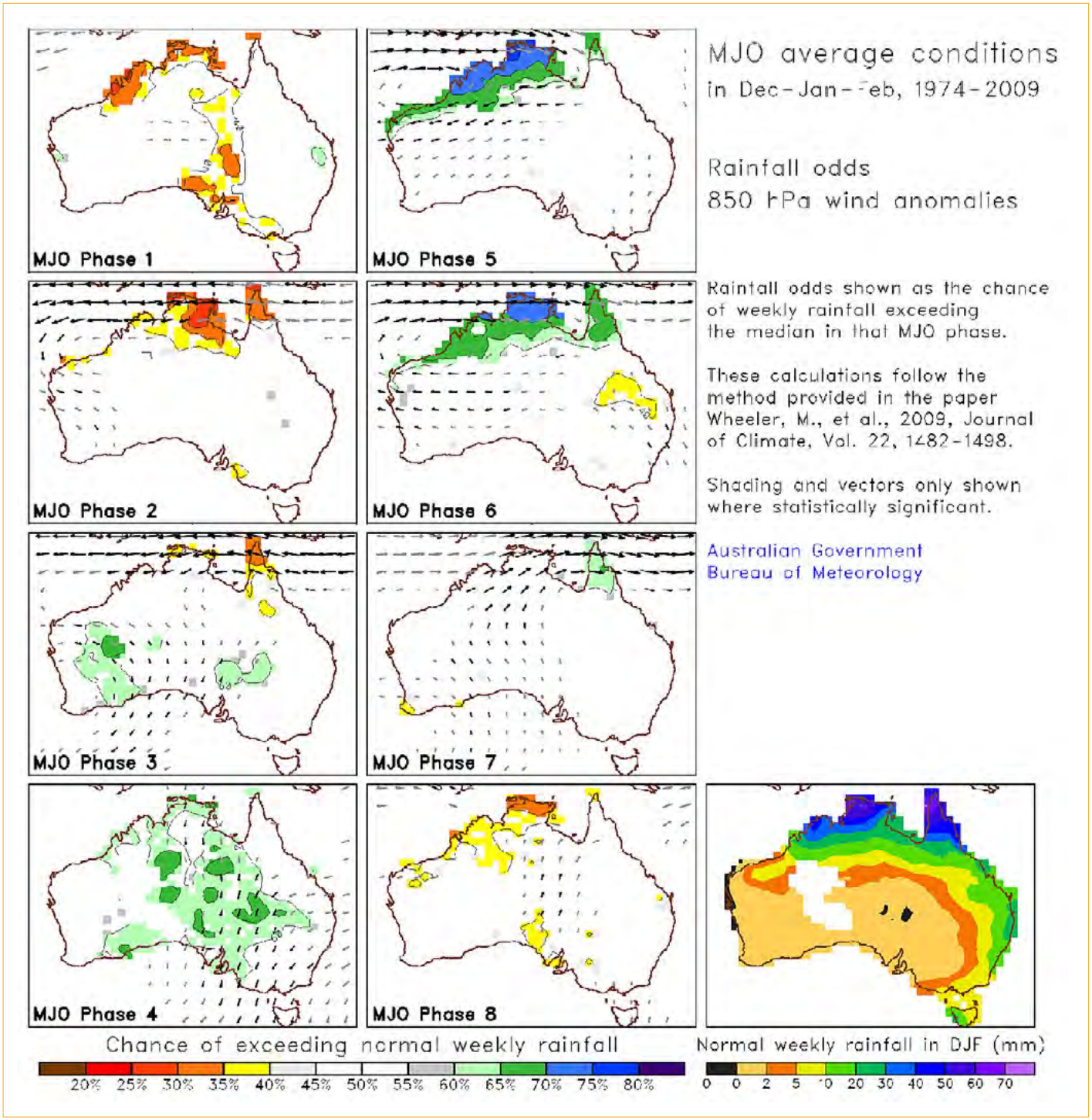
Direction and length of the arrows:

- Indicates the direction and strength of the wind anomaly.
- The darker the arrow, the more reliable the information.

BIOPHYSICAL INTERACTIONS: MJO



The relationship of the MJO with Australian rainfall and winds changes with seasons can be observed at the following website. http://www.bom.gov.au/climate/mjo/#tabs=Average-conditions



Maps: http://www.bom.gov.au/climate/mjo/#tabs=Average-conditions

BIOPHYSICAL INTERACTIONS: MJO

The Bureau of Meteorology track the influence of the Madden Julian Oscillation as it passes across the north of Australia using a range of tools including a radiosonde, launched here by Dr Matthew Wheeler off the coast of northern Australia. Source: Bureau of Meteorology.

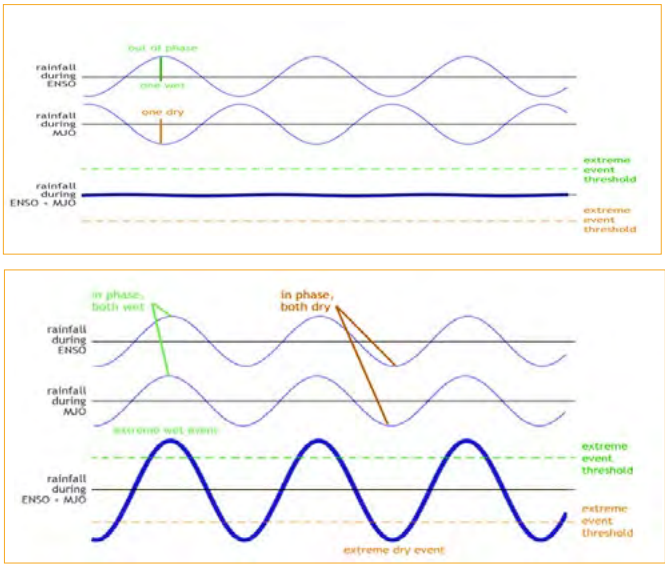
http://www.climatekelpie.com.au/index.php/2020/08/10/what-goes-around-may-bring-rain-to-northern-australia/

How does MJO differ from ENSO? How does MJO impact on ENSO?

- Imagine **ENSO** as a person riding a ***stationary*** exercise bike in the middle of a stage all day long. His unchanging location is associated with the persistent changes in **tropical rainfall** and winds that we have **previously described** as being linked to ENSO.
- Now imagine another bike rider entering the stage on the left and pedalling slowly across the stage, passing the stationary bike (ENSO), and exiting the stage at the right. This bike rider we will call the **MJO** and he/she may cross the stage from left to right several times during the show.
- So, unlike ENSO, which is stationary, the MJO is an ***eastward moving*** disturbance of clouds, rainfall, winds, and pressure that traverses the planet in the tropics and returns to its initial starting point in 30 to 60 days, on average.
- The MJO atmospheric disturbance is distinct from ENSO, which once established, is associated with persistent features that last several seasons or longer over the Pacific Ocean basin.
- There can be multiple MJO events within a season, and so the MJO is best described as ***intra-seasonal*** tropical climate variability (i.e. varies on a week-to-week basis).
- *MJO can block or enhance the effects of the La Niña in the western Pacific.

Source: https://www.climate.gov/news-features/blogs/enso/what-mjo-and-why-do-we-care

Line graphs: Two climate signals interfering (i.e., combining) with each other. Bold blue curve sketches the result of the combination. Horizontal bars indicate conceptual thresholds for occurrence of extremely wet and dry events.



Animation adapted by Climate.gov http://www.acs.psu.edu/drussell/Demos/superposition/superposition.html. Source: https://www.climate.gov/news-features/blogs/enso/catch-wave-how-waves-mjo-and-enso-impact-us-rainfallpact-us-rainfa

HOW WILL GLOBAL WARMING AFFECT MJO?

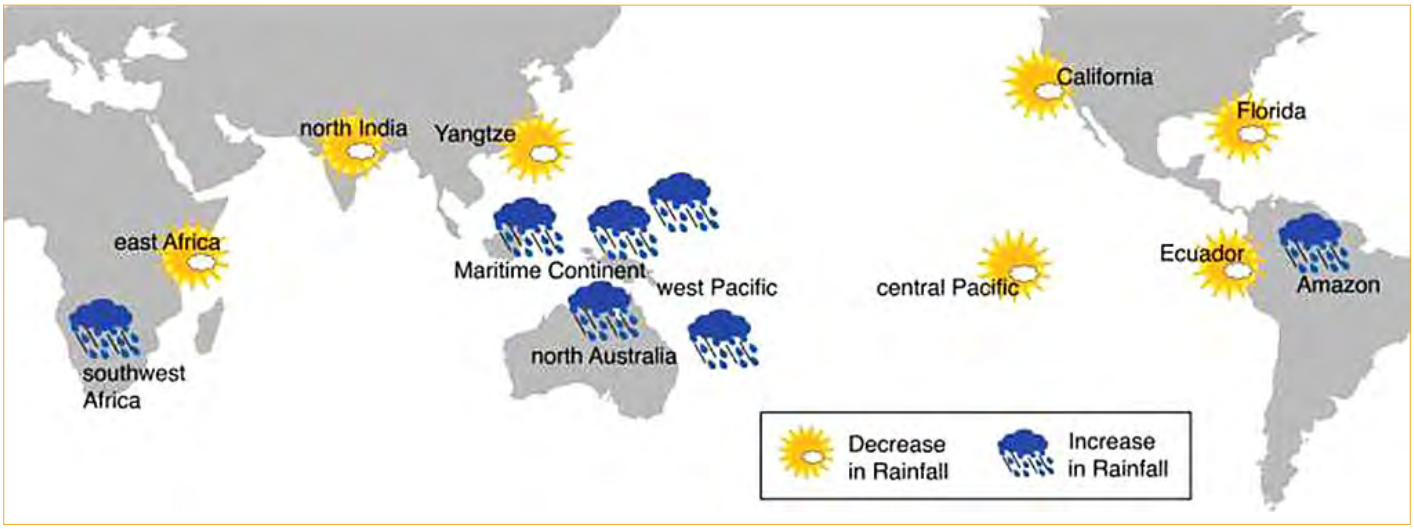
ARTICLE 1

The MJO travels 12,000–20,000 km over **tropical oceans,** mainly the **Indo-Pacific warm pool** which has ocean temperatures generally warmer than 28 °C.

This **Indo-Pacific warm pool** has been warming rapidly, altering the **residence time** of MJO over tropical oceans. While the total lifespan of MJO remains in the 30–60 day timescale, its **residence time has shortened over the Indian Ocean** by 3–4 days (from an average of 19 days to 15 days) and **residence time increased** by 5–6 days over the West Pacific (from an average of 18 days to 23 days). **This change in the residence time of MJO has altered the rainfall patterns across the globe.**

Source: https://en.wikipedia.org/wiki/Madden%E2%80%93Julian_oscillation globe

Indo-Pacific Ocean warming is changing global rainfall patterns and altering the MJO



Map Source: https://phys.org/news/2019-11-indo-pacific-ocean-global-rainfall-patterns.html

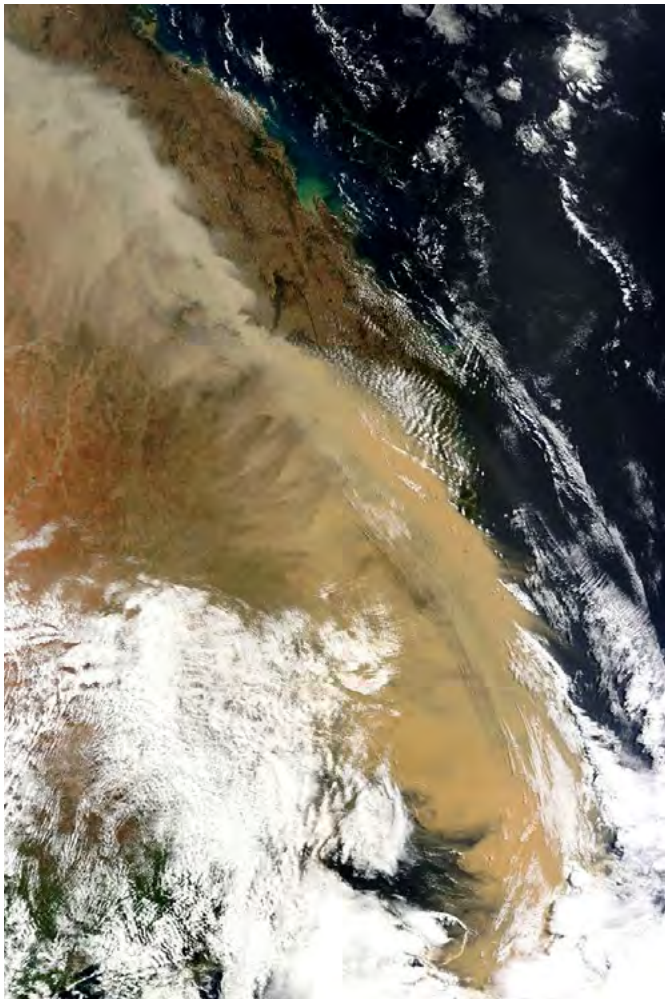
ARTICLE 2

Atmospheric scientists have studied how the MJO modulates **extreme weather events** across the globe, from hurricanes to floods and droughts.

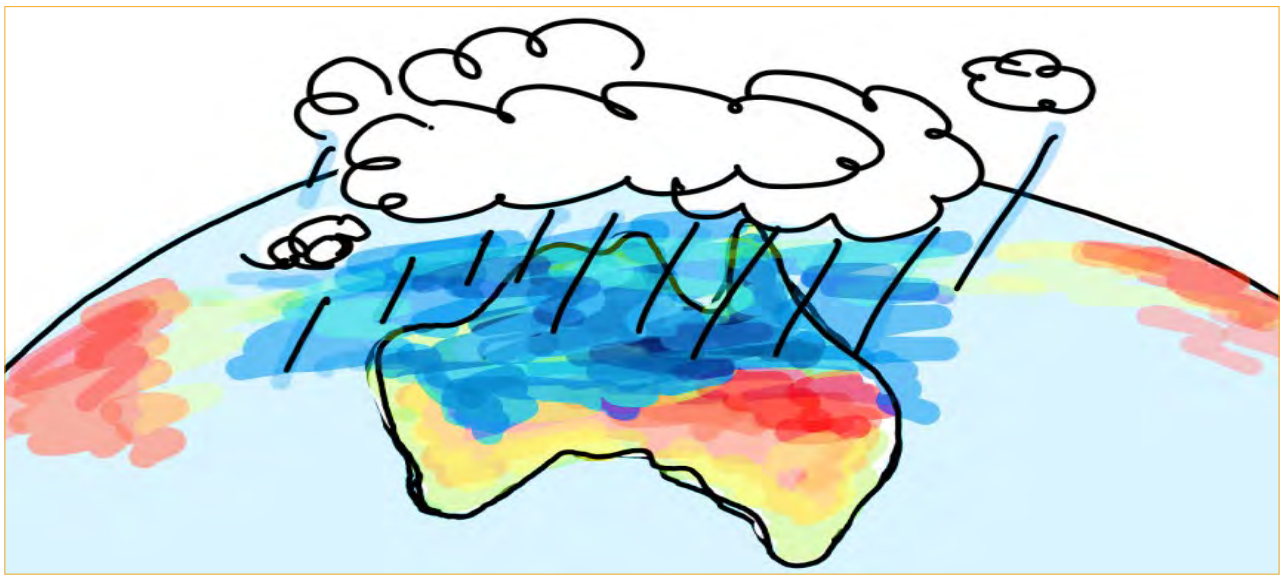
As **human activities** cause the Earth's temperature to increase, weather patterns like the MJO will also change. Eric Maloney, professor in the Department of Atmospheric Science, Colorado State University led a study published in *Nature Climate Change* that **attributes future changes in the behaviour of the MJO to anthropogenic global warming.** Maloney and co-authors used data from six climate models to synthesise current views of such changes projected for the years **2080 – 2100.**

Read the full article, "Reliable tropical weather pattern to change in a warming climate." https://engr.source.colostate.edu/reliable-tropical-weather-pattern-to-change-in-a-warming-climate/?utm_source=newsletter&utm_medium=email&utm_campaign=t0103-19

Additional article: "Prof. Maloney leads study on how global warming will affect MJO"_https://www.atmos.colostate.edu/2019/01/prof-maloney-leads-study-on-how-global-warming-will-affect-mjo/



Dust storm over eastern Australia, NASA image Source: https://commons.wikimedia.org/wiki/File:Dust_storm_over_eastern_Australia_-_MODIS_Terra_250m_-_23_Sept_2009.jpg



The Madden-Julian Oscillation, ABC Weather: Drawing by Kate Doyle
Source: https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346

STUDENT ACTIVITIES

Before you start the questions check YouTube to gain a better understanding of the topic.

Understanding the MJO:

- YouTube video – https://www.youtube.com/watch?v=UsWHHE_jkGE
- ABC: MJO the bearer of tropical rain – https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346
- Weatherview – https://weatherview.in/madden-julian-oscillation/
- ABC: MJO causing WA cyclones – https://www.abc.net.au/news/2019-03-03/madden-julian-oscillation-causing-wa-cyclones-to-vanish/10855032?nw=0
- BOM summer 2020-21 climate and water outlook – https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346

Refer to the article, YouTube and websites on the Madden-Julian Oscillation (MJO) to complete the following sentences. – http://www.bom.gov.au/climate/mjo/

1. MJO is a pulse of ……., enhanced cloud and rainfall that cycles……around the globe near the ……
2. MJO is a global feature of the…… atmosphere.
3. MJO is the…….fluctuation in tropical weather on ……to monthly timescales.
4. MJO can forecast weather …… (Timescale) in advance.
5. MJO recurs every…….to …….days
6. MJO is associated with variations in……, cloudiness, and……...
7. MJO effects are most evident over the…….. Ocean and …….. equatorial Pacific.
8. MJO influences the timing, development and strength of the major global monsoon patterns, including the ……..and……..Monsoons.

STUDENT ACTIVITIES

9. MJO can be monitored by using …… measurements.

10. The area most affected by the MJO in Australia is in northern or southern Australia …… during summer or winter?……

11. MJO can have an effect on the timing and intensity of "active" monsoon periods in northern Australia. Explain this statement ……
……

12. Describe an example of the active MJO in Australia in 2006.
Include weather map and satellite image.
    a. The satellite image showed increased convective activity (……) over …….. Australia during an active phase of the MJO.
    b. Explain the impacts of this event
……
……

13. Describe the current situation of the MJO. http://www.bom.gov.au/climate/tropical-note/.
……
……

14. Refer to the current MJO phase diagram for the next 40 days.
Summarise its conclusions http://www.bom.gov.au/climate/mjo/
……
……

15. Indicate True or False to the following statements:
    [ ] Tropical cyclones are less likely when the MJO is active.
    [ ] El Nino can be triggered by MJO.
    [ ] An active MJO results in increased precipitation in northern Australia in summer.
    [ ] There is evidence that the MJO influences the ENSO cycle. It does not cause El Niño or La Niña, but contributes to the speed of development and intensity of El Niño and La Niña periods.

A storm preluding an MJO event over the tropical Indian Ocean. Credit: Yuji Kashino, RIGC/JAMSTEC Source: https://eos.org/editors-vox/mysterious-engine-of-the-madden-julian-oscillation

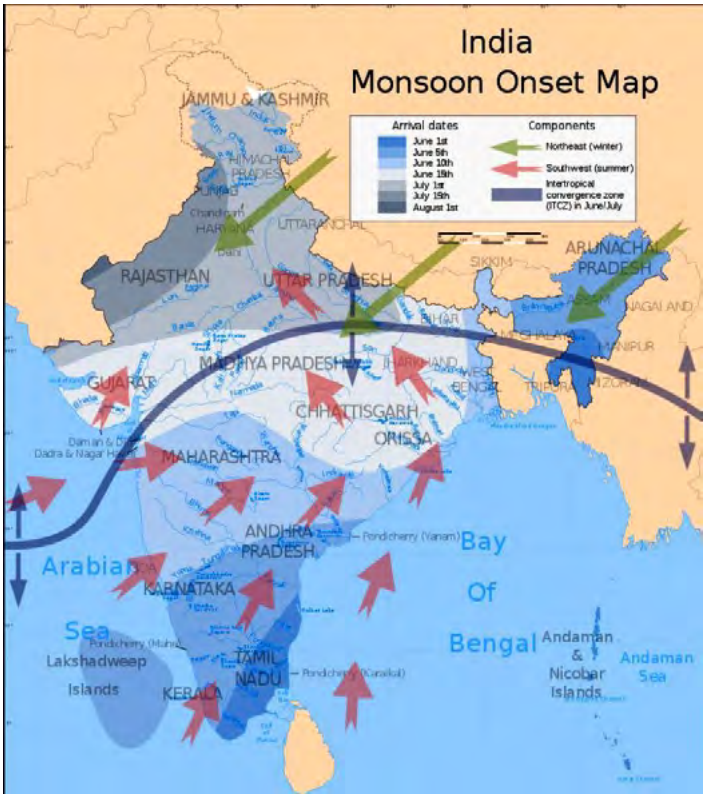
EXTENSION ACTIVITIES

Monsoon India

- In groups research the link between the MJO and the onset of the summer monsoon in India.
- Present as an oral report supported using ICT.

  https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/met.1901

  https://www.researchgate.net/publication/304345025_Linkages_between_MJO_and_summer_monsoon_rainfall_over_India_and_surrounding_region



Map https://en.wikipedia.org/wiki/Madden%E2%80%93Julian_oscillation#/media/File:India_southwest_summer_monsoon_onset_map_en.svg

Pineapple Express USA

- In pairs describe the Pineapple Express and its impacts on North American weather patterns.
- Discuss the links between MJO and the Pineapple Express.
  https://en.wikipedia.org/wiki/Madden%E2%80%93Julian_oscillation#/media/File:Mjo_north_america_rain.png

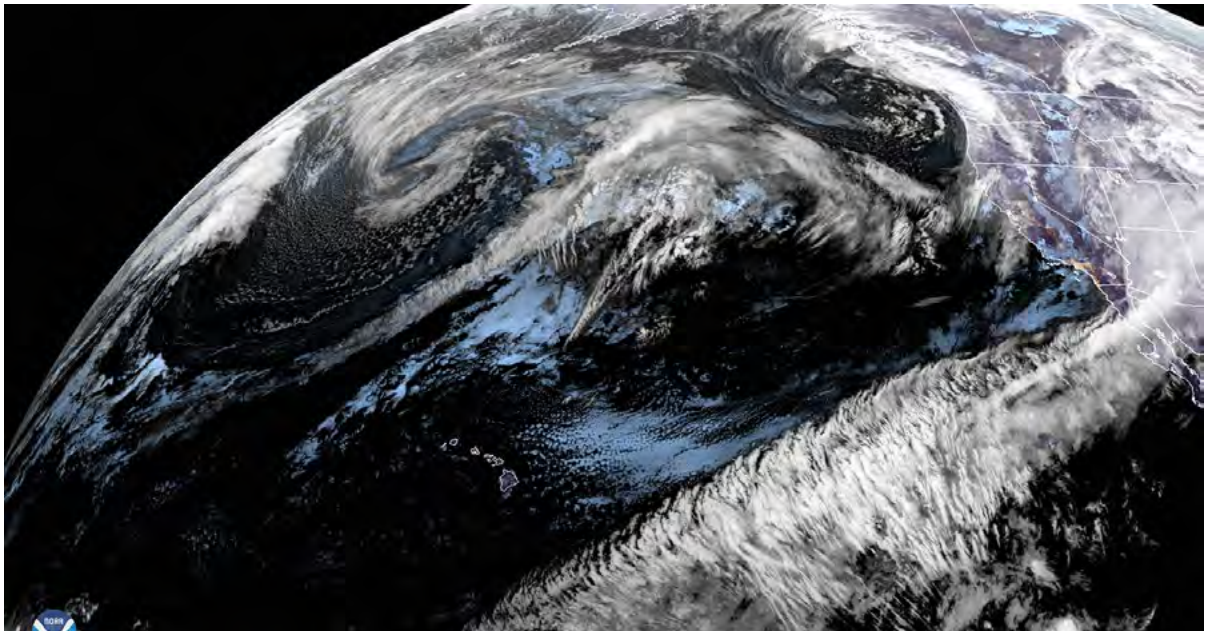
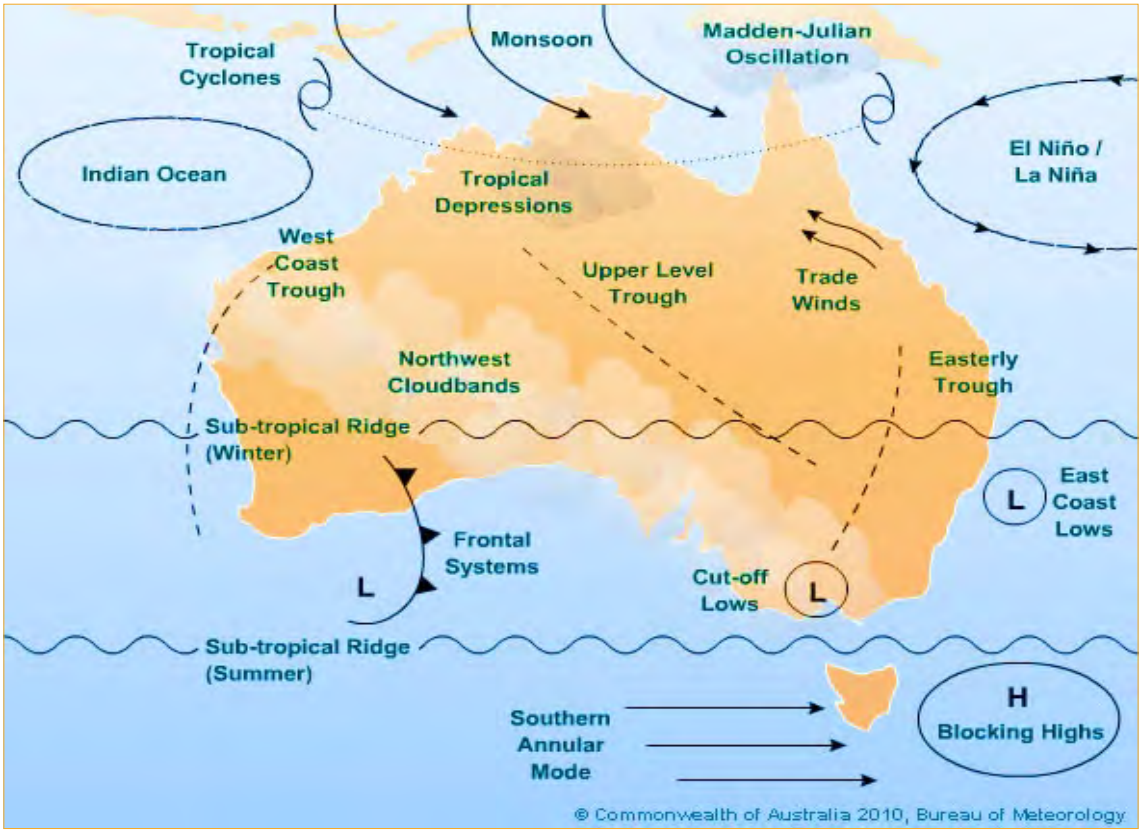


Image: The Pineapple Express brings precipitation to Western USA. January 2020.

EXTENSION ACTIVITIES



A strong flow of moisture streaming across the Pacific toward the western coast of USA. This phenomenon, colloquially known as the "Pineapple Express", brings deep atmospheric moisture from around the Hawaiian Islands to the Pacific coastline Source: https://www.nesdis.noaa.gov/content/pineapple-express-brings-precipitation-western-us

Climate and weather influences on Australia

- In pairs select one climate and weather influences on Australia from the list below

Australian climate and weather influenced by the following:

1. Blocking Highs
2. Cut-off Lows
3. East Coast Lows
4. Easterly Trough
5. Frontal Systems
6. Northwest Cloud bands
7. Southern Annular Mode
8. Sub-tropical Ridge
9. Monsoon
10. Trade Winds
11. Tropical Cyclones
12. Tropical Depressions
13. Upper Level Trough
14. West Coast Trough

Include in your investigation:

- What is it?
- When does it occur?
- Where does it occur?
- How long does it occur?
- Provide an example
- Map
- Latest update http://www.bom.gov.au/climate/mjo/

- Present investigation as a short response using ICT.

WANT TO LEARN MORE?

Image: https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346

The Bureau of Meteorology has great resources for learning more about climate

- The three phases of the El Niño–Southern Oscillation (ENSO) http://www.bom.gov.au/climate/enso/history/ln-2010-12/three-phases-of-ENSO.shtml
- Indian Ocean influences on Australian climate http://www.bom.gov.au/climate/iod/
- The Southern Annular Mode (SAM) http://www.bom.gov.au/climate/enso/history/ln-2010-12/SAM-what.shtml
- Subtropical ridge leaves us high and dry this June http://www.bom.gov.au/climate/updates/articles/a025.shtml
- About East Coast Lows http://www.bom.gov.au/nsw/sevwx/facts/ecl.shtml
- Madden-Julian Oscillation (MJO) http://www.bom.gov.au/climate/mjo/
- Impacts of the Madden-Julian Oscillation on Australian Rainfall and Circulation (Journal Article) https://journals.ametsoc.org/view/journals/clim/22/6/2008jcli2595.1.xml

Image: https://www.bcg.org.au/old-dog-new-tricks-new-look-climate-kelpie-website-unveiled-at-cotton-conference/

Resources – ICT

- Current Hunt: Madden-Julian Oscillation (MJO) http://currenthunt.com/2019/05/madden-julian-oscillation-mjo/
- An All-Season Real-Time Multivariate MJO Index http://www.atmos.albany.edu/daes/atmclasses/atm421/Reference_Material_files/WheelerHendon_2004.pdf
- Madden-Julian Oscillation: The bearer of tropical rain https://www.abc.net.au/news/2020-12-11/madden-julian-oscillation-mjo-the-bearer-of-tropical-rain/12961346
- The Madden–Julian Oscillation (MJO) https://www.daculaweather.com/4_mjo_phase_forecast.php
- MJO Model Forecasts https://trackthetropics.com/mjo-model-forecasts/
- Catch a wave: how waves from the MJO and ENSO impact US rainfall https://www.climate.gov/news-features/blogs/enso/catch-wave-how-waves-mjo-and-enso-impact-us-rainfall
- Prediction of the Madden–Julian Oscillation: A Review https://journals.ametsoc.org/view/journals/clim/31/23/jcli-d-18-0210.1.xml
- MJO Climate Prediction Centre https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml
  - Current Conditions
  - Forecasts
  - MJO Task Force Dynamical Model MJO Forecasts
  - Additional MJO Products
  - Expert Discussions
  - Composites
  - Educational Material
  - Publications
- MJO detailed information https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/MJO_summary.pdf

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GOING GLOBAL WITH CASE STUDIES TROPICAL RAINFOREST HERITAGE OF SUMATRA

David Latimer
Vice President GTA NSW & ACT

During my time teaching the Stage 6 Geography syllabus and marking the HSC Geography examination, it has been extremely rare to see other teachers using a non-Australian case study for the HSC Ecosystem at Risk topic. This may be due to the difficulty of building up enough content independently or a lack of confidence to move beyond the traditional case studies provided by textbooks. Yet there is no reason why case studies from outside Australia would not be acceptable. Indeed, there are several reasons why international case studies might be preferable. Firstly, they may appeal to particular student interests by taking them to an unfamiliar part of the world. They might also allow your class to explore a particular issue of interest that links in well with other syllabus topics or even cross-curricular areas. For example, the deforestation of mangrove forests across South East Asia is closely linked with the increasing production of aquaculture.

Table 1. Potential obstacles for using global case studies

Obstacle	Solution
Limited availability of fieldwork	• Complete fieldwork with the other HSC topics • Organise an overseas excursion • Create a virtual fieldtrip
Access to data and examples	• Largely available online
Unfamiliarity of students with context	• Excellent opportunity for student learning and broader contexts
Lack of textbook content	• Textbooks often steer students to think in particular terms

This year, my HSC class baulked at having to study mangroves or sand dunes and I thought they would find an Alpine ecosystem very conceptually difficult. I'm a huge fan of giving students voice and choice in their learning and so after some discussion about the pros and cons, we decided to study an overseas case study topic. The students had been fascinated by tropical rainforests in the Preliminary course and the case study of Palm Oil driven deforestation was still resonating positively from their Stage 5 classes. The **Sumatran Tropical Rainforest Heritage** was shaping up to be a case study that would generate student interest and allow students to compare and contrast some of the management perspectives used in a High-Income Country (HIC) like Australia with an Upper Middle-Income Country (UMIC) like Indonesia. An excited lunchtime conversation with the Indonesian Teacher at my school sealed the deal! Indonesia is a fascinating country for Australia. It's a very near neighbour with a massive population of over 270 million people that should be a significant partner with Australia. Yet, there have been tense political relations and limited trade for many years.

Source: https://upload.wikimedia.org/wikipedia/commons/f/f3/Yuli_Seperi_Orangutan_TNGL-1.jpg

About 80% of the world's documented species can be found in tropical rainforests, even though they cover only about 6% of the Earth's land surface – less than half the area they covered not so very long ago (WWF, 2020).

The Tropical Rainforest Heritage of Sumatra was inscribed as a natural UNESCO World Heritage site in 2004. It was listed as *In-Danger* in 2011 and its conservation outlook is identified as *Critical* by International Union for Conservation of Nature (IUCN) demonstrating that this really is an Ecosystem at Risk. Although there are a very broad range of reasons justifying the management and protection of the Tropical Rainforest Heritage of Sumatra, the massive extent and the high levels of biodiversity are perhaps most significant factors. The rainforest is home to a variety of large endemic mammals such as the Orangutan, Sumatran Tiger, Elephant and Rhinoceros which are found nowhere else on Earth.

Relevant syllabus content

TWO case studies of different ecosystems at risk to illustrate their unique characteristics including:

- spatial patterns and dimensions: location, altitude, latitude, size, shape and continuity
- biophysical interactions including:
  - the dynamics of weather and climate
  - geomorphic and hydrologic processes such as earth movements, weathering, erosion, transport and deposition, soil formation
  - biogeographical processes: invasion, succession, modification, resilience
- adjustments in response to natural stress
- the nature and rate of change which affects ecosystem functioning
- human impacts (both positive and negative)
- traditional and contemporary management practices.

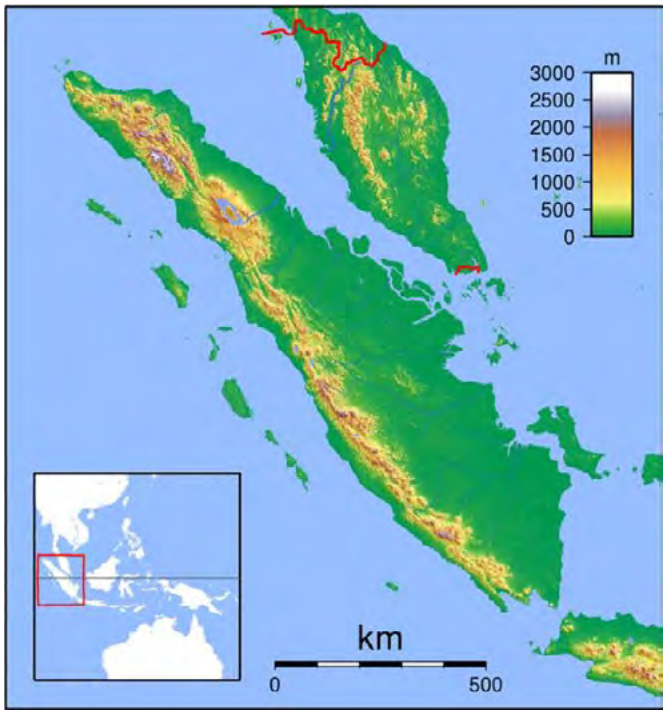
Stage 6 Geography Syllabus (page 26)

THE TROPICAL RAINFOREST HERITAGE OF SUMATRA

Spatial patterns and dimensions

Although originally occupying the whole island, The Tropical Rainforest Heritage of Sumatra is now largely confined to three national parks. There are 2.5 million hectares of Tropical Rainforest in Gunung Leuser National Park, Kerinci Seblat National Park and Bukit Barisan Selatan National Park.

The Bukit Barisan mountain range stretches along Sumatra, which means its rainforest can be found at altitude ranges from sea level to around 3 500m. The change in altitude allows for two distinct ecoregions to form. The lowlands rainforests create a buffer zone between the sea and mountains. Above 1000m montane rainforest grow in the slightly cooler climate.



Source: https://commons.wikimedia.org/wiki/File:Sumatra_Locator_Topography.png

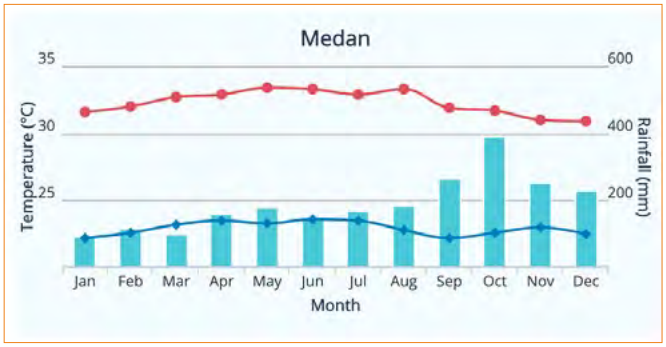
Biophysical interactions

As with all ecosystems, this terrestrial rainforest ecosystem has a number of biophysical interactions that contribute to it unique character and functioning.

The dynamics of weather and climate

Like all tropical rainforests, the lush, dense forest growth relies on high levels of heat and water being available to facilitate growth. Being located between 5˚ North and South of the equator, Sumatra experiences low pressure systems forming within the intertropical convergence zone (ITCZ). Many parts of Sumatra receive up to 4000

millimetres of rainfall annually. Day time temperatures usually reach above 30˚C. However, the high altitude of the Bukit Barisan mountain range also creates cooler Montane rainforest with high levels of precipitation, but cooler temperatures of less than 25˚C.



Climate graph from Medan, Sumatra Source: www.worldweather.wmo.int

Geomorphic and Hydrologic processes

The convergence of the Indo-Australian tectonic plate and the Eurasian plate creates a subduction zone under Sumatra which has been responsible for producing the Bukit Barisan mountain range. An undersea earthquake in this same convergence zone which sparked the 2004 Boxing day tsunami. This convergent plate line is responsible for frequent volcanic activity on Sumatra. While this helps to produce rich fertile soils, it is also a source of natural stress events.

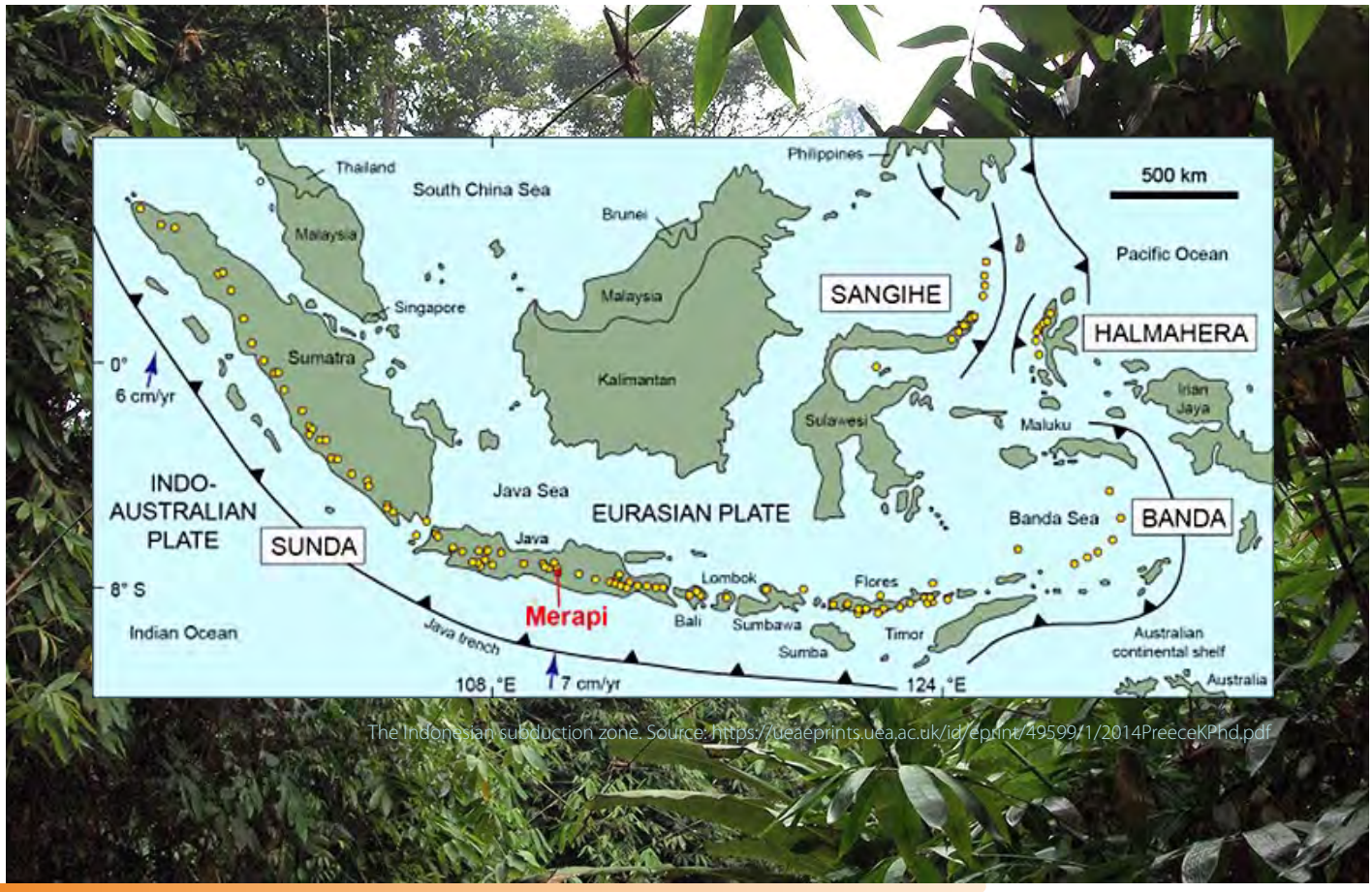
The Bukit Barisan mountain range also drives the rainfall and hydrology of Sumatra. Orographic rainfall will make its way East or West towards the coastline. As the water and eroded organic material slows on the coastal plains swamps and peat marshes have formed from the abundant organic matter.

Biogeographical processes

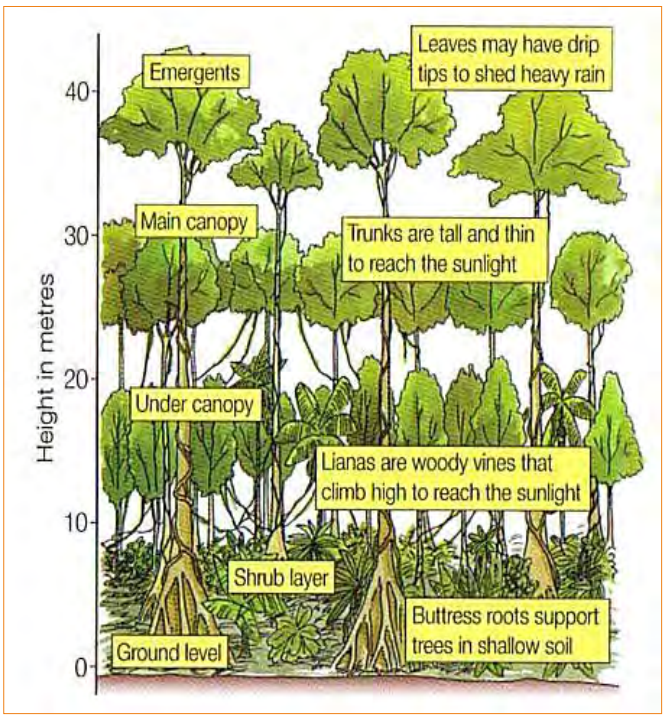
The layered canopy of tropical rainforests is central to its functioning. The thick canopy traps heat producing a very high level of humidity. Different layers of the rainforest use a range of adaptations to suit conditions. For example, the understory plants need particular leaf structures to utilise the limited light. While the giant canopy trees and emergent rely on buttress roots to support their growth which can reach up to 60m.

The plant processes of Invasion and succession are a core resilience mechanism which allow the forest to restore functioning after a stress event such as a landslide or a volcanic eruption.

Like all rainforests the Sumatran rainforest is a site of extraordinarily high biodiversity. The interconnections with the rainforest are significant. For example, orangutans are the largest arboreal (tree-dwelling) animals and their fruit-eating results in ecologically significant seed-dispersal helping to shape the rainforests. Orangutans are a keystone species.



The Indonesian subduction zone. Source: https://ueaeprints.uea.ac.uk/id/eprint/49599/1/2014PreeceKPhd.pdf



Typical rainforest canopy structures

Adjustments in response to natural stress

The rainforest is well suited to its local conditions. However, the high levels of rainfall and steep topography occasionally produce landslides. Though volcanic activity provides the most serious natural stress events on Sumatra. During eruptions forest area can be destroyed by pyroclastic flows or flows of lava. Low lying areas are also subject to damage from tsunami following underwater seismic activity.

These natural stress events will all produce an invasion and succession response which allows the rainforest to recolonise areas after a natural stress event.

The nature and rate of change which affects ecosystem functioning

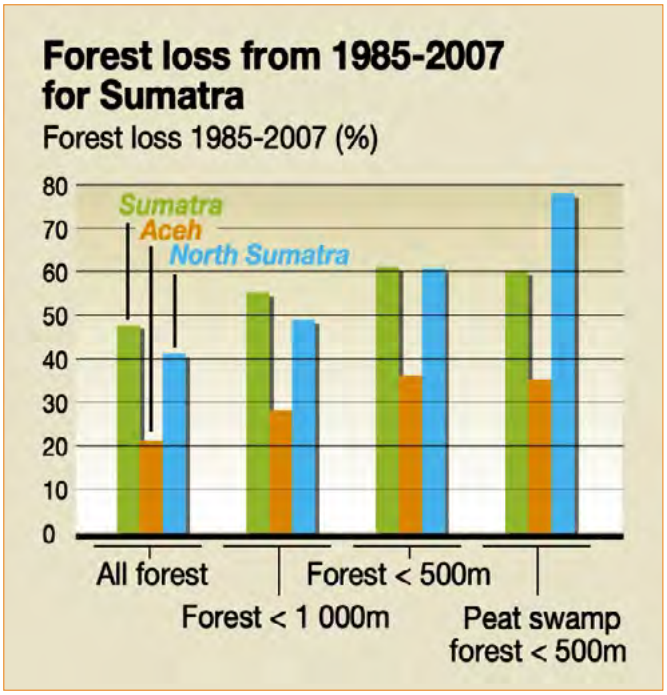
Table 2. the nature and rate of change in the Sumatran tropical rainforest

Rapid changes	Logging Palm oil plantations
Intermediate changes	Poaching and hunting
Gradual changes	Climate change Tourism transition

Human Impacts

Land clearing is the most serious threat and occurs mainly for the extraction of timber resources and to utilise the land for agriculture. The deforestation of large tracks of Sumatran rainforest results in the fragmentation of forest into smaller, more vulnerable areas.

Logging is conducted both legally and illegally. Logging is an important source of revenue in a UMIC nation. Unfortunately, most logging is illegal and does not contribute to Indonesia's development.



Source: UNEP, 2011

The main form of agriculture on Sumatra has been the establishment of palm oil plantations. Palm oil consumption has rapidly expanded in the last 30 years.

Underneath the lowland rainforests a thick layer of peat has formed. When clearing land for plantations this peat is dried and becomes prone to fires. Fire is also used by companies to clear the deforested land. Such fires pose a significant air pollution issue for neighbouring South East Asian nations such as Singapore and Malaysia.

Poaching and hunting is a significant threat to large Sumatran mammal species, such as the Orangutan, Tiger and Elephants. This may occur due to the international pet trade or to prevent damage to palm oil crops. However, hunting for meat is still a significant activity in Northern Sumatra where most megafauna are found.

National park creation is a positive impact. The federal Indonesian government has also been able to create a moratorium on further land clearing.

One of the few hopes for the Sumatran Tropical Rainforest is that the values of ecotourism might be able to generate more revenue than that from resource extraction.

Traditional and contemporary management practices

Traditional management practices

Traditionally there have been a variety of styles of management practiced on Sumatra. The farmers of Ache cleared land for permanent agriculture but also used and valued the rainforest for hunting and gathering. In the interior of Sumatra, however, indigenous groups collectively known as Orang Rimba practiced a semi-nomadic, forest dependant lifestyle.

The Orang Rimba exist on a continuum with some groups living as relatively settled slash and burn farmers while others (***kubu***) maintained a hunter-gather existence. For the Orang Rimba, an intensely thorough ecological knowledge passed on through cultural means like language, stories and dances is the most important management practice. Orang Rimba groups also maintain various taboos, such as a prohibition on the hunting of elephant or eating rice (preferring gathered yams instead). Their semi-nomadic lifestyle was another management practice which allowed for periods of ecological recovery. The Orang Rimba migrate large distances following the death of a loved one in a practice known as Melangun.

The traditional peoples of Sumatra largely kept the rainforest as a common which could be used to provide for people without title held land ownership.

Contemporary management practices

Unfortunately, since the 1980s exploitation of the timber resources and the establishment of palm oil plantation has been the main goal of ecosystem management. The Indonesian authorities have been primarily concerned with economic development meaning a lack of governance is the more significant aspect of management in Sumatra.

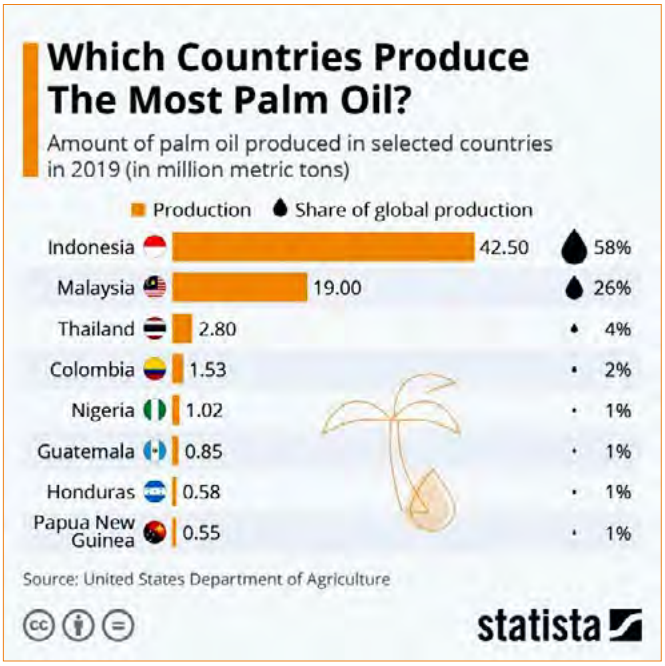
The most significant management actions aimed at protecting the rainforests have come from international NGOs such as WWF and Greenpeace. Their monitoring activities have provided significant base line data. In some cases, larger international NGOs partner with smaller local groups, such as Eyes on the Forest to monitor the land gabbing and disregard for tenurial rights shown by multinational corporations. The Sumatran Rainforest Institute uses the promotion of agroforestry to address the economic disadvantage that drives poaching and illegal logging. The growth of coffee and cocao trees also provides a microclimate buffer between rainforest and cleared land.

Individuals have worked to establish reserves. Although these are a good methods of preserving a genetic pool, these reserves often lack the range and extent required by large mammals.

Table 3. Contemporary Management Practices

Local Management Practices	– Establishing reserve populations.
Federal Management Practices	– Logging Laws – National Park Creation
Global Management practices	– Paris Agreement – REDD+ – CITIES – UNESCO World Heritage Listing

There have been recent agreements to prevent further logging from Sumatra at the national level. In 2017, the Indonesian President approved an extension on a moratorium banning extensions of logging. The area protected now exceeds 66 million hectares. However, illegal logging has proved very difficult to prevent and the management authorities are often the main perpetrators of the logging.



Major global producers of palm oil Source: https://cdn.statcdn.com/Infographic/images/normal/23097.jpeg

The promotion of palm oil as an export commodity has prevented the rainforest from undergoing succession. Similarly, the large tracks of rainforest required to support large mammals like tigers and elephant mean that smaller reserves and fragmented tracks of land are not sufficient in quantity to support healthy populations. Between 1985 and 2007, nearly half of the forest on Sumatra disappeared. The two Indonesian provinces where Sumatran orangutans occur, Aceh and North Sumatra, have witnessed a total forest loss of 22.4% and 43.4%, respectively from 1985-2008/9 (UNEP, 2011)

A challenge faced in the management of timber is that the demand comes from international sources. If illegally logged timber is being feed into a global supply chain then consumers are unable to make ethical choices. Similarly, many products that use palm oil will not be required to make consumers aware of this. Genetic marking of timber has proven to be a useful way of preventing illegally logged timber from entering the global market. Many transnational corporations are also ensuring that the palm oil they use is sourced ethically.

There is a strong link between indigenous rights and rainforest protections. Similarly neighbouring countries of Singapore, Malaysia and Thailand have made complaints about the impacts of Sumatran forest fires.

Similarly, there is little reason for optimism in protecting this ecosystem as risk unless the economic value of the forest can be shown to outweigh the value of the timber and palm oil resources. The UNEP produced a report outlining the economic value of rainforest ecoservices to Sumatran agriculture. As the global economy moves towards carbon accounting there is also an opportunity for Indonesia to revalue to its forests as assets in a global carbon market. The REDD+ international agreement does this and gives additional rationale for preserving forested lands.

Source: IUCN World Heritage Outlook

Source: IUCN World Heritage Outlook

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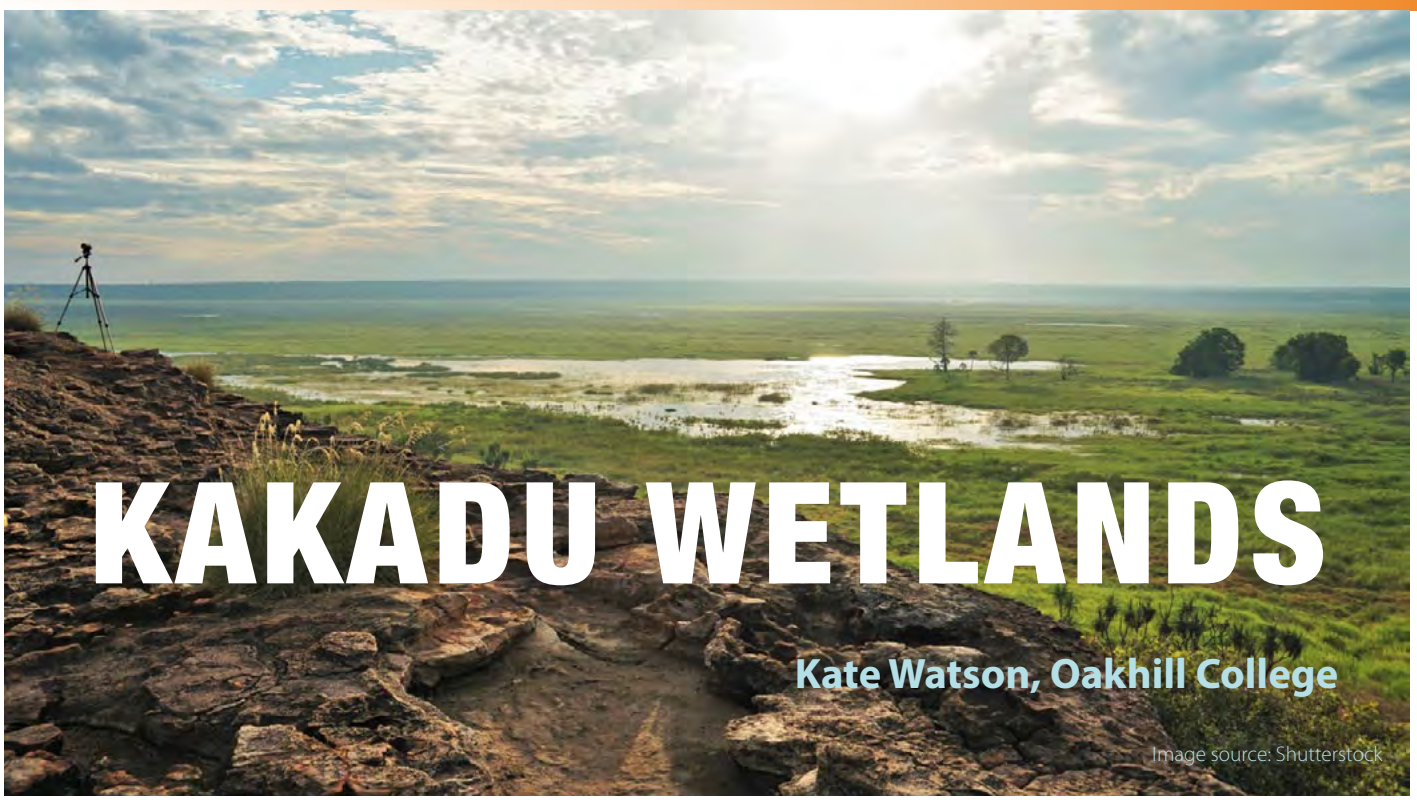
ABOVE: Sumatra's rainforest situation critical according to World Heritage Outlook. Source: https://worldheritageoutlook.iucn.org/explore-sites/wdpaid/902335

LEFT: This image depicts the natural values of the Sumatran rainforest Source: https://whc.unesco.org/en/list/1167



KAKADU WETLANDS

Kate Watson, Oakhill College

Image source: Shutterstock

INTRODUCTION

Wetlands (also known as billabongs, mangroves, tidal flats, swamps, estuaries, lowlands and floodplains) are areas of land that are either permanently or temporarily inundated (flooded) with water. Wetlands make up about 6% of the world's surface. There are salt-water, inter-tidal and freshwater wetlands.

The wetlands of Kakadu have four habitats:

1. Rivers and billabongs (freshwater wetlands)
2. Floodplains of grasses and sedges (freshwater wetlands)
3. Paperbark swamps (freshwaterwetlands)
4. Mangrove forest (inter-tidal wetlands)

Billabong - Koolpin Gorge, Kakadu National Park
Source: Traveller.com.au

Sedge. Source: en.wikipedia.com

Paperbark Swamp. Source: journeyjottings.com

SPATIAL PATTERNS AND DIMENSIONS

Location, altitude, latitude, size, shape and continuity

Location

The Kakadu area is situated about 200km east of Darwin in the Northern Territory. The wetlands of Kakadu lie within the Kakadu National Park and are found in the lower reaches of the Park's four major rivers: East Alligator River, South Alligator River, West Alligator River, Wildman River.

Altitude

The altitude of the wetlands is 0–4m above sea level. The altitude of the Arnhem Plateau where the Stone Country habitat exists extends to 465m above sea level.

Latitude

The Kakadu wetlands are located in the tropics 12–14°S, 132–133°E.

Size

The Park covers almost 20,000km^2 of the Alligator Rivers region in the tropical north of Australia and is approximately 100km x 200km in dimension. This makes Kakadu Australia's second largest national park. The wetlands occupy 10–15% of the area of the Park and are estimated as having an area of approximately 2,335km^2.

Shape

The wetlands form a band along the coastline approximately 10–20 km in width. They also extend inland in fingers following the 4 major rivers for approximately 10 km on each side of the rivers.

Continuity

The wetlands of Kakadu have developed over the last 6,000–7,000 years and are superimposed over an old marine environment. The four habitats of the wetlands become one entity (spatially continuous) during the wet season, linked by floodwater and sharing the same species These habitats are known as 'the wetlands.' In the dry season the water dries up and the wetlands become fragmented and frequented by different species - for this reason they are treated as different wetland habitats.

Figure 1: Location of Kakadu. See Appendix 1 for a tourist map of Kakadu National Park

Map 1: Location in Australia SOurce:https://www.beautifulworld.com/oceania/australia/kakadu-national-park/
Map 2: Location in the Northern Territory Source: http://asiapacific.anu.edu.au/mapsonline/base-maps/kakadu-national-park-location

Image source: https://upload.wikimedia.org/wikipedia/commons/0/02/Kakadu%2C_2004_-_panoramio.jpg

To fully understand the ecosystem of the Kakadu wetlands it is important to also understand the neighbouring habitats as they function together. This case study will therefore also refer to the other four habitats in the Kakadu National Park:

- Stone country (located on the Arnhem Plateau and in small outcrops called outliers)
- Monsoon rainforests (located in small, protected pockets with moist microclimates)
- Tropical savanna woodlands (75% of the Park, located between the Plateau and the wetland
- Shorelines (coastal)

***COMPLETE STUDENT ACTIVITIES 1** (Appendix 2)

BIOPHYSICAL INTERACTIONS: THE DYNAMICS OF WEATHER AND CLIMATE

The weather pattern and climate of Kakadu allows the wetlands to exist and brings changes over the year. Precipitation affects the height of the water table, the amount of freshwater, soil salinity, photosynthesis, respiration, growth rates and transpiration – processes essential to the functioning of the wetlands.

Kakadu has a distinct wet and dry season resulting from the monsoon, a seasonal reversal in wind direction. During summer (November – April), warm, moist air blows from the ocean to the north, bringing rain. During winter (May– October), very dry winds blow northwards from central Australia. Kakadu's closeness to the Equator, makes average temperatures high throughout the year.

To the Mirarr, the traditional owners of parts of Kakadu National Park, Kakadu is a place of living culture used by Mirarr peoples and other Bininj (Aboriginal people) every day. Figure 2

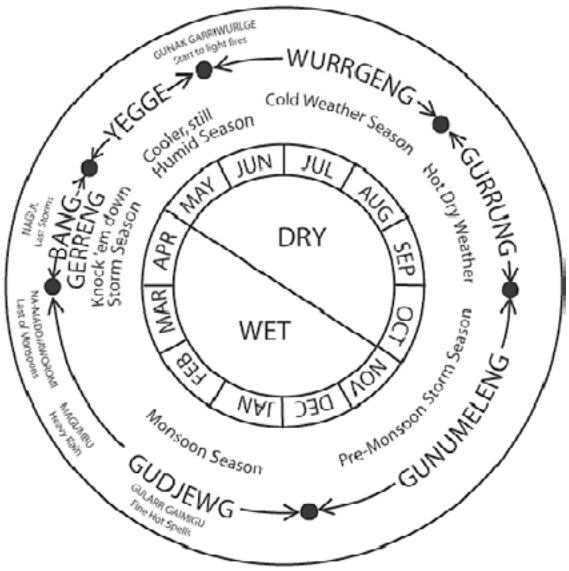
'Local Aboriginal people (Bininj) see six seasons with distinct weather and biological patterns.

Gudjewg – monsoon season
Banggerreng – storm season
Yegge – harvest season
Wurrgeng – cool and dry season
Gurrung – hot and dry season
Gunumeleng – storm season

These varied weather patterns account for the diversity of landscapes in Kakadu, which include tidal flats, mangrove forests, floodplains, billabongs, savannah woodlands, monsoon forests and sandstone escarpments.'

https://www.mirarr.net/pages/kakadu

Figure 2: Aboriginal calendar for the Kakadu region



Source: ABC Science https://www.abc.net.au/science/features/indigenous/firecalendar.htm

See Appendix 1:

- Kakadu Ngurrungurrudjba-Yellow-Water-Seasons Landscape changes with the seasons
- Gardening Australia. Kakadu in Yegge season.

COMPLETE SKILLS ACTIVITIES (Appendix 2)

BIOPHYSICAL INTERACTIONS: GEOMORPHIC AND HYDROLOGIC PROCESSES

***Geomorphological processes** are natural mechanisms of weathering, erosion and deposition that result in the modification of the surficial materials and landforms at the earth's surface.*

***Hydrological processes** – Hydrology is the branch of science concerned with the properties of the earth's water, and especially its movement in relation to land.*

The geomorphic (landform) and hydrologic (water) processes responsible for forming and changing the Kakadu wetlands are both ancient and current i.e., they have formed the wetlands over thousands of years and are still shape them. The monsoonal climate continues to drive the hydrological and geomorphic processes shaping Kakadu today. The outliers, escarpment and plateau are eroding slowly and provide the material for deposition on the wetlands. Figure 3

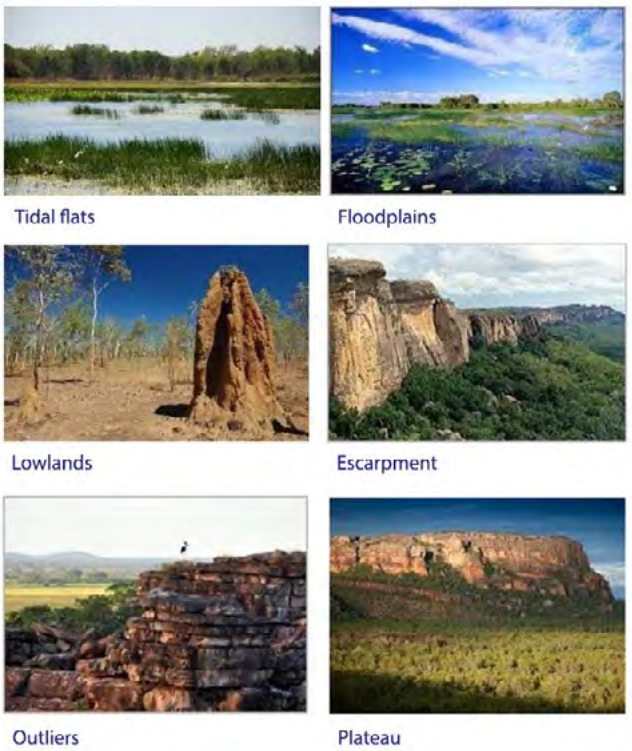
The hydrology (water) of the park is characterised by the drainage systems of the main rivers. Most floodplain areas are under water for up to four months each wet season. Many billabongs and smaller water bodies along a river line last throughout the dry season. As water

levels drop, remnant waterbodies become important as places for many animals and plants to survive the dry season. The most accessible places to view the floodplains are Yellow Water, Mamukala, Iligadjarr, Ubirr and Bubba wetland.

Earth Movements

- **140 million years** ago, Kakadu wetlands were under a shallow sea. The escarpment was a sea cliff.
- **23,000 years ago**, Kakadu was in the midst of an Ice Age. It was drier, more sparsely vegetated and relatively cool. The coastline was 350 km further north and Australia was connected to New Guinea.
- **12,000 years** ago, melting caused sea levels to rise. The lowlands were underwater. The climate was becoming warmer.
- **6000 years** ago, the sea levels had fallen and stabilised at present levels. Large areas of tidal flats and mangroves were formed.

Figure 3: The major landforms of Kakadu



Source: https://www.newworldencyclopedia.org/entry/Kakadu_National_Park

Weathering

Large amounts of weathered material accumulate in the wetlands during the wet season. This alluvial material, together with organic material produced by wetland vegetation forms nutrient-rich soils. Nutrient-rich soils and the abundance of water and sunlight make the floodplains an area of high biodiversity (plant and animal life).

Erosion

The low-lying wetlands accumulate sediment (deposition) rather than of experience erosion. The wetlands are flood mitigators that can absorb floodwaters and release them slowly, minimizing erosion. Erosion may occur during storm events, when the erosive power of storms overwhelms protective vegetation.

Transport and Deposition

The sediments are fine, having been transported from the Arnhem plateau by the Alligator Rivers. The deposition of sediment in the wetlands creates new land. Natural levee banks on the floodplains form barriers between salty tidal water and ponded freshwater.

Soil Formation

The soil found in the wetlands reflects the parent material from which it is derived, and the topography, climate and vegetation of the area. The soils are generally poorly drained, rich in organic matter and are anaerobic (i.e., they lack oxygen). Water logging and a fine soil structure limit the amount of oxygen present. The wetland soils are also unstable as they are constantly shifted and sorted by water movements.

Changes in geomorphic and hydrologic processes can place the wetlands at risk. For example:

- Erosion can expose soils, especially after heavy rainfall.
- Increased turbidity can lead to a deterioration in the health of the wetlands.
- The deposition of alluvial material may include toxic pollutants
- If global climate changes proceed as predicted, sea level rise will cause saltwater intrusion into Kakadu on a very large scale.

Source: https://upload.wikimedia.org/wikipedia/commons/2/23/Really_wet_%28Kakadu_National_Park%29.jpg

BIOPHYSICAL INTERACTIONS: BIOGEOGRAPHICAL PROCESSES

Invasion, succession, modification, resilience

Biogeography *refers to the study of the distribution of species and ecosystems in geographic space and over (geological) time. Patterns in the biosphere are influenced by latitude, elevation, isolation and habitat area.*

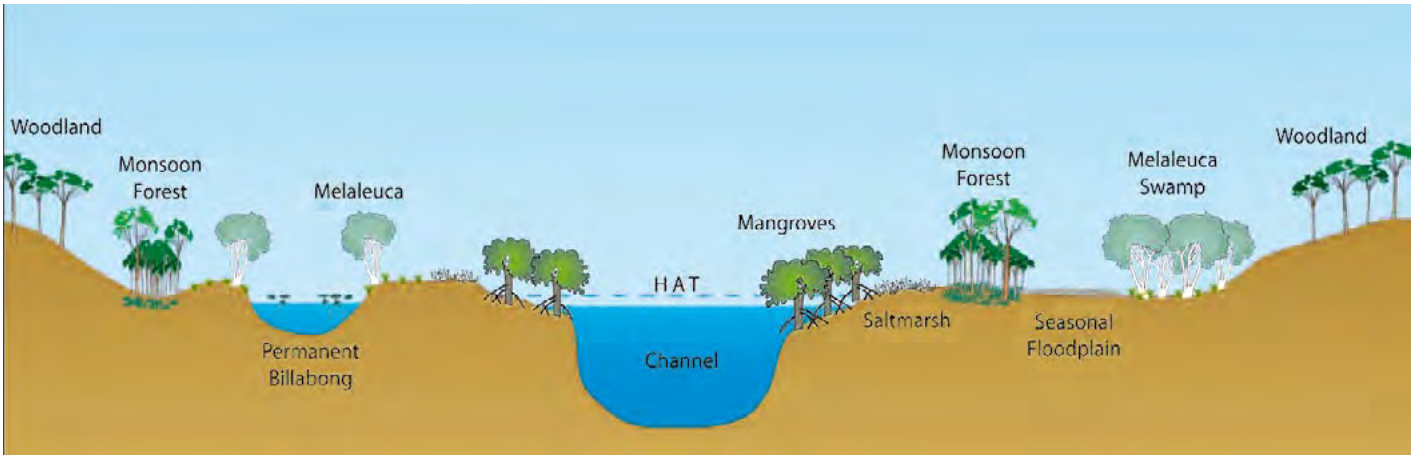
Ecosystem Functioning: Biosphere

Plants (Ecosystem producers) Appendix 1

With more than 2,000 plant species, Kakadu is bursting with life. Many plants have been used by local Aboriginal people for generations as bush foods, medicines and weaving materials. Where floodplains are inundated for two to six months a year, grasses and sedges such as spike rush occur. Clumps of freshwater mangroves (itchy tree), pandanus and paperbarks are found on slightly higher ground. Herbaceous swamp vegetation dominates areas covered by water for six to nine months a year. A variety of waterlilies, such as the blue, yellow and white snowflake, are commonly found in these areas. Figure 4

Source: https://upload.wikimedia.org/wikipedia/commons/8/8c/Kakadu_%28AU%29%2C_Kakadu_National_Park%2C_Yellow_Water_--_2019_--_3840.jpg

Figure 4: Wetland habitats in the South Alligator River Catchment



Source: Kakadu Coast https://www.environment.gov.au/system/files/resources/b2915be6-16e4-4cb3-8533-471ed879bfc1/files/kakadu-coast.pdf

Animals (Ecosystem consumers) Appendix 1

Kakadu is home to an astonishing array of animals, some which are found nowhere else in the world. Floodplains undergo dramatic seasonal changes. Following wet season rains, a sea of shallow freshwater spreads over the plains for hundreds of square kilometres. As the floodplains start to dry, waterbirds and crocodiles seek refuge in the remaining wet areas such as Yellow Water.

Floodwaters add nutrients to already nutrient rich floodplain soil, which, along with an abundance of water and sunlight, make the floodplains an area of prolific plant and animal life. During the dry season the water recedes into rivers, creeks and isolated waterholes or billabongs. The wetlands of Kakadu are registered as a Ramsar site for their rare and unique wetlands, and importance in conserving biological diversity.

The floodplains and wetlands of Kakadu are important refuges and feeding grounds for many Australian *waterbirds*, especially during the dry season. Many abundant waterbird populations are restricted to a narrow band along the northern coastline. These birds include the magpie goose, green pygmy goose, Burdekin duck, and wandering whistling duck. Other commonly seen and more widespread waterbirds are the jabiru, the comb-crested jacana (or lotus bird), cormorants, darters, egrets, ibises and herons.

Kakadu's wetlands are visited each wet season by about 30 species of *migratory birds*, such as the little curlew, the snipe and the godwit. The birds' breeding grounds are in the Northern Hemisphere, in places such as Siberia, China and Japan. Birds leave their breeding grounds at the end of the northern summer to fly south to warmer climates.

A number of *reptiles* live on the floodplains. Northern snake-necked turtles bury themselves in mud at the end of the dry season. Larger pig-nosed turtles and the Arafura file snake are seen less frequently. The snake lives in billabongs among the roots of the river pandanus. Freshwater and Macleay's water snakes, king brown snakes and water pythons are common on the floodplains where they eat dusky rats.

Estuarine or saltwater crocodiles are found in both freshwater and saltwater. Their nests are usually mounds of mud and rotting vegetation next to permanent water. Nesting occurs during the wet season (between December and April), and about 80 per cent of mature females nest each year, laying about 50 eggs. Generally, at least 75 per cent of the eggs laid fail to hatch because the nest becomes flooded.

The paperbark forests that fringe the floodplains provide nesting sites for *wetland birds* such as the jabiru, the white-bellied sea eagle, the whistling kite and the green pygmy goose. Paperbark forests are also home to the brush cuckoo, the lemon-bellied flycatcher, the rufous-banded honeyeater, and the restless flycatcher. Flowering paperbarks provide food for nectar-feeding birds such as honeyeaters and lorikeets. Kingfishers such as the blue-winged kookaburra and forest kingfisher, rainbow bee-eater and species of flycatcher are often seen in the paperbarks. The mistletoe bird feeds on the berries of the mistletoe plant, a parasite growing on the paperbarks, spreading the plant's seed to other parts of the forest.

Figure 5: Producers & consumers in Kakadu wetlands

Producers	Primary Consumers	Secondary Consumers
Billygoat plum	Termites	Dingoes
Darwin woollybutt	Blue-winged kookaburra	Crocodiles
Fern-leafed grevillea	Northern brown bandicoot	Frill-necked lizards
Green plum	Mice and rats	Gould's goanna
Sand palm		
Spear grass		
Spiar pandanus		
Eucalyptus		

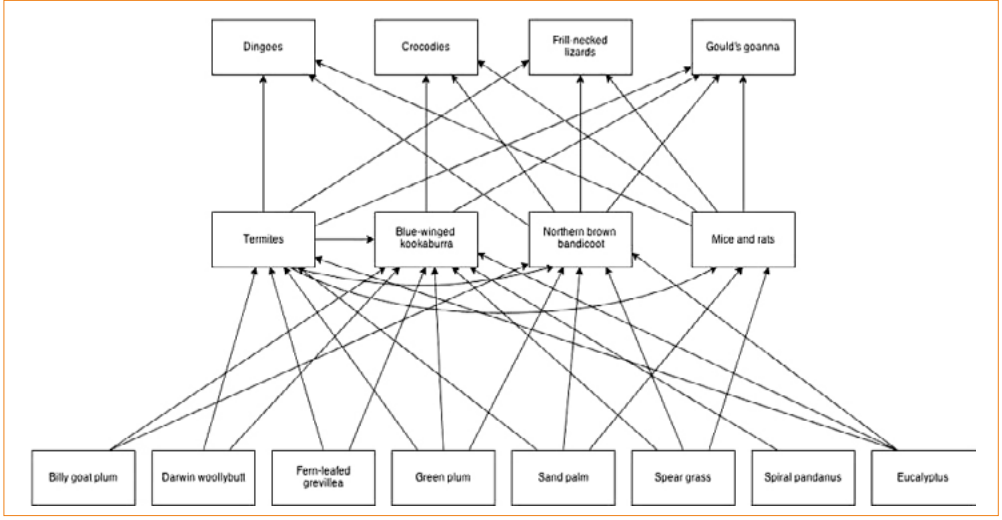
Keystone Species: Termites

*A **keystone species** is a species that exerts a greater influence on the structure and functioning of an ecosystem than might be expected solely on the basis of its abundance.*

Termites play an essential role in their ecosystems. They build huge mounds, which can become home to other animals and plants. Abandoned mounds can become islands in marshy areas. In the food web, termites are prey to many animals including aardvarks and even some ants. Termites eat dead plant matter such as wood and grasses and as decomposers they return nutrients to the soil. Figure 6

If termites disappeared, so would the ecosystem. Termite mounds are rich in nutrients like nitrogen and phosphorus, and termites also help loosen soil to promote water absorption. Plants grow and are sustained by termite mounds, and if the termites disappeared, consumers species could starve.

Figure 6: Example of the Food Web of a biome in Kakadu



Source: kakadunatpark.weebly.com

Kakadu floodplain wetland Source: https://parksaustralia.gov.au/kakadu/plan/when-to-come/

Change over time

Biogeographical processes *also involve changes in the flora and fauna. These changes include Invasion and succession.*

Invasion

Invasion refers to the encroachment of new species of plants or animals. An invasive species is a plant, fungus, or animal species that is not native to a specific location (an introduced species), and which has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health.

Succession

Succession refers to the eventual replacement of new species of flora and/or fauna. Thus, pioneer species are replaced by secondary species utilising the soil, moisture and shade conditions created by the pioneer species.

In Kakadu, the coastal and floodplain vegetation exemplifies a vegetation succession linked to processes of sea-level change and sedimentation and extends from lower intertidal mangroves to estuarine mangroves to floodplain vegetation. Succession in the wetland can be seen in the transition from tidal flats to mangroves to salt bush to casuarina as distance from the river increases. Mangroves are an example of a secondary species.

Mangroves grow in an intertidal environment which most plants cannot tolerate (i.e., they display remarkable resilience). Mangroves survive in the salty water and mud because of their aerial roots. These stick out of the mud at low tide and allow the tree to breathe. These roots are called pneumatophores and have the ability to change saltwater into freshwater. Protection is given against the heat of the sun and the damaging salt spray by the shiny and leathery leaves.

Adjustments in response to natural stress

Natural stresses include:

- **High rainfall** (strong monsoon) creates the necessary conditions for the rejuvenation, recolonisation and spread of wetland flora. The migratory and sedentary aquatic and terrestrial fauna of the wetlands is also affected by variations in rainfall.
- **Low rainfall** (weak monsoon) may only be sufficient to flood the plains to a depth of 10cm rather than the usual 3m
- **Storms/Cyclones:** Magpie Geese nest during April ('Knock-em' down storm season'). A late cyclone or storm can destroy nests and chicks. This means that the Magpie Geese cannot breed again until next year
- **Fire:** Tropical savanna woodlands (paperbark trees) are highly flammable. The region's seasonally wet-dry climate creates conditions that make large scale fires inevitable. Fires are caused by lightning strikes and 8% of the woodland is burnt annually. Intense fires cause substantial loss of biomass.
- **Excessive Temperatures:** The August – October period is the hot, dry weather season. This is the toughest season for all wildlife. The area is intensely hot and surface water is scarce. During this time, entire plant communities go into stress.
- **Salinity levels:** Many of Kakadu's wetlands receive fresh and saltwater. They must be able to survive the extreme conditions of both salt water (e.g., at high tide) and freshwater (e.g., low tide and at times of flood). Low lying freshwater wetlands are susceptible to saltwater intrusion.

COMPLETE STUDENT ACIVITIES 2 Appendix 2

THE NATURE AND RATE OF CHANGE AND ECOSYSTEM FUNCTIONING

Natural change affects the Kakadu wetlands in a variety of scales, from daily tidal fluctuations to seasonal monsoonal changes and the longer-term changes associated with changes in sea level. In recent years, human induced changes have accelerated the nature and rate of change in this ecosystem.

Ecosystems function via *energy flows and nutrient cycling.* Energy from the sun is transferred to plant life (producers) and then to each trophic level (consumers). Energy is lost throughout the ecosystem as it naturally operates (functions). Nutrients (e.g., carbon, nitrogen, potassium) are cycled throughout the ecosystem as it naturally (functions). Nutrients can be gained or lost at the various levels. Figure 7

Ecosystems exist in a state of *dynamic equilibrium* (i.e., they function with all the components in balance). However, if a natural change occurs, the ecosystem is able to adjust and alter its functioning to remain in equilibrium or balance.

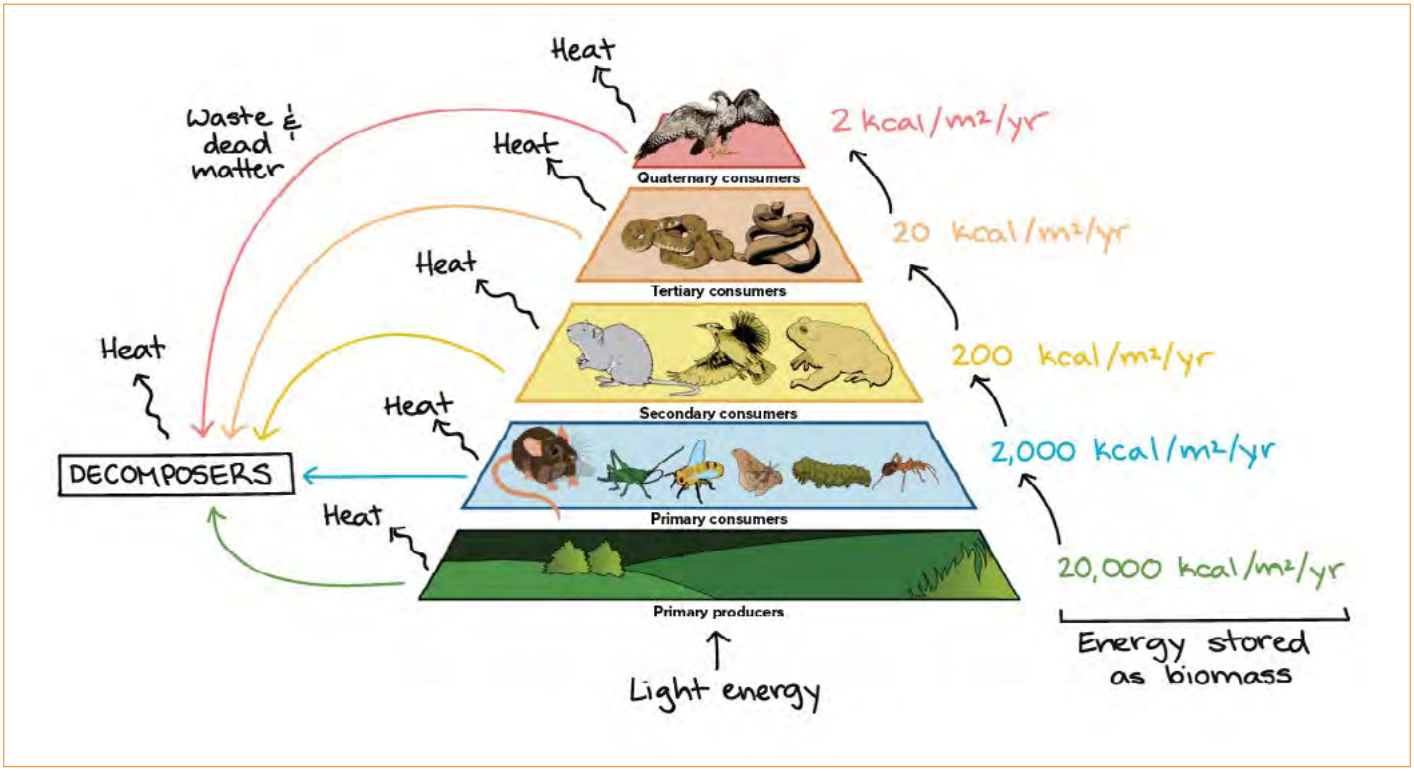
At times, natural changes can be so severe and catastrophic (e.g., an earthquake or a volcanic eruption) so as to totally destroy the ecosystem functioning. However, over a long period of time and via a series of changes (seral progression, plant succession) the ecosystem will return to its state of equilibrium.

Source: https://upload.wikimedia.org/wikipedia/commons/1/1d/Anbangbang_gallery_Mimi_rock_art_cropped.jpg

Human change

Aboriginal people lived continuously in the area for over 60,000 years and is recognised as one of Australia's oldest sites of human occupation. The dynamic equilibrium of the wetland ecosystems was maintained over a long period of time. In comparison, British occupation only dates back to the 1890s - a short time. Roads, Jabiru township, mines, airstrips and the national park are recent changes (1970s onwards). Cultural and economic changes in Kakadu increased the rate of change and impact on wetland ecosystems and Bininj (local Aboriginal people) and threaten the balance between components of the biophysical environment. Anthropogenic climate change is the largest potential future threat to the functioning and values of Kakadu's wetland ecosystems.

Figure 7: Trophic pyramid



Source https://www.blendspace.com/lessons/x_dwtHrswVyCbA/food-webs

COMPLETE STUDENT ACIVITIES 3 Appendix 2

Positive human impacts

Tourism/Ecotourism

Tourism provides necessary income to ensure the on-going management of the Park. The promotion of ecotourism has significantly reduced human impacts. Examples include solar powered showers in the camping areas and the recycling of sewerage. In addition, boardwalks, viewing platforms and launching ramps have been constructed to reduce impacts. Figure 8

Kakadu Culture Camp is an Aboriginal-owned-and-operated camp in the heart of Kakadu and is 100% solar powered, including the bore pump. It has solar hot water and 40 solar panels providing electricity. From May to November visitors can stay in one of the spartan safari tents or camp, sharing three-course meals of crocodile, kangaroo or buffalo meat, or anything else with the Bininj people who live and work there. There is a range of cultural and natural heritage tours, including the only night-time tour in Kakadu.

Ecological, cultural and economic sustainability is the aim of the new Kakadu National Park Tourism Management Plan 2020 – 2030.

Education

The Bowali Visitors Centre, with impressive and award-winning habitat-based displays, educates people about the significance of the wetlands. Signage throughout the park is designed to educate tourists.

Restriction of Access

Many areas of the park have restricted access to ensure they remain free of any human impacts.

Negative human impacts

Introduced/Feral Animals Figure 8

- **Buffalos**

  Asian water buffalos were introduced into northern Australian settlements between the 1820s and the 1840s, as work animals and for meat. When settlements were abandoned, buffalo were released and quickly spread across the lowlands. By the 1960s, numbers had reached enormous proportions, causing damage such as soil compaction and erosion. Wallowing erodes riverbanks and muddies the water, making it unsuitable for many aquatic plants and animals. They eat large volumes of plants, competing directly with native wildlife. Movement between wetlands creates 'swim channels' which, when they intersected with tidal creeks, result in saltwater intrusion and loss of freshwater species.

- **Wild Pigs**

  Wild pigs cause damage to a broad range of Kakadu's habitats. They degrade the environment around springs and small rainforest patches, especially in the wet season. They also dig up areas in their search for food and compete directly with magpie geese and Aboriginal people for bulbs that grow along the wetland shores. The ground they expose is vulnerable to weed infestation (pigs are thought to be the main agents of spreading the weed 'mimosa' through the Park).

- **Wild Horses**

  Wild horses are particularly common in the southern woodlands of the Park. They spread weeds and damage waterholes by eroding soil and fouling the water.

- **Feral Cats**

  Feral cats are present in low numbers throughout the Park. Cats' hunting activity is having a detrimental effect on native wildlife.

- **Wild Dogs**

  Wild dogs that have become feral have some impact in that they interbreed with the dingo population in the Park, changing the dingo gene pool.

- **Cane Toads**

  Cane toads were found in Kakadu National Park in 2001. Cane toads are poisonous throughout most of their life cycle and current information suggests that they will have an initial impact if eaten by animals such as snakes, goannas and quolls, who will try to eat them. This species is a major problem for the future as their control is very difficult.

Figure 8: Examples of negative human impacts


Water buffalo


Cane toads


Uranium mine

Image sources: In order swaindestinations.com, Shutterstock; Dreamstime

ECOSYSTEMS AT RISK: KAKADU

Poinciana Image source: https://upload.wikimedia.org/wikipedia/commons/8/81/Poinciana_-_flowers%2C_buds%2C_leaves_%284079673439%29.jpg

Introduced Weeds

A weed is defined as a plant that is not native. Weeds compete with native plants for light, moisture and nutrients and often do not provide appropriate food and shelter for native wildlife. Particularly invasive weeds reduce plant and animal diversity, change burning regimes, and alter the structure, function and species composition of natural ecosystems.

Kakadu remains one of the most weed free conservation areas in Australia. Only a small number of weeds found in the Park are considered invasive (ie mimosa, salvinia, para grass, mission grass, gamba grass, candle bush, calopo, Gambia pea, golden shower, Poinciana and coffee bush). Of these, salvinia, mimosa and para grass are given priority in control schemes because of their potential to spread over large areas.

- **Salvinia** (Salvinia molesta)

  Salvinia is an aquatic, free floating fern which can double in population size in two days. Despite eradicating areas that had this weed, new infestations of this weed are continually being found.

- **Mimosa** (Mimosa pigra)

  Mimosa is a Central American woody shrub that, under ideal conditions, grows up to 4m tall and is highly invasive. It can replace all native vegetation on ecologically and economically valuable wetlands. Large infestations have been found throughout the Park due to mimosa's lack of natural enemies, a rapid growth rate, production of large quantities of easily transported viable seed, and a tolerance of drought and flood. Unchecked, mimosa forms impenetrable thickets across floodplains.

- **Para grass** (Brachiaria mutica)

  Para grass was introduced to the area as pasture grass in the 1930s. Like mimosa, para grass can take over huge areas of floodplain and is invading a number of Kakadu's wetlands and threatening wildlife habitats.

Tourism

In 1985 approximately 100,000 people visited Kakadu National Park. In the late 1980s visitor numbers increased rapidly and during the early 1990s visitor numbers averaged about 230,000 people per year. Currently about 250,000 people visit Kakadu each year. Visitor numbers are greatest during the dry season months of June to September (approximately 33,000 people visit each July) and lowest during the wet season months (approximately 7,000 people visit each January).

Uranium Mining Figure 8

Australia has about 40% of the world's uranium reserves. The Ranger Uranium Mine opened in 1980 and occupied 5km^2 site in the middle of the Park near Magela Creek, a tributary of the East Alligator River. Uranium has the potential to be a highly dangerous substance when not treated in the proper manner, remaining radioactive for hundreds of thousands of years.

Concerns over uranium mining at Kakadu included mine tailings and contaminated water, poisoning Aboriginal water and food supplies, with fatal consequences for local indigenous groups and the environment. There were reportedly more than 150 leaks, spills and license breaches at the Ranger uranium mine since the mine opened in 1981. Uranium concentrations 100 times the original levels were recorded in the Magela wetland system downstream of the mine. Sulphate, manganese, magnesium, copper and zinc concentrations also rose steadily.

Management of contaminated water has proven difficult due to the variable monsoonal climate and the environmental sensitivity of the area's wetlands and floodplains. In January 2021 the processing of uranium ended, eight years after mining finished. The challenge now is to remediate the site and retore the environment to pre mining conditions.

Global Warming

Rising sea levels, as a result of global warming, may be beginning to show in Kakadu. There is evidence that freshwater environments are converting to saltwater wetlands, leading to extensive dieback of paperbark and freshwater grasses across these plains. The low-lying coastal plains in Kakadu are just 0.2 – 1.2 metres above mean high water level. This makes them very vulnerable to the projected sea level rises of 10-30 cm by 2030.

COMPLETE STUDENT ACIVITIES 4 Appendix 2

TRADITIONAL AND CONTEMPORARY MANAGEMENT PRACTICES

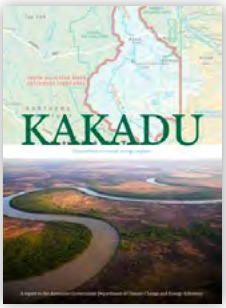
The large size of Kakadu National Park is critical to maintaining the region's biodiversity. Worldwide, there is a growing recognition that most national parks are too small and that loss of biodiversity in them is inevitable over time. It is hoped that this loss can be avoided in Kakadu.

'Kakadu is home to the world's oldest living culture. Bininj live in Kakadu and continue to undertake cultural practices, follow customary law and uphold tradition. Maintaining a connection to land is vital to upholding the cultural values of Kakadu, and the maintenance of living culture in Kakadu is dependent on Bininj living and travelling across their country and undertaking activities such as collecting bush tucker, land management, passing on oral knowledge and speaking in Aboriginal language. Furthermore, within Kakadu can be found perhaps 60,000 years accumulation of archaeological material cultural resources and internationally significant rock art. The Kakadu landscape is overlain by a complex spiritual and social system sustained by the Bininj of the land.'

Source: https://www.environment.gov.au/system/files/resources/b2915be6-16e4-4cb3-8533-471ed879bfc1/files/kakadu-coast.pdf

Traditional Management

The Aboriginal community, currently numbering about 550 people, plays a major role in the management of the Kakadu National Park. As the traditional owners and land managers, the Aboriginal community enjoys certain rights and responsibilities. One of the responsibilities is to ensure that future generations of traditional owners are able to exercise the same rights and understanding of their culture as the current traditional owners. The close spiritual bond that exists between the Gagudju and the land means that they do not seek to dominate nature, instead they live in harmony with it.



For a greater understanding of traditional management in *Kakadu* refer to Chapter 3 of Kakadu: Vulnerability to climate change impacts, pages 25–30 and Gundjeihmi Aboriginal Corporation https://www.mirarr.net/pages/kakadu

Fire Management

Traditional management of Kakadu included the use of fire. Patch burning (also known as mosaic burning and fire stick farming) was used to maintain a diversity of habitat conditions for species with differing requirements.

The academic paper *'Indigenous Wetland Burning: Conserving Natural and Cultural Resources in Australia's World Heritage-listed Kakadu National Park'* provides a case study of Aboriginal fire management of wetlands in the World Heritage-listed Kakadu National Park.

'In Kakadu, traditional ecological knowledge is being used in powerful combination with Western science to manage and monitor vital cultural and natural resources, leading to a dramatic enhancement of biodiversity and cultural values, and to a deeply enriched tourist experience.'

The arrival of non-Aboriginal people saw the Aboriginal population decrease. With fewer people on the land, less burning was carried out so hot, late dry season wildfires became more common. These hot fires were often large and destructive, changing the distribution of plants and animals. Since proclamation of the Park, traditional cool fire management practices have been used in the winter months to reduce the number of hot fires at the end of the dry season. Examples include:

- Firebreaks were burnt around fire-sensitive communities such as monsoon forest, sandstone heath and mature paperbark forest.
- Burning in the fire-sensitive stone country to reduce the amount of fuel along creeks
- Firebreaks burnt around art sites, buildings, camping areas and other permanent structures
- Parts of the park boundary are burnt to reduce the risk of fires entering or leaving the Park.
- Research and monitoring are integral to fire management in Kakadu.

Monitoring of the Park's fire-management program and its effectiveness involves ground observation, photographic points that show the effect of burning over time, and satellite mapping of fire scars.

Contemporary Management

Declaration of Kakadu as a National Park 1979

Kakadu was established at a time when the Australian community was becoming more interested in the declaration of national parks for conservation and in recognising the land interests of Aboriginal people. A national park in the Alligator Rivers region was proposed

as early as 1965 but it took until 1978 for the Australian Government to make arrangements to acquire the titles over various tracts of land that now constitute the Park. Kakadu was declared a National Park in 1979, Stage 2 added in 1984 and Stage 3 in 1987 with supplementary proclamations in 1989 and 1991. The most recent plan for the management of the national park covers the ten years from 2016 – 2026. Figure 9.

Listed as a World Heritage Area 1981

Kakadu was declared a World Heritage area in 1981, Stage 2 added in 1987 and the whole park in 1992. The international significance of the Kakadu region was based on criteria that recognised:

- significant ongoing geological processes, biological evolution and human interaction with the natural environment
- unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty
- species of plants and animals of outstanding universal value for science and conservation

The World Heritage Act is the legal instrument for implementing Australia's obligations under the World Heritage Convention. It aims to protect the values of the World Heritage property, including from impacts originating outside the property. Any action that has, will have, or is likely to have, a significant impact on the values of the World Heritage property, must be referred to the responsible Minister for consideration. Penalties apply for taking action without approval. The Act requires the preparation of management plans which set out the significant heritage aspects of the place and how the values will be managed.

Listed as a Wetlands of International Importance by the Ramsar Convention

This convention aims to stop the world from losing wetlands and to conserve, through wise use and management, those that remain. More than 90 countries are contracting parties to the Convention.

Wetlands are selected as Ramsar sites for the list of Wetlands of International Importance because of ecological, botanical, zoological or hydrological criteria. Wetlands in Kakadu were listed in stages in 1980, 1987 and 1996. In total 683,000 ha are listed as wetlands of international importance.

Other Treaties

Kakadu is also subject to international treaties for the protection of other wildlife and habitats. Kakadu wetlands are on the list of Wetlands of International Importance and Australia has entered into agreements with governments in China and Japan to protect the breeding and summer grounds of migratory birds.

Other agreements include:

- The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA). Forty-six of the 76 birds listed under this agreement are found in the park
- The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA). Fifty of the 81 birds listed under this agreement are found in the park
- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).
- Twenty-two of the species listed under this convention are found in Kakadu
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- The Convention on Conservation of Nature in the South Pacific (Apia Convention).

Management of Mining Activities

The Ranger Uranium Mine was one of the most highly regulated mines in the world. Regular testing of the tailings dam and more than 50 pieces of government legislation governed its operations. Regulations were backed up by a research program to ensure radioactive ore was mined and processed safely. The mine employed a large team of environmental officers. Remediation of the now defunct mine will take many years and careful management. Legislation prevented the development of the Koongarra, Jabiluka (Uranium) and Coronation Hill (Gold) mines.

Management of Feral Animals

- **Eradication of Buffalo**

  The removal of buffaloes from Kakadu National Park began in 1979. Of an estimated population of 20,000 buffaloes, it is thought that only a few hundred remain. The difficult nature of the country and the consequent costs make total eradication almost impossible. Since the reduction in buffalo numbers, degraded areas have recovered dramatically, there are fewer buffalo wallows, water in billabongs is clear, there is less salt intrusion, and plants such as red water lilies, grasses and sedge plants are reappearing.

- **Feral Pigs, wild horses, cats and dogs**

  Feral pig control work is conducted by park staff regularly. Feral pigs, wild horses, cats and dogs are shot by park staff on an opportunistic basis. Cats are not allowed to be kept as pets in Jabiru. Jabiru residents are allowed to keep up to two dogs within the confines of the township and park residents can keep dogs at the discretion of the Director of National Parks.

  In 2016 over 6,000 wild horses, buffalo, pigs and donkeys were killed in Kakadu national park as part of a new feral animal management plan negotiated with traditional owners the cessation of culling in 2009 and subsequent rapid increase in feral animals.

- **Cane Toads**

  Cane toads in the park are likely to be one of the most pressing management problems facing Kakadu in the coming decade. Currently there are no effective control measures available.

Management of Introduced Weeds

- **Salvinia**

  A biological control agent, the weevil Cyrtobagous salviniae, was introduced and effectively controls the weed in most years. A cycle of weevil population increase and salvinia decline and vice versa led the CSIRO to develop a management plan to closely monitor the weevil's effect. Floating booms are also used to contain salvinia, and occasionally a low-impact herbicide is used to prevent excessive build-up of the weed and reduce the chance of it spreading further.

- **Mimosa**

  Prompt action has meant that the Park is largely free of large mimosa infestations (it remains virtually an 'island in a sea of mimosa'). Control requires considerable resources, for example, since the 1980s four people have been employed full time in the Park to locate and destroy mimosa. Mimosa is controlled by pulling out or mattocking and by spraying. Seed Banks are burnt, and sites fenced to limit spread by animals. Several biological control organisms have been tried with little impact on mimosa populations.

- **Para Grass**

  Biological control is not an option at the moment since para grass is still being promoted as a valuable pasture grass for cattle outside the Park. Control involves pulling out small infestations.

  Tourists are encouraged to help prevent the introduction of weeds and minimise their spread by checking their vehicles, trailers and equipment before entering the Park, keeping to established roads and tracks, and not entering quarantine areas.

- **Crocodile Management**

  Crocodile management in Kakadu aims to minimise the danger of crocodile attack while ensuring the protection of crocodile populations. Park staff carry out surveys in all the major waterways to obtain data on distribution, numbers and size. If a particular crocodile's behavior is thought to be a potential threat to people, the crocodile is either captured, tagged and released (a process that makes crocodiles wary of people) or given to an Aboriginal community for food. The emphasis of Kakadu's crocodile management is to educate visitors about crocodiles and their dangers through brochures, signs and advice.

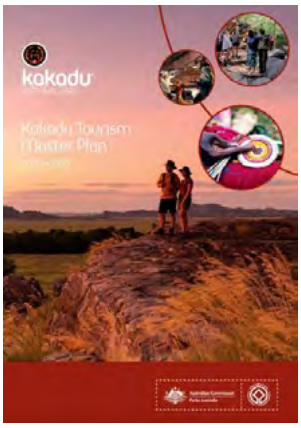
- **Tourism Management**

  Kakadu National Park Tourism Master Plan 2020 – 2030 contains details of plans to sustainably expand culturally appropriate tourism and maintain the cultural and environmental World Heritage values of the Park. Significant parts of this plan relate to tourism activities in the wetlands including tourism facilities such as visitor hubs, accommodation and boardwalks and visitor experiences such as billabong tours, crocodile watching and fishing. The plan is available on the Kakadu National Park website at https://parksaustralia.gov.au/kakadu/growing-tourism-in-kakadu/

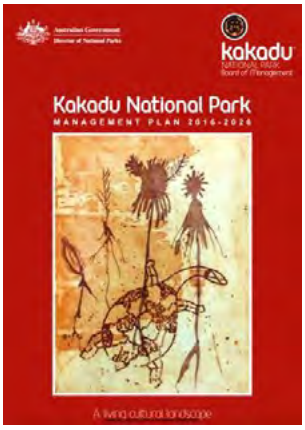
There are several tourism management tools employed by Kakadu National Park:

- Control of tourism by restricting the amount of accommodation. The Gadudju operate commercial enterprises including Gadudju Crocodile Hotel in Jabiru, Gadudju Lodge Cooinda Hotel-Motel, Yellow Water boat tours.
- Restricting access by not constructing roads or not sealing roads
- Education of tourists (e.g., Bowali Visitors Centre)
- Scheduling visitor use by regulating coach timetables
- Licensing of all commercial activities and accreditation of tour operators in the Park
- Restricting areas where fishing can take place
- Ban on fishing certain species (e.g., Barramundi)
- Restriction of boats and their speed to certain areas
- Protection of Rock Art with silicone drip lines to divert water from painted surfaces; the removal of wasp nests and vegetation and creating defined walking tracks, boardwalks, fences

Figure 9: Important management documents



Kakadu Tourism Plan https://www.environment.gov.au/system/files/resources/296f549b-b7f6-402a-b283-61ea58e57db4/files/tourism-brochure-summary.pdf



Kakadu National Park Management Plan 2016 – 2026. https://www.legislation.gov.au/Details/F2016L00002

EFFECTIVENESS OF MANAGEMENT

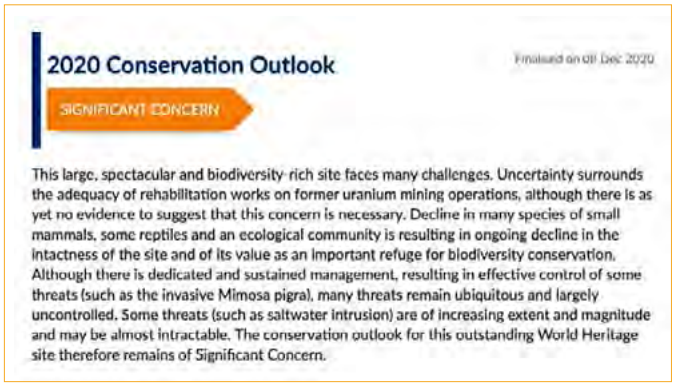
The quality of the park's management and protection has been widely recognised. However, recent reports are question the management of the national park and its World Heritage values.

In 2021 a Four Corners Program 'Crisis in Kakadu' drew attention to issues in the management of Kakadu National Park. The program contained accusations of mismanagement and neglect which have fuelled a bitter dispute between the park's traditional owners and the authority that runs the park.

ABC Four Corners: Kakadu in Crisis (2021) Source: https://www.youtube.com/watch?v=vT6Vlw6dMDc

On the IUCN World Heritage Outlook website:

- the **Conservation Outlook** for Kakadu National Park is shown as *Significant concern*
- For **Values** the current state is High Concern and the Trend – *Deteriorating*
- For **Overall Threats** the status is *Very High Threat*
- For **Overall Protection and Management**, the status is *Mostly Effective*



IUCN World Heritage Outlook. Source: https://worldheritageoutlook.iucn.org/explore-sites/wdpaid/2572

Key management issues

- **Tourism** –increased visitation as a result of World Heritage inscription. Visitors are encouraged to enjoy the park in ways that do not adversely affect its natural and cultural values
- **Mining** – management of abandoned uranium mining sites and monitoring the Ranger mine site. Rehabilitation programs to reduce the physical and radiological hazards of old mine sites.
- **Cultural sites** – work to conserve rock art sites from natural and chemical weathering due to increasing age and damage from water, vegetation, mud-building wasps, termites, feral animals and humans.
- **Introduced flora** – ongoing management to control and prevent the spread of introduced weeds (particularly Mimosa pigra and Salvinia molesta)
- **Introduced fauna** – removal of Asian water buffalo and the resulting restoration of affected ecosystems.

Additional threats to World Heritage values have emerged since 1991:

- **Climate change** – *saltwater intrusion* into freshwater ecosystems, changing fire seasons and regimes and an increased potential for spread of exotic flora and fauna. Park managers are implementing a climate change strategy for the park that recommends a range of adaptation, mitigation and communication actions to manage the anticipated consequences of climate change.
- **Decline of small mammals** across northern Australia – the causes of decline are unclear however initial theories suggest fire management regimes, feral cats and introduction of disease as the likely causes; and
- **Cane Toads** – rapid colonisation by cane toads. Monitoring programmes are in place to determine cane toad distribution and the impacts on native wildlife within different habitats of the park. There are no known methods to manage populations of cane toads over large areas; however, the Australian Government is undertaking research into potential control and adaptation options.

COMPLETE STUDENT ACIVITIES 5 Appendix 2

GTANSW & ACT Support for teachers in 2021

- Annual Conference May 13 and 14, Stadium Australia. See Conference website **HERE**
- Scholarships to attend the Annual Conference
- Webinar Program staring Term 2. See page 22
- Online Learning Courses for flexible, affordable professional learning.
- Geography Bulletin – 4 Editions plus 1 Special HSC Edition
- Geography Bulletin Guide to assist in finding resources **HERE**
- Classroom Posters and activities via GTA NSW & ACT website **HERE**
- Young Geographer Awards. See page 4
- Ask a question via the GTA NSW & ACT website button at the bottom of the homepage **HERE**
- Facebook Page **HERE**
- Facebook Groups –Teachers of HSC Geography in NSW and Primary Teachers
- Scoop.it Ten topic pages for Geography K –12.

GTA NSW&ACT Webinars in 2021

In 2021 the webinars will be co-ordinated by a small team: Susan Caldis, David Latimer, Alex Pentz and Beck Sutcliffe.

Due to recent changes in accreditation processes, the webinars will be available as 'Elective PD' to complete as part of your ongoing professional learning. As greater clarity and certainty emerges about accreditation of professional learning, the webinar team will take steps to ensure accreditation of the program is possible.

Webinars will operate in Terms 2, 3 and 4, between 4.30pm – 5.30pm and cost $20 (members and non-members).

The webinar team are excited to announce two concurrent themes to the webinar program:

- **From the Academy**, where Geographers from universities around Australia will present their research, with pre-reading, in alignment with a syllabus focus; and
- **From the classroom**, where Geography teachers (and perhaps their students!) will share their practice, spark curiosity, and prompt dialogue amongst practitioners. A call for presenters was issued recently via social media

Coming soon!

Although dates are to be confirmed and further information will be available shortly, we are delighted to announce the following program so far:

- Chris Betcher, Program Manager, Google for Education, will be the first presenter for the 'From the Classroom' series, and he will present about Google's Geo tools.

Presenters for the 'From the Academy' program will include:

- Professor Sue Jackson and Dr Lana Hartwig, from the Australian Rivers Institute, Griffith University, QLD will share their research findings about Indigenous water management in south-eastern Australia (April 22, registrations to open soon)
- Dr Susannah Clement and Dr Carrie Wilkinson, Australian Centre for Culture, Environment, Society and Space (ACCESS), University of Wollongong, NSW; Founder of 'Geographers Declare….A climate emergency?'
- Dr Dallas Rogers, School of Architecture, Design and Planning, University of Sydney, NSW; Founder of City Road Podcast
- Associate Professor Fiona Miller, Associate Professor Donna Houston, Dr Jessica McLean, Discipline of Geography and Planning, Macquarie University, NSW; Shadow Places Network

An exciting year is ahead for the webinar program and we look forward to your participation.

CONNECTING TOPICS: DEFORESTATION and NATURAL CYCLES

Lorraine Chaffer

SOURCE 1: Deforestation in Borneo and Sumatra

Source: https://awfborneoproject.files.wordpress.com/2012/02/pie-chart2.jpg

ACTIVITY 1: Describe the trends in deforestation between 1985 and 2020. Refer to absolute losses and % change.

SOURCE 2: Forest Fires in Indonesia

Source: Global Forest Watch https://theaseanpost.com/article/return-indonesias-forest-fires

ACTIVITY 2: Draw conclusions about forests and forest fires on three different Indonesian islands from careful observation of Source 2. Refer to a map to name the three islands.

SOURCE 3. Rainforest Deforestation

ACTIVITY 3

a. **Create** an appropriate heading for each of the following photographs.

b. Annotate each photograph with relevant information and ideas about rainforests, the atmosphere, hydrosphere, lithosphere and biosphere. Refer to water, carbon and biodivesity where appropriate.

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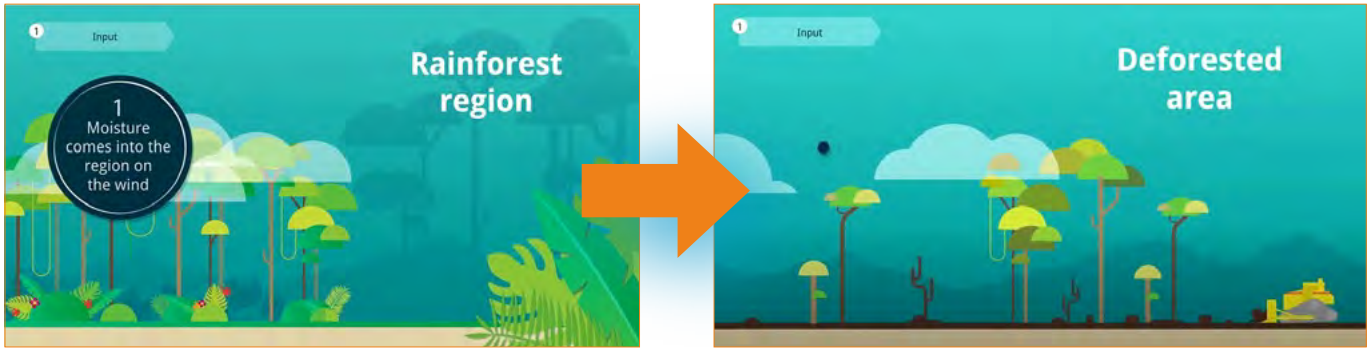
Images: Shutterstock and Greenpeace Source: https://www.greenpeace.org.au/what-we-do/protecting-forests/forests-indonesia/palm-oil/

SOURCE 4: Tropical Deforestation and The Water Cycle

Watch the animated film illustrating the impact of deforestation weather, climate and flood risk in local and downstream areas.



Film https://www.metlink.org/resource/rainforest-deforestation-the-carbon-water-cycles/

ACTIVITY 4: Write a voiceover for the film, demonstrating your understanding of the concepts involved.

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- **Record** your voiceover to play to another student in your class.
- **Listen** to feedback and adjust your script.

ACTIVITY 5: Complete the following sentence based on the film (cross out the wrong information).

When rainforests are deforested, places downwind are left with ***more/ less/ the same amount*** *of rainfall and* ***greater/ less/ the same amount*** *of flood risk.*

ACTIVITY 6:

a. **Look at** www.globalforestwatch.org/map and identify a Tropical region which has experienced deforestation in the last decade. .....

b. **Look a**t earth.nullschool.net. What is the prevailing wind direction in that region? .....

c. **Refer to** www.google.com/maps to write a paragraph explaining how you think the water cycle has been affected by deforestation for a place downwind from the rainforest region you identified.

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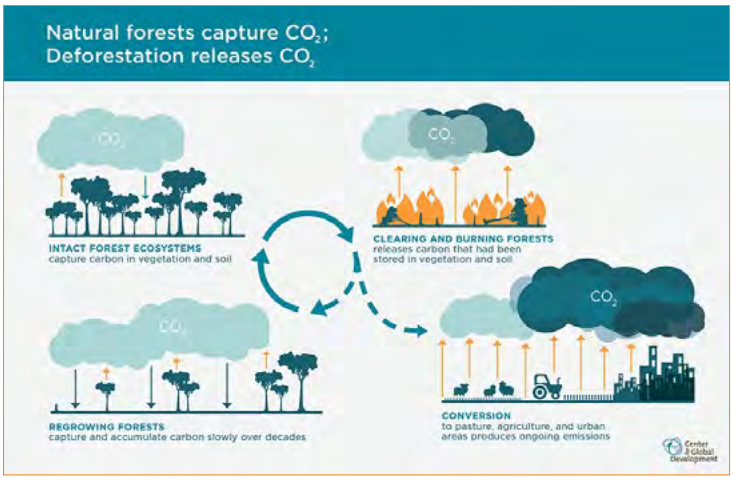
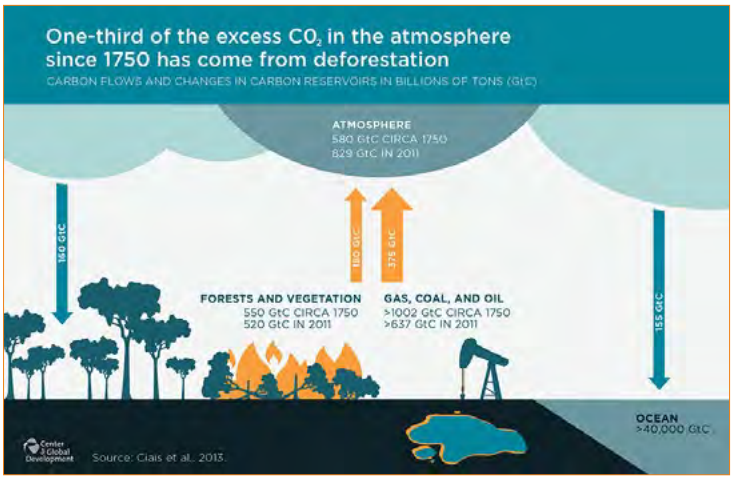
Questions adapted from https://www.metlink.org/resource/rainforest-deforestation-the-carbon-water-cycles/

SOURCE 5: Deforestation and the Carbon Cycle

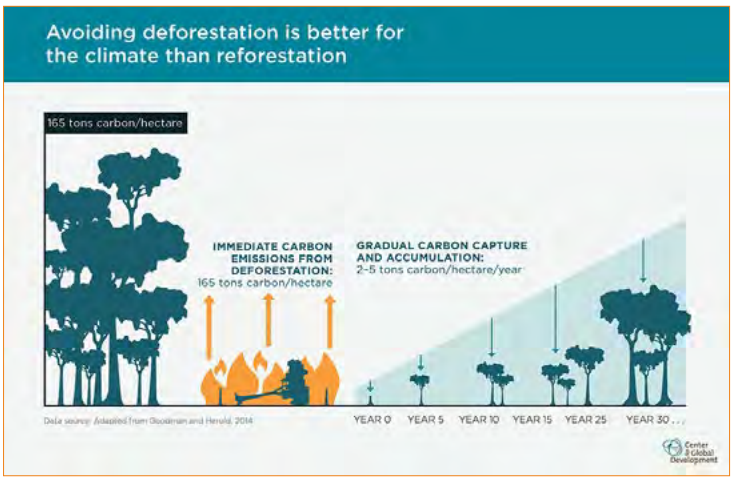
ACTIVITY 7: Justify the heading used for each diagram using the information illustrated.



Source: https://www.cgdev.org/sites/default/files/WFWN/natural-forests-capture.jpg



Source: https://www.cgdev.org/sites/default/files/WFWN/one-third-carbon.jpg



Source: https://www.cgdev.org/sites/default/files/WFWN/avoiding-deforestation-better.jpg

ACTIVITY 8:

a. **Revisit –** Activity 3 and add to your annotations based on what you learned doing activities 4 to 7.

b. **Summarise** the impact of tropical deforestation on the carbon and water cycles.

- Use original diagrams in your answer.
- Give each diagram a heading, appropriate labels and reference in your summary.

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.

Books for review should be sent to:

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PO Box 699
Lidcombe NSW 1825

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