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ON THE COVER

Front cover Greens Pool, William Bay National Park.
Photo – Tourism WA

Back cover Lichen on rocks at William Bay National Park.
Photo – Peter Nicholas/DBCA



Where is your special place in the natural world and why? I'm guessing it's a favourite family picnic spot you remember from childhood, a holiday destination you go back to year after year, some place you first met old friends or maybe a place where you found a connection that meant something more?

Whatever the reason, these strong attachments to place help motivate us to care for and speak up for the places that matter to us. Getting to know the place where you live or a place that you love creates a special bond that connects you forever.

As the weather warms, more of us will seek out these special places to relax, reflect, play and discover. During the past couple of years, Western Australians have visited parks, trails and campgrounds in record numbers. Restrictions to interstate and overseas travel see people ticking trips off bucket lists—and loving it. Trails are seeing so many new users, many taking their first full-day walk or trying an overnight hike or ride. Campgrounds are full and adventure seekers are looking for their next challenge. There is also a surge in people wanting to find out more about the nature and culture of Western Australia. In a time of uncertainty, nature appears to be the healer that we are seeking to help us through this challenging pandemic (see 'Prescribing nature in a pandemic' *LANDSCOPE* Spring 2020).

On your next park visit, take some time to soak in the place you are visiting, dig a bit deeper and your visit will be more rewarding. Aboriginal connection with place is long and deep and you will learn so much by taking a tour with an Aboriginal guide (see 'Wandering out west' page 40). The landscape and place will make more sense when seen through the eyes of someone with a deep spiritual connection to that place—and your visit will be all the richer for it.

Take care when you are out there. The cool inviting water needs to be respected so that everyone returns home safely. It's easy to overestimate your ability or underestimate the risk, and in many parks, help is a long way away (see 'Testing the waters' page 12).

So, get out there. Go back to your special place or find a new one. Appreciate what the bush gives you and think about how you can leave it better than you found it.

Rod Annear, ***Assistant Director, Parks and Visitor Services***
Department of Biodiversity, Conservation and Attractions

Contributing

Ross Dowling AM is Emeritus Professor of Tourism at Edith Cowan University. He has worked at the nexus of tourism and the environment for more than 40 years. He has backgrounds in geology and environmental science, was a member of the Conservation and Parks Commission for almost a decade and is an Ambassador for the WA Parks Foundation. In early 2021 he established the Australian Geoparks Network and is now directing his energy into establishing geoparks in WA.



Jackie Crooks is the Acting Director of the Destination Development and Projects team at Tourism Western Australia. Jackie is passionate about WA as a holiday destination, and believes Aboriginal tourism is a sector that has a huge part to play in telling our story. Jackie has worked closely with WA Indigenous Tourism Operators Council, Aboriginal tourism operators and other government agencies to see the development of the first Statewide action plan to grow the sector.



Dr Georgia Ward-Fear is a wildlife biologist and research fellow at Macquarie University. She developed a conservation program to decrease the impacts of cane toads on the goannas of northern Australia, using taste aversion. She also leads the Cane Toad Coalition a—collaboration of government, NGO and Indigenous stakeholders—and is one of Science and Technology Australia's 'Superstars of STEM'. Her aim is to inspire the public to become more connected to nature so they protect it.



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Editorial assistance Karla Forrest.

Scientific/technical advice Margaret Byrne, Lesley Gibson, John Huisman, Stephanie Kruger.

Special thanks to Andrew and Merilyn Burbidge.

Design and production coordinator Tiffany Taylor.

Design Sonja Rose, Katie Bryden, Karen Shaddock, Lynne Whittle, Gooitzen van der Meer.

Illustration Gooitzen van der Meer.

Cartography Promaco Geodraft.

Prepress and printing Advance Press, Western Australia.

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ISSN 0815-4465

Please do not send unsolicited material, but feel free to contact the editors by email (landscope@dbca.wa.gov.au).

Published by the Department of Biodiversity, Conservation and Attractions, 17 Dick Perry Avenue, Kensington, Western Australia.

© State of Western Australia, December 2021.

Subscription information

Annual subscriptions to *LANDSCOPE* are available for $33* (four issues plus free postage within Australia). *Overseas subscriptions add $22.

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By free post Reply Paid 25, Locked Bag 29, Bentley DC, Western Australia 6983

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This page Mimbi Caves are part of an Aboriginal cultural experience with Girloorloo Tours.
Photo – Tourism WA

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

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Snap shot



READER'S PIC

Lesmurdie Falls National Park

Photo and words by Steven Emmerson

"It's hard to get a picture of the falls without someone in it because it's such a popular spot! The recent rains had the falls flowing this day and it was great to be able to capture all that water cascading down the rocks."

Have you got a fantastic nature photograph you would like to see published in *LANDSCOPE*? Send it, along with a 100-word description of the species or how and where you took the shot, to landscope@dbca.wa.gov.au.

Joystick-operated adaptive mountain bike launched

During Spinal Awareness Week 7 to 13 September 2021, not-for-profit adaptive mountain bike and hiking organisation Break the Boundary launched their latest piece of adaptive mountain biking equipment at their Adaptive Trail Hub in Kalamunda.

Hailing from France, the Quadrix Touch is Australia's first joystick-operated all-terrain off-road mountain bike, available for Break the Boundary members to access hiking and mountain biking trails.

The purchase was made possible thanks to the organisation's Secretary, coach and program coordinator, Kate, who cycled across New Zealand's South Island in 2019 and raised half the funds with the help of Deputy Chair, Wade.

DBCA's Parks and Wildlife Service matched each dollar donated and provided support for volunteer training, maintenance, upgrades and the delivery of free demo sessions after the launch.

For more information about getting outdoors and onto the trails with Break the Boundary, visit breaktheboundary.com.au.





Below left and right The Quadrix Touch joystick-operated all-terrain off-road mountain bike.
Photo – Steph Lock



Above Jane Brook Promenade in John Forrest National Park.
Photo – Sean Renner

Jane Brook Promenade upgrade

The Jane Brook Promenade in John Forrest National Park has recently been upgraded.

A newly asphalted trail surface makes the walk an all-weather and all-access trail suitable for wheelchairs and prams. Those with limited mobility can now access the park to enjoy the bush.

Extensive mortared stone retaining walls keep the rustic character of the trail while ensuring it remains stable and free of flooding during heavy rains.

Native vegetation has been planted and introduced weeds removed. Infrastructure has been upgraded like the footbridge over the brook and mortared stone steps have been installed on the trail above the brook.

Particular attention was paid to the trail design so that water sheds off the trail and into the brook to prevent the trail from flooding.



Wheatbelt plan released

A ten-year management plan for the Wheatbelt's parks and reserves has been released, outlining how the outstanding natural and cultural value of areas such as Dryandra Woodland and the Wongan Hills Complex will be protected.

The plan covers specific parks and reserves located across 48 local government authorities totalling more than 1,118,168 hectares, from Dalwallinu in the north to Cranbrook in the south, and from Victoria Plains in the west to the Yilgarn and the State Barrier Fence in the east.

It protects a high number of species of conservation significance as well as Lake Bryde and Toolibin Lake threatened ecological communities, the latter of which is also a Wetland of International Importance under the Ramsar Convention.

Above Toolibin Lake is a seasonal wetland in the Wheatbelt.
Photo – Karla Forrest/DBCA

Oldest known bilby fossils

Recent research has filled in some gaps in the documented history of the endangered bilby.

Fossils located in central Australia have recently been confirmed to be 24.9 million years old and the oldest known evidence of bilbies from the bandicoot family tree, representing a new genus and species. Previously, the oldest recorded fossil find was 10 million years old.

The fossils have been named *Bulbadon warburtonae* after Dr Natalie Warburton from the Harry Butler Institute at Murdoch University in recognition of her ongoing research on marsupial anatomy and palaeontology. The genus name combines 'bulba' meaning bulbous, and 'don' meaning tooth, referring to the bilby's bulbous premolars.



Right Bilby.
Illustration – Gooitzen van der Meer/DBCA

Guest column



Dr Syd Shea
Former Executive Director, Department of Conservation and Land Management

I have always been frustrated by the barriers resulting from compartmentalisation of research and management, and the lack of funds preventing solutions to natural resource management problems being implemented.

The *Western Shield* program (see 'Restoring the balance' on page 24) is an example of how it's possible to make a giant leap forward in conservation when there is access to a diversity of skills and resources, which allows an integrated approach.

In the 1990s, we couldn't have even contemplated *Western Shield* without the brilliant work of a team of research workers — I wish I was one of them, I was not. Their work proved the devastating effects of feral animals, particularly foxes, on native wildlife. They made the connection between the presence of native wildlife and thickets of a *Gastrolobium* species, which contained the poison sodium fluoroacetate or 1080.

They also were able to prove that because there were a number of species of *Gastrolobium* in Western Australia native wildlife are tolerant of it. This was a major research achievement.

It is easy to forget that for decades researchers were unable to explain the frightening demise of native wildlife across Australia.

When I became aware of the success of fox eradication, I questioned why we couldn't expand the program. I managed to dismiss claims that 1080 was too dangerous to distribute and the cost of baits was prohibitive when I discovered that 1080 was widely available to pastoralists.

I insisted that we expand the trial to an operational scale. We had equipped aerial resources (the bushfire spotters and bombers), people trained to make our own baits and an exceptionally good marketing team who creatively explained the program to politicians, local communities and private companies who helped fund the project.

Western Shield continues today because it produced stunning results early in its implementation and continues to provide a unique shield to WA's native wildlife.



Wellington National Park

Hidden among the jarrah, marri and yarri forests is an ancient valley gorge, flowing waters and an abundance of wildlife. It comes as little surprise that Wellington National Park is popular all-year-round, with spectacular shows of colourful wildflowers in spring and misty, moody fog over still waters in winter.

Wellington National Park is approximately a 2.5-hour drive from Perth or 30 minutes from Bunbury or Collie. Being so close to Perth, it's a popular destination for city dwellers for a day or overnight visit.

The iconic and central feature of the park is the beautiful Collie River Valley, with its ancient valley gorge and scenic landscapes. Visitors enjoy sightseeing, picnics, swimming, rafting, canoeing, fishing in spots like Rapids, Big Rock, Little Rock and Long Pool, and camping in Honeymoon Pool and Potters Gorge.

The spectacular scenery and height differences of up to 240 metres along the valley chasm make for an exciting network of hiking and mountain bike trails that attract tourists from all over the world.

In 2020, plans were announced to expand Wellington National Park to include an additional 7000 hectares along the southern boundary to the Preston River, increasing the park to 25,000 hectares. The expansion area includes the Glen Mervyn Dam, a popular recreation site for waterskiing, fishing and hiking, will be completed in 2021.

Planning is currently underway to develop additional infrastructure in the expansion area, which is likely to involve new camping areas, walk trails, and recreation sites. Hiking and mountain biking offerings in the area are currently being expanded, with works expected to be completed in 2023. These upgrades will be a huge drawcard for visitors to the area.

A LONG HISTORY

The boundaries of the Kaneang and Wiilman Noongar people intersect with the park. The Collie River is believed to be sacred and created by a Walgu spirit that formed the surrounding hills while manifested as a water snake.

Traditional Custodians of the Collie River speak of the Ngarngungudditj Walgu, the hairy-faced rainbow serpent. They say the Ngarngungudditj Walgu came from the north of Collie, passed through the area and moved towards Eaton, forming the Collie River. When the serpent reached Eaton, it turned its body creating the















Leschenault Estuary and then travelled back up the river to rest at Minningup Pool.

Waterways in WA's south-west have long played an important role in the lives of Noongar people and their connection to the Collie River is not only mythological and spiritual. Noongar migratory routes incorporated the area and the river served as a water source and hunting ground.

European exploration of the area began in the mid-1800s. After Captain James Stirling ventured up the river in the 1830s, Collie developed a coal industry. Workers' cottages still present in the park are evidence of the district's forestry history. During World War II, the park hosted a number of army training camps for young men preparing to go to New Guinea. They stumbled upon local couples honeymooning alongside the river; hence the pool earned its colourful nickname, Honeymoon Pool.

NATURAL PLAYGROUND

The area is popular all-year-round with magnificent shows of some of the 300 species of colourful wildflowers every spring and a rich mosaic of vegetation communities. Networks of rock outcrops, wetlands and forested valley ecosystems intersect with distinct and interesting floral communities and more than 70 bird species. Visitors may even spot animals such as a chuditch, quenda, quokka, brushtail possum, woylie or western ringtail possum.

Despite its proximity to major population centres and travel routes to the

Opposite page
Main Wellington Dam near Collie. *Photo – Frances Andrijich/Tourism WA*

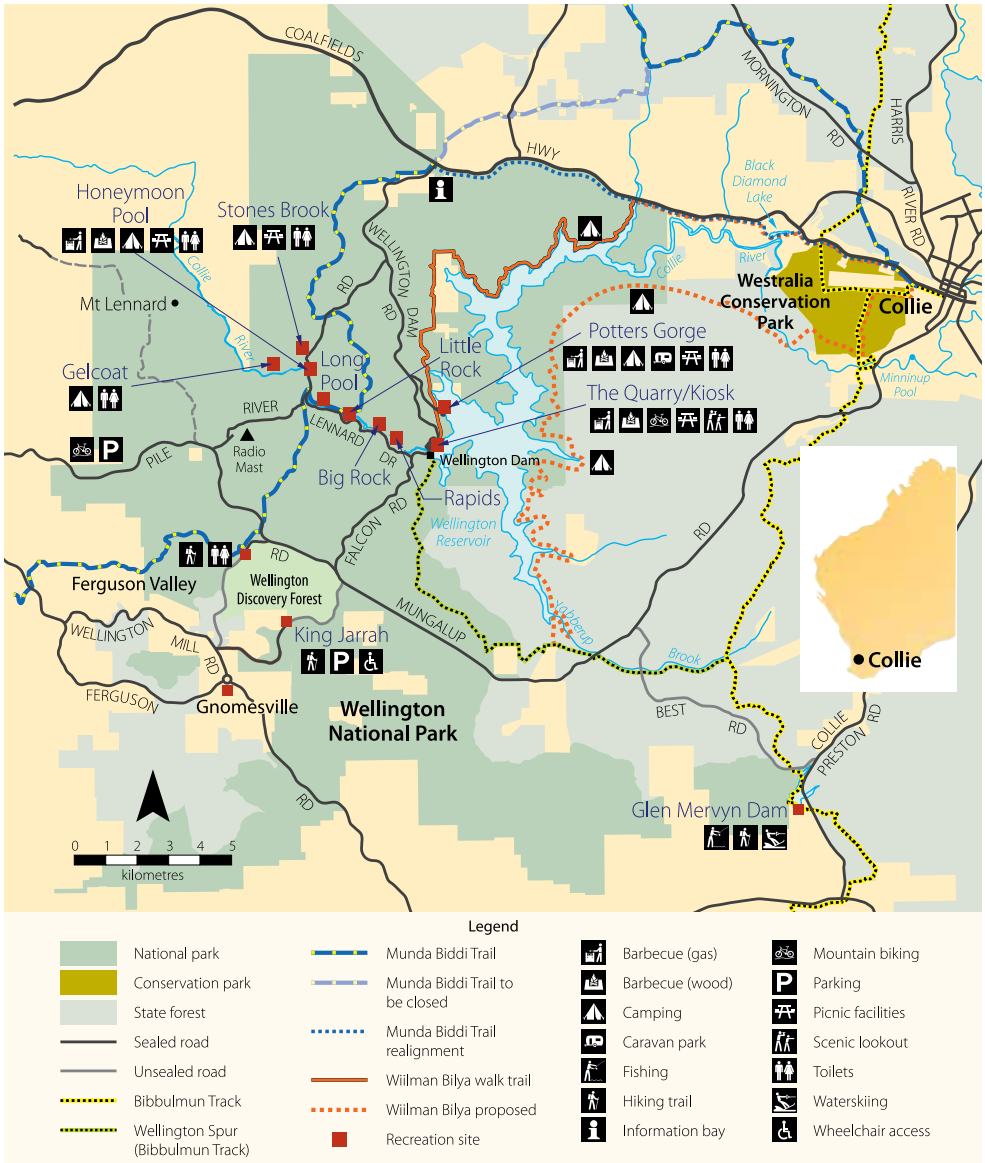
Anticlockwise from left to right Camping at Honeymoon Pool. *Photo – Lauren Cabrera;* Arklow adaptive mountain bike trail. *Photo – DBCA;* Pink rainbow (*Drosera menziesii*). *Photo – Rob Davis;* Wellington Dam. *Photo – Shem Bisluk/DBCA;* Potters Gorge new sheltered barbecue overlooking Wellington Dam. *Photo – DBCA;* Family toasting marshmallows in Wellington National Park. *Photo – Amanda Smith/DBCA;* Wellington Dam mural. *Photo – Stuart Harrison/DBCA*

Right Woylie (*Bettongia penicillata*). *Photo – Sallyanne Cousans*



Learn more about Wellington National Park

Scan this QR code or visit Parks and Wildlife Service's '*LANDSCOPE*' playlist on YouTube.







south-west of the State, the park has a sense of seclusion. It has a varied landscape with well-defined and steeply-sloping valleys, granite outcrops, mature forest and rivers that are enjoyed by walking on the Bibbulmun Track or cycling on the Munda Biddi Trail that both pass through the area.

The Wellington Dam no longer supplies public drinking water but is a popular attraction for visitors, due to its close proximity to Perth and the recently completed 8000-square-metre mural by artist Guido van Helten.

Entitled 'Reflections', the mega-mural was inspired by local stories and photographs, and celebrates the significance of the waterways. Other than visiting the mural, the most popular activities around the dam are swimming, fishing and marroning.

Recreational use near the dam goes back to when the dam was first constructed in the 1930s. The area is now a popular recreation destination and intrinsically linked to the lifestyle of the local community, who have a strong connection to the area.

Most visitors come during the summer period from October to April, particularly around public and school holidays, the marron season and when the dam overflows, which it does every few years.

Visitation is increasing and during peak periods recreation sites are often filled to capacity.

Top New facilities at Potters Gorge.

Above Pump track in Potters Gorge.
Photos – DBCA

Do it yourself

Where is it? 2.5-hour drive from Perth or 30 minutes from Bunbury or Collie

Total area Approximately 25,000 hectares

Recreational activities Sightseeing, picnics, swimming, rafting, canoeing, fishing, marroning and camping

Nearest Parks and Wildlife Service Office Collie, 147 Wittenoom Street, Collie WA 6225 (08) 9735 1988

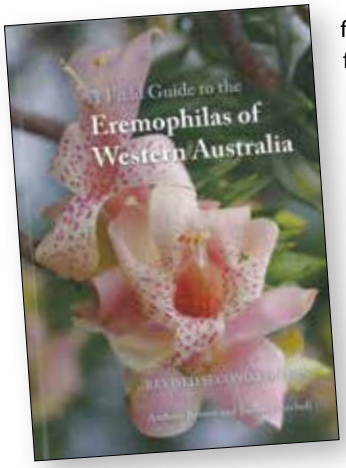
A FIELD GUIDE TO THE EREMOPHILAS OF WESTERN AUSTRALIA

BOOK

Given *Eremophila* species thrive in WA's remote deserts and semi-arid environments, it's no wonder these plants are also known as the 'lover of lonely or desert places'.

But there's something pretty special about seeing a desert in bloom, and authors Andrew Brown and Bevan Buirchell remind us of how lucky we are in WA to have such natural beauty.

A Field Guide to the Eremophilas of Western Australia is a beautifully produced resource that provides an overview of the 209 formally described species and the 45 subspecies known across the State.



Now in its second edition, you can flick through the pages and find a well-researched guide that details where each species is found, which months they flower and a description of what the plant looks like.

The photography of each flower is really gorgeous and deserves high praise.

Given how widespread and remote some of these plants are, you really must appreciate the time, effort and passion behind collecting all the photos.

Just as the title suggests, the guide is a great resource to look to when you are travelling around the State.

Before you jump on the road, grab a copy to leave in your car and use it as a reference guide and see how many *Eremophilas* you can tick off your plant bucket list.

Find a copy of A Field Guide to the Eremophilas of Western Australia *online.*

FROG ID

APP

If croaks, bleats and whistles are common sounds in your neighbourhood, you might have some valuable scientific data about frogs up your sleeve.

The Australian Museum's *Frog ID* app is harnessing the power of citizen science to learn more about particular frog species, their movements and habitats.

Much like other citizen science apps, *Frog ID* is user-friendly, informative and simple to use.

Just open it up when you hear a sound, press record, select the relevant habitat or nearby waterbody and the app will identify which species you might have on your hands.

Using your location, *Frog ID* can also tell you what species are regularly found in your area and even has recordings of what they sound like.

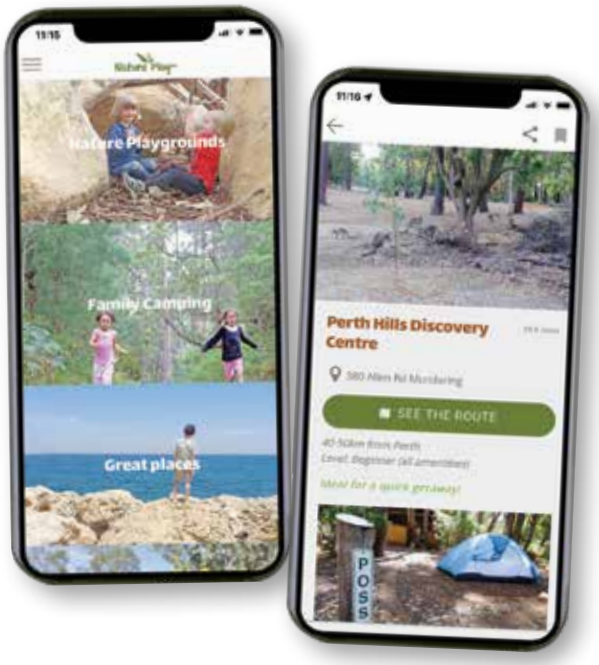
As I'm a frog novice, the app certainly came in handy when I was trying to decipher the mystery sounds in my neighbourhood. And thanks to the app, now I know we have a group of fairly loud western banjo frogs living next door!

If you are a keen frog spotter or just want to understand a bit more about your local environment, *Frog ID* is definitely worth a download.

Plus, it's a really valuable tool that can provide insight into frog conservation, which can help scientists support our frog populations across the country. A win-win!



Frog ID *app is available to download free on the App Store and Google Play.*



PLAY IN WA

APP

Your next family outdoor adventure awaits, and you can find it with the click of a button.

Nature Play WA's app *Play in WA* is an interactive guide to the State's best family-friendly, nature-based recreation sites.

The app is categorised into different activities like hiking trails, bike trails, picnic areas, playgrounds and more.

Often, the simplest apps are the best, and I would say 'simple' is the perfect way to sum up *Play in WA*.

It has a very user-friendly interface that gives you the information you are looking for without the unnecessary bells and whistles.

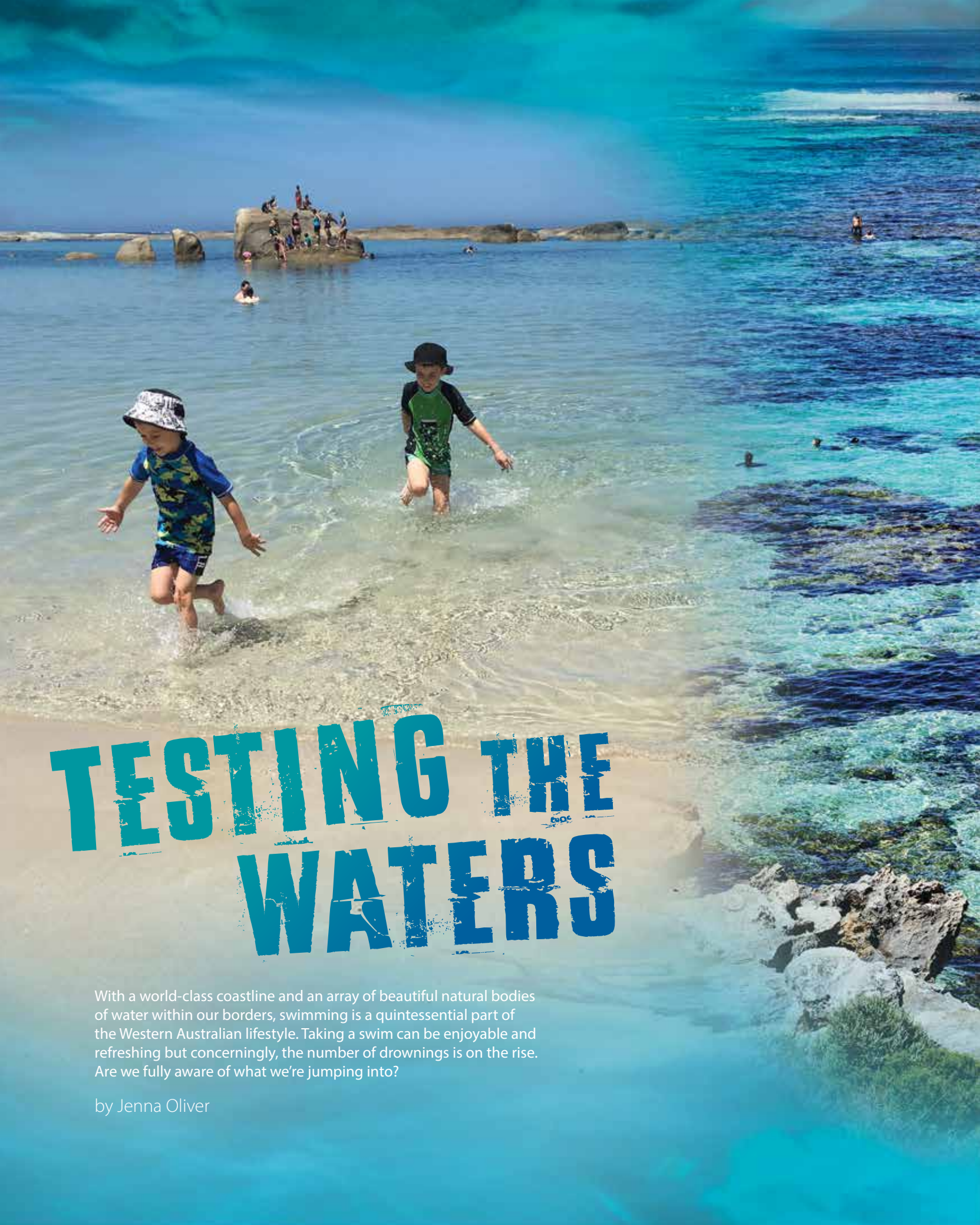
It is clean in design, and the user journey is easy to navigate.

Each location is marked on a map and complemented with photos of available activities, suggestions on how to make the most of your visit and what to expect in terms of accessibility and facilities.

Simply turn your location settings on, open the app and let it give you suggestions on where your closest nature playground, camping spot or swimming hole might be.

A good one for parents and carers to download and keep as a trusty tool next time you need a family adventure.

Download Play in WA *at natureplaywa.org.au/play-in-wa*



TESTING THE WATERS

With a world-class coastline and an array of beautiful natural bodies of water within our borders, swimming is a quintessential part of the Western Australian lifestyle. Taking a swim can be enjoyable and refreshing but concerningly, the number of drownings is on the rise. Are we fully aware of what we're jumping into?

by Jenna Oliver



Western Australians are spoilt with seemingly endless stretches of turquoise beaches, world-class surfing spots, natural pools and rugged gorges unrivalled anywhere in the world.

The allure of pristine water can sometimes mask its dangers and it's not just visitors to the State that find themselves in trouble—locals are quick to become complacent when it comes to the risks in their own 'backyard'.

While faced with a global pandemic, locals are exploring their island home with greater enthusiasm and more people are seeking out locations off the beaten track to escape crowds and seek new adventures. However, unfamiliar and unpatrolled locations present increased risk.

Royal Life Saving Society Australia's (RLSSA) *National Drowning Report 2021* revealed a 20 per cent spike in drowning deaths across the country in 2020–21 compared to the preceding year, with unfamiliar locations and exhaustion considered key factors.

CARRIED AWAY

Compared with the ten-year average, beach drownings in 2020 recorded an alarming 25 per cent increase (*National Drowning Report 2021, RLSSA*).

Rip currents are one of the greatest, and most common, hazards on Australian beaches. Being dragged away from the shoreline towards the ocean at speeds faster than an Olympic swimmer can achieve means rips simply cannot be outswum.

Surf Life Saving Australia (SLSA) suggests the best way to survive a rip is to stay calm and either float with the current (it may return you to a shallow sandbank) or if possible, swim parallel to the beach to escape it.

Large waves and swells can also occur in many coastal areas, even on calm days, and waves can sweep over rocky headlands without warning, so you don't even have to be swimming to risk drowning. Incidents are continually reported regarding visitors fishing from rocks, boating or simply being too close to a ledge and being swept in by strong waves. At least a quarter of the fatal drowning deaths in WA in 2019–20 were people who weren't prepared to enter the water (*WA Drowning Report 2020*, *Royal Life Saving WA*).

DBCA's visitor risk management coordinator Michael Phillips has seen first-hand the effects of people taking risks around water.

"Take Torndirrup National Park in Albany as an example where, despite warning signs and other measures like anchor points that are in place for safety, some visitors continue to fish from the rocks without any safety precautions and unfortunately, most years, we record some sort of incident," Michael said.

"You only have to stand on the bridge at The Gap for a few seconds to view the full force of nature along that coastline."

"While rock fishing might be tempting, it's not worth putting your life on the line. Keep the sand between your toes and fish from the beach. If you choose to fish from the rocks make sure you are wearing a personal flotation device and watching the ocean at all times."

SLSA's *Beachsafe* app provides comprehensive information on nearly every beach of the almost 3500 in WA. Nearly all beach areas within national parks are not patrolled by lifeguards so check this information, ensure you are familiar with it and do not underestimate the risks in coastal environments.



"Compared with the ten-year average, beach drownings last year recorded an alarming 25 per cent increase." (*National Drowning Report 2021, RLSSA)*

Previous page
Clockwise from left Enjoying Greens Pool, William Bay National Park. *Photo – Tiffany Taylor;* Snorkelling around Rottnest Island. *Photo – Tourism WA;* Kayaking in Lane Poole Reserve. *Photo – Shem Bisluk/DBCA;* Swimmers in Karijini National Park. *Photo – Rick Dawson*

Above Large swells can sweep over rocks without warning.
Photo – Peter Nicholas/DBCA





As important as it is to know the environment you're entering, knowing your personal limits and swimming well within your capabilities are major factors in staying safe.

As Australians, many of us are confident swimmers having grown up surrounded by water, so we can be quick to overestimate our swimming prowess. According to research by the RLSSA, males are overwhelmingly the greatest risk takers and are four times more likely to drown than females; a statistic that has remained consistent over many years. Adolescent and young adult males exhibit the most apparent risk-taking behaviour.

Drowning incidents don't always meet the same end. In 2019–20 alone, for every fatal drowning incident recorded in WA, there were six non-fatal drowning incidents (*WA Drowning Report 2020*, *Royal Life Saving WA*). Non-fatal incidents can have life-long consequences and could significantly impact an individual's long-term health outcomes and quality of life.

In an effort to make our beaches safer and improve emergency response times, many popular and remote beaches from Geraldton to the South Australian border have been fixed with Beach Emergency Numbers (BEN).

BEN is a coding system where unique numbers are installed on fixed signage at beach access points. Quoting the information on the nearest BEN sign when calling for emergency services will help first responders accurately pinpoint the location in the event of a shark sighting, attack or other beach emergency.



Above Fishing from the shores of Salmon Beach, D'Entrecasteaux National Park. *Photo – Cliff Winfield*

Above right Turquoise Bay in Cape Range National Park is not patrolled. It's important to check information on site.

Right Example of a BEN sign. *Photos – Tiffany Taylor*



Five top tips for swimming

1. Know your capabilities and your limits, and swim within them.
2. Check for and adhere to warning signs.
3. Never swim alone.
4. Enter the water slowly and feet first.
5. If someone gets into trouble, throw them something that floats and seek help—don't put yourself in danger too.





Above Fern Pool in Karijini National Park.
Photo – Rick Dawson

Far left Turquoise Bay in Cape Range National Park.
Photo – Livlodge Creative/Tourism WA

Left Coastline of D'Entrecasteaux National Park.
Photo – Cliff Winfield

While there are plans to extend the program north to Kununurra, where there are currently no BEN signs, using the free *Emergency+* app to contact emergency services will automatically give your GPS coordinates to first responders. If there is no reception at the location, the app will still give the coordinates; however, a personal locator beacon (PLB) should be used to call for help instead of a mobile phone.

LOOKING INWARD

All bodies of water are far from equal, and each aquatic environment has its own particular way of behaving. It pays to become acquainted with the place you plan to swim.

Most inland waterways are made up of fresh water, defined as water that has a low salt concentration of less than one per cent. This makes it less dense and lighter than saltwater and therefore makes objects in it—including swimmers—less buoyant.

Some people get into trouble around water and don't have the swimming ability or physical fitness to get themselves out of dangerous situations. Even though inland waterways look inviting, especially when the surface is calm, they can pose hidden dangers such as strong undercurrents, underwater obstacles and unstable or deep-seated riverbeds.

On a national scale, rivers and creeks have consistently topped the list as the deadliest locations for drownings and in 2020–21 they accounted for 75 deaths across Australia (*National Drowning Report 2021, RLSSA*). Previous reports indicate this is due to the incidents occurring in isolated environments with changeable conditions and geographical remoteness. Of the 75 reported deaths, 69 per cent were male.

Risk-taking behaviour involving poor decision-making such as alcohol consumption and not wearing a lifejacket







"…if you're in a gorge and it starts raining, the message is simple—leave immediately."

can also increase the risk of drowning. Inland waterways are not patrolled by lifeguards and there may be no-one else around to assist, so it's important never to swim alone. If someone gets into trouble, throw them something that floats and seek help—don't put yourself in danger too.

WHEN THINGS HEAT UP

Karijini National Park is famed for its beautiful gorges and swimming holes, which are a major drawcard for tourists wanting to cool off from the hot Pilbara weather.

However, it's not common knowledge that gorges may experience temperature extremes often up to 10 degrees higher, or significantly lower if shaded by steep walls. When swimming, the water can be a lot colder than it appears and, in some circumstances, can cause hypothermia, hyperventilation, shock and lack of mobility.

Gorges are also prone to sudden changes in conditions where you can experience wind gusts, torrents or flash floods following heavy rainfall. Read surrounding warning signs before entering.

"Basically, if you're in a gorge and it starts raining, the message is simple—leave immediately," Michael said.

If travelling further north from Karijini, it's important to note that crocodiles can be found in freshwater rivers and billabongs in the Kimberley up to 200 kilometres from the coast. Heed all risk warning signs. However, just because a sign isn't there doesn't mean crocodiles aren't present.

If you're unsure which parks are suitable for swimming, head to the Parks and Wildlife Service website (exploreparks.dbca.wa.gov.au). Park pages indicate whether you can swim in waterways and list places you can safely access. Before you go, always check for park alerts at alerts.dbca.wa.gov.au so you can safely visit and enjoy WA's stunning parks and reserves.

Top left Hidden dangers of inland waters.
Photo – Peter Nicholas/DBCA

Above left Waterskiing on Lake Kepwari. Waterskiing is a high-risk activity on inland waters.

Above Canoeing in freshwater in a gorge at Kalbarri National Park.
Photos – DBCA

Below Torndirrup National Park.
Photo – Cliff Winfield



Jenna Oliver is a communications officer with DBCA's Public Information and Corporate Affairs branch, focusing on visitor safety communications. She can be contacted at jenna.oliver@dbca.wa.gov.au or (08) 9219 9902.

Editor's note: *As this article was being produced, an incident occurred at Mount Frankland National Park that sadly resulted in the loss of a life. The* LANDSCOPE *team sends our condolences to the family and urges anyone visiting Fernhook Falls to take the utmost caution, especially around Deep River where the water can be fast flowing.*



GOANNAS
beyond the toad

It has been 17 years since the impending cane toad advance was declared a risk to Western Australia's biological values and 12 years since the poisonous species crossed the border into WA. Strategies and activities continue to be adapted as new research provides insights into how to minimise the impacts on native wildlife, including apex predators like goannas.

by Clare Forward, Dian Fogarty, Corrin Everitt and Dr Georgia Ward-Fear





When poisonous introduced cane toads (*Rhinella marina*) crossed the Western Australian border in 2009 (see 'United effort on cane toad front', *LANDSCOPE*, Winter 2009), the focus for government and community was assessing what damage the toads had the potential to cause to wildlife in the Kimberley, as well as community education, surveillance and quarantine.

Over the years, independent research programs undertaken by the Department of Biodiversity, Conservation and Attractions (DBCA) Biodiversity and Conservation Science principal research scientist David Pearson have been complemented by significant contributions from universities and Indigenous science. This collaborative research has informed the adaptive management of cane toads. WA's cane toad strategy was released in 2009 to guide these actions.

Twelve years later, collaborative research continues to provide insights that inform government and community groups about how best to minimise the impacts on native species, in particular apex predators.

Arguably one of the most effective strategies over the past 12 years to reduce the impacts on native species is conditioned taste aversion. The strategy involves exposing native animals to a small amount of cane toad meat, enough to make them sick but not be fatal, in order for the animal to associate the taste and smell of cane toads with sickness and avoid them in future.

FOCUSING ON GOANNAS

DBCA and Macquarie University have partnered for an Australian Research Council (ARC) grant focusing on taste aversion programs for wildlife that are particularly vulnerable to being poisoned by cane toads. This ARC linkage project has been focused on northern quolls (see 'Quolls on country', *LANDSCOPE*, Autumn 2017) and goannas. Goannas are an apex predator and an important component of a healthy ecosystem.

Maintaining healthy populations of native predators in the ecosystem keeps things in balance. When a novel predator is added (e.g., feral cats or foxes) or a native predator is removed (e.g., goannas or northern quoll) the disruption can be significant.

Take the yellow-spotted goanna (*Varanus panoptes*), for example. Through predation, these goannas keep meso (middle)-predators in check, such as medium-sized snakes and even feral cats. But when goannas decline, these meso-predators breed up and exert enormous predation pressure on small birds, mammals and lizards, causing declines in these species. Furthermore, other native predators, such as large pythons, suddenly have substantially less prey available to them.

Research has been focused on minimising the impacts of cane toads on yellow-spotted goannas and maintaining ecosystem balance in the savannah grasslands of northern WA.

The Cane Toad Coalition is a strategic partnership between DBCA, conservation organisations, Indigenous organisations and cultural groups, and regional NRM groups. It was established in 2017 by

Macca

'Macca', a wild goanna from the floodplains of the Kimberley, had his first taste aversion trial with a small toad. This was the first time he had seen one, so he gobbled it down. A month later, Macca approached the trial boxes. He investigated the small toad extensively but recognised it by sight and smell, then left it alone. Macca survived in toad-infested areas until the end of the study (three years later).



Previous page
Main Yellow-spotted goanna (*Varanus panoptes*).
Photo – Jiri Lochman
Inset Cane toads have a distinctive m-shaped ridge over their nose.
Photo – Ken Griffiths/Alamy

Above King George River, Kimberley.
Photo – Tourism WA

Left 'Macca', a wild goanna.
Photo – Dr Georgia Ward-Fear

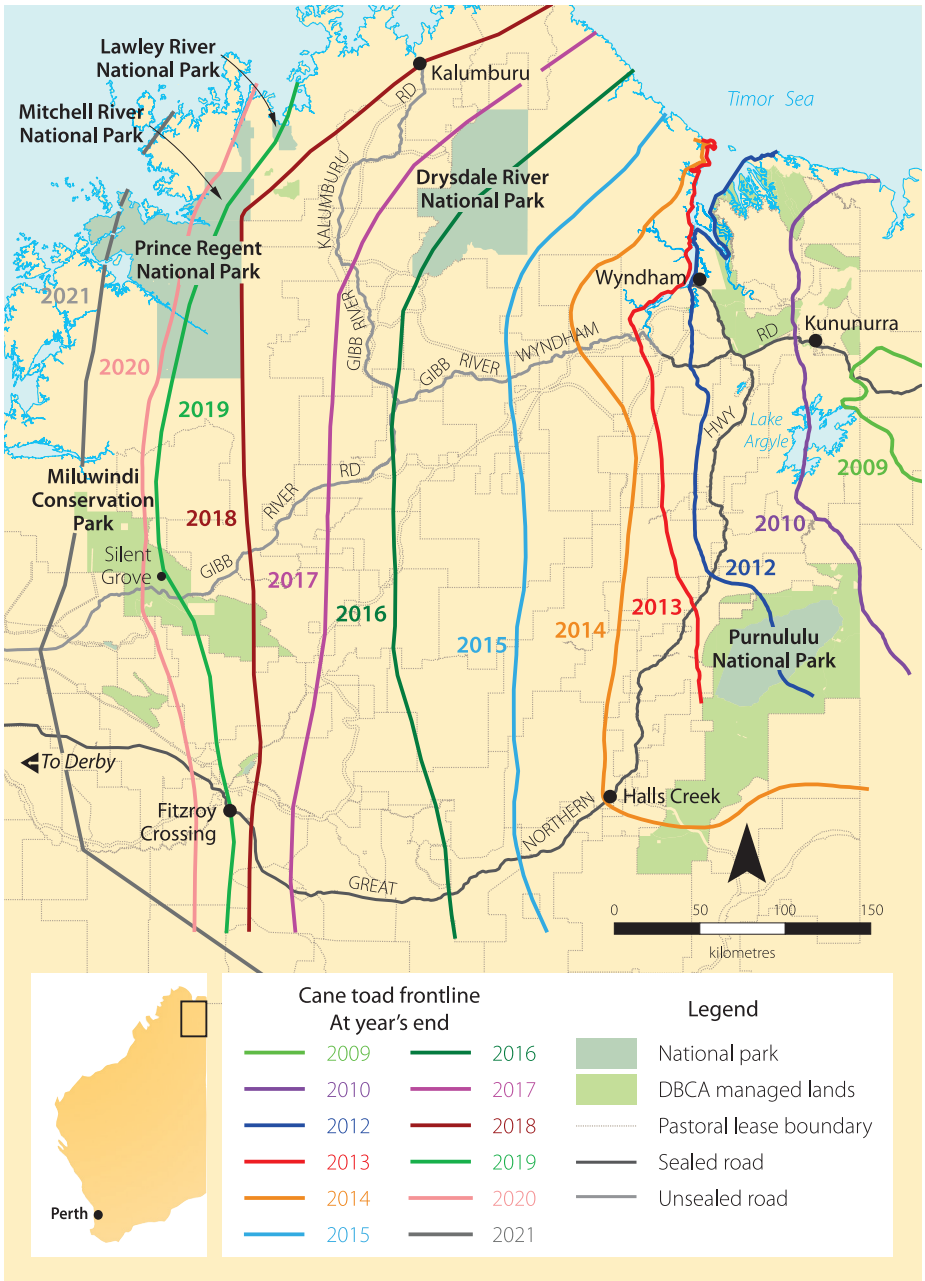
Cane toads in WA

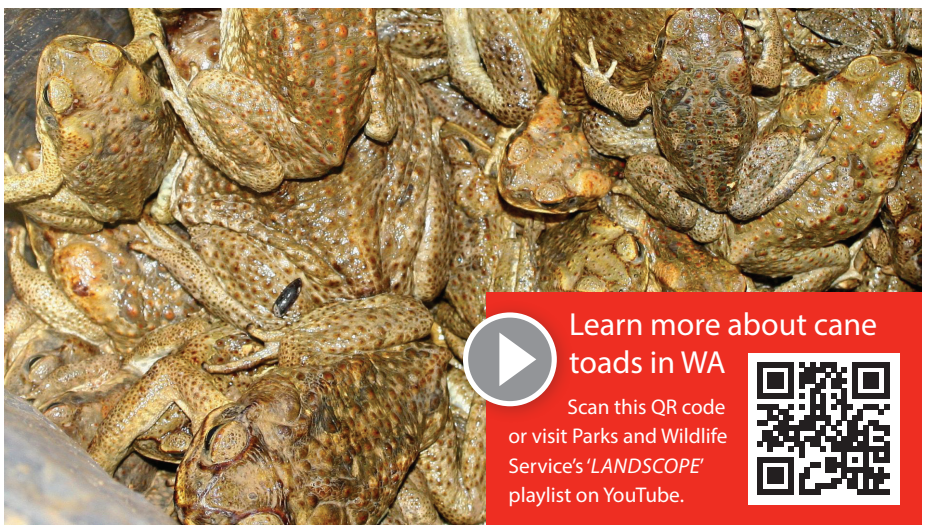
Cane toads (*Rhinella marina*), native to south and central America, were deliberately introduced into Australia in the 1930s to control sugar cane beetles in North Queensland cane plantations. Since their introduction, cane toads have spread, both naturally and with human assistance, through Queensland, the Northern Territory and into New South Wales and WA. The toads are poisonous to native wildlife and indirectly impact natural predator–prey relationships.

In 2004, when the WA State Government and community realised the risk to the State's biological assets from the impending cane toad advance, significant resources were put to efforts to try to stop cane toads from entering the State. Despite these efforts, cane toads crossed the WA border in 2009.









Learn more about cane toads in WA

Scan this QR code or visit Parks and Wildlife Service's *'LANDSCOPE'* playlist on YouTube.

Top Cane toads were introduced to control cane beetles.
Photo – DBCA

Above Goannas are being taught to avoid cane toads.
Photo – Dr Georgia Ward-Fear

Right Cane toads are collected by the community.
Photo – DBCA





Left Dr Georgia Ward-Fear working collaboratively with Aboriginal rangers.

Above Rangers checking traps on country.
Photos – DBCA

Inset left Northern quoll (*Dasyurus hallucatus*).
Photo – Jiri Lochman

Inset below left Conditioned taste aversion (CTA) sausages.
Photo – DBCA





Major successes from the Cane toad strategy 2014–2019

- Conditioned taste aversion (CTA) training of northern quolls using CTA sausages (see 'Tackling toads', *LANDSCOPE*, Winter 2014). CTA occurs when an animal associates the smell and taste of an animal (cane toad) with sickness. The process involves making sausage baits from cane toad meat and adding a nausea-inducing chemical to invoke a negative reaction when eaten.
- Pheromones extracted from cane toad toxin have been used to cause cane toad tadpoles to congregate in traps or disrupt cane toad tadpole metamorphosis. Research trials of both techniques were carried out in and around Kununurra and helped to inform decisions about effective strategies to manage cane toads in high priority areas.
- Monitoring the long-term impact of toads on the fauna of Adolphus Island, including one of the last remaining populations of northern quolls in the east Kimberley. Cane toads arrived on the island in 2014. DBCA has been monitoring quolls and susceptible reptile species to determine long-term survival of these species in the presence of cane toads. This information will help predict the impact and survival of cane toads on other Kimberley islands and inform management options.
- Toad drop-off boxes were installed in numerous locations in the Kimberley to aid community toad-mustering and provided an important source of cane toad meat for CTA baits.
- Large community toad musters have been organised (see 'Travelling toad show', *LANDSCOPE*, Winter 2020), engaging the help of local community organisations, Indigenous ranger groups and individuals across the Kimberley to collect thousands of cane toads required for CTA bait production.
- DBCA in collaboration with Rangelands NRM, Balanggarra Aboriginal Corporation and researchers at the University of Sydney and Macquarie University have progressed a range of actions funded through the National Landcare program. This included the development of a ranger handbook, continuation of the goanna teacher-toad research, freshwater crocodile monitoring at Windjana and Dimalurra (Tunnel Creek) and the delivery of the monitoring program on Adolphus Island.

Dr Georgia Ward-Fear, a conservation scientist, reptile biologist and research fellow with Macquarie University.

"The cane toad invasion is a huge threat to apex predators, ecosystem stability and cultural practices across northern Australia," Dr Ward-Fear said.

One strategy to mitigate the impact on goannas involves releasing small cane toads in trial boxes into the wild just before the cane toad frontline. The hope is the goannas first eat a small cane toad that makes them sick but is not fatal, and the goanna will develop an aversion before encountering a large toad.

INDIGENOUS KNOWLEDGE

Critical to success has been the integration of western science with Indigenous knowledge, sharing of Aboriginal rangers' skills, knowledge of where to find goannas, how to catch or monitor them and knowing the best seasons and areas to work on their country.

Yellow-spotted goannas are an important food source for Indigenous

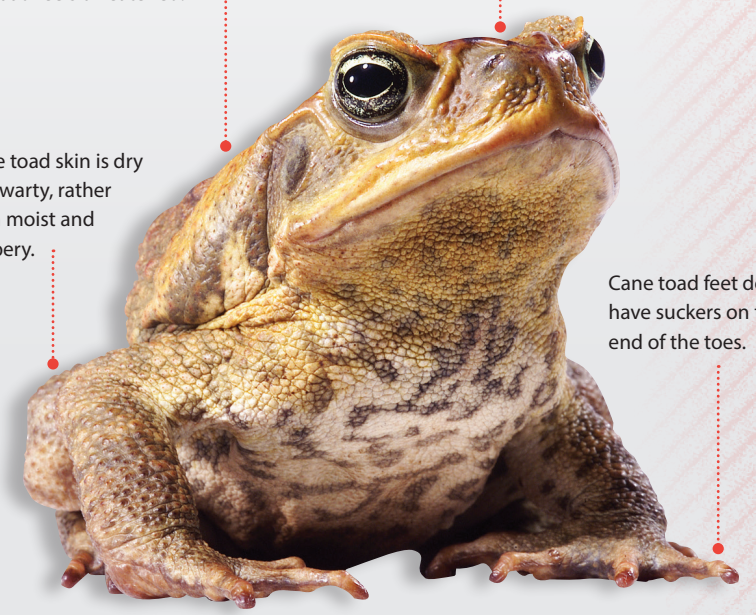
How to spot a toad

The big glands on the cane toad's shoulder release a poisonous milky substance when the toad feels threatened.

Cane toads have a very distinctive bony 'm'-shaped ridge over their nose.

Cane toad skin is dry and warty, rather than moist and slippery.

Cane toad feet don't have suckers on the end of the toes.



Adult cane toads are heavily built, and average between 100–150mm in length.

Does the toad have:



'M-shaped' bony ridge between its eyes?

☐ Yes ☐ No



Dry warty skin?

☐ Yes ☐ No



Poison glands on its shoulders (behind its round ears)?

☐ Yes ☐ No

If you have ticked 'yes' to all the boxes you may have found a toad.

Send a photo to DBCA on 0400 693 807 or email canetoads@dbca.wa.gov.au for further advice.

peoples of Northern Australia (an unofficial geographical area that includes northern parts of Queensland and Western Australia as well as the Northern Territory) and so the protection of their populations is important culturally as well as ecologically.

Balanggarra rangers in WA were integral to initial landscape trials and subsequent research work has been done in collaboration with Bunuba, Nyikina Mangala, Yawuru, Uunguu and Wunggurr ranger groups on country through Rangelands NRM funding and the ARC linkage grant.

"Aboriginal rangers bring skill sets, knowledge and background to the research program that has been pivotal to its success," Dr Ward-Fear said.

So far, the work is looking positive with goanna populations showing good resilience to the constantly advancing cane toad front line.

WHAT'S NEXT

"Taste aversion is innovative, capitalising on behavioural mechanisms already possessed by the native animals themselves. It's exciting!" Dr Ward-Fear said.

The findings and success of taste aversion research have led to a landscape-scale mitigation strategy being delivered to areas of high biodiversity ahead of the invasion frontline in the Kimberley for species including large goannas, northern quolls and freshwater crocodiles.

The DBCA invasive animals program continues to be adapted and refocused as new research is published, recently releasing the new *Cane toad strategy for Western Australia 2021-2026*, which is the most comprehensive strategy for cane toad management in Australia.

Above It can be really hard to tell the difference between frog and toad eggs, tadpoles and metamorphs (babies). Before you euthanase any animals, check with DBCA to make sure it is a cane toad.

Below Community toad mustering. *Photos – DBCA*

Clare Forward is DBCA's cane toad strategy program leader within DBCA's Ecosystem Health branch. She can be contacted at clare.forward@dbca.wa.gov.au or (08) 9752 5555.

Dian Fogarty is a former project officer – education and community for DBCA's Ecosystem Health branch, based in Broome.

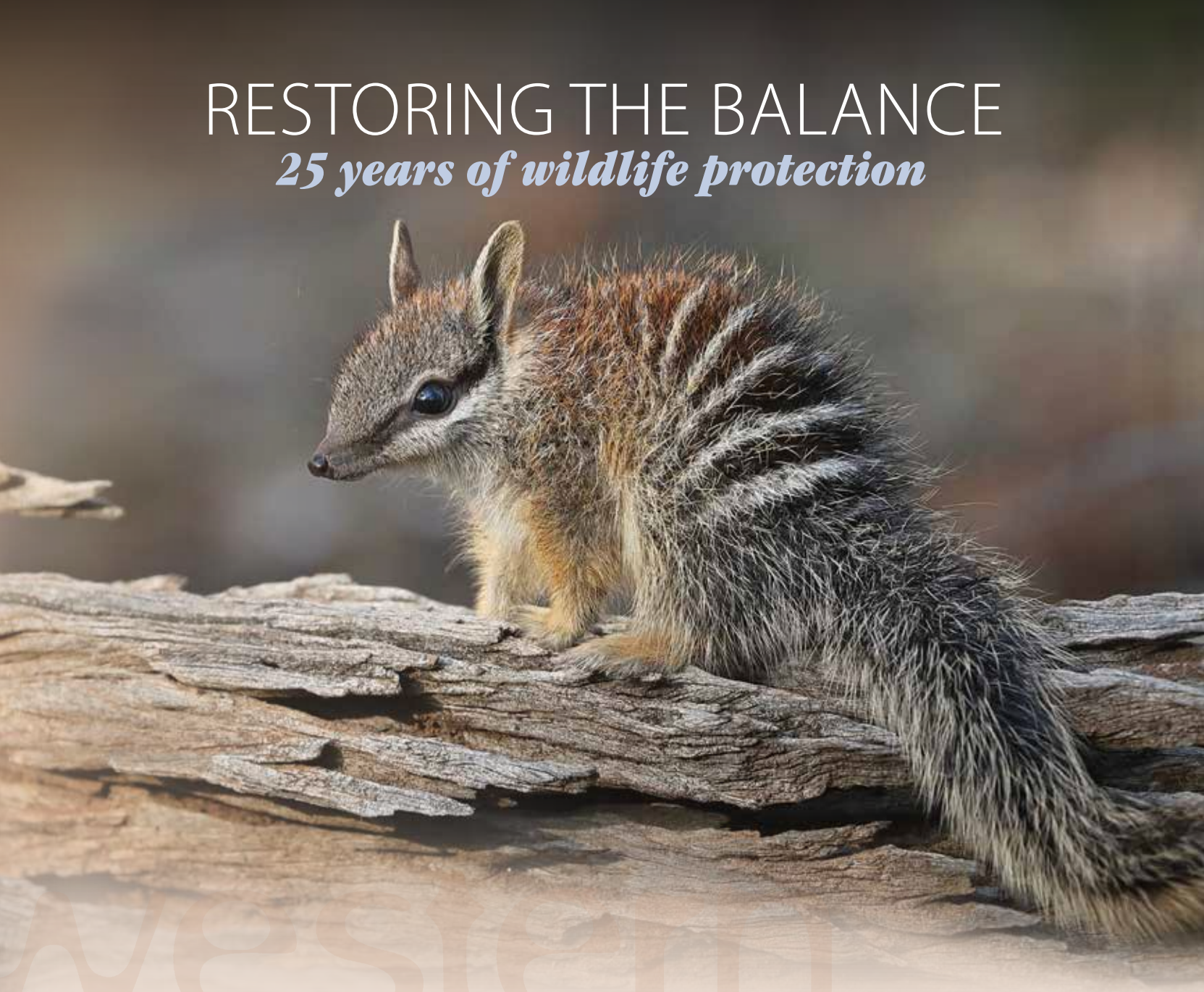
Corrin Everitt is the invasive animals program coordinator with DBCA's Ecosystem Health branch. She can be contacted at corrin.everitt@dbca.wa.gov.au or 0400 693 807.

Dr Georgia Ward-Fear is a conservation scientist, reptile biologist and research fellow with Macquarie University. She can be contacted at georgia.ward-fear@mq.edu.au



RESTORING THE BALANCE

25 years of wildlife protection



by Sophie Henderson

From humble beginnings as an operation to control foxes in 1996, *Western Shield* has grown to become Western Australia's leading wildlife recovery program and one of the most comprehensive wildlife conservation programs ever undertaken in Australia.

For a quarter of a century, *Western Shield* has been protecting some of Western Australia's most threatened native animals from introduced predators, specifically the European red fox (*Vulpes vulpes*) and feral cat (*Felis catus*).

Launched in 1996, the program is one of the most comprehensive wildlife conservation programs undertaken in Australia.

The program has led to significant population increases for many native species, including the numbat, woylie, western brush wallaby, and black-flanked rock-wallaby, including through translocations for reptile and bird species like the western swamp tortoise and western ground parrot.

The primary tool used to manage these introduced predators is landscape-scale baiting, which covers approximately 3.8 million hectares of land across Western Australia.

Run by the Parks and Wildlife Service at the Department of Biodiversity, Conservation and Attractions (DBCA), the *Western Shield* program is reducing the impact of foxes and feral cats on WA's native animals, particularly threatened species.

DBCA Executive Director of Conservation and Ecosystem Management Dr Fran Stanley said the program started with Operation Foxglove in 1994, using 1080 baits to control foxes in the northern jarrah forest.









Learn more about the program's success

Scan this QR code or visit Parks and Wildlife Service's '*LANDSCOPE*' playlist on YouTube.

"Operation Foxglove was only possible after significant scientific research by the likes of Dr Jack Kinnear which demonstrated the impact foxes were having on native wildlife and the benefits of using 1080 to control this introduced predator."

"The success of controlling foxes and increasing the abundance of predator-sensitive species like the woylie led to *Western Shield* being established in 1996 and expanding to other sites in the south-west, then to other parts of the State, including the Pilbara, Midwest, Wheatbelt and South Coast," Dr Stanley said.

This expansion occurred under the bold direction of then Executive Director of the Department of Conservation and Land Management, Syd Shea (see 'Guest column' on page 7).

"*Western Shield* was successful in reducing fox numbers in baited areas, which led to increases in native species, some to such an extent that they were removed from the threatened species list. However, feral cats proved much more difficult to control and evidence suggests that removing foxes from the landscape allows feral cat numbers to increase," Dr Stanley said.

"After around a decade of research by DBCA scientists to develop the feral cat bait, *Eradicat*®, cat control began to be integrated into the program."

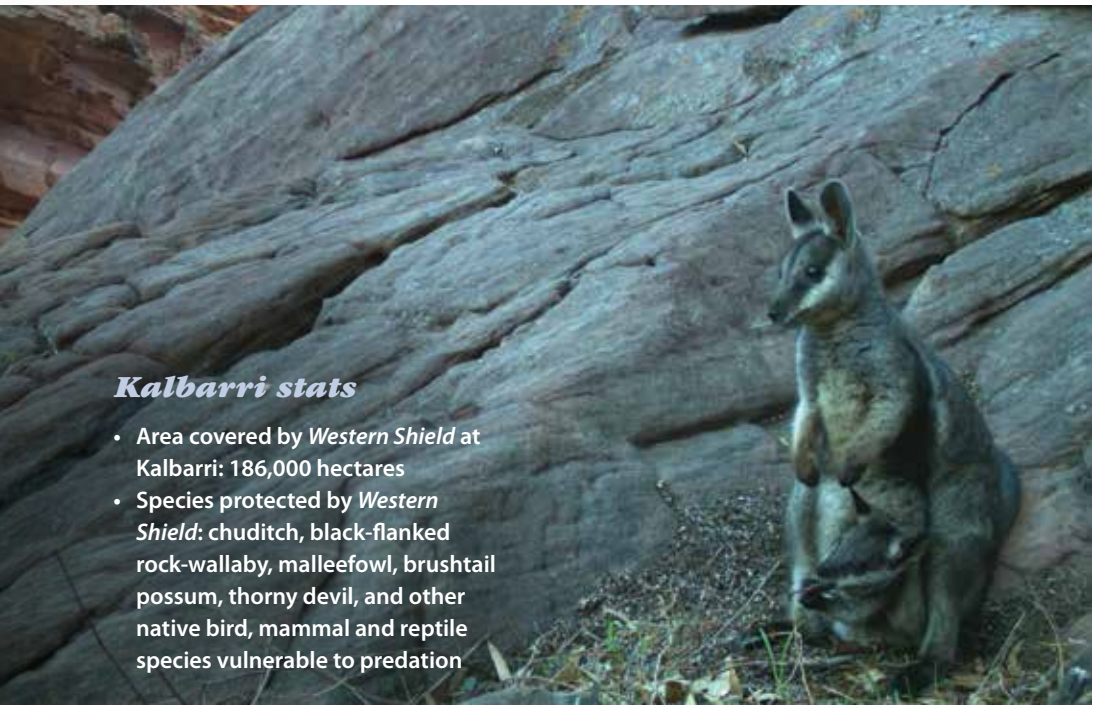
Partnerships are integral to the success of the program. Efforts to control foxes and feral cats across different tenures and neighbouring lands create larger impact areas, providing enhanced protection for native fauna but also for farmers in protecting livestock.

Previous page
Main Juvenile numbat (*Myrmecobius fasciatus*) at Dryandra Woodland.
Photo – John Lawson
Inset far left and right Feral cat and fox.
Photos – Babs and Bert Wells/DBCA

Top right School students learn about *Western Shield*.

Top far right *Western Shield* coordinator Ashley Millar with a numbat in Dryandra Woodland.
Photos – DBCA

Above right Juvenile woylie (*Bettongia penicillata*).
Photo – Sabrina Trocini



Kalbarri stats

- **Area covered by *Western Shield* at Kalbarri: 186,000 hectares**
- **Species protected by *Western Shield*: chuditch, black-flanked rock-wallaby, malleefowl, brushtail possum, thorny devil, and other native bird, mammal and reptile species vulnerable to predation**





Top Remote camera image of black-flanked rock-wallaby (*Petrogale lateralis lateralis*), Kalbarri.
Photo – DBCA

Above Fauna monitoring in Kalbarri.

Above right Scats of chuditch (*Dasyurus geoffroii*) spotted in Kalbarri after a successful reintroduction of the species to the area.
Photos – Anthony Desmond

The program is run with support from partners including Alcoa of Australia, Tronox, Western Areas Limited, South32 Worsley Alumina, Newmont Boddington Gold, Commonwealth Department of Defence and Ventia.

Western Shield also contributes to a range of educational programs in both primary and secondary schools, helping to improve the community's knowledge of threatened species and the role fox and feral cat management can play in ensuring the survival of native fauna in the wild.

KALBARRI NATIONAL PARK

Kalbarri National Park provides tourists with a world-class experience and spectacular scenery, complemented by the recently completed skywalk. The park is home to a diverse range of wildlife, that has been supported by *Western Shield* since 1996.

Kalbarri National Park made national news in 2015, when a tiny population of black-flanked rock-wallabies was rediscovered in the park, after being thought to be locally extinct for 20 years. To boost conservation of this species, 72 rock-wallabies were released into the park between 2016 and 2017.

The released animals were initially monitored using radio collars to understand their movements. The collars were later removed and the population has since been monitored using remote cameras.

Rock-wallabies continue to be recorded at the three release sites including the public lookout at Hawk's Head, and in 2021 a rock-wallaby was sighted at the skywalk—a considerable distance from the original release sites. This information suggests the population is expanding, with intensive monitoring planned for 2022 to assess the overall health and size of the population.

The resurgence in rock-wallaby numbers in the park has been facilitated by *Western Shield*. Outcomes of the program have reduced the impact of feral cats and foxes, providing a safe environment for black-flanked rock-wallabies to thrive.

Local Nanda Aboriginal rangers facilitated the program by providing fuel and baits to the aircraft and the rangers were integral to delivering ground baiting operations.

The team has recently expanded from two to six rangers, increasing capacity to assist with operations including maintenance of cameras for predator detection and monitoring native species.

WESTERN SWAMP TORTOISE

Western Shield is also helping protect one of the world's most critically





Above Western swamp tortoise (*Pseudemydura umbrina*).
Photo – Bethany Nordstrom

Right Western swamp tortoise fitted with radio transmitter.

Top right Echidna (*Tachyglossus aculeatus*) captured on *Western Shield Camera Watch*.
Photos – DBCA

Far right Western swamp tortoise release east of Augusta.
Photo – Gerald Kuchling/DBCA

endangered reptiles, the western swamp tortoise, from predators.

In 2021, 73 Perth Zoo-bred western swamp tortoises were released into habitat in the State's south-west to test if developing a new self-sustaining wild population is possible for the future and to improve the security of the species across the State.

DBCA, Traditional Owners and researchers from the School of Biological Sciences at The University of Western Australia (UWA) released 16 tortoises east of Augusta and a further 57 into a swamp at nearby Scott National Park.

Forty-eight tortoises were fitted with radio transmitters and data loggers to allow scientists from UWA to continue to track the animals' movements and collect valuable data on the outcomes of the release.

This translocation effort follows a pilot program conducted in 2016 and 2018 in the south-west to determine whether these types of habitats were suitable for the species and could provide an insurance against the effects of habitat loss and climate change on the swamp tortoises' natural habitat near Perth.

Routine fox control activities are conducted as part of the *Western Shield* program to protect the western swamp tortoise from the threat of predation.

These new habitats could complement areas of remnant bushland north of Perth that continue to provide critical habitat for the survival of the western swamp tortoise.



Citizen science

Western Shield Camera Watch hosted by Zooniverse, is an online citizen science project utilising a worldwide network of volunteers. The project has helped to identify thousands of animals from automated wildlife cameras.

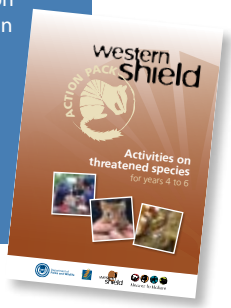
Since launching in 2016, more than 9700 volunteers have registered with the *Western Shield Camera Watch* project and have helped with the huge task of identifying animals captured on thousands of images from automated wildlife cameras deployed in conservation lands in the northern jarrah forest.

The photos are used to record species distribution and better understand the success of wildlife recovery efforts.



Sophie Henderson is a communications officer with DBCA's Public Information and Corporate Affairs branch. She can be contacted at (08) 9219 8243 or sophie.henderson@dbca.wa.gov.au

Lesson plans and activities on threatened species are available in the Western Shield Action Pack, *free to download from dbca.wa.gov.au/westernshield*





BELOW THE SURFACE

karst systems of Western Australia

We explore the magnificent caves and karst systems in Western Australia that give us a window to the past.

by Professor Ross Dowling and Andy Spate





Caves are our 'windows to the past'. They are natural museums that can preserve the remains of past megafauna, be sites of early human occupation, and often contain vital natural evidence of past climate.

In addition, they can contain spectacular cave decorations termed speleothems (stalactites, stalagmites and other forms), as well as bizarre communities of creatures such as troglobites, which are creatures that have adapted to permanent life in a cave (see 'Life down under: the mysterious world of subterranean fauna', *LANDSCOPE*, Spring 2021).

In Australia there are fewer caves and karst landscapes than on other continents but there are incredible examples of these—caves, cliffs, depressions and extensive underground water systems.

In Western Australia there are four main areas of karst systems—Pleistocene near-coastal lime-rich dunes and limestones derived from dunes in the south-west; Palaeocene-Oligocene limestones of Cape Range and Barrow Island; Devonian reef limestone ranges of the Kimberley; and Tertiary limestones of the Nullarbor Plain.

SOUTH-WEST

The coastal limestone of this area was formed during the Pleistocene era (during the past two million years) and the largest area of this limestone sits on the Leeuwin-Naturaliste Ridge within Leeuwin-Naturaliste National Park. The ridge has many popular caves and extremely important karst aquifers.

Commonly, limestone forms from deposits under the sea, but in the south-west the rock is aeolian (windblown) and is formed by cementation of lime-rich sand blown up from beaches into dunes up to nearly 200 metres high.

Aeolian limestone is much more porous than marine limestone, so it can be dissolved quite easily by mildly acidic groundwater. It also allows the water from the surface to percolate through the rock strata relatively easily, creating the perfect conditions for very fast crystal growth.

Previous page
Main Fig Tree Cave, Cape Range National Park.
Photo – Danny Wilkinson

Above Brides Cave, Boranup Karri Forest Leeuwin-Naturaliste National Park.
Photo – Tourism WA

COASTAL CAVES

The remarkable history of Aboriginal occupation of WA's south-west as well as the extinction of animals at the end of the last Ice Age have been documented through fossil finds in the caves.

Mammoth Cave in Margaret River contains fossil remains of a dozen species of megafauna—giant animals that became extinct about 46,000 years ago. These include giant two-metre tall kangaroos, giant emus, and *Thylacoleo carnifex*, a tree-climbing marsupial, sometimes called a marsupial 'lion'.

Giants Cave is 575 metres long and 86 metres deep, and offers adventurers exciting finds such as the spectacular Ballroom Chamber (see 'Adventure out:







Above Thick roots of a fig tree, growing through the ceiling of an unnamed cave near Exmouth.
Photo – Darren Brooks

Above right Weelawadgi Cave in Beekeepers Nature Reserve near Eneabba.

Right Arumvale Cave, Boranup Karri Forest Leeuwin-Naturaliste National Park.
Photos – Danny Wilkinson

Cave terms

- **Anticlinal crest** – a convex fold of rock layers that are progressively older towards the centre of the fold.
- **Column** – forms when a stalactite and stalagmite join.
- **Flowstone** – occurs when solution seeps out of the wall of the cave or flows over a gently sloping section of floor depositing sheets of calcite over a relatively large area.
- **Helictite** – speleothem that defies gravity growing in many different directions, twisted and worm-like.
- **Karst** – a landform type found on soluble rocks, usually limestone, characterised by underground drainage systems with sinkholes and caves.
- **Phytokarst** – a type of karst rock formation created in areas of limestone caves where sunlight is present.
- **Shawl** – wavy sheet of calcite that hangs from the ceiling or wall.
- **Speleothem** – cave decoration. They are usually made from calcite, a crystalline form of calcium carbonate.
- **Stalactite** – a speleothem that looks like an icicle and hangs from the roof of a cave.
- **Straw** – a long, thin stalactite with a hollow centre resembling a drinking straw in appearance.
- **Stalagmite** – a speleothem rising from the floor of a cave.

Giants Cave', page 37). Lake Cave, with its mirrored waters, is particularly impressive and has been described as a crystal wonderland with its range of cave features including showers of straws, actively-dripping/growing flowstone and the iconic five-tonne upside-down 'suspended table'.

Jewel Cave is the largest tourist cave in Western Australia and is centred on a cathedral-like chamber. It houses a number of spectacular features such as the 'frozen waterfall', the 'organ pipes', thousands of mind-bending helictites; and crystal 'worms' that grow against gravity.

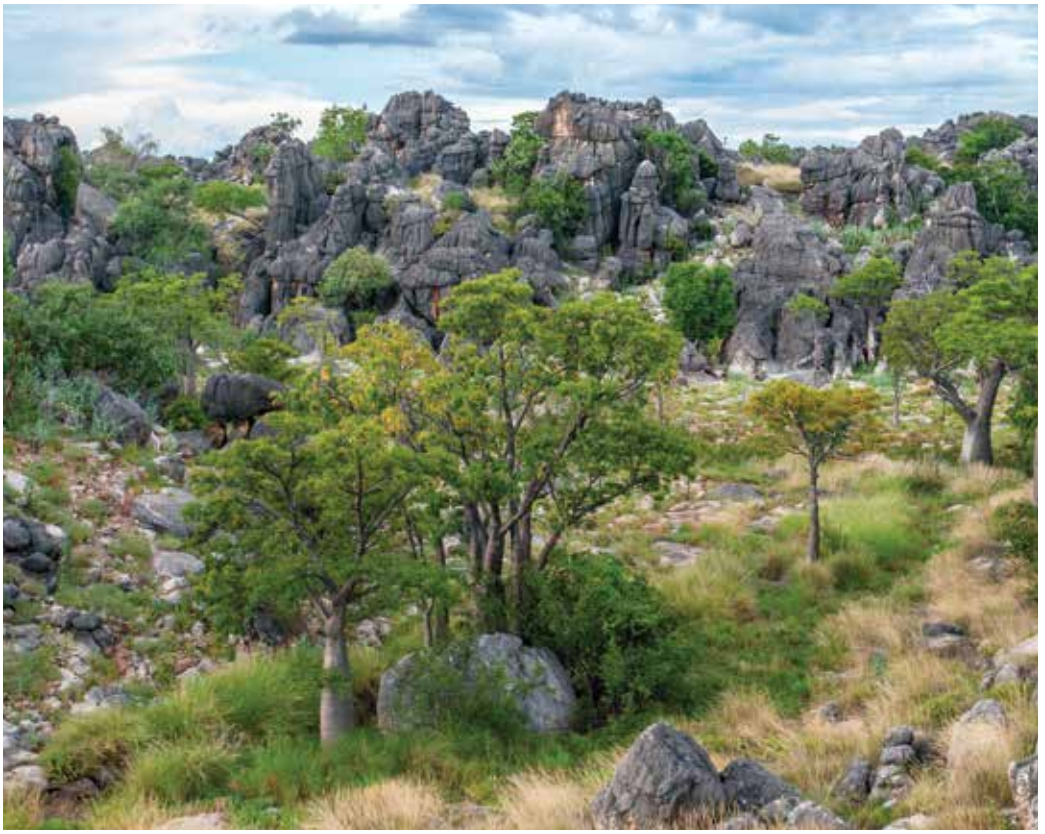
Calgardup Cave is a self-guided cave with two separate large sections and a subterranean lake that is home to an excellent array of crustaceans. Further to the north of the Leeuwin-Naturaliste Ridge, Ngilgi Cave is like a labyrinth of discovery with its multiple levels and chambers and was WA's first cave tourist attraction.

YANCHEP NATIONAL PARK

Nearest to Perth are the caves of Yanchep National Park. Located on the Swan Coastal Plain just 50 kilometres north of Perth, this park has an Aboriginal history dating back more than 40,000 years. The park contains extensive outcrops of limestone and under the surface lies a labyrinth of more than 580 caves.

The caves are geologically young at around 500,000 years old, and feature some stunning speleothems including stalactites, stalagmites, shawls, columns and straws.

The park is popular, averaging 350,000 visitors per year. The main tourist attraction, Crystal Cave, has been open to the public as a tourist attraction since the late 1960s and Cabaret Cave has been used as a function centre for weddings and other events since the early 1930s.



Above right Napier Range, West Kimberley, showing the exposed Devonian reef. *Photo – Marie Lochman*

Crystal Cave recently underwent some renovations. A new boardwalk within the cave reduces dust levels and provides an experience for all ages.

In recent decades, the Yanchep caves have experienced a drying trend. This has been attributed to the falling water table of the Gnangara Mound through a combination of pine plantations on the land surface, reduced rainfall as a result of climate change and ongoing extraction of groundwater for urban use.

Another threat to the caves and the park is bushfires. One which occurred on 11 December 2019 has resulted in a slow-down of the karst processes due to the changes in cave hydrology. The fire history at Yanchep can be found in the stalagmite records dating back to the first European settlement and beyond.

CAPE RANGE

Cape Range, 1200 kilometres north of Perth, is a limestone range which is about 100 kilometres long and 20 kilometres wide. It was deposited on the sea floor as horizontal beds of lime during the Palaeocene to Pliocene eras (approximately 60 to two million years ago). The range comprises an eroded anticlinal crest having the character of plateau karst, flanked by typical plains karst and areas of coastal karst. A variety of sinkholes and hundreds of caves occur throughout the range.

The rock comprises broken fossil material, including coral, crustacean fragments and sponges, and the caves are also rich in calcareous (carbonate-rich) microfossils. In the depths of the caves live troglobitic cave fauna that date back millions of years. Interestingly, there are variations in the species present in different parts of the range suggesting that the cave systems are not connected to each other, which allowed the fauna to evolve in isolation.

KIMBERLEY DEVONIAN REEF

Three hundred and fifty million years ago, a vast tropical sea covered much of Australia's north-west. A 'great barrier reef' fringed the ancient Kimberley land mass during the Devonian period (375–350 million years ago). These rocks were initially covered and protected by younger sediments, which have since slowly eroded



to expose the remnants of the reefs as low but very rugged limestone ranges.

Located in western Kimberley, these magnificent limestone ranges are between 0.1 and 1.8 kilometres wide, rising up to 100 metres above the surrounding plains and, although crossed by a number of gorges, extend for hundreds of kilometres and represent an exhumed Devonian reef in the Napier, Oscar and Ningbing ranges. They extend in a south easterly direction for 350 kilometres. Today the Devonian Reef, Danggu Geikie Gorge, Bandilngan (Windjana Gorge) and Dimalurru (Tunnel Creek) national parks include parts of these ranges.

There have been suggestions that the Devonian Reef complex warrants World Heritage status.

Numerous caves are found within the limestone with the best-known being Tunnel Creek Cave. A creek flows through this large cave once known as 'The Cave of Bats' as it is home to five species of bats. Tunnel Creek Cave is approximately 750 metres long and reaches a height of 12 metres and a width of 15 metres. It cuts right through the limestone Napier Range. Visitors can hike through the entire cave system with ease, guided by daylight from a large roof window in the centre. On the floor of the cave are large pools of water where freshwater crocodiles can be found.

THE NULLARBOR PLAIN

Western Australia hosts more than two-thirds of the 220,000 square kilometres of tertiary limestones of the Nullarbor Plain that were deposited between about 35 and five million years ago. Decried by many travellers as 'flat and boring', the Nullarbor is anything but! It has thousands of karst features—big and small—hundreds of caves including deep caves with extensive lakes and suites of shallow to deep caves associated with uplift occurring over the past 30 million years or so, giving us the Nullarbor's iconic vast limestone sea cliffs. Ancient river valleys traverse this karst reflecting a much wetter past. Many experts consider that the Nullarbor has World Heritage significance for its natural and cultural values.

The Nullarbor Plain is among the world's largest single exposures of limestone bedrock. The name of this vast plain comes from the latin 'null arbor'



Top Ngilgi Cave near Yallingup, Leeuwin-Naturaliste National Park.
Photo – Danny Wilkinson

Above Crystal Cave in Yanchep National Park, now dry, was once filled with water.
Photo – DBCA







Geological age of WA cave regions

Caves	Period	MYBP*
Yanchep National Park	Pleistocene	0.04 – recent
Leeuwin-Naturaliste National Park		
Cape Range National Park	Palaeocene - Oligocene	66 – 23
Nullarbor Plain		
Devonian reefs of the Kimberley	Devonian	419 – 358

** MYBP = Millions of years before present*

meaning 'no trees'. At its widest point, it stretches about 1100 kilometres along the southern coast of WA extending into South Australia. It is a former shallow seabed, which is now a world-class karst region comprising Nullarbor limestone of Oligocene and Miocene ages.

It includes the Old Homestead Cave, one of Australia's longest cave systems comprising about 34 kilometres of tunnels and chambers across four levels. They are filled with speleothems and gypsum crystals that grow out from the walls. A number of the large deep caves feature underwater lakes and extensive water-filled tunnel systems.

The WA Museum staff and other people have been finding important information about the former wildlife of Australia as the remains of animals that fell into these caves have been protected in the stable and dehydrating environment deep within the caves.

The visibility in these waters has been measured at more than 50 metres and the Nullarbor is a mecca for the world's cave divers. In 2002, in one of the caves, a WA Museum expedition, which included Eve Taylor, a cave guide at Yanchep National Park, found an almost complete skeleton of the *Thylacoleo carnifex* or marsupial 'lion', which is described as being the size of a leopard but built like a bear.

When you're driving across or flying over the Nullarbor, it is a good time to reflect on what lies beneath.

Top left WA's oldest cave system in Dimalurru (Tunnel Creek) National Park.
Photo – Peter Nicholas/DBCA

Top Sampling the world's tallest salt stalagmite in Webbs Cave, Nullarbor Plain, that fell and broke some time between the 1930s and 1980s.
Photo – Adrian Davey

Above A cave entrance on the Nullarbor Plain.
Photo – Jiri Lochman

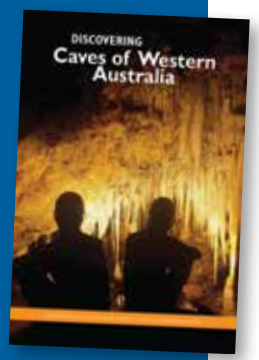
Professor Ross Dowling AM is Emeritus Professor of Tourism at Edith Cowan University. Professor Dowling was appointed a Member of the Order of Australia in 2019 for his 'significant service to higher education, and tourism and conservation'. He can be contacted at r.dowling@ecu.edu.au or (08) 6304 5891.

Andy Spate AM is the managing director of Optimal Karst Management and is the Australian expert on caves and karst. He was appointed a Member of the Order of Australia (AM) in 2019 for 'significant service to conservation, particularly to caves and karsts'.

Acknowledgements

The authors wish to thank the following people for their contribution to this article – Darren Brooks, Dr Bert De Waele, Andrew Green, Prof Bill Humphreys, Daniel Lansom, Ian Lewis, Mike Freeman, Rob Susac and Eve Taylor.

Learn more about WA's caves systems in Discovering Caves of Western Australia*, available for $6.95 from shop.dbca.wa.gov.au*





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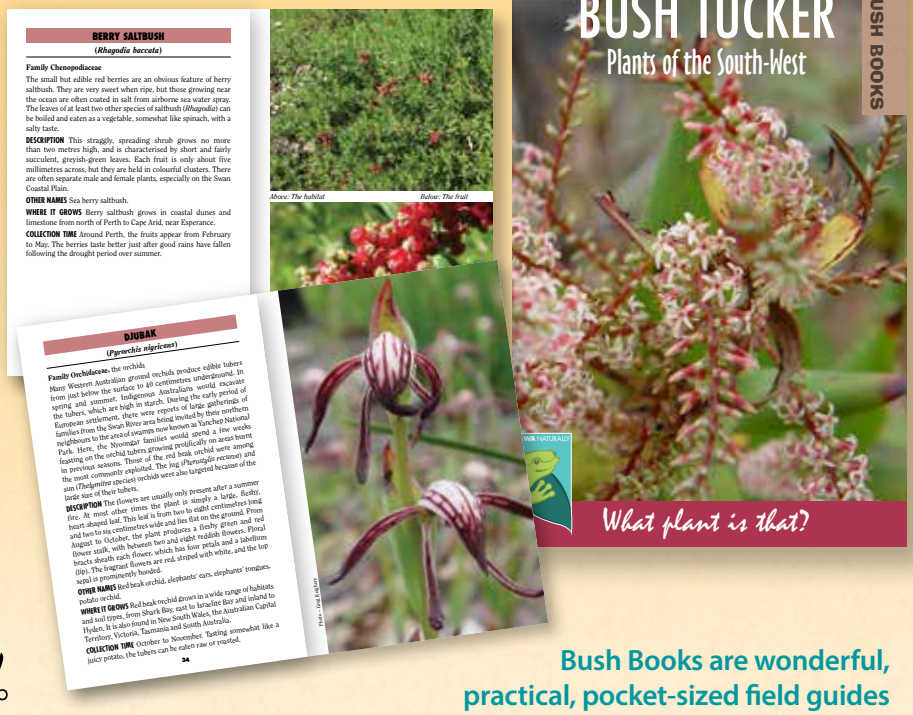
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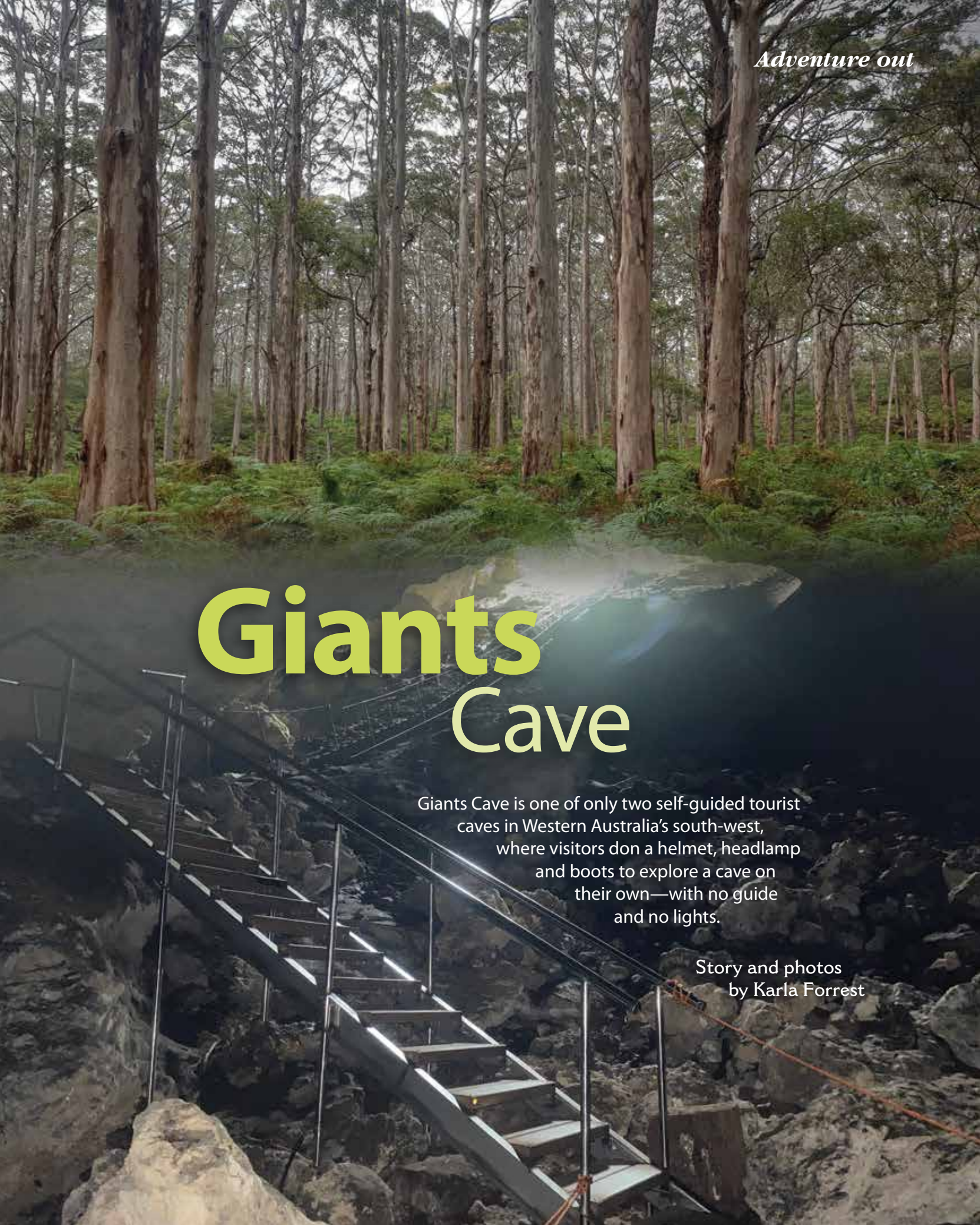
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GOVERNMENT OF WESTERN AUSTRALIA



Giants Cave

Giants Cave is one of only two self-guided tourist caves in Western Australia's south-west, where visitors don a helmet, headlamp and boots to explore a cave on their own—with no guide and no lights.

Story and photos by Karla Forrest





My day began travelling along Caves Road in the stunning Leeuwin-Naturaliste National Park, an area famed for its towering karri forests and incredible beaches. The drive was punctuated by flashy signs for wineries, expensive restaurants and other tourist attractions, but my destination was a little bit different.

ADVENTURE AWAITS

About 20 kilometres south of Margaret River, I turned off the road, parked and headed toward the signposted entry hut. I was greeted with a friendly smile by Parks and Wildlife Service staff Bob and Kristy, who gave me a 10-minute briefing about the task ahead. I was about to enter Giants Cave, one of the deepest caves on the Leeuwin-Naturaliste Ridge. Reaching 86 metres at its deepest point, the cave is as deep as a 30-storey building is tall. I would need to scramble over rocks, crawl through narrow openings and climb ladders. There would be no guide to lead me and there are no lights installed in the cave.

When Bob warned me there was a 'point of no return'—a narrow part of the cave known as the Chimney—I felt a slight sense of foreboding, coupled with excitement. I was fitted with a helmet, headlamp and back-up torch, and Kristy checked that I had suitable footwear.

I set out along a short boardwalk surrounded by lush green forest.

Just 20 metres beyond the entry hut, the cave entrance loomed into view. Tall karri trees gave way to a spectacular 100-metre-wide sinkhole below me. Known as a doline, it is the result of a cave roof collapse that happened thousands of years ago. Dolines are a common feature of this area—the Leeuwin-Naturaliste Ridge—due to the number of streams that once ran through here, eroding the windswept limestone and carving underground channels. Eventually, when a high dome was all that remained, it would crash in on itself and form a sinkhole. This one, adorned with phytokarst structures and filled with trees and bushes, was really quite beautiful.

THE BEAUTY BENEATH

A long series of stairs took me from the dappled light of the doline to the growing darkness of the cave. My eyes took a moment to adjust and I turned on my headlamp. Looking back, I thought of the aching legs I would surely feel tomorrow.

I entered the Twilight Chamber and the wonders of the cave unfolded before me. Ghostly, pale structures hung from the ceiling—stalactites of all shapes and sizes. Water droplets clung to the fragile structures, ever so slowly building them. Stalagmites rose from the sandy floor. There were some good examples of shawl formations here, draping delicately from above.

Descending more stairs and edging further underground, I passed beneath Caves Road and entered the Ballroom Chamber. At 75 metres long, 45 metres wide and 18 metres high, it is the largest chamber within Giants Cave. This is where the stream that created the cave had once run, but it is not known exactly when the stream dried out. The Ballroom is also the site where bones of the extinct short-faced kangaroo (*Simosthenurus*) were found. This kangaroo was one of Australia's most common megafauna species. Aboriginal artefects have also been found throughout the Leeuwin-Naturaliste cave system, including fire hearths, stone and bone tools, jewellery and even teeth. This highlights the Wadandi Noongar peoples' knowledge and use of the caves dating back more than 55,000 years.

QUIET CONTEMPLATION

It was a quiet day in the cave. The wet weather may have been keeping other visitors away, so I decided to stop for a while. I sat cross-legged on a wide boardwalk and switched my headlamp off. I held my hand in front of my face and saw nothing. Somewhere far above me, I heard a drip of water. I strained my ears to hear

Previous page
Above Giants Cave is set among towering karri trees within Leeuwin-Naturaliste National Park.
Below Stairs leading into the cave. In the early days of the 20th century there was a platform installed at the base of these stairs for tourists to enjoy picnics.

Above Descending the 'rope slope', more than halfway through the cave.

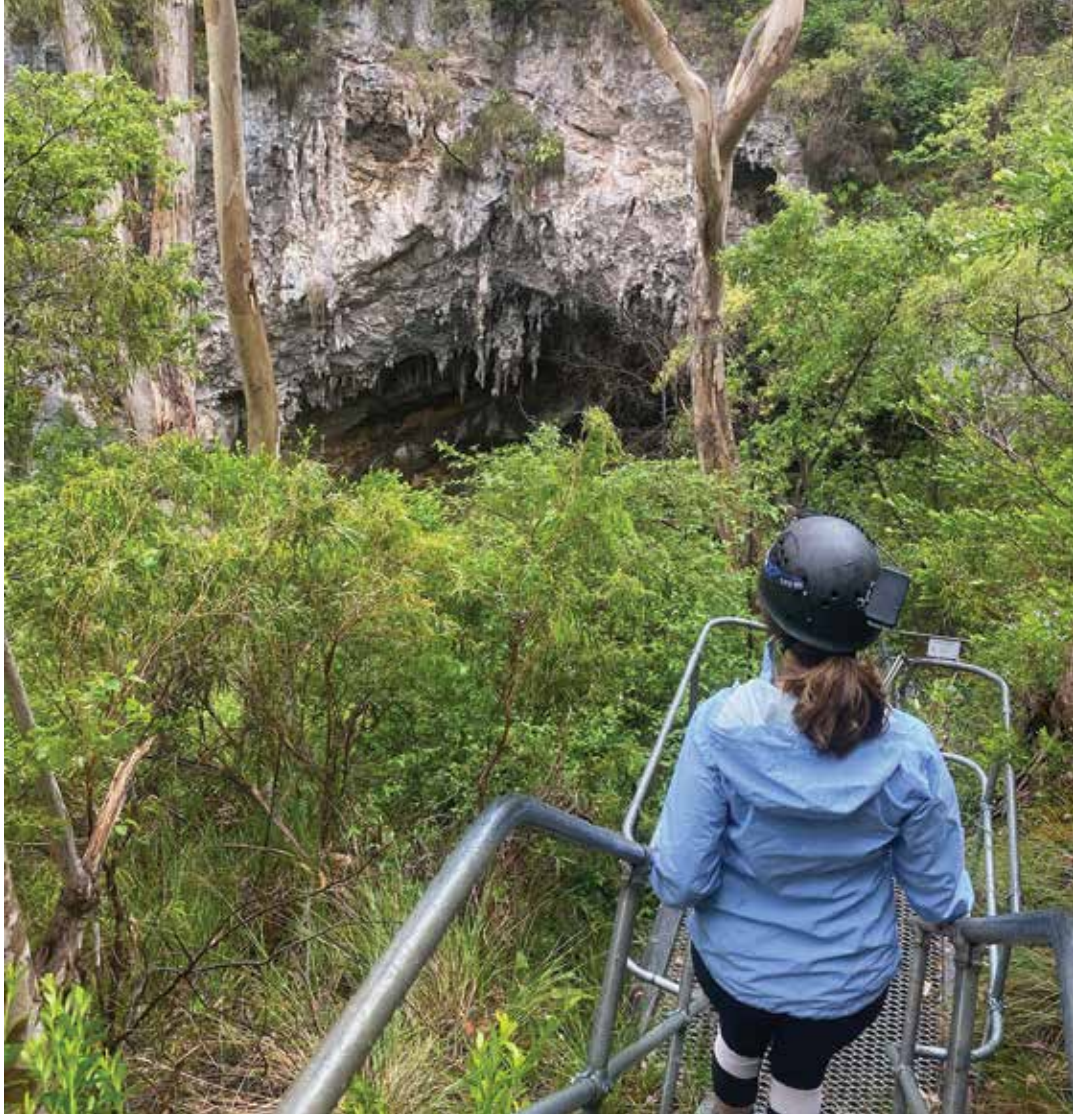
DO IT YOURSELF

Where is it? Giants Cave is approximately 20 kilometres south of Margaret River in Western Australia's south-west.

Planning your trip Giants Cave is open between October and April from 10am until 1pm. During school holidays and public holiday weekends, the cave is open from 9.30am until 3.30pm. Other times and group bookings by prior arrangement. Entrance fees apply.

Staying safe Visitors should have a reasonable level of fitness, wear sturdy enclosed footwear, and be prepared for dark, enclosed spaces. Helmets and lights are supplied. Giants Cave is not suitable for children under six years old. However families with children under six are encouraged to visit nearby Calgardup Cave.

Contact Visit the Leeuwin-Naturaliste National Park Information Centre at Calgardup Cave. Ph (08) 9757 7422 or email calgardup@dbca.wa.gov.au.



the scurrying of a mouse, the light flap of wings. Nothing. Then… another drip. The darkness and the silence somehow seemed to deepen, but in a peaceful way. Drip. What a wonderful place to practice mindfulness. I resumed my journey feeling relaxed, ready for the next part of the adventure.

CLIMBING AND CRAWLING

I reached the Chimney, the point of no return—a series of three narrow ladders. It is the smallest part of the cave system. Looking up at the first six-metre steel ladder, I saw that I'd need to keep my body close to the ladder to avoid hitting the wall behind me. A sign here tells visitors to turn back if they are reluctant to continue.

Up I went, grasping the cool metallic rungs tightly. I clambered over a huge boulder holding onto a steel chain, climbed another two ladders and crawled beneath some low-hanging rock. This was a far cry from my childhood memories of cave tours with wide, brightly-lit walkways, a confident tour guide and people chattering excitedly. I never felt unsafe, however. The 575-metre route through the cave is clearly marked. Exiting the Chimney section, I entered the Arborite Chamber, where twisted tree roots, some white from calcification, descended from the lofty ceiling. The name of the chamber is a combination of 'arbor' (the Latin word for 'tree') and 'stalactite'. Moving on and climbing down yet more stairs, I reached a section known as the 'rope slope'. This was a low-roofed 10-metre section where I had to use a rope to guide me down a slippery rock surface. At almost the deepest point of the cave, this area once contained a small lake that had since dried due to climate change and a decrease in rainfall. A series of white reflectors directed me to the end of the cave, where there was another series of small ladders to negotiate, and more rocks to scramble across, before making a final climb through a grate into the crisp, open air of the karri forest. After a short walk through the forest and back across Caves Road—over land this time—I returned to the entry hut. Giants Cave was certainly something to remember.

Above Visitors enter Giants Cave through a large sinkhole, or doline, formed thousands of years ago when part of the cave roof collapsed.

Below Cave structures such as stalactites are formed from calcium carbonate deposits found in water droplets.



Karla Forrest is a DBCA communications officer. She can be contacted at karla.forrest@dbca.wa.gov.au or (08) 9219 9818.



wandering out WEST

With Western Australian borders shut for some time to international and interstate travellers, the impact has been felt by the Aboriginal tourism sector. As locals enthusiastically 'wander out yonder', we are encouraged to see the State through the eyes of a Traditional Owner and add a cultural experience to our intrastate itinerary.

BY JACKIE CROOKS AND DI BELOW





Travelling to foreign lands is an experience filled with excitement and intrigue. Immersing in traditional culture as we explore new places is one of the great joys of travel but something that is often left to tourists.

When it comes to exploring the Indigenous culture of our home country, the desire among locals is somewhat different. Traditionally, it has been the international visitor (and to a lesser extent those from the east coast) who have sought out and participated in Aboriginal tourism experiences in Western Australia.

Aboriginal and Torres Strait Islander history is taught in schools and there is great interest in connecting with and learning about Aboriginal culture, but Western Australians are less likely to take up the opportunity to immerse themselves in cultural experiences.

The impacts of COVID-19 have meant that intrastate travel has increased so Aboriginal tourism operators have pivoted and refocused on the intrastate market, encouraging WA residents to learn and experience local Aboriginal culture.

WONDERS OUT WEST

WA has one of the oldest living cultures on Earth and its tourism potential is largely untapped. WA's ruggedly picturesque landscapes have been home to Aboriginal people for more than 60,000 years, comprising a vast network of ancient tracks that link more than 120 language groups, each with their own unique story and heritage.

With a size comparable to western Europe, WA has an enormously diverse range of Aboriginal culture throughout the State and the experience you receive in the north is very different from the south. No one Aboriginal experience is the same.

Experiencing WA through the eyes of Traditional Custodians opens up a whole new way of seeing things. The bush becomes a supermarket full of an array of foods to sustain and heal. Exploring a limestone cave is magical and intriguing, but visiting with an Aboriginal guide as they play a didgeridoo in the cavernous underground takes the experience to a whole new level.

WHAT'S NEXT

Through the support of State Government and member organisations such as the WA Indigenous Tourism Operators Council (WAITOC), Western Australians are opening their eyes to what Aboriginal culture is really about.

The Jina: Western Australian Aboriginal Tourism Action Plan 2021–2025 (Jina Plan) was launched in May 2021 and outlines 69 actions aimed at building, developing and growing the Aboriginal tourism sector in WA.

The vision is for WA to become the premier authentic Aboriginal tourism destination in Australia—a place for sharing cultural experiences and enriching the lives of Aboriginal people. The Jina Plan sets out how to achieve this through strong partnerships, enabling Aboriginal people to develop their own businesses to showcase their culture on their country.

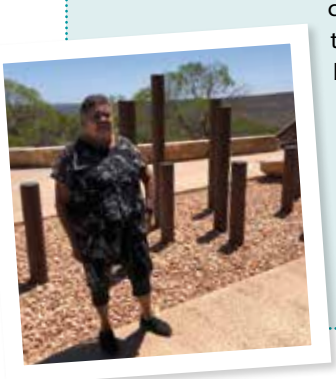
Discover the Dreaming

Colleen Drage is a Nanda woman and cultural leader who lives and works on Yamatji country. Along with fellow artists Mauretta Drage and Kayla Hampton, Colleen's art enlivens the new Kalbarri Skywalk with cultural meaning.

DBCA is working with Colleen to deliver cultural talks at the skywalk under the 'Discover the Dreaming' program. These small-group talks provide visitors with a cultural perspective on the landscape and are a wonderful way to connect with country and enrich your visit. The talks have been designed to be affordable and are less than one hour to suit families and visitors exploring other parts of the park.

Colleen is planning to provide a range of unique experiences for visitors to learn about the culture and history of Nanda country.

Join Colleen on a visit to Kalbarri as she shares her knowledge of ancient culture and country. Information is available at exploreparks.dbca.wa.gov.au/whats-on.



Previous page
Main Peedamulla Campground, Pilbara.
Photo – WAITOC
Inset (previous page) and above Uptuyu Aboriginal Adventures.
Photos – Tourism WA

Inset left Colleen Drage delivers a cultural talk in Kalbarri National Park.
Photo – Tracy Shea

Hear more about Aboriginal tourism in WA

Scan this QR code or visit Parks and Wildlife Service's podcast.



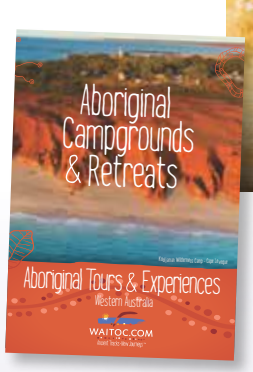
49 Mercedes Cove Coastal Retreat

Camping and retreat experiences

The Aboriginal communities who own and operate private campgrounds and retreats are passionate about sharing their country with visitors. These spectacular and often secluded locations are on traditional lands, some with private beaches, uncrowded fishing spots, pristine bushwalks and abundant wildlife. Income generated from these businesses helps sustain the communities that own and operate them, often providing employment and training. 'Camping with Custodians' campgrounds offer visitors the opportunity to truly experience country and culture by connecting with Traditional Owners. Each campground provides a unique experience—tour ancient limestone caves and rock art sites, visit an Aboriginal art gallery, stay close to iconic natural attractions or just enjoy a yarn around the campfire. See map on page 44–45.



22 Girloorloo Tours at Mimbi Caves



Left Information about Aboriginal-owned and operated accommodation is available at waitoc.com.
Photos this page – WAITOC, Tourism WA



57 Peedamulla Campground



31 Imintji Campground



11 Bush Ghoodhu Wongutha Tours



56 Oongkalkada Wilderness Camp

Tour operator			
1. Ardyaloon Hatchery			•
2. Banana Well Getaway	•		•
3. Baiyungu Dreaming			•
4. Bilya Koort Boodja Cultural Centre		•	•
5. Bindi Bindi Dreaming		•	•
6. Borrgoron Cultural Tours		•	•
7. Brian Lee Tagalong Tours		•	•
8. Bundy's Cultural Tours		•	•
9. Bungle Bungle Guided Tours		•	•
10. Bungoolee Tours			•
11. Bush Ghoodhu Wongutha Tours	•	•	•
12. The Crossing Inn	•		
13. Darngku Heritage Cruises			•
14. Dale Tilbrook Experiences		•	•
15. Deadly Divas Experiences		•	•
16. Djirrily Dreaming		•	•
17. Djurandi Dreaming	•		•
18. Doon Doon Campground	•		
19. Echo Tours			•
20. Experience Murujuga			•
21. Fitzroy River Lodge	•		
22. Girloorloo Tours at Mimbi Caves	•	•	•
23. Go Cultural Aboriginal Tours and Experiences			•
24. Goojarr Goonyool Whale Research and Campground	•		
25. Goolaraboolo Millibin Yarri			•
26. Goolamwiin	•	•	•
27. Goombaragin Eco Retreat	•	•	•
28. Gumbanan Wilderness Retreat	•	•	•
29. Gwoonwardu Mia			•
30. Honeymoon Bay	•	•	•
31. Ilkurlka Roadhouse Gallery and Campground	•		
32. Imintji Camprground	•		
33. The Kodja Place		•	•
34. Jilnya Adventures		•	•
35. Kaarak Dreaming		•	•

Tour operator			
36. Karalundi Caravan and Camping Park	•		
37. Karijini Eco Retreat	•		•
38. Kimberley Country Tours	•	•	•
39. Kimberley Cultural Adventures		•	•
40. Kingfisher Tours	•	•	•
41. Koomal Dreaming		•	•
42. Kuarla Bed and Breakfast	•		
43. Kurrah Mia		•	•
44. Lombadina Community	•	•	•
45. Lucky Bean Café		•	•
46. Luridgii Tours	•	•	•
47. Mabu Buru Tours		•	•
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49. Mercedes Cove Coastal Retreat	•	•	•
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51. Ngalang Wongi Aboriginal Cultural Tours		•	•
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53. Njaki Njaki Aboriginal Cultural Tours		•	•
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55. Ngungar Tours		•	•
56. Oongkalkada	•	•	•
57. Peedamulla Campground	•		•
58. Pilbara Tours			
59. Ribinyung Dawang Ord River Cultural Tour	•	•	•
60. Roelands Village		•	•
61. Southern Cross at Lullumb		•	•
62. Uptuyu Aboriginal Adventures		•	•
63. Uunguu Visitor Pass and Munurru Campground	•		•
64. Violet Valley Campground	•		
65. Waringgarri Aboriginal Art		•	•
66. Warrang-Bridil			•
67. Wijingarra Tours		•	•
68. Wuddi Cultural Tours		•	•
69. Wula Gura Nyinda Eco Adventures Shark Bay	•	•	•
70. Wunan House	•		

Camping and accommodation

Bushfood

Tours

Reconciliation Barometer

The Australian Reconciliation Barometer shows that the majority of Australians believe it's important to learn about Aboriginal history and cultures. The biennial national research study undertaken by Reconciliation Australia in 2020 showed that 86 per cent of the Australia's Aboriginal and non-Aboriginal people agree that it is important that all Australians know about Aboriginal cultures.



"Experiencing WA through the eyes of Traditional Custodians opens up a whole new way of seeing things."



Cape Leveque
1 2 6 7 8 24 27 28 44 49 61
Derby
25 39 Broome 47 50 62
56
Fitzroy Crossing
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13 38
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46 40
67
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59 65
Wyndham
Kununurra
Port Hedland 58
20
Karratha
52
Onslow
57
Exmouth
3
37
29
Shark Bay
69 69
36
42
Geraldton
Laverton
31
Kalgoorlie
11 54
53
5 14 15 16 23 26 55 66 Perth
4
Fremantle
17
35
48
60
Bunbury
51
68
33
Yallingup
41
43
Albany
45
Esperance

0 100 200 300 400 500
kilometres

Do it yourself

Information about cultural tours and experiences, and Aboriginal-owned and operated campgrounds and retreats, as well as Aboriginal art galleries, is available on the WAITOC website.

For more infomation visit waitoc.com or scan this QR code.

Above Bundy's Cultural Tours.

Inset right Koomal Dreaming.

Below right Uptuyu Aboriginal Adventures.

Below Wula Gura Nyinda Eco Adventures, Shark Bay.
Photos – Tourism WA




40 Koomal Dreaming

Bushfood and wildflower experiences

WA's wildflowers rank among the most spectacular flower displays in the world. Between July and October, many parts of the State become blanketed with colour. Everything from tiny crimson myrtles, dainty smokebushes, fiery mountain bells and more than 150 species of orchids come into bloom. For Aboriginal people, these flowers are also a traditional source of food and medicine—part of WA's great big bush supermarket, full of highly nutritious foods that can be found throughout the land, the seas and the waterways. On an Aboriginal bushfood tour, you will be treated to interactive and delicious cultural encounters as your Aboriginal guides share ancient cultural knowledge of what the land has to offer. See map on page 44–45.



Left Information about bushfood and wildflower experiences is available at waitoc.com.
Photos pages 46–47 – Frances Andrijich, Tourism WA, WAITOC


5 Bindi Bindi Dreaming


51 Ngalang Wongi Aboriginal Cultural Tours


Pigface and icecream


Maalingup Aboriginal Gallery

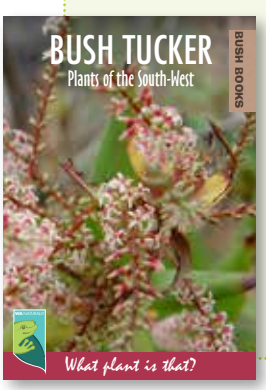
Quandong (Santalum acuminatum)

This tree has attractive round, succulent fruits that turn bright red when ripe and make a tasty snack. They have red outer skin, like orange peel, surrounding a hard outer kernel, which can be cracked open to reveal the nut. The nuts are delicious when roasted. The outer part of the fruit can be made into jams or jellies. Quandong is a close relative of sandalwood, and it too parasitises other plants through its roots.

Other names Dumbari, jawirli, native peach, Vasse apple, walku, wanga, wayanu, wongil.

Where it grows Quandong is found in all Australian states, but in WA it grows from Carnarvon southwards, and into inland areas. In metropolitan Perth it is largely a plant of coastal dunes and limestone areas, but also grows on the Darling Scarp.

Other uses Pounded quandong leaves were reportedly used by some Aboriginal people to treat diseases introduced by European settlers. The seed contains a large amount of oil, which can be used as a moisturiser for the skin. Children may use the stones as beads or marbles.



Left Learn more about Noongar plant food in *Bush Tucker Plants of the South-West* bush book, available for $6.95 from shop.dbca.wa.gov.au.
Right Fruit of the quandong.
Photo – Greg Keighery




50 Narlijia Experiences Broome


16 Djirrily Dreaming

Cultural tour experiences

Cultural tour experiences provide opportunities to interact with new environments. Passing on skills and ancestral knowledge has been part of traditional Aboriginal culture for millennia. Practising lore and maintaining customs has preserved the Aboriginal way of life, making it the oldest living culture in the world today. The tours include hands-on examples such as hunting and gathering, making tools and implements using only natural resources and fostering a deeper understanding of the unique cultural identity of the first Australians. Many of the tours offer authentic 'on country' experiences, interacting with Traditional Custodians and elders, who share their knowledge of the land and offer an insight into Aboriginal culture through Dreaming stories, song, dance and a range of activities that encourage group participation and cooperation. See map on page 44–45.


52 Ngurrangga Tours


53 Njaki Njaki Aboriginal Cultural Tours


6 Borrgoron Cultural Tours

Jackie Crooks is Acting Director – Destination Development with Tourism WA and an advocate for promoting Aboriginal tourism.

Di Below is the marketing manager for WAITOC. She can be contacted at info@waitoc.com

Find out more at westernaustralia.com or waitoc.com

Blind Pilbara beetles



Above The blind beetle (*Magnanillus serenitatis*), which is only known from the Serenity mining area, Pilbara.

Photo – Dr Giulia Perina/Subterranean Ecology Pty Ltd

If you've ever wandered about the Pilbara, your eye will be drawn to the stunning, rugged scenery and the distinctive vegetation comprising spinifex, Acacias and the odd ghost gum. Animals are harder to spot, especially during the day, when all sensible creatures apart from birds are usually sheltering from the extreme heat, particularly in the hotter months.

You're more likely to see animals at night when they are out searching for food.

You might be surprised to learn that there's a teeming underground community of animals living beneath your feet as you stride through the landscape. Spiders, beetles, scorpions, amphipods, sprickets (schizomids) and isopods, to name just a few. And these aren't sitting just below the soil surface. They live in small open spaces that occur deep within the Pilbara rocks. The voids are not big enough to be called caves, and they lack obvious openings to the surface. They have formed over millions of years as the rock itself has slowly dissolved from water running through it. These little homes join to form networks, much like a miniature interconnected village that provides habitat and a safe haven for underground species that can't tolerate the baking Pilbara sun.

Most of these underground species evolved from ancestors that lived on the Pilbara surface when the land was wetter and the landscape was vegetated with rainforest. As the surface became progressively drier during the Miocene Period (ca. 23–5 million years ago) many forest inhabitants became extinct, unable to deal with the new climatic conditions. Others became arid-adapted, presumably by changing their lifestyles and physiology. And yet others found solace in the cracks and voids below ground. They slowly developed traits that enabled them to survive in a lightless, humid ecosystem, such as long legs, or lost features that were no longer needed, such as eyes and pigmentation.

A recent publication by Dr Pier Mauro Giachino (Italy), Dr Stefan Eberhard (Subterranean Ecology Pty Ltd) and Dr Giulia Perina (Western Australian Museum) in the scientific journal *ZooKeys* has described six new genera and 18 new species of subterranean carabid beetles from the Pilbara. This research builds on earlier research by the late Dr Martin Baehr (Germany) who described 16 new subterranean carabid species from the region.

These underground beetles look like their surface cousins but they lack eyes. Like other carabids, the larvae and adults are predators, feeding on other subterranean organisms that they come across.

The vast diversity of the beetles and other troglobites in the Pilbara is thought to be the result of different incursions into the subterranean voids, followed by diversification as different parts of the landscape eroded away and became separated from each other. This formed 'island' habitats—often in the form of mesas—that the beetles were unable to move between. And just like island organisms that are incapable of dispersal, the lack of gene flow inexorably led to speciation and morphological changes in the beetles. Hence the large number of newly named species in the scientific study. Millions of years of underground isolation has produced remarkable diversity, not just in beetles, but in many other subterranean animals currently being studied by taxonomists.

Most of the new beetle species have been collected once only, suggesting that they are rather rare and that each possesses very small natural distributions. This poses a problem for developers who are obliged to consider each of these species when applying to mine or otherwise alter the landscape. If beetle species exist only at a single site, care must be taken to avoid destroying the entire population and hence the entire species.

Next time you visit the Pilbara, spare a thought for these ancient remnants of those long-lost days when rainforests blanketed most of WA. They've survived the past five million years eking out a living in these tiny voids, slowly adapting to a permanent life underground. Let's hope they survive the next five million years.

Mapping fire history for the **Great Victoria Desert**

A recent partnership between the Great Victoria Desert Biodiversity Trust and the Department of Biodiversity, Conservation and Attractions has developed a better way of mapping fire scars in this remote and vast desert biome.



by Dorian Moro, Jaume Ruscalleda Alvarez and Richard van Dongen



The Great Victoria Desert is Australia's largest desert, covering an area of approximately 42.2 million hectares. This bioregion extends across Western Australia and South Australia and is divided into six floristic sub-regions.

The Western Australian extent of the Great Victoria Desert covers an area of 21.8 million hectares, primarily managed by Traditional Owners, Pastoral and mining leases cover parts of the desert.

The landscape is dominated by spinifex grasslands and mallee eucalypts, which present a highly flammable environment after heavy rainfall and during dry periods.

FIRE PATTERNS

The contemporary fire pattern in the Great Victoria Desert is characterised by cycles of large areas burnt by hot bush fires in spring and summer. In this regard, intense bushfire is one of the critical threats facing this bioregion.

While fire has always been part of the deserts, the scale and intensity of fire in the Great Victoria Desert has increased at a dramatic rate in recent years.

Previous page
Main Great Victoria Desert.
Photo – Jiri Lochman
Inset Great Victoria Desert cool season burn.

Above Great Victoria Desert landscape.
Photos – DBCA



"While fire has always been part of the deserts, the scale and intensity of fire in the Great Victoria Desert has increased at a dramatic rate in recent years".

An analysis of aerial photography from the Great Victoria Desert in 1960 to 1961 showed mean and maximum fire scars of 11 hectares and 3953 hectares, respectively.

However, analysis of more recent fire scars using satellite imagery showed a mean and maximum fire scar size of 3699 hectares and 1,033,121 hectares.

INDIGENOUS KNOWLEDGE

Fire management is a necessary tool to maintain diversity in desert environments. While cultural burning practices have been widely disrupted over a number of generations, there is a growing recognition of the value of returning these practices to the desert country for cultural and biodiversity reasons.

Cultural burning practices have resulted in 'patchy' burns that reduce the effects of large-scale bushfires. Traditional Owners are now taking ownership of their land management practices through Indigenous Protected Area management planning.

MAPPING FIRE HISTORY

Identifying which areas in the landscape to patch burn is pivotal to burn planning, and subsequent fire management operations. Management actions need to be informed by fire history maps that are sufficiently accurate at the scale of the area that is being managed.

Satellite imagery is useful to identify fire history boundaries and to predict and manage bushfire risk in the area.

The Northern Australian Fire Information (NAFI) uses MODIS satellite imagery to generate fire scar maps with 250-metre resolution. NAFI was originally designed to detect fire patterns in northern parts of Australia; however, its accuracy is less reliable in the desert and rangeland environments.

These errors have a considerable impact when attempting to define fire





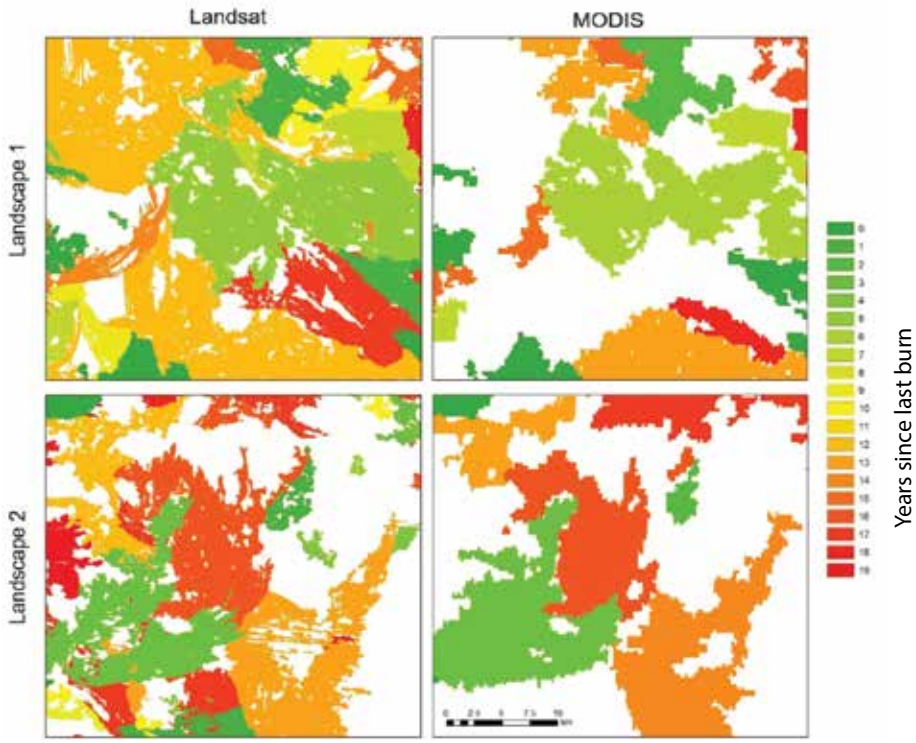


Figure 1. Landscape-scale level comparison of years since last burn maps, using Landsat and MODIS fire scar maps. Areas that appear white are considered unburnt from1995 to 2019.



boundaries for planning operational burns, and for identifying long-unburnt habitat that may support conservation significant species.

The Great Victoria Desert Biodiversity Trust partnered with the Remote Sensing and Spatial Analysis program at the Department of Biodiversity, Conservation and Attractions (DBCA) to develop a more accurate way to map fire boundaries.

Landsat imagery is better suited to mapping the distribution of fire across the desert landscape of the Great Victoria Desert with 30-metre resolution.

Satellites measure different wavelengths of infrared light that are undetectable by the human eye.

Top Sandhill dunnart *(Sminthopsis psammophila*).
Photo – Jeff Turpin

Above left Honeysuckle grevillea (*Grevillea juncifolia*).
Photo – Garry Middle

Above Great Victoria Desert.
Photo – DBCA





This higher resolution imagery across several spectral bands helps identify differences in vegetation health and map historically burnt areas (see Figure 1 on page 51).

Landsat imagery detected and profiled fire scars with relatively lower errors than MODIS. At the habitat scale, we were able to show that Landsat can be confidently used to estimate burn areas as small as 500 square metres.

MANAGEMENT IMPLICATIONS

Improving the accuracy of satellite-derived fire maps for these desert biomes has practical implications for fire management planning. In the Great Victoria Desert, retaining vegetation 12-24 years since fire is important to protect spinifex (*Triodia* sp.) habitat for conservation-significant species such as sandhill dunnarts (*Sminthopsis psammophila*). Similarly, reducing the flammability around mulga (*Acacia aneura*) patches at least 18 years since fire helps to conserve malleefowl (*Leipoa ocellata*) nesting and breeding sites.

WHAT'S NEXT

This work serves as a precursor to a broader assessment of the fire history and vegetation fire parameters of the landscape across the Great Victoria Desert, and for delivering ecologically sustainable fire management in this bioregion.

Traditional Owners can use the maps to help decide which areas to burn and which to protect. Maps also offer a useful tool for future opportunities such as carbon farming surveillance under the Australian Emissions Reduction Fund to manage landscapes and habitats for fire.

The information also has application for fire managers with an interest in planning prescribed burns to protect important fauna habitats.

Above left An example of old growth spinifex (*Triodia* sp.) in the Great Victoria Desert.
Photo – DBCA

Above Large-fruited mallee (*Eucalyptus youngiana*.)
Photo – Garry Middle

Below After a hot summer fire in the desert.
Photo – Great Victorian Desert Biodiversity Trust



Dr Dorian Moro worked as manager of the Great Victoria Desert Biodiversity Trust to support the development and initiation of projects for landscape management and species conservation. He now manages the Wiluna Martu Rangers Program for the Matuwa Kurrara Kurrara Indigenous Protected Area. He can be contacted at environment@tmpac.com.au.

Jaume Ruscalleda-Alvarez is a technical biodiversity officer at the Great Victoria Desert Biodiversity Trust. He worked as a research officer with DBCA, contributing to historical fire mapping in the Great Victoria Desert. He is also a PhD candidate at The University of Western Australia investigating remote sensing methods to assess drought stress in plants growing in restored mine sites. He can be contacted at jaume.ruscalledaalvarez@gvdbiodiversitytrust.org.au

Richard van Dongen is a research officer with DBCA. He uses imagery captured from drones, aircraft and satellites on a range of vegetation monitoring projects at Dirk Hartog Island, the jarrah forests of the south-west and the banksia woodlands. He can be contacted at ricky.vandongen@dbca.wa.gov.au.

by Joselyn Juraszek

kaleidoscope
kids exploring nature

Wet and wild **summer fun**

Spending time in the great outdoors in summer is so much fun. Beach days are the best, playing in the water and cooling off with a swim. With lots of fantastic places to explore you could take a dip in the ocean, a river, or even a lake. Swimming is fun but it's important to keep yourself, your friends and family safe around water.

Splash through summer safely and remember to always:

1. Read the safety signs.
2. Swim together.
3. Look out for hazards.

Can you spot these hazards in the picture below?

Fallen branches, hidden rocks and dangerous creatures.



Find the animals

Can you find the **25 animals** hidden in the picture?

There is a jellyfish, seahorse, sting ray, sea snake, crocodile, swan, duck, pelican, ibis, seagull, lobster, starfish, octopus, dolphin, whale, 6 fish in the water, and 4 birds in the sky.

LANDSCOPE's **Kaleidoscope kids exploring nature** page is an exciting regular feature for kids.



Red-tailed black cockatoo (*Calyptorhynchus banksii*)

The red-tailed black cockatoo is a noisy, active species that spends much of its day feeding in large trees around most of mainland Australia. These iconic birds use their incredibly strong bills to extract seeds by tearing open seed pods of eucalypts, casuarinas and banksias. The cockatoo has largely black plumage and scarlet panels in the tail. Females have yellow spots on the head, neck and wings, and orange-yellow barring on the breast and undertail. Flocks of red-tailed black cockatoos are often seen flying and screeching loudly at sunset back to their roost in large trees, often on the banks of rivers or streams.

Illustration by Gooitzen van der Meer

Reference photo by Rick Dawson

Nature's pin-ups

PRINT COLLECTION

Artwork featured in *LANDSCOPE* magazine



Artwork by Gooitzen van der Meer and Gwendolen Monteiro, as featured in *Nature's pin-ups* on page 54 in each issue of *LANDSCOPE*, is now available for purchase.

Using a watercolour technique or acrylics, the pieces depict species featured in the magazine.

Prints of these beautiful pieces of artwork can now be purchased in A3 size ($35), A4 size ($25) or A5 size ($15) plus $3.30 postage for domestic large letters up to 250g. Printed on high quality art paper and delivered to your door, ready to be framed and hung somewhere special.

Proceeds from your purchase go towards managing and conserving WA's plants, animals and natural environment.

To see the collection visit **shop.dbca.wa.gov.au/collections/prints**



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ISSN 0815-4465

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WA NATURALLY