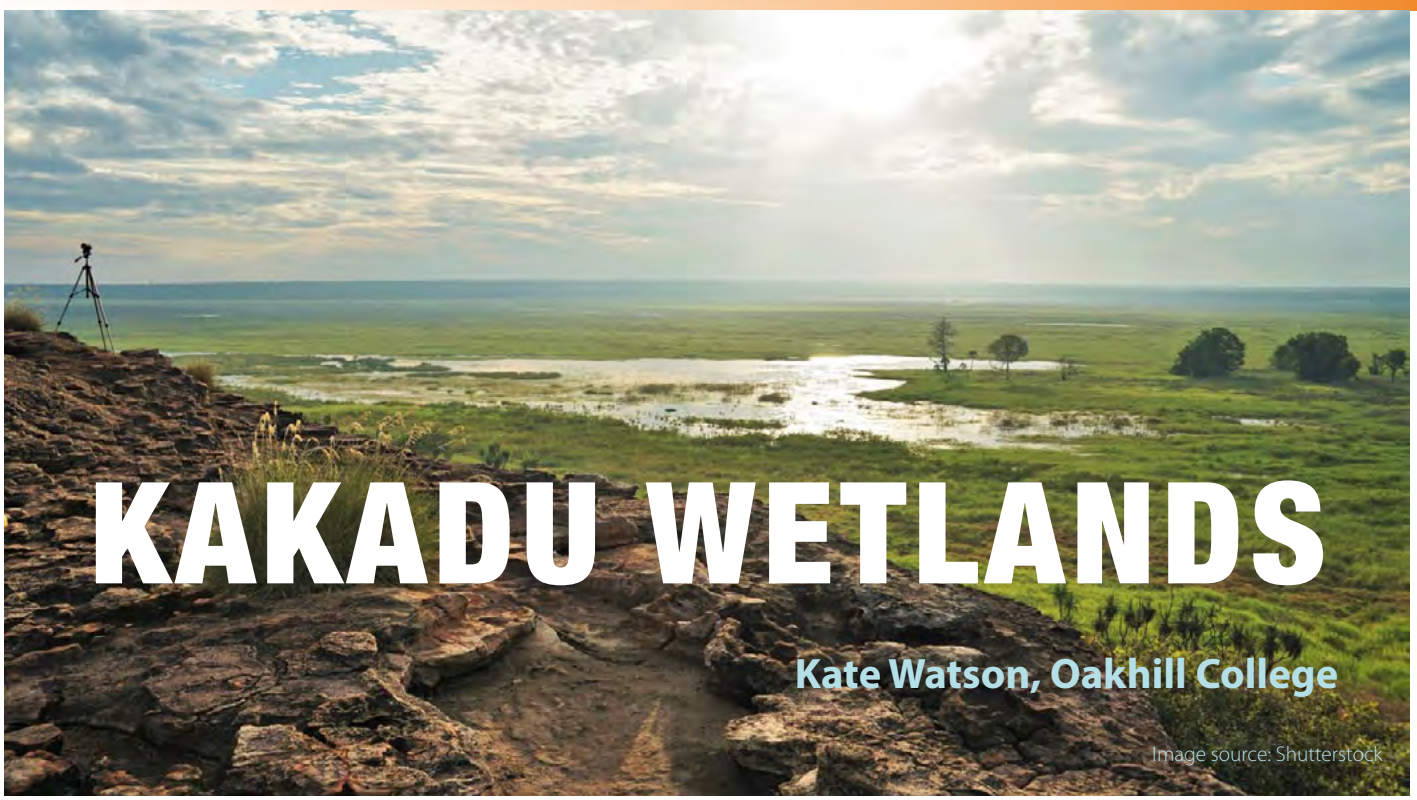


KAKADU WETLANDS

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

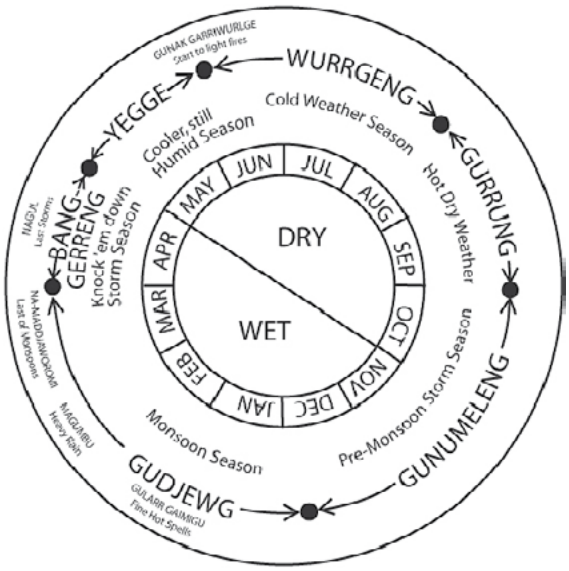
'Local Aboriginal people (Bininj) see six seasons with distinct weather and biological patterns.

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

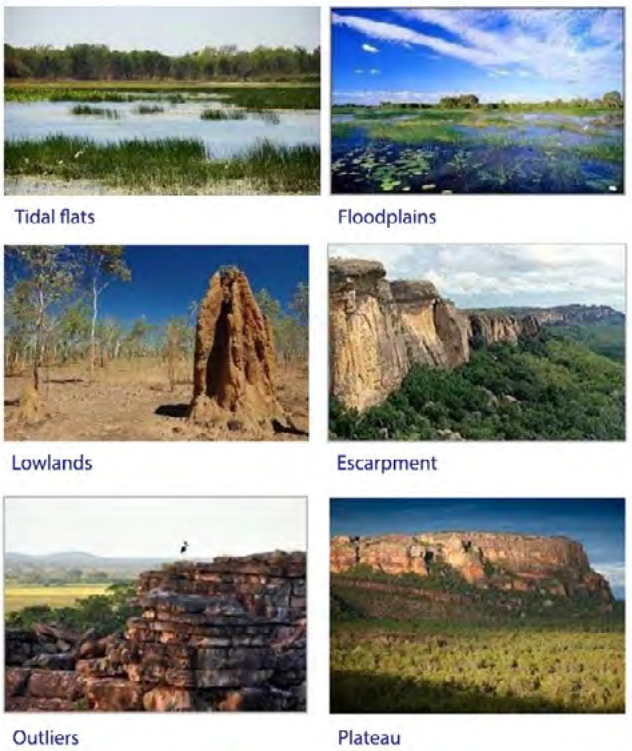
The hydrology (water) of the park is characterised by the drainage systems of the main rivers. Most floodplain areas are under water for up to four months each wet season. Many billabongs and smaller water bodies along a river line last throughout the dry season. As water

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.*

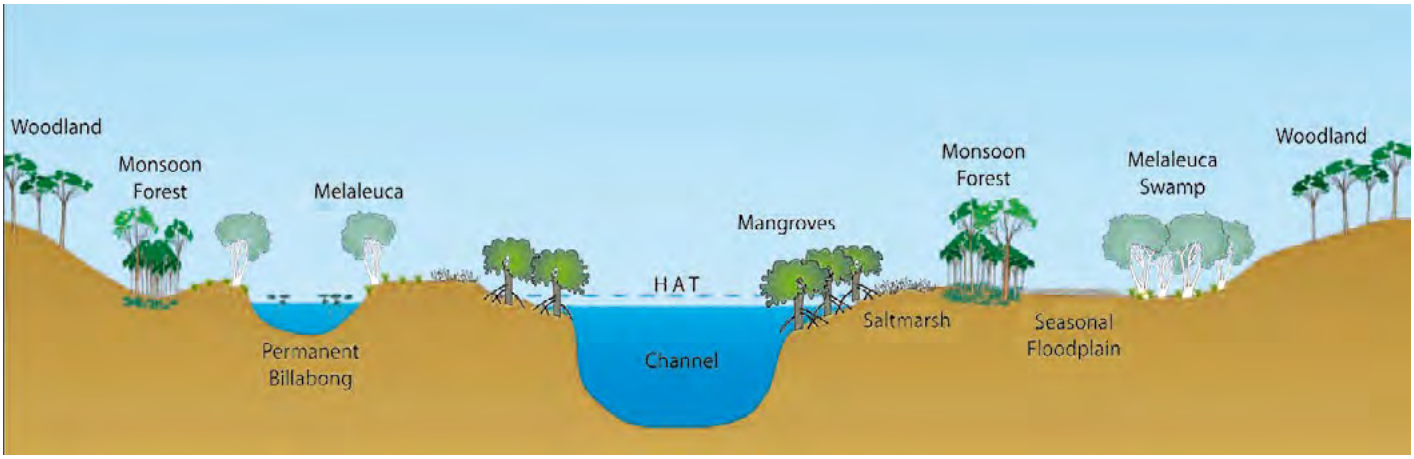
Ecosystem Functioning: Biosphere

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		

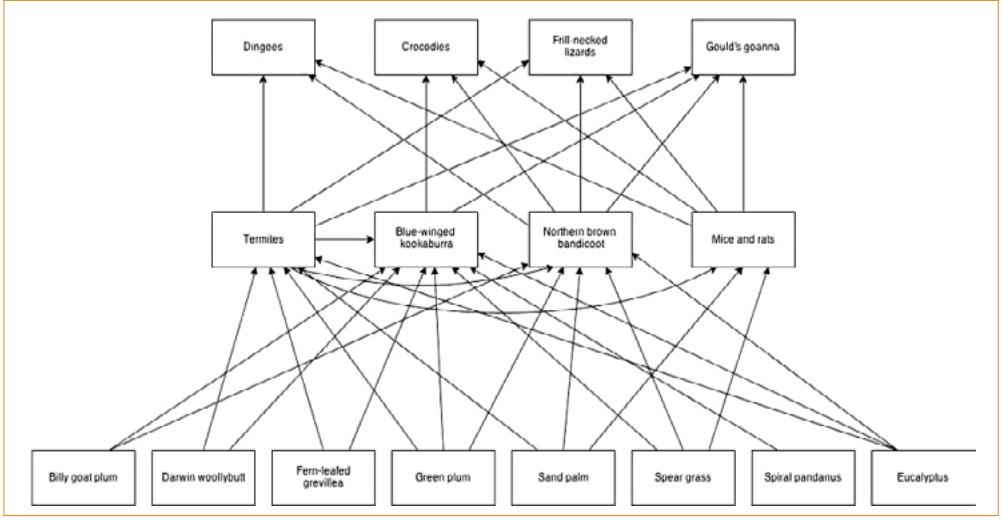
Keystone Species: Termites

*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.

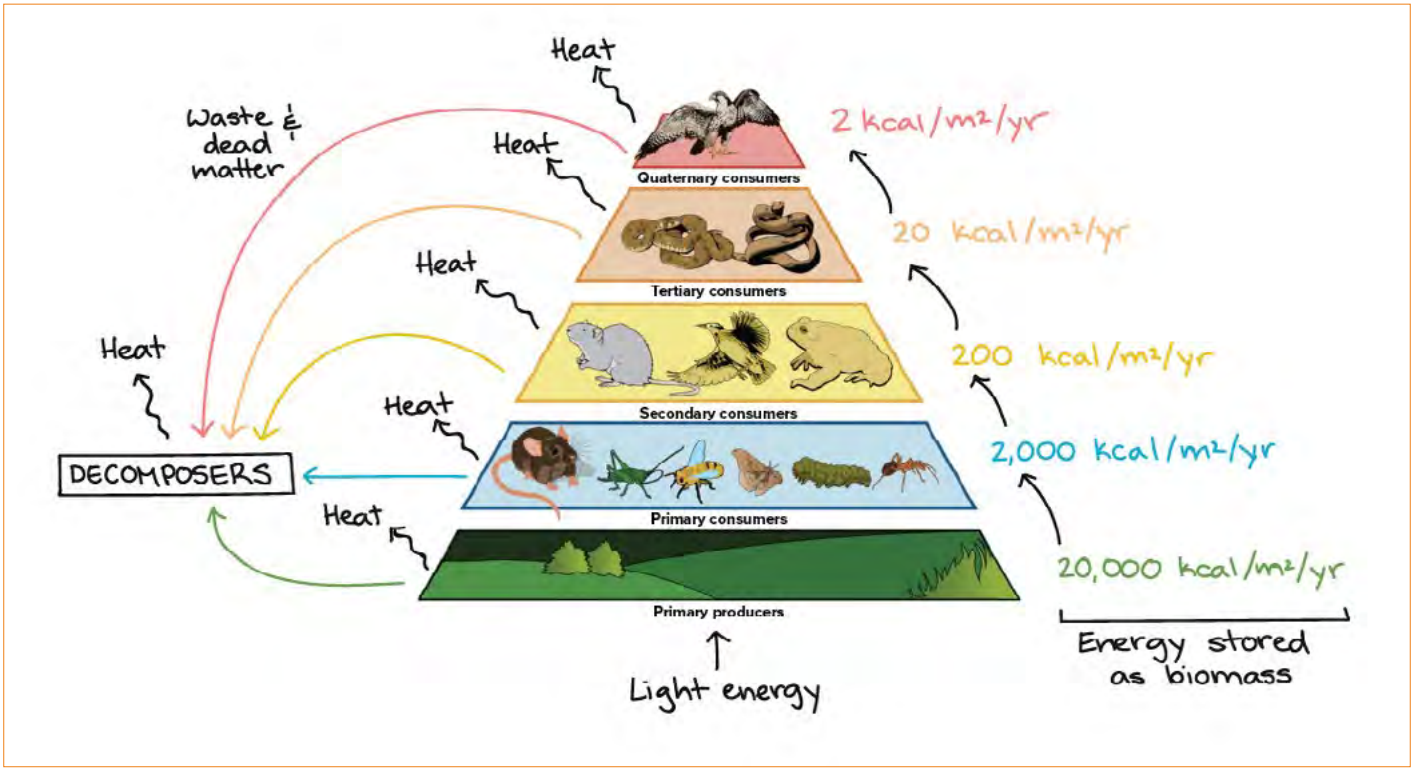
At times, natural changes can be so severe and catastrophic (e.g., an earthquake or a volcanic eruption) so as to totally destroy the ecosystem functioning. However, over a long period of time and via a series of changes (seral progression, plant succession) the ecosystem will return to its state of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

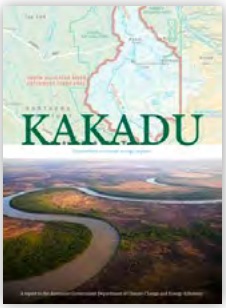
The large size of Kakadu National Park is critical to maintaining the region's biodiversity. Worldwide, there is a growing recognition that most national parks are too small and that loss of biodiversity in them is inevitable over time. It is hoped that this loss can be avoided in Kakadu.

'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.

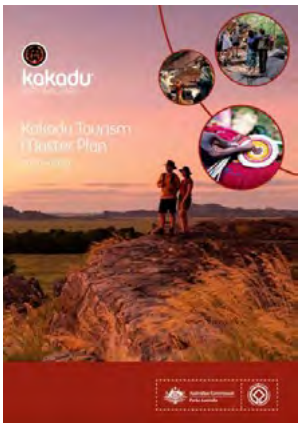
- **Tourism Management**

  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/

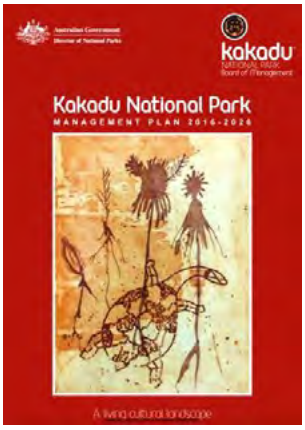
There are several tourism management tools employed by Kakadu National Park:

- 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

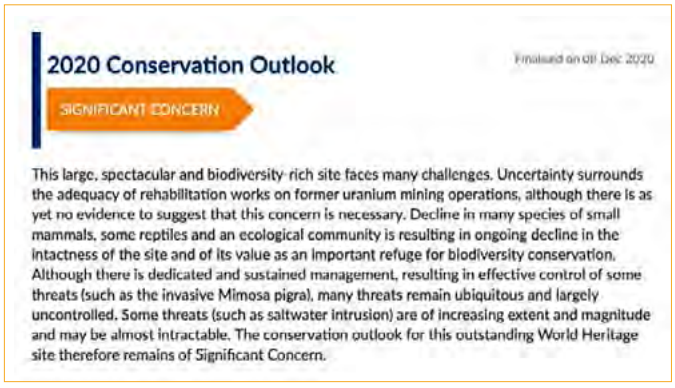
The quality of the park's management and protection has been widely recognised. However, recent reports are question the management of the national park and its World Heritage values.

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.