2021 Volume 53 Special Edition Appendices 1 – 4

Appendix 1: Kakadu Wetlands STIMULUS

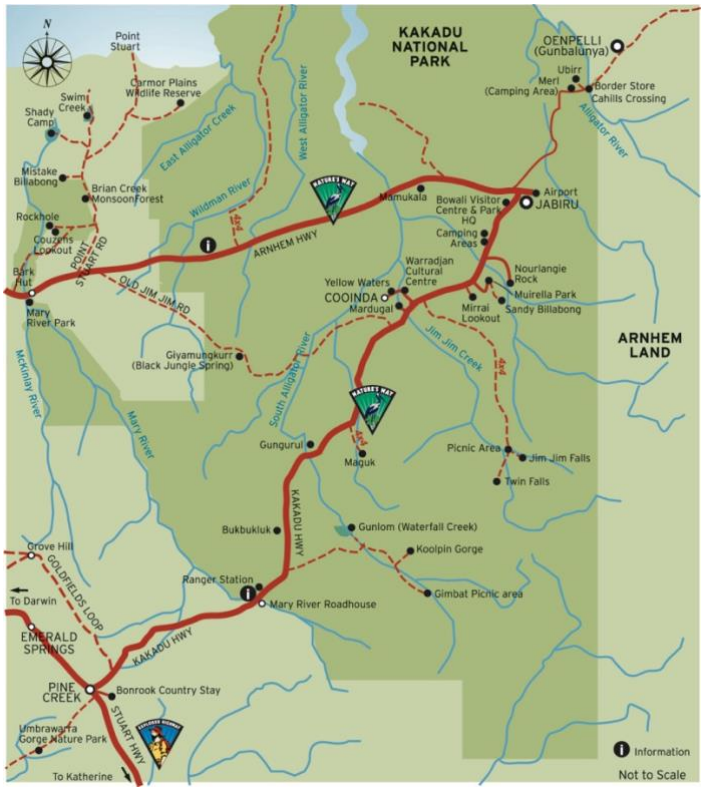
Appendix 2: Kakadu Wetlands STUDENT ACTIVITIES

Appendix 3: Carbon Cycle and Climate Change Worksheet.

Appendix 4: Carbon Cycle and Climate Change. Suggested answers. Worksheet

APPENDIX 1: KAKADU WETLANDS

Source 1: Kakadu National Park Tourist map

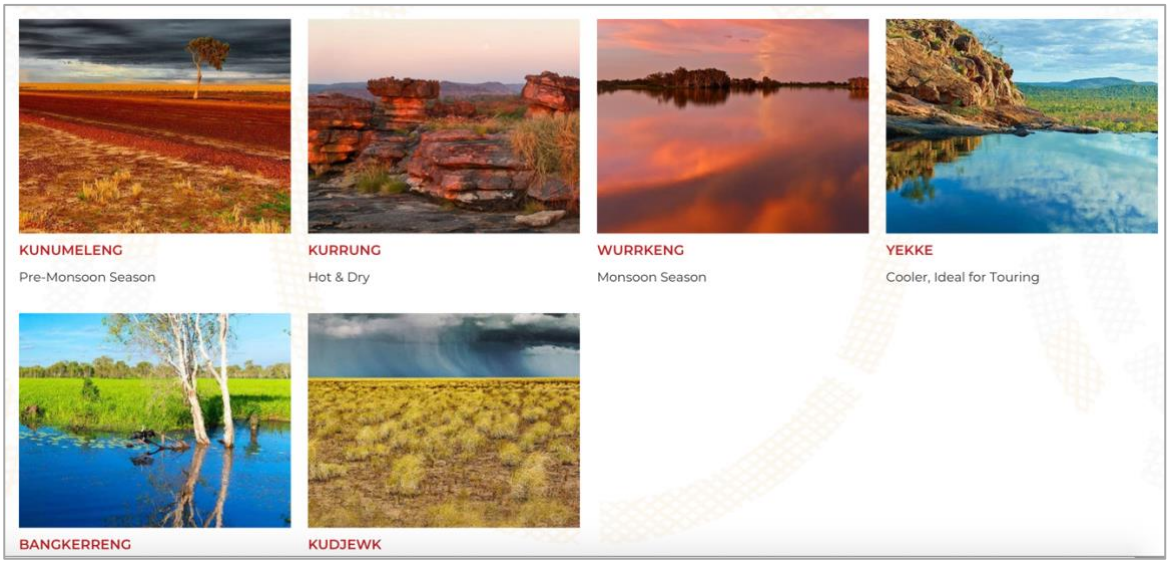


Source: https://www.kakadutoursandtravel.com.au/info/kakadu-national-park-map/

Source 2: Kakadu Ngurrungurrudjba-Yellow-Water-Seasons Calendar

Source: https://www.nespnorthern.edu.au/wp-content/uploads/2016/10/Ngurrungurrudjba-Yellow-Water-Seasons.pdf

Source 3: Landscape changes with the seasons in Kakadu



Images from Kakadu Tourism
https://kakadutourism.com/seasons/

Source 4: Gardening Australia in Kakadu

Costa Georgiadis and Millie Ross visit Kakadu in **Yegge**, 'a short season of cooler weather, indicated by the flowering of many important species. The billabongs are covered in waterlilies, which are collected for their bulbs – the seeds can be mashed up to make damper.

Screen capture from Gardening Australia SERIES 29 | Episode 27

'*When the Andjalen or woollybutt (Eucalyptus miniata) start flowering, it indicates it is time to start* ***patch-burning*** *the country. Burning has been used for millennia. The rangers aim for cool fire, which is slow moving and allows trees to hold onto their leaves, animals have time to move, and the morning dew puts the flames out. Hot fires are avoided because many creatures, such as lizards and even some rare insects and plants, don't recover'.*

'Plants develop adaptations to dry times. Becoming deciduous and or dormant is a characteristic more commonly associated with northern hemisphere winters, but also happen to the Kapok tree through the driest months, just as the bright yellow flowers emerge. The Bininj people from the north of Kakadu have many uses for this plant, such as eating the flowers raw or cooked and using the roots of the young plant as a food source between September and December. Kapok (Cochlospermum fraseri) is used for ceremonial body decorations and the bark of the tree can be used to make string and paint brushes.'

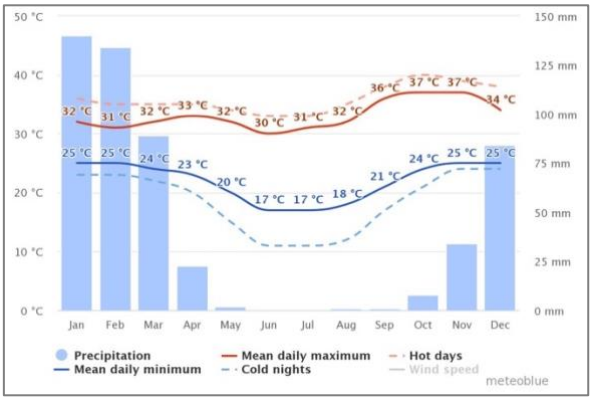
Source Gardening Australia https://www.abc.net.au/gardening/factsheets/kakadu/10043804

Source 5: KAKADU CLIMATE

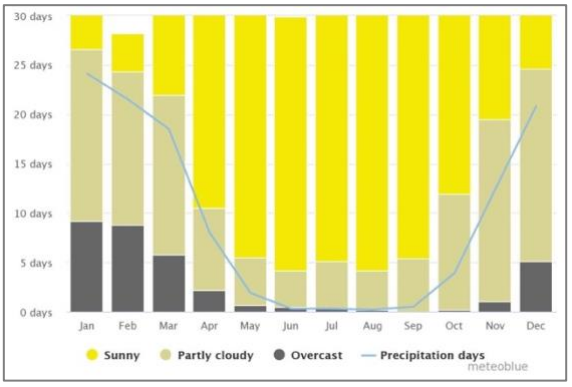
Kakadu National Park, Northern Territory, Australia, 13.04°S 132.44°E, 53m asl

The **meteoblue** climate diagrams are based on 30 years of hourly weather model simulations and available for every place on Earth. They give good indications of typical climate patterns and expected conditions (temperature, precipitation, sunshine and wind).

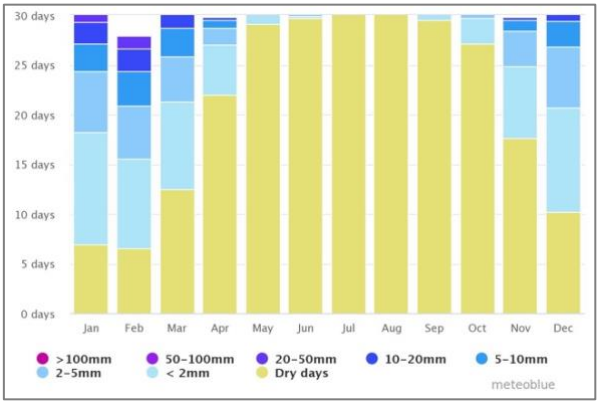
Graph 1: Average temperatures & precipitation



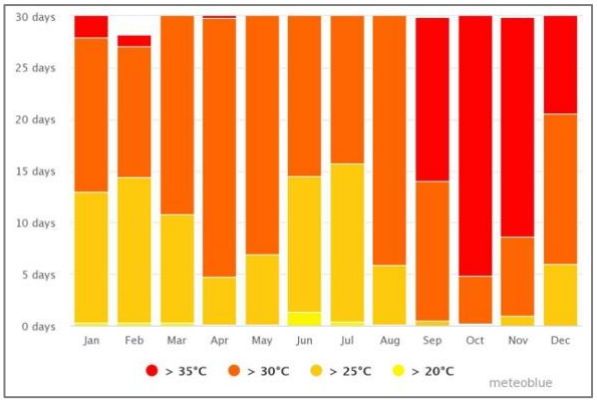
Graph 2: Cloudy, sunny and wet days



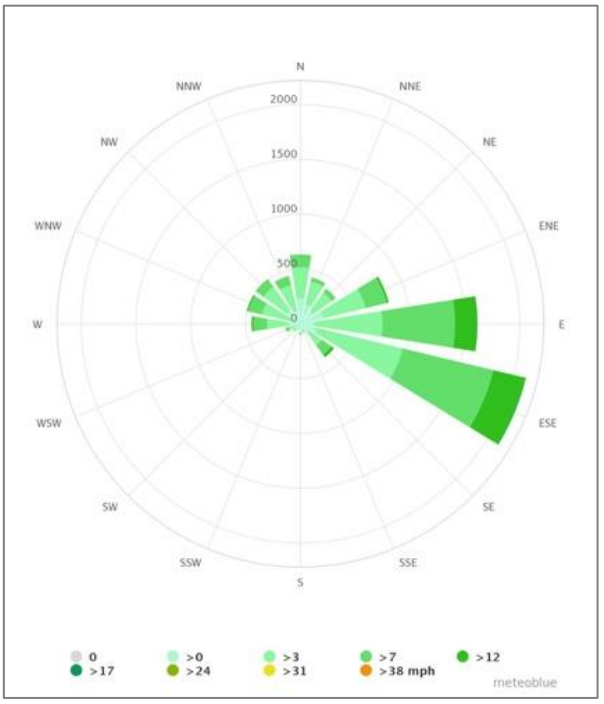
Graph 3: Precipitation amounts



Graph 4: Maximum temperatures



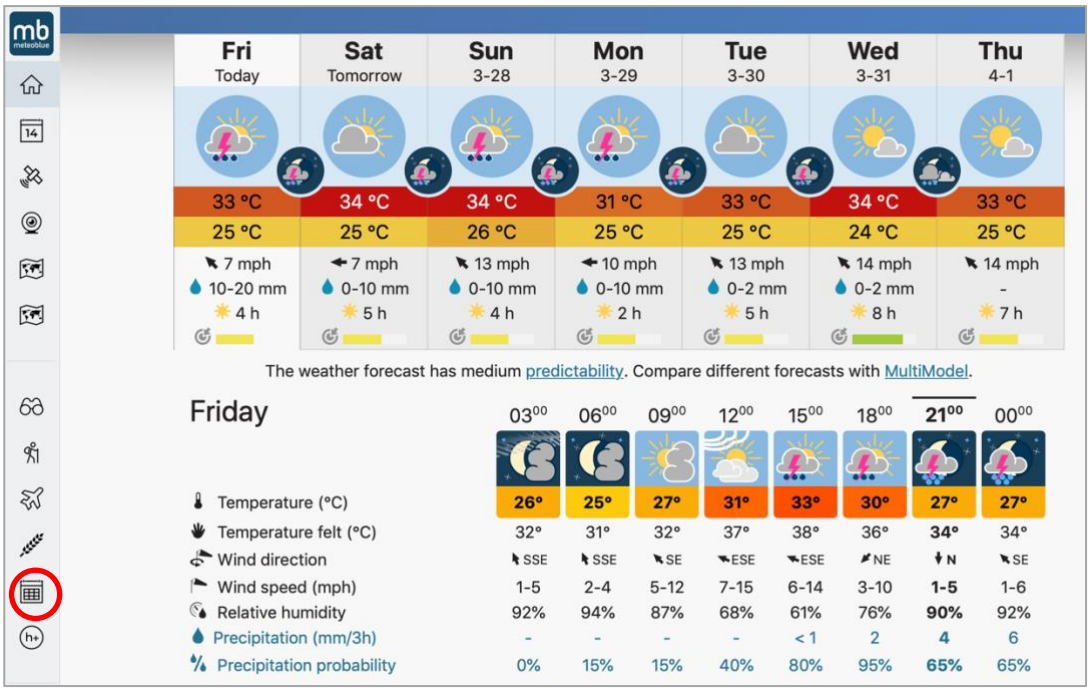
Graph 5: Wind rose

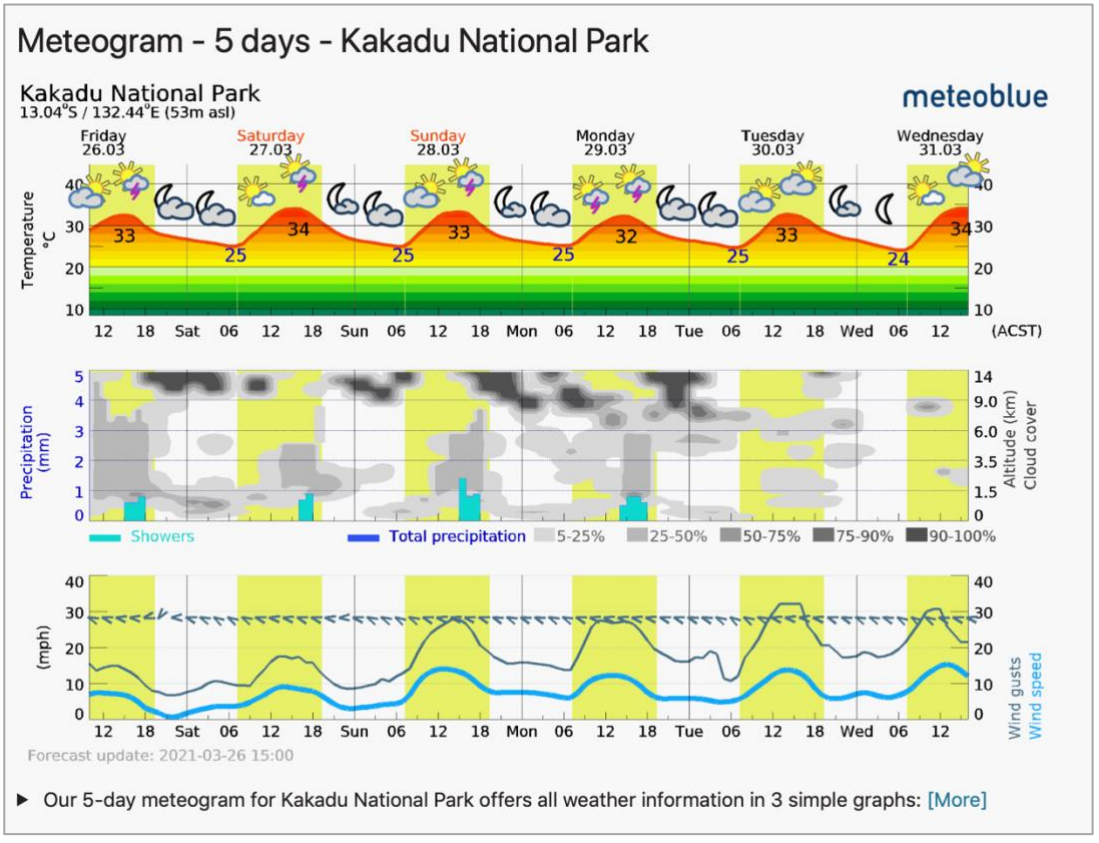


The wind rose shows how many hours per year the wind blows from the indicated direction.

Source 6: KAKADU WEATHER

Weather forecasts from meteoblue March 26, 2021





https://www.meteoblue.com/en/weather/week/kakadu_australia_8348394

Source 7: Kakadu wildlife

For more photos of the biosphere at Kakadu National Park visit the website

Source 8: Wet Season / Dry Season

The dry season is peak tourist season when it is safe to swim in upstream waterholes where crocodiles have migrated downstream or been removed.
Source: https://venturenorth.com.au/northern-territory-tourism-blog/when-is-the-best-time-to-visit-kakadu/

Source 9: Kakadu primary producers

	**Paperbark** Tall, dense stands of paperbark trees grow on the margins of Magela Creek, Yellow Water, Anbangbang billabong and other floodplains and permanent waterholes. The dominant species are the broad-leafed and weeping paperbarks. Freshwater mangroves and water pandanus are also common
	**Blue lily Nymphaea violace a Barradjungga** Commonly seen along the margins of billabongs. Its violet-tipped white flowers appear between January and July. The seeds and stems can be eaten raw; the tuberous underground bulbs can be eaten after cooking.
	**Freshwater Mangroves** Mangroves are common along the banks of tidal creeks and rivers. Thirty-nine of the forty-seven Northern Territory species of mangrove occur in Kakadu. Mangroves are important for stabilising the coastline and serve as feeding and breeding grounds for many animals, including fish such as barramundi.
	**Red lily Nelumbo nucifera Wurrmarninj** Grows in lowland wetlands. Its leaves are very large and stand erect above the water. Large, fragrant deep-pink flowers appear between March and November
	**Pandanus** Gonggirr is the most common of the three species of pandanus found in Kakadu. It is easily recognised by its 'cork-screw' leaf arrangement. The dead leaves hang in skirts, providing a sanctuary for wrens, bats, mice and lizards. The ripe orange fruits are a favourite food of sulphur-crested cockatoos. Aboriginal people use the leaves of this pandanus for weaving baskets and mats. The large clusters of woody nuts, madjamairerri, contain seeds that are eaten raw or roasted.
	**Speargrass** This tall grass lines Kakadu's lowlands in the late tropical summer (February-March), when its flower spikes can grow up to 4 metres high. It gets its name from the spear-like shape of its sharp, pointed seeds. These seeds are harvested by ants and provide an important food source for birds such as finches. In Banggerreng time, around April each year, the 'knock em down storms' arrive and flatten the speargrass ahead of another dry season.
	**Kapok** A small native tree with beautiful yellow flowers appearing in the dry season as the plant loses its leaves. The flowers develop into green capsules, then harden and turn brown. The capsules split open to release a cotton wool-like material called kapok to which the seeds are attached. Aboriginal people used Andjedj, eating the flowers raw or cooked, the roots of young plant as a food source (September and December), Kapok for ceremonial body decorations and bark for string and paint brushes.
	**Darwin Wollybutt (Andjalen)** A common tree in Kakadu – with dark woolly bark on the lower half of the trunk, and smooth white bark on the upper trunk and branches. It is known as Andjalen. This is a calendar tree – a tree that helps Aboriginal people determine the season and what they need to do. At the beginning of the cold dry season (May-June) the woollybutt produces spectacular orange flowers signaling the time to start lighting fires, to 'clean up the country' and prevent intense wildfires late in the dry season.

WEBLINKS

Kakadu National Park Ramsar Site Ecological Character Description
https://www.environment.gov.au/system/files/resources/72c10ebd-7eeb-4841-89ab-a5004052f2ae/files/2-ecd.pdf -

Kakadu Ngurrungurrudjba-Yellow-Water-Seasons Calendar
https://www.nespnorthern.edu.au/wp-content/uploads/2016/10/Ngurrungurrudjba-Yellow-Water-Seasons.pdf

New World Encyclopedia
https://www.newworldencyclopedia.org/entry/Kakadu_National_Park

https://naturalworldheritagesites. org/sites/kakadu-national-park/ – Natural World Heritage sites
https://sites.google.com/a/miamioh.edu/geo121s18/home/kakadu-np-05

Kakadu: Vulnerability to climate change impacts (Chapter 3)
https://www.environment.gov.au/system/files/resources/b2915be6-16e4-4cb3-8533-471ed879bfc1/files/kakadu-coast.pdf

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

Gundjeihmi Aboriginal Corporation
https://www.mirarr.net/pages/kakadu

Conserving Kakadu
https://www.environment.gov.au/topics/national-parks/kakadu-national-park/management-and-conservation/conserving-kakadu

End of mining operations at Ranger Uranium mine.
https://gac-v3.katalyst.com.au/news_items/cessation-of-mining-operations-at-ranger-uranium-mine

Closure and rehabilitation of Ranger Uranium mine
https://www.environment.gov.au/science/supervising-scientist/ranger-mine/closure-rehabilitation

Indigenous Wetland Burning: Conserving Natural and Cultural Resources in Australia's World Heritage-listed Kakadu National Park
https://www.researchgate.net/publication/226721117_Indigenous_Wetland_Burning_Conserving_Natural_and_Cultural_Resources_in_Australia%27s_World_Heritage-listed_Kakadu_National_Park

Kakadu aerial cull kills more than 6,000 horses, buffalo and pigs
https://www.theguardian.com/australia-news/2017/mar/17/kakadu-aerial-cull-kills-more-than-6000-horses-buffalo-and-pigs

Ranger calls it a day
https://www.afr.com/companies/mining/kakadu-s-most-controversial-ranger-calls-it-a-day-20210107-p56sim

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

Tourism master plan 2020 - 2030
https://parksaustralia.gov.au/kakadu/growing-tourism-in-kakadu/

Kakadu wildlife
https://www.thewildlifediaries.com/kakadu-animals/

Kakadu board pushes vote of no confidence against park director
https://www.abc.net.au/news/2020-07-04/kakadu-no-confidence-vote-against-parks-management/12421666

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

APPENDIX 2: STUDENT ACTIVITIES

STUDENT ACTIVITIES 1

Compose an introductory paragraph for a generic extended response on Kakadu.
Use the 'Introduction' and 'Spatial Patterns and Dimensions' sections to complete this.

Spatial technology and mapping

Visit Kakadu National Park in Google Earth and /or Google Streetview.
Follow the rivers, identify areas of wetland and describe their continuity.
Do the images portray the wet season or the dry season? Use evidence to justify your answer.
Use Source 1 in Appendix 1 to create a precis map of the KNP drainage pattern (river network) and shade areas where wetlands would be located.

STUDENT ACTIVITIES 2

- Discuss why precipitation is so important in Kakadu?
- Describe Kakadu's distinctive weather pattern.
- Distinguish between hydrological and geomorphic processes.
- Describe what is driving the hydrological and geomorphic processes in Kakadu?
- Outline the major landforms formed as a result of these processes?
- Briefly describe the hydrological processes of Kakadu.
- Outline the difference between weathering, erosion, transport and deposition. How is Kakadu affected by each of these processes?
- Examine how changes in geomorphic and hydrologic processes impact on Kakadu?
- Define biogeography.
- Outline the important role that termites play in an ecosystem such as Kakadu.
- Define: Invasion and Succession
- Distinguish between a pioneer species and a secondary species?
- Explain why mangroves are considered a secondary species?
- List three natural stresses occurring in Kakadu and describe adjustments in response to this stress.

EXRENDED RESPONSE: With reference to at least ONE ecosystem you have studied, explain the biophysical interactions which lead to diverse ecosystems and their functioning. (2002 HSC).

STUDENT ACTIVITIES 3

- Provide an example of three different levels of change occurring in Kakadu.
- Describe the process involved in the trophic pyramid.
- Define dynamic equilibrium.

EXTENDED RESPONSE: Compare the nature and rate of change that affect the functioning of TWO different ecosystems at risk. (2008 HSC).

STUDENT ACTIVITIES 4

- Outline two positive impacts humans have had on Kakadu National Park.
- Outline two examples of feral introduced animals in Kakadu National Park that have had a negative impact.
- Outline two examples of introduced weeds in Kakadu National Park that have had a negative impact.
- Explain how tourism can be a negative impact on Kakadu?
- Describe the impact that uranium mining has on Kakadu National Park.
- Describe the impact of global warming on Kakadu National Park.

EXTENDED RESPONSE: Assess the impact of humans on the functioning of TWO ecosystems at risk. (2013 HSC)

STUDENT ACTIVITIES 5

- Outline the role of the Aboriginal community as managers of the land in Kakadu.
- Explain how the arrival of non-Aboriginal people affected the use of fire as a management tool?
- List and explain 4 examples of traditional fire management practices used today.
- In which year was Kakadu declared a national park?
- In which year was Kakadu declared a World Heritage area? What was the decision based on?
- Outline the aim of the Ramsar Convention?
- In which year was Kakadu listed as a Wetlands of International Importance by the Ramsar Convention?
- Briefly explain how mining activities were managed in Kakadu National Park.
- Explain how two different feral animals are managed in Kakadu National Park.
- Explain how two different introduced weeds are managed in Kakadu National Park.
- Describe the aim of crocodile management in Kakadu? Explain how this is carried out?
- List and outline 5 tourism management tools employed by Kakadu National Park.
- Watch the Four Corners report "*Kakadu in Crisis'* and identify issues that relate directly to the Kakadu wetlands.
- Has management in Kakadu achieved the *Vision for Tourism* stated below.
- Evaluate the success of management strategies used to protect the cultural and environmental values of the Kakadu wetlands.

EXTENDED RESPONSE: Evaluate the impact of both traditional and contemporary management strategies on TWO ecosystems at risk. (2012 HSC)

SKILLS ACTIVITIES: Weather and climate

USE Sources 5 and 6 in Appendix 1

1. Explain the difference between weather and climate.
   Refer to sources 5 and 6 as examples in your answer.

Source 5 - Graph 1

2. Describe the Annual Rainfall Distribution
3. Calculate the Average Annual Rainfall.
4. Calculate the average temperature of the hottest and coldest months
5. Calculate the Annual Temperature Range

Refer to Source 5 - Graph 1 and Graph 2

6. Explain the relationship between rainfall distribution, cloudiness and sunshine.

Refer to Source 5 – Graph 3 and Graph 4

7. How many days in January received less that 2mm of rainfall?
8. What % of days in December received over 10 mm of rainfall?
9. Calculate the % of days in October that were over 35 degrees C.
10. Suggest a reason why there are more hot days in October than November and December

Refer to Source 5 – Graph 5

11. State the three directions from which most winds blow at Kakadu.
12. State the number of hours wind blows from the East South East
13. Calculate the % of South Southeasterly winds that were over 12 miles per hour.
14. Convert the answer to Q13 to kph (12 mph = 19.31 kph)

Refer to Source 6

15. Describe the weather forecast for Kakadu NP on March 28th, 2021
16. List the weather features included in a Meteogram.

Visit the Meteoblue website at
https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/kakadu-national-park_australia_6941907

Use the HOME SYMBOL on the left-hand menu to select the current 7 day forecast for Kakadu. Compare the forecast now to that of the week beginning March 28th, 2021.

Identify the season for each forecast period (now and march). Choose from:

- Wet season
- Start of wet season / End of dry season
- End of wet season / Start of dry season
- Dry season

Justify your choice using statistical evidence from each forecast

THE CARBON CYCLE and CLIMATE CHANGE WORKSHEET

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 can 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. _____

B. Poster Pack Activities (Teamwork)

Team members: _____

1. Agreed definitions

   Phytoplankton:

   Photosynthesis:

   Respiration:

   Hydrocarbon:

   Combustion:

   Calcium carbonate:

   Carbonic acid:

   Chemical weathering:

   Subduction (crustal):

   Gigaton:

   Reservoir:

   pH:

   Anomaly:

COMPLETE QUESTIONS 2 and 3 ON A BLANK PAGE

2. Draw a diagram of the natural carbon cycle without using any resources. Label each sphere on the diagram - atmosphere, lithosphere, biosphere and lithosphere.

3. Each team member in turn will visit the large carbon cycle poster and return 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 following worksheet questions.

Refer to the **Carbon Reservoirs** poster.

- List the global storages of carbon from highest to lowest stores.

_____

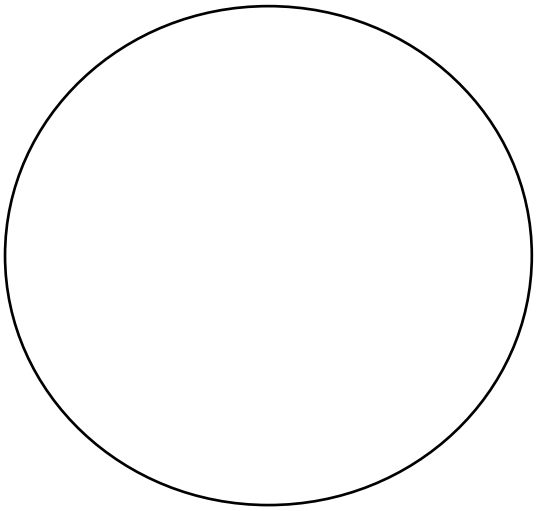
_____

- 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)



Key	Reservoir	Gts	% of total Carbon	Degrees
	Earth	Total =	100%	360 degrees

- Identify two sources on carbon in the biosphere.

- Calculate the total amount of atmospheric carbon in another 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 4 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?

- 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) and the impact of the change identified?

- 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, Reliability and Usefulness of the information in this poster.

_____

_____

_____

_____

_____

4. Add at least one human change to each sphere on your Carbon Cycle Diagram

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.

Explanation: The Carbon Cycle and Climate Change

SUGGESTED ANSWERS (with some explanation)

A. True and False

1. **True**. Carbon is the foundation of all life on Earth, required to form complex molecules like proteins and DNA

2. **False**. The amount of carbon does not change, however, where the carbon is located is constantly changing via the Carbon Cycle.

3. **False**. Most Carbon is stored in rocks and sediments.

4. **True.** The ocean is a carbon sink. Carbon is circulated between the oceans and atmosphere and can be is stored for a long time in the deep ocean. As a storage, oceans hold about 50 times more carbon than the atmosphere. Too much carbon lowers the ocean's pH which impacts marine organisms.

5. **True**. Carbon dioxide is an important greenhouse gas, helping Earth's atmosphere to retain heat from the Sun. Too much carbon dioxide going into the atmosphere can lead to a planet that gets unnaturally hot – Enhanced Greenhouse Effect.

6. **True**. Natural processes in the lithosphere move carbon between storages. Erosion releases carbon back into the atmosphere slowly and volcanic activity releases it quickly. This movement of carbon from storage to storage is the carbon cycle. Other natural processes transferring carbon are respiration and photosynthesis.

7. **True**. Hydrocarbons are compounds comprising Hydrogen and Carbon atoms. Oil and gas are hydrocarbons formed through natural processes.

8. **True**. Natural processes move carbon from the atmosphere into the biosphere through food chains via photosynthesis. Another example of natural processes is the trapping of dead plants and animals over time through geologic processes such as deposition, trapping carbon in the lithosphere. For millions of years natural processes effectively recycled carbon through the carbon cycle.

9. **Partly false**. Carbon reduction technologies are both experimental and existing solutions to removing carbon from the atmosphere. Examples of experimental technologies include those capturing and storing carbon through geoengineering such as turning carbon into rock and blue hydrogen. An example of an existing technology used the remove carbon from the atmosphere is carbon sequestration into soils and biomass (plants).

10. **Personal response**