WA's conservation, parks and wildlife magazine

LANDSCOPE

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Shark Bay Marine Park

Bound by a love for flora

Warlu Way

Rowley Shoals **Fungi and invertebrates** World Heritage

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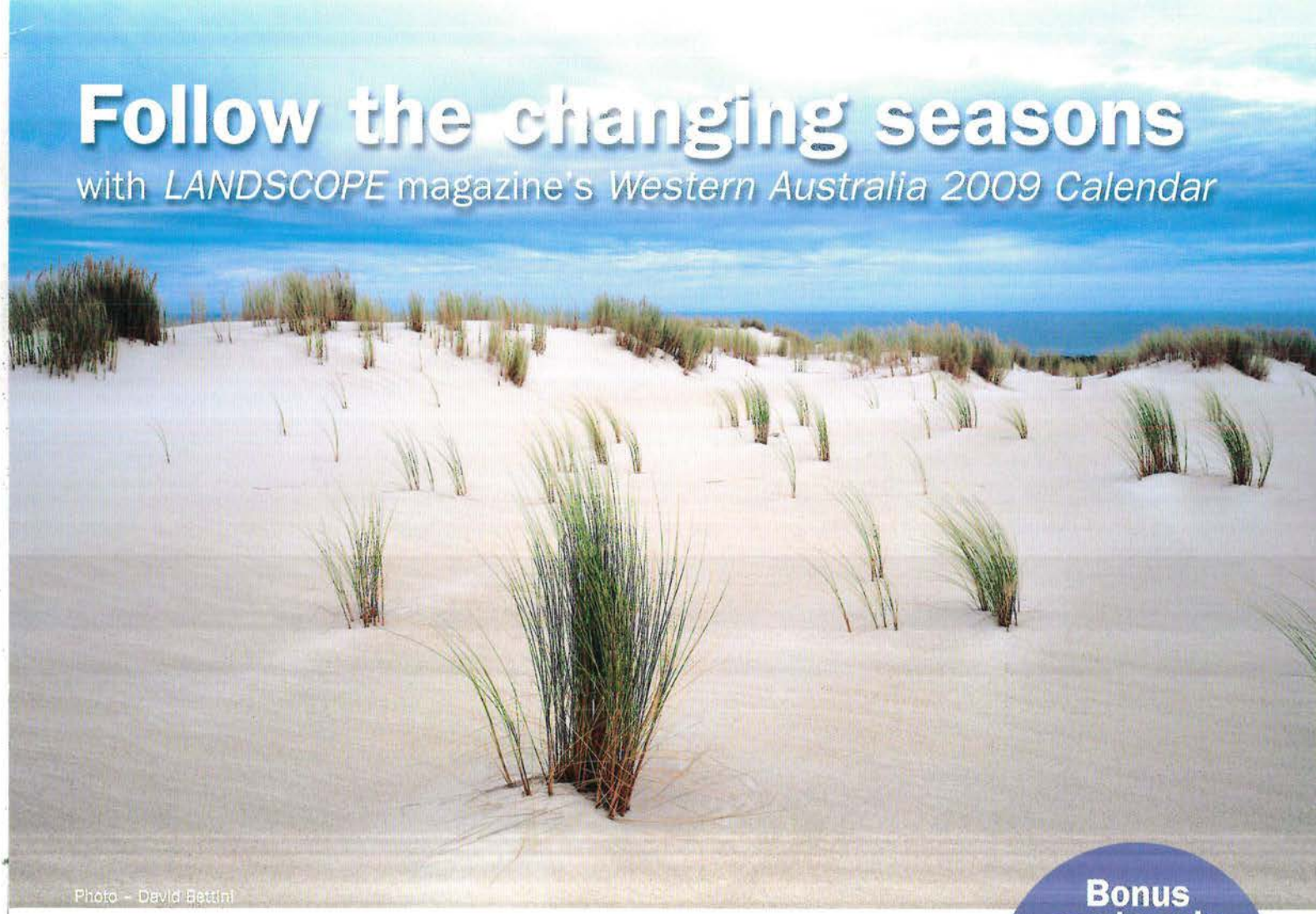

Photo - David Bettini

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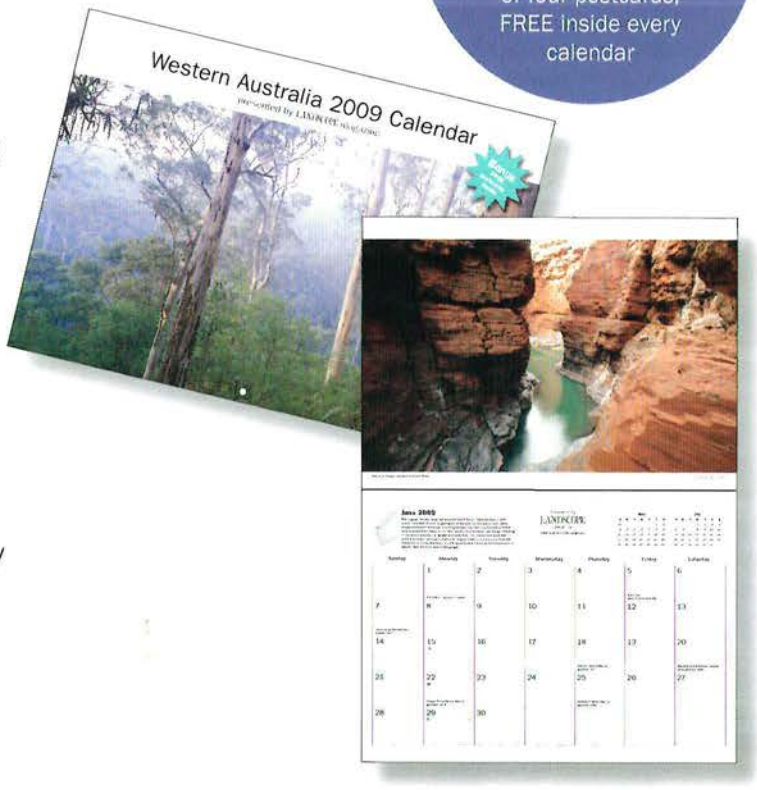

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ACT NOW FOR THE FUTURE

Department of Environment and Conservation

Our environment, our future

contributors

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Janet Newell has worked in Albany as a technical officer for DEC for the past 18 months on the South Coast Natural Resource Management Biodiversity Inventory Program. She has just completed a PhD on the reintroduction and ecological roles of bilbies and boodies at Arid Recovery, a fenced reserve near Roxby Downs, South Australia. Janet's interests are in biodiversity conservation. She is enjoying the contrast between her research in an arid ecosystem and her current position assessing a small part of the south-west's rich biodiversity.

editor's letter

In science, as in other areas of life, knowledge is power. In order for land management agencies and conservation groups to effectively manage Western Australia's unique biodiversity, we need to build a picture of what we are dealing with. To help achieve this, scientists and community groups around the State are carrying out surveys to identify what exists and where. This edition of *LANDSCOPE* includes a number of stories which give an insight in to some of the projects under way.

The Rowley Shoals, made up of three atolls in WA's north, houses a diverse range of marine life. In 'On the edge: exploring the Rowley Shoals' we look at a survey carried out thanks to a successful partnership between the Department of Environment and Conservation and the Australian Institute of Marine Science. The results of the survey will provide information needed to successfully manage this important area in the hope it will become the benchmark for coral reef biodiversity conservation. Teams of dedicated scientists were involved in the project, combing the ocean floor for data and recording their work on video. The project included catching sharks which they measured, tagged and collected DNA from to help them learn more about the marine life of this precious area.

'Discovering the coral life of Shark Bay Marine Park' is another feature that takes us underwater to find out more about corals in the Shark Bay Marine Park. Data collected will build a profile of the distribution and diversity of coral reef communities.

Back on land along the south coast, 'Hidden biodiversity: fungi and invertebrates' looks at a biodiversity inventory program which is improving our knowledge of poorly documented groups such as fungi and invertebrates. The program has uncovered some surprising new finds with many more expected to follow. It has also helped raise awareness among south coast land managers and the public of the importance of biodiversity conservation.

Public involvement teamed with the quest for knowledge is the theme of 'Bound by a love of flora', the story of a band of dedicated volunteers who have carried out a 20-year survey of plants found in the State's south-west. The group, under the lead of the Wildflower Society of Western Australia, has worked tirelessly to collect, identify and record tens of thousands of common and not so common Western Australian plants.

This edition also gives us a view of the Warlu Way, a self-drive trail from Coral Bay to Broome that takes visitors on a journey of discovery into the natural and cultural values of WA's north-west.

And, of course, with our stunning front cover in recognition of this year as the Year of the Frog, we feature a report on 'Fascinating frogs'.

Kaye Verboon
Executive Editor

Kevin Bancroft has been involved with DEC's Marine Science Program since May 2006. He works as a research scientist in the area of marine biodiversity patterns. As part of his work, Kevin has been conducting habitat surveys, biological surveys and establishing long-term monitoring of benthic communities. Before that, Kevin worked with the now defunct Marine Conservation Branch from 1998. Initially employed as Marine Conservation Officer then as Acting Senior Marine Ecologist, he provided and facilitated the science information requirements for planning and management of existing and proposed marine protected areas. Kevin's work is focused on providing an understanding of the patterns and distribution of marine biodiversity in the State's system of marine protected areas. He has also been involved in marine water quality monitoring and research into the ecology of marine communities.

David Bettini is a renowned landscape, aerial and wildlife photographer based in Perth and has been contributing to DEC's publications since 1998. David spent much of his life living and working on an outback sheep station and is a passionate environmentalist and a keen photographer of WA's wilderness areas. David's other interests include geography, meteorology and botany. He has published three books on Western Australia.

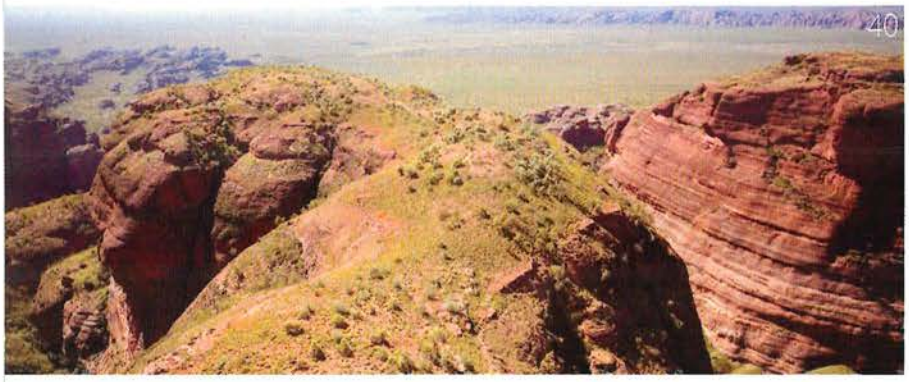
also contributing . . .

Joanna Moore, Anne Cochrane, Katrina Syme, Melinda Moir, Mark Harvey, Deon Utber, Tony Friend, John Huisman, Suzanne Long, Brian Moyle, Ann Gunness, John Hunter and Samille Mitchell.

Features

Cover illustration by Gooitzen van der Meer
The motorbike frog (*Litoria moorei*) is a common tree frog found from Kalbarri south to Cape Riche. Its common name is in reference to the frog's call—a 'grr, grr, grr' which sounds like a motorbike changing gears. The motorbike frog lives in sites with permanent water and is sometimes found in backyard ponds and swimming pools. It often shelters beneath bark on trees, underneath rocks or other objects.

Back cover photo by Rob Olver
Meekadarabee Falls area, Leeuwin-Naturaliste National Park.



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Department of Environment and Conservation
Our environment, our future

by Samilla Mitchell

World Heritage:

protecting the world's most treasured places

Shark Bay's riot of marine wonders and Purnululu National Park's geological marvels may not appear to have much in common. But these two areas are blessed with the title of a World Heritage Area—a prestigious crown awarded by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) that recognises the world's most treasured natural and cultural places.

Now the Ningaloo Coast is being nominated for consideration as a World Heritage Area (look out for an article on what makes this area worthy of nomination in the next edition of *LANDSCOPE*). But what exactly is a World Heritage Area and what are the benefits of bearing this coveted and internationally recognised title?

World Heritage beginnings

In 1972, worldwide concern over the potential destruction of the Earth's cultural and natural heritage led UNESCO to establish an international treaty called the Convention Concerning the Protection of the World Cultural and Natural Heritage. More commonly known as the World Heritage Convention, the treaty aims to identify, celebrate and protect the Earth's irreplaceable natural and cultural heritage, and to ensure it is conserved for all people, for all time.

UNESCO's World Heritage Committee started listing World Heritage sites—places it considered to be among the best possible examples of cultural and natural heritage in the world. To date, there are 878 sites across the globe, of which 679 are recognised for their cultural value, 174 are recognised for their natural value and 25 for their mixed cultural and natural values. Australia has 17 sites on the World Heritage list—11 recognised for their natural attributes, four sites listed for both natural and cultural attributes and two cultural sites (see box on page 8).

In the words of the World Heritage Centre staff:

"Heritage is our legacy from the past,

Main Piccaninny Creek, Purnululu National Park.
Photo – Bill Bachman
Insets from left
Ningaloo Marine Park.
Photo – Alex Steffe/Lochman Transparencies
Zuytdorp cliffs at Shark Bay.
Photo – Marie Lochman
Cape Range National Park wildlife.
Photo – Damon Annison

what we live with today, and what we pass on to future generations. Our cultural and natural heritage are both irreplaceable sources of life and inspiration. They are our touchstones, our points of reference, our identity. What makes the concept of World Heritage exceptional is its universal application. World Heritage sites belong to all the peoples of the world, irrespective of the territory on which they are located."

Because of its international recognition, World Heritage listing can prove a major boost to tourism in the area—something which can produce flow-on benefits for nearby communities in terms of economic injections, improved visitor interpretation and supply of other facilities. And, because parties to the World Heritage Convention are obliged to protect and maintain their country's heritage, World Heritage listing also affords enhanced protection to an area. In the case of WA, there is an international, Commonwealth and State commitment to protecting World Heritage Areas such as Shark Bay and Purnululu.

Why Shark Bay and Purnululu?

Shark Bay World Heritage Area is one of only 20 places across the globe that satisfies all four of the natural criteria for World Heritage listing (most meet only one or two categories). It has superlative natural phenomena, it displays the major stages in the Earth's evolutionary history, it has outstanding examples of significant ongoing ecological and biological processes and it contains important and significant habitats for conserving biological diversity. Key to meeting this criteria are the area's stunning natural beauty, its stromatolites—which provide keys to the earliest life on Earth—its extensive seagrass meadows and its rich suites of native plants and animals, many of them threatened and unique to the area. A recently launched draft management plan on

Australian World Heritage Areas and year of declaration

Cultural World Heritage Areas

- Royal Exhibition Building and Carlton Gardens, Vic (2004)
- Sydney Opera House, NSW (2007)

Natural World Heritage Areas

- Australian Fossil Mammal Sites (Riversleigh/Naracoorte), Qld (1994)
- Fraser Island, Qld (1992)
- Gondwana Rainforests of Australia, Qld (1986)
- Great Barrier Reef, Qld (1981)
- Greater Blue Mountains Area, NSW (2000)
- Heard and McDonald Islands, Southern Ocean (1997)
- Lord Howe Island Group, NSW (1982)
- Macquarie Island, Tas (1997)
- Purnululu National Park, WA (2003)
- Shark Bay, WA (1991)
- Wet Tropics of Queensland (1988)

Mixed cultural and natural World Heritage Areas

- Kakadu National Park, NT (1981)
- Tasmanian Wilderness, NT (1982)
- Uluru-Kata Tjuta National Park, NT (1987)
- Willandra Lakes Region, NSW (1981)

'The Shark Bay Terrestrial Reserves and Proposed Reserves Additions' suggests future management guidelines for conservation lands in this biologically significant area.

The Shark Bay World Heritage Area is afforded additional protection through DEC-managed parks—Shark Bay Marine Park and Francois Peron National Park—which lie within the World Heritage Area boundaries.

Hundreds of kilometres to the north, Purnululu National Park in the Kimberley was selected for World Heritage listing for two reasons—the area's stunning natural beauty and its outstanding geological value. Here, visitors are inspired by massive beehive-like sandstone domes of the Bungle Bungle Range, which tower 250 metres high (see this issue's feature park on page 40).

UNESCO rated the park's Bungle Bungle Range as "by far, the most outstanding example of cone karst in sandstone anywhere in the world".

Although the aesthetic beauty of this area was not widely publicised until the 1980s, the World Heritage Area listing afforded in 2003 has helped ensure it is now internationally recognised as a natural icon of Australia.

With plans afoot to nominate the Ningaloo Coast for similar recognition, this area too may soon enjoy the prestige and recognition that go hand in hand with World Heritage Area listing.

Above left Sandstone domes of the Bungle Bungle Range.
Photo – David Bettini

Above Birridas (clay pans) in Francois Peron National Park.
Photo – DEC

Left Stromatolites at Shark Bay.
Photo – Eva Boogaard/Lochman Transparencies

Below The white pigface is the only species with white flowers found in Shark Bay.
Photo – Andrew Brown/DEC

Samille Mitchell is a *LANDSCOPE* Editor and Department of Environment and Conservation Publications Officer. She can be contacted on (08) 9389 8644 or by email (samille.mitchell@dec.wa.gov.au).

endangered by Tony Friend

Dibbler

An enigmatic and elusive animal, the dibbler (*Parantechinus apicalis*) is small and stockily built—40 to 120 grams in weight—with bright white rings around the eyes, body hairs tipped with silver giving a grizzled appearance, and a hairy, short and strongly tapering tail. It is classed as endangered on international, national and Western Australian threatened species listings. Like all small carnivorous marsupials, it has a pointed snout and a mouth that opens wide to expose many sharp teeth. Dibblers feed mostly on insects, but will eat berries and feed on banksia flowers, probably taking nectar as well as the insects that feed on the blooms.

Dibblers are most active during the hours around dawn and dusk. They spend the remainder of the day and night resting above ground, under vegetation, or in natural hollows or burrows of other species.

Early collectors found dibblers near the west coast, (Perth, the Victoria Plains and New Norcia districts) inland near Kojonup and on the south coast near Albany, where the Nyoongar people used the name 'dibbler'. However, no dibblers were seen after 1904 and they were feared to be extinct.

In 1967, wildlife photographer Michael Morcombe was trying to catch honey possums in traps set over slender banksia (*Banksia attenuata)* flowers at Cheyne Beach east of Albany when he captured two dibblers. Subsequently, dibblers were also discovered near Jerdacuttup, 300 kilometres east of Cheyne Beach, at Torndirrup National Park in Albany, in Fitzgerald River National Park and on Boullanger and Whitlock islands off Jurien Bay. Although the Cheyne Beach population was still present in 1994, the only reliable sites are now at Fitzgerald River National Park and the Jurien Bay islands.

Recent surveys in Fitzgerald River National Park show that the species occurs patchily, mainly in mallee-heath vegetation that has been unburnt for more than five years. Dibblers thrive where foxes are controlled, but *Phytophthora* dieback threatens their habitat by killing proteaceous plants like banksias and changing vegetation structure dramatically.

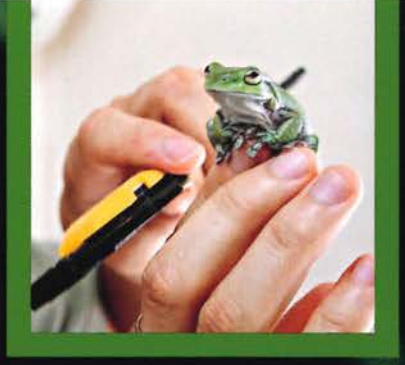
Dibblers are seasonal breeders. They mate in late March and up to eight tiny young appear in the females' open pouches in late April. The young are deposited in nests in June and are first seen out and about in August.

On Boullanger Island, in some years, most or all adult male dibblers die in April after the mating season, in some ways resembling the phascogales and *Antechinus* species. This hasn't been seen on nearby Whitlock Island, or in mainland sites. It has been suggested that the occasional male die-off is in response to the low nutrient status of Boullanger Island, in contrast to Whitlock Island, where breeding shearwaters have raised nutrient levels by depositing guano.

A research and recovery program led by the Department of Environment and Conservation has been in action since the 1990s and has resulted in a far greater understanding of this animal's ecology, the establishment of a breeding colony at Perth Zoo, and a new wild colony of dibblers on Escape Island, near Jurien. Mainland reintroduction efforts are under way, at the proposed Peniup Nature Reserve and in the Stirling Range National Park.

Photo by Babs and Bert Wells

The international Association of Zoos and Aquariums has declared this year the **'Year of the Frog'** to highlight the plight of frog species. Many frog populations across the globe are threatened with extinction. But what is causing their decline and how are we helping them to retain their tentative grip on life?



Fascinating frogs

by Samille Mitchell

Some people believe our planet could be facing the single biggest mass extinction since the disappearance of the dinosaurs. But this extinction doesn't affect frightening, reptilian giants. It targets amphibians—charismatic frogs that delight with their weird and wonderful traits and often wild designs.

After thriving for more than 360 million years, these animals are under threat. One third to one half of the 6,000 amphibian species across the world are considered by some to be at risk of becoming extinct in our lifetime. Australia is no exception. With 219 species across the country, we have one of the most diverse frog populations in the world. Of these species, 93 per cent are endemic to Australia and 27 per cent are threatened with extinction. Four are already believed extinct and at least 16 species are now ranked as endangered or critically endangered. In Western Australia we have 77 frog species, of which three are on State and national threatened species lists.

This extinction rate is the worst for any vertebrate species in the world—worse than birds listed as 12 per cent and mammals at 23 per cent. Their loss is not only devastating for humans who marvel at their colours and form. In

the words of Amphibian Ark chairman Jeffrey Bonner:

> "Widespread extinction of amphibians would be catastrophic. In addition to their intrinsic value, they offer many benefits and are a critical part of a healthy world. They play an important role in the food web as both prey and predator, eating insects which benefits agriculture and minimises disease spread. Their skin also has substances that protect them from some microbes and viruses, offering promising medical cures for a variety of human diseases."

What's to blame?

Many people regard frogs as an 'indicator' species. Their permeable skin means they may be among the first species to suffer from environmental threats like air pollution. Like most other species, frogs are also vulnerable to habitat loss, introduced animal invasion, pesticides and climate change.

In WA, the drought which has gripped many areas of the State is drying up many frog habitats. But some fear the biggest single threat facing frog species across the world is an infectious disease called chytridiomycosis, which is caused by chytrid fungus (*Batrachochytrium dendrobatidis*).

Chytrid fungus was discovered in frogs in the mid 1980s (see 'In pursuit of the frog fungus', *LANDSCOPE*, Autumn 2001). While intensive research into the fungus followed, researchers don't yet fully understand how chytrid fungus kills frogs, other than to know it damages their skin by attacking the keratin layer.

Previous page
Main Motorbike frog (*Litoria moorei*).
Photo – Jiri Lochman
Inset Cave dwelling frog (*Litoria cavernicola*).
Photo – Barry Baker

Above The sharp-snouted day frog (*Taudactylus acutirostris*) is believed extinct.
Photo – Stanley Breeden/Lochman Transparencies

Below The magnificient tree frog (*Litoria splendida*) occurs in the Kimberley.
Photo – Jiri Lochman

So how did this fungus start to affect frog populations? It is believed to have spread from Africa in the 1930s when African clawed frogs (*Xenopus laevis*), which are resistant carriers of the fungus, were shipped across the world for use in human pregnancy tests and laboratory studies. A pregnant women's urine would induce ovulation in the frogs and therefore indicate pregnancy. This species is thought to have inadvertently spread the fungus across the globe. The introduction of frog species to new environments and the aquarium and commercial trade may also have contributed to the spread of the disease. It moves at rates of one to 280 kilometres a year. Now the fungus has invaded frog populations across the globe.

The disease is largely unstoppable and untreatable in the wild. The International Union for the Conservation of Nature (IUCN) rates it as the worst infectious disease ever recorded among vertebrates in terms of the number of species impacted and its potential to drive them to extinction. It can wipe out 80 per cent of native amphibians within months. In some populations only a few frogs die, in others 100 per cent of the population is destroyed. What's worse, climate change may exacerbate the problem. As warmer temperatures dry moist areas where most frogs thrive, increased stress can leave frogs more susceptible to the disease.

While some species are highly susceptible and die quickly, others seem to be able to handle an invasion. Several species in Queensland affected by chytrid fungus were killed at high altitudes but those sites are now being reinvaded by frogs from resistant lowland populations.

Even so, dozens of frog species are thought to have already succumbed to the disease—never again to delight onlookers with their form or play their vital role in nature's intricate web of life.

The situation in WA

In WA, chytrid fungus has been active for at least 23 years. It is thought to occur over most, if not all, areas of the State where frogs occur. However, although it has killed many individuals, it is not clear whether it is the main cause of population decline. It has been prevalent in populations of the orange-bellied frog (*Geocrinia vitellina*) and the motorbike frog (*Litoria moorei*) with no obvious impact on these populations. Regrettably, the cane toad is also immune to its effects.

Above The western banjo frog (*Limnodynastes dorsalis*) occurs in south-western Australia.
Photo – Babs and Bert Wells/DEC

However, further afield, some people point the finger at chytrid fungus for the extinction of two species of gastric-brooding frogs (*Rheobatrachus* spp.) and the sharp-snouted day frog (*Taudactylus acutirostris*) in Queensland. It is also blamed for the decline of other eastern states' species such as the waterfall frog (*Litoria nannotis*), common mistfrog (*L. rheocola*), spotted tree frog (*L. spenceri*) and the lace-eyed tree frog (*Nyctimystes dayi*).

The Department of Environment and Conservation (DEC) regularly monitors populations of frog species on the threatened species list to determine their conservation status. Recent monitoring has revealed some alarming trends in calling behaviour. DEC monitoring of the sunset frog (*Spicospina flammocaerulea*), which is listed as vulnerable, is particularly troubling. The species is currently monitored by listening for its call during breeding season. However, during the last monitoring period, very low calling activity was recorded, which could be an indicator of reduced reproductive behaviour and population decline. More field research is required to determine whether this is a true decline. While chytrid may be responsible for at least part of the reduced reproductive behaviour, DEC scientists believe it is more likely attributed to several years of low winter rainfall and a subsequent reduction in groundwater recharge processes, which has caused groundwater levels to drop and water acidity levels in the peat-based ecosystems to rise. It is possible that tadpoles of the sunset frog are unable to survive these high acidity levels.

The story is similar with the critically endangered white-bellied frog (*Geocrinia alba*), which has also dramatically declined in number. If the decline doesn't halt, this species is expected to become extinct within the next few decades. Monitoring for this species, and the vulnerable orange-bellied frog, started in 1993 and now

Above Perth Zoo Native Species Breeding Program Coordinator Glen Gaikhorst with a cave dwelling frog (*Litoria cavernicola*).

Above right Measuring a roseate frog (*Geocrinia rosea*) at the Perth Zoo.
Photos – Barry Baker

Right Monitoring for the sunset frog (*Spicospina flammocaerulea*) near Walpole.
Photo – Karlene Bain/DEC

encompasses 126 sites, representing all known sub populations of both species. The study has shown that 25 per cent of all known white-bellied frog monitoring populations have disappeared. However, in the same period no orange-bellied frog populations have disappeared. While wildfire, pigs and chytrid fungus may have contributed to the decline of the white-bellied frog, habitat loss and disrupted hydrological patterns are thought to be the major culprits. The orange-bellied frog lives in protected, uncleared lands so has not suffered from the same pressures.

Saving frogs

As frog populations continue to nose-dive, an ambitious, worldwide project is seeking to save frogs from extinction by developing an 'Amphibian Ark'. Zoos across the world are taking part, conserving frogs from their section of the globe in a bid to save the species. The Perth Zoo is on board, focusing on developing breeding and husbandry techniques for Western Australian frogs. It has established a four-year frog breeding research program through a grant from the Department of Industry and Resources' Office of Science, Technology and Innovation to develop successful captive breeding and management techniques for frogs. By developing this expertise, the zoo hopes to be able to provide a safety net for threatened frog species if their populations collapse in the wild as a result of disease or the impact of cane toads.

The zoo's amphibian research facility includes three rooms of different temperatures to deal with frogs from different climates within WA. At first the zoo started with common frogs to hone their breeding techniques. They started with the motorbike frog and began successfully breeding them immediately. Next they focused on the roseate frog (*Geocrinia rosea*) and the cave-dwelling frog (*Litoria cavernicola*), which are now also successfully being bred. It is hoped that common species like the motorbike frog and the roseate frog can provide valuable information about husbandry, reproductive biology, growth, development and captive management for threatened species, in particular the threatened orange-bellied frog and white-bellied frog species found in south-west WA.

As well as developing breeding techniques, Perth Zoo staff are also researching growth rates, bone density, feeding techniques and quarantine requirements. In addition, the zoo is trialling chytrid treatment procedures using a fungicide called Itraconizole. Zoo staff have discovered the fungicide doesn't necessarily kill the fungus, but does keep it under control. However, treating frogs in a controlled laboratory environment is one thing, attempting to treat them in the wild is quite another.

Critics argue there is no point saving frogs if they can't survive in the wild. But efforts to conserve the frogs in the Amphibian Ark will buy time until a better solution arises. The IUCN believes the only hope for populations and species at immediate risk of extinction is immediate establishment and management of captive colonies.

DEC is also playing a role. It has experimented with translocation of the threatened orange-bellied frog since 2000. The relocation works by moving burrows containing eggs to a new location of frog eggs—a long, frustrating and painstaking task. DEC staff usually need to find at least five or

Sunset frog

(Spicospina flammocaerulea)

While the sunset frog evolved some 30 to 40 million years ago, this species was not discovered until 1994. It occurs only in south-west Australia, in the Walpole–Nornalup area. It is an easily recognisable frog, with knobbly skin, bright orange hands and feet and a belly that is half orange and half covered with striking, light blue spots. It grows to just 35 millimetres long. Of the 17 sites where it was known to exist, only seven are now believed to be inhabited by this frog. A drying environment, chytrid fungus, clearing for agriculture, water extraction pressures for domestic water use and the introduction of exotic plant and animal species are thought to be to blame for its decline.

Sandhill frog

(Arenophrynexyphorhynca – Kalbarri region species)
(A.rotunda – Shark Bay region species)

Think of frog habitats and most people imagine a wet environment. But the sandhill frog inhabits arid homes in sandhills. It is also unusual in that it does not develop a tadpole stage and never inhabits water. Young frogs develop in eggs deep underground and hatch after about two months. There are two slightly different species of sandhill frog—one is endemic to sandhills in the Kalbarri area while the other lives around Shark Bay. The sandhill frog emerges from the sand after rains or on dewy nights to feed on ants and other insects. Its nocturnal behaviour means you are unlikely to see one. But you may spot their distinct tracks which are marked at the beginning and end with a small depression. The frog features unusually short legs, a squat body and makes a strange squelching noise.

Orange-bellied frog

(Geocrinia vitellina)

This threatened species is probably the most restricted vertebrate on mainland Australia. It occurs only in an area of six square kilometres within State forest to the north of the Blackwood River, north-east of Augusta. The orange-bellied frog does not have a free-swimming tadpole stage. Eggs are laid in burrows, moist depressions between litter or under dense vegetation. After hatching, the tadpoles remain in the burrow feeding on the jelly surrounding the eggs until they metamorphose into tiny froglets, with a body about the size of a thumbnail.

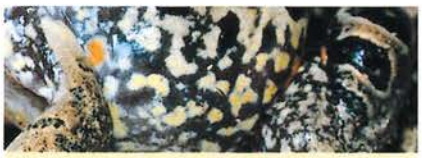
Left to right Sunset frog, sandhill frog, orange-bellied frog.
Photos – Gunther Schmida/Lochman Transparencies, Jiri Lochman, Grant Wardell-Johnson/DEC

six active burrows to locate a burrow suitable for translocation. To find a burrow, they must work deep within the bush at night, listen for the call of the frogs, follow the sound to a burrow sized about two centimetres across and then excavate the burrow and move it to a new location. While the mechanics of this technique have now been proven successful and at least some of the translocated frogs have survived, the fact that frogs take four years to reach sexual maturity (and can only be located by their call during breeding season) means it's too early to tell if these translocated frogs are surviving to breed successfully.

Frog future

The effects of climate change, habitat and probably chytrid fungus, mean many of WA's amphibian species are facing a bleak future. The difficulty in monitoring populations adds to the problem. And yet there is hope. Not everyone prescribes to the doomsday predictions. Some argue that frog populations have survived the threat of chytrid fungus so far, so there's no reason they shouldn't continue to do so. And, while the fungus is prevalent among WA's threatened frog species, it can't be conclusively proven to be responsible for their decline.

So, with the continued success of DEC translocation projects and the research and successful captive breeding at Perth Zoo, these charismatic creatures may retain their grip on life. They have, after all, seen the coming and going of the dinosaurs and already survived extreme changes in the environment. Let's hope, with help, they can battle on in the face of disease, drought, declining habitats and other pressures.



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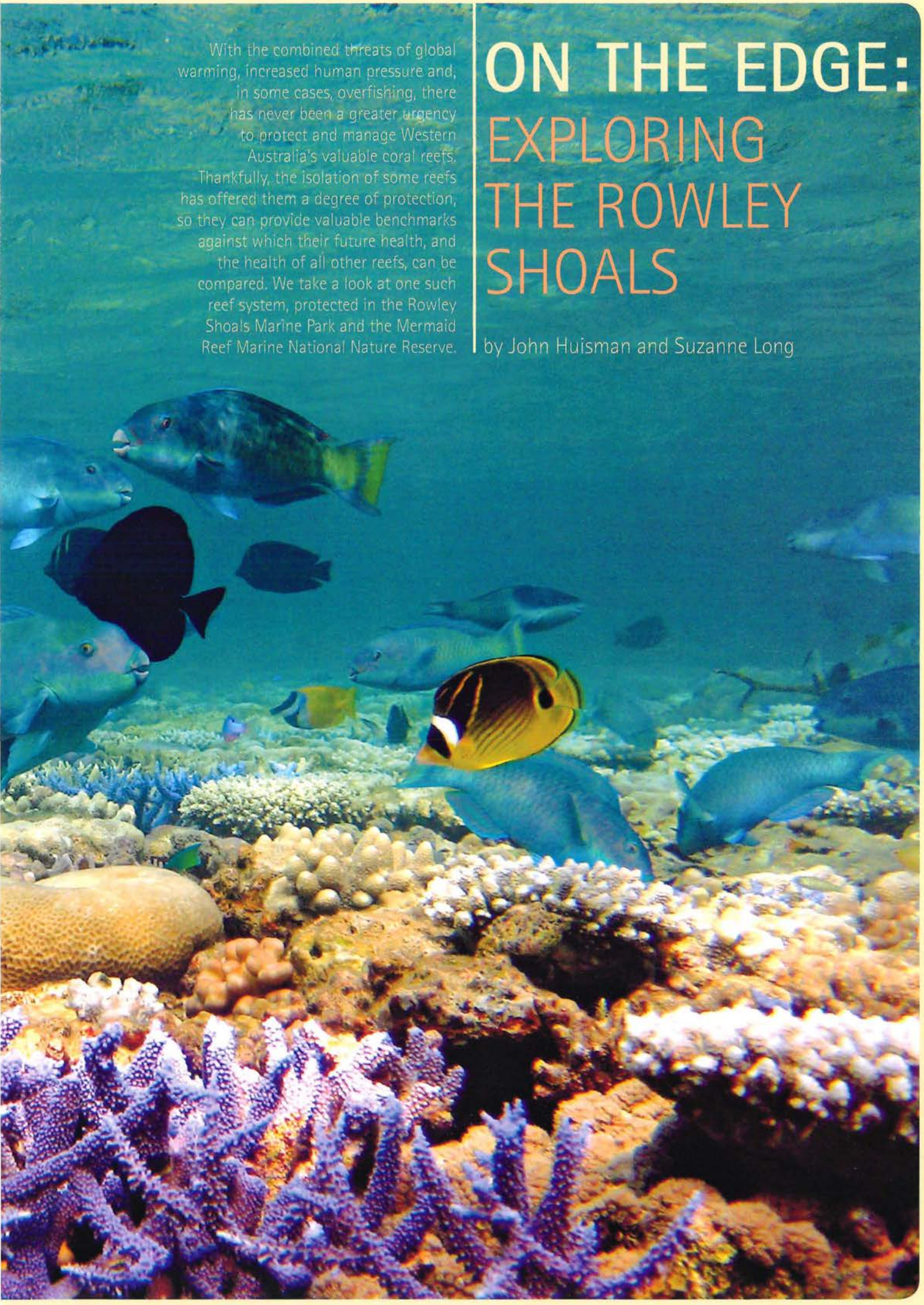
This article is largely based on information provided by Perth Zoo. The zoo's Native Species Breeding Program Supervisor Glen Gaikhorst provided important input into the article, as did Western Australian Museum Curator of Herpetology Paul Doughty, The University of Western Australia's Professor Dale Roberts and DEC staff Kim Williams and Karlene Bain.

ON THE EDGE: EXPLORING THE ROWLEY SHOALS

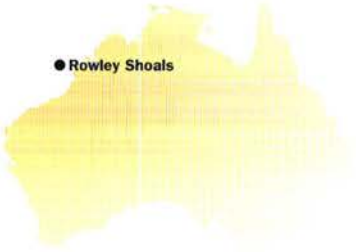
With the combined threats of global warming, increased human pressure and, in some cases, overfishing, there has never been a greater urgency to protect and manage Western Australia's valuable coral reefs. Thankfully, the isolation of some reefs has offered them a degree of protection, so they can provide valuable benchmarks against which their future health, and the health of all other reefs, can be compared. We take a look at one such reef system, protected in the Rowley Shoals Marine Park and the Mermaid Reef Marine National Nature Reserve.

by John Huisman and Suzanne Long



Lying some 300 kilometres west-north-west of Broome, on the edge of the continental shelf in deep, clear oceanic waters, are three atolls that comprise the Rowley Shoals. These atolls, often described as the best geological examples of shelf-edge reefs in Australian waters, are largely protected from most human impact due to their isolation, which has kept them among the most pristine in the world. But with increasing pressure from human activities, however well-intentioned, plus the threats from global warming and coral bleaching, the health of the atolls could be at risk. The Rowley Shoals are protected by State and Federal laws, but keeping them in good shape requires more than just legislation; it requires an intimate knowledge of the reefs and their inhabitants, ongoing management based on detailed scientific research, and vigilant surveillance to deter illegal activities.

With this in mind, a team of marine biologists from the Department of Environment and Conservation (DEC) and the Australian Institute of Marine Science (AIMS) visited the three atolls in December 2007. This expedition represented a major collaboration between the two institutions, and was also the maiden voyage for the new AIMS research vessel, the RV *Solander*, a 35-metre high-tech vessel, built in Fremantle.



Discovery

The Rowley Shoals were named in 1818 by Lieutenant Phillip Parker King, who charted much of the north-western Australian coast. He named the atolls "in compliment to the discoverer of the westernmost (the Imperieuse [Reef])", Admiral Sir Josias Rowley (1765–1842). Rowley had encountered the most south-western of the atolls in HMS *Imperieuse* in 1800, and the reef bears the name of his ship. King, in the cutter *Mermaid*, visited Imperieuse Reef and fixed its position, then headed north-east and charted the position of the second reef, which he named Clerke Shoal (now Clerke Reef) after the whaler Captain Clerke, who first reported the reef some 10 years earlier. King named the most north-eastern reef Mermaid's Shoal, after his "little vessel" (as he described it). The small island at Imperieuse Reef was later named Cunningham Island in honour of Allan Cunningham, the botanist who accompanied King. The island at Clerke Reef is now known as Bedwell Island, for Frederick Bedwell, the master's mate aboard the *Mermaid*.

However, western mariners weren't the first to visit the shoals, as it is likely that fishermen from Indonesia had visited them from at least the mid-eighteenth century. The fishermen, who knew the shoals as *Pulau Pulo Dhaoh*, were collecting or hunting for trepang (holothurians or sea cucumbers), turtle shell, trochus shell and shark fin.

Management

Each atoll covers an area of about 80 to 90 square kilometres within the rim of the reef, including the lagoons, while the land areas are negligible. The reefs are about 30 kilometres apart and rise steeply from the ocean floor, the shallowest being Imperieuse Reef at 230 metres deep, becoming progressively deeper northward to Mermaid Reef, which sits in water 440 metres deep.

Imperieuse and Clerke reefs are protected in the Rowley Shoals Marine Park, which was gazetted in 1990 and then extended in 2004 to the limits of State waters, covering about 87,632 hectares. These reefs come under the jurisdiction of Western Australia because each has a permanent island. Bedwell Island is home to one of only two colonies of red-tailed tropicbirds in WA. Shearwaters, sea-eagles, terns, plovers and egrets also nest on Bedwell, and numerous migratory birds from Asia and even Siberia use the island as a resting site during their epic yearly flights.

Previous page
Main Healthy fish and coral communities in the sheltered lagoon of Clerke Reef.

Below A tender departs the new purpose-built AIMS research vessel *Solander*.
Photos – Suzanne Long/DEC

Below right Red-tailed tropicbird.
Photo – Huw Dilley/DEC

Above Coral bommie in Clerke Reef.
Photo – Suzanne Long/DEC

Right Suzanne Long working on a benthic community transect.
Photo – Eric Matson/AIMS

Mermaid Reef contains no permanent land above the high-water mark so lies in Commonwealth waters. It forms part of the Mermaid Reef Marine National Nature Reserve managed by the Department of the Environment, Water, Heritage and the Arts. The 53,984-hectare reserve was declared by the Australian Government in 1991 and is managed to preserve its ecological processes and systems and to protect it from the pressures associated with human use.

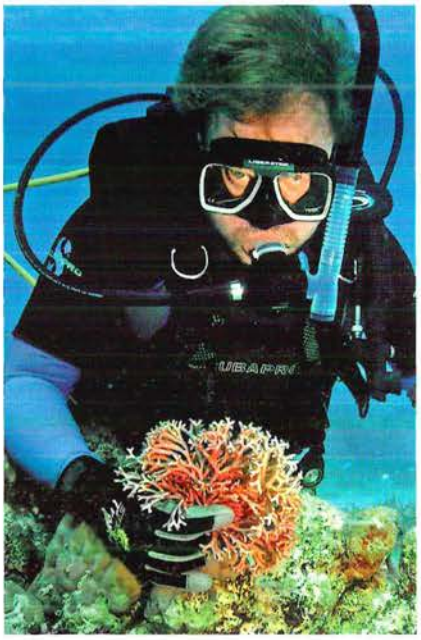
Although very remote, the Rowley Shoals are visited regularly by adventurous divers, fishers and sightseers. Fishing is not permitted anywhere within the Mermaid Reef Marine National Nature Reserve. In the Rowley Shoals Marine Park fishing is permitted only outside sanctuary zones. However, potato cod, Maori wrasse, coral trout, Queensland groper and all shellfish within 1.6 kilometres of the reefs are fully protected.

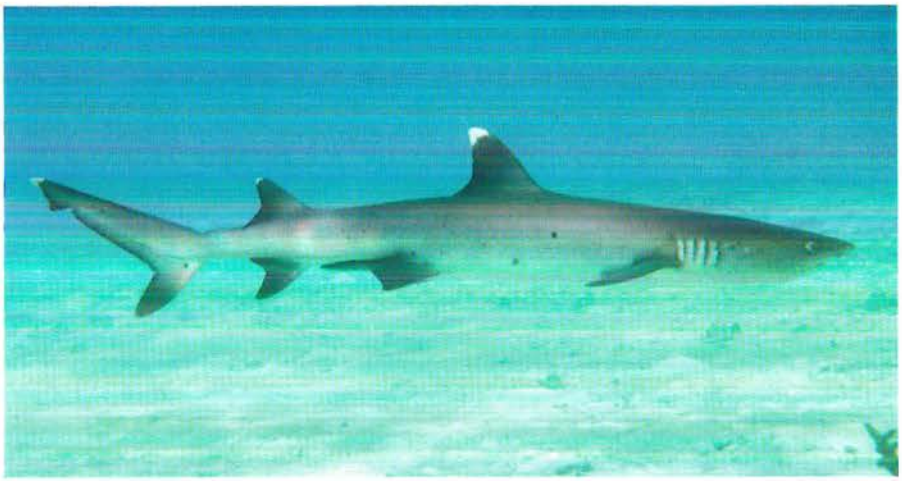
The collaborative expedition targeted several aspects of the reefs' biodiversity, with small teams of three to four biologists responsible for each. The survey aimed to collect data that could directly inform management of the Rowley Shoals Marine Park and the Mermaid Reef Marine National Nature Reserve. Together with results generated from earlier expeditions undertaken by the Western Australian Museum (see 'Life in isolated oases', *LANDSCOPE*, Winter 2007), this survey has dramatically increased our knowledge of the reefs' biology.

Bottom dwellers

Coral reef communities are highly dynamic ecosystems. This is reflected by periodic shifts of dominant species and relative cover of some key inhabitants of these communities: hard corals, soft corals and seaweeds. Dramatic changes are often caused by disturbance, such as domination of the reef by soft corals or seaweed following stress-related reductions in hard corals, or the loss of sensitive habitat-forming corals due to acute disturbances such as bleaching. Both these scenarios can cause significant detrimental flow-on effects to the ecosystem as a whole. Work to understand the responses of coral reef communities to different kinds of disturbance is essential for effective conservation management, particularly as the nature of such responses is often a good indicator of the health of the ecosystem.

This component of the expedition aimed to provide a snapshot of the





Above left Animals that are heavily fished elsewhere in the world, such as clams, are found in high numbers at the Rowley Shoals.
Photo – Shannon Armstrong/DEC

Above John Huisman examines the unusual red seaweed *Ganonema farinosum*.
Photo – Eric Matson/AIMS

Left Whitetip reef sharks (*Triaenodon obesus*) were regularly seen at all reefs.
Photo – Iain Field/Charles Darwin University

composition of the benthic communities (those that grow attached to underwater surfaces). Twenty-two long-term monitoring sites were revisited and three new sites established. At each, video footage was taken of five 50-metre transects. The footage will provide detailed information that can be used to monitor the health of the reefs. Soft corals were surveyed at 18 sites. Those encountered were identified (so far as possible in the field), most were photographed, and samples were taken of new observations for later taxonomic analysis. Spectacular sea fan gardens comprising both Pacific and Indian ocean species were found in the deeper waters. This survey was the first step towards understanding the importance of the ecological role played by soft corals on Western Australian reefs.

All seaweed species encountered at each site were photographed to form part of an identification guide to assist with the analysis of videos of benthic communities at the Rowley Shoals. The benthic team was led by Suzanne Long, who worked with DEC's Marine Science Program, with seaweed surveys by John Huisman from DEC's Western Australian Herbarium and soft coral surveys by Katharina Fabricius of AIMS. The team was supported by Eric Matson from AIMS and Steve Dutton from DEC.

Cucumbers and snails

High-value edible holothurians (sea cucumbers), trochus shells and giant clams perform important ecological functions and have been overfished on most Indo-Pacific reefs. At each site visited during the expedition, the 'slug team' traversed large distances by snorkel, counting and measuring the sea cucumbers and trochus. This will give a clear indication of the health of the populations and will be compared with similar studies undertaken at Scott Reef, further to the north.

Since fishing of these species is prohibited at all three atolls of the Rowley Shoals, but permitted at Scott Reef by traditional Indonesian fishermen under a memorandum of understanding between the Australian and Indonesian governments, monitoring populations of these commercially important invertebrates will provide information about pristine population characteristics and give indications of illegal fishing. Although illegal fishing at the shoals is thought to be uncommon, a Taiwanese fishing vessel was apprehended at Mermaid Reef Marine National Nature Reserve in 1984 with a large quantity of clam meat. Apart from this incident, the extent and impacts of illegal fishing activity are unknown.

The slug team was led by Jamie Colquhoun of AIMS and included Kylie Cook of AIMS and DEC's Huw Dilley and Shannon Armstrong, supported by volunteer Phil van Dyk.

Right Yellow margined moray eel at Imperieuse Reef.
Photo – John Huisman

Below right Dive support vessel in the channel at Imperieuse Reef.
Photo – Suzanne Long/DEC

Shark tales

Sharks are under relentless pressure worldwide from overfishing, both legal and illegal. This is reflected in the dwindling populations in many areas, but arresting this decline is hampered by how little is known about many aspects of their biology, including home ranges, stock sizes and migration patterns. This information is essential if management strategies, such as establishing marine parks and reserves at scales appropriate to ensure the survival of sharks in reef systems, are to be implemented.

The abundant populations of reef sharks at the Rowley Shoals, primarily silvertip (*Carcharhinus albimarginatus*) and grey reef sharks (*C. amblyrhynchos*), provided a unique opportunity to gather baseline biological information on habitat use and migration over time that can be used to ensure protection and survival of these species. This aspect of the expedition, led by Iain Field of AIMS and Charles Darwin University and supported by Warren White from Wildlife Resources, first established an array of acoustic listening stations at the reefs. Then came the hard part—catching the sharks. This was done at night using baited barbless hooks, with the sharks then gently cajoled into a specially designed hammock.

The sharks were measured, small tissue samples taken for DNA analysis, and an acoustic transmitter tag attached to the dorsal fin before being returned to the water. Thirty-seven sharks were tagged across all three shoals. Data will be downloaded from the listening stations periodically during the next 18 months, which will track the movement of individual sharks across the reef atolls, showing patterns of reef attendance, habitat use and migrations between reefs.

The expedition found the coral reef communities of the Rowley Shoals were generally in an excellent condition. Maori wrasse, sharks and commercially important invertebrates such as trochus shells, trepang and clam species are abundant at the Rowley Shoals and are larger in size and inhabit a more diverse habitat range than populations to the north at the heavily fished Scott, Ashmore and Cartier reefs.

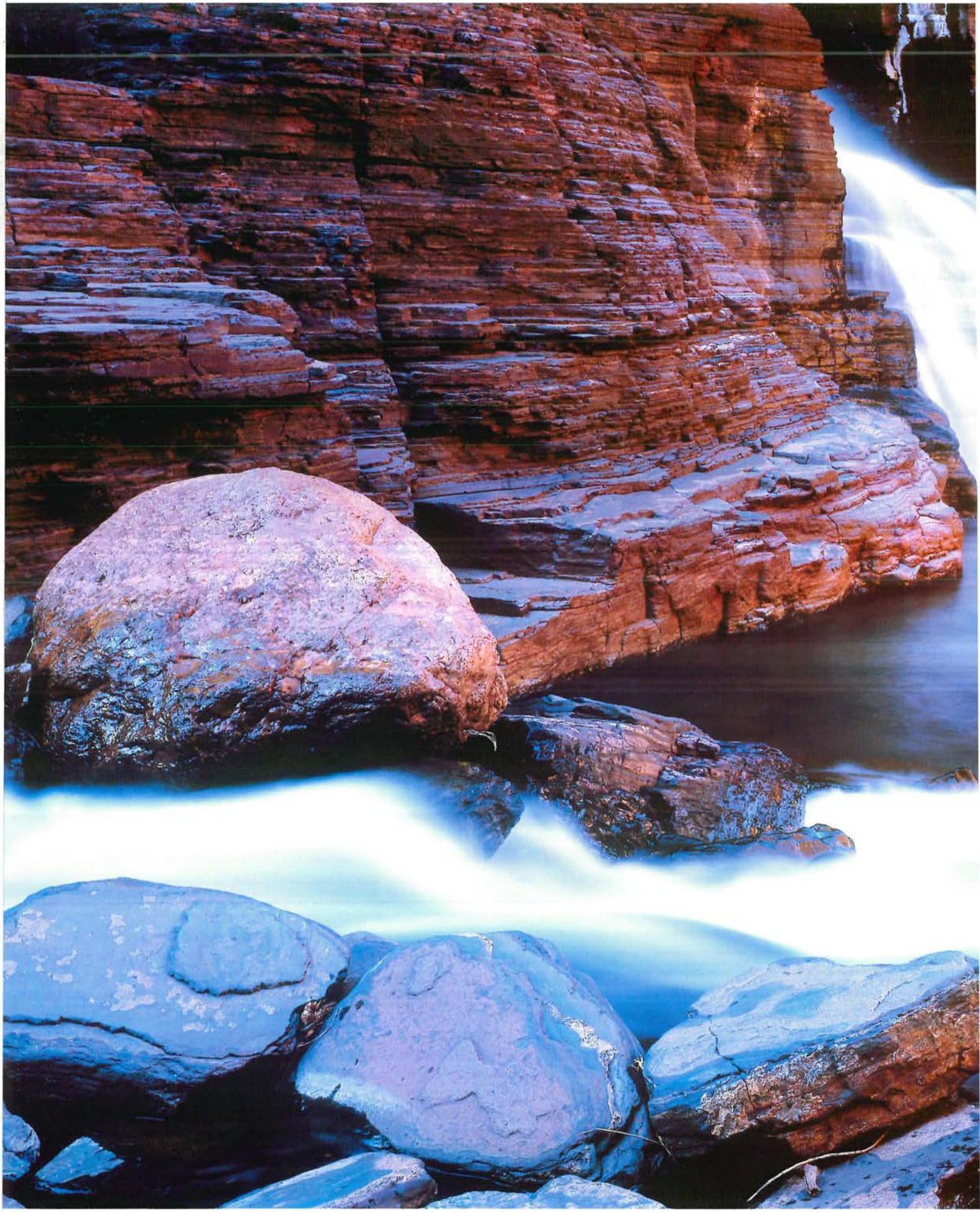
It doesn't end here

WA's remote coral atolls are among the most pristine in the world, but keeping them that way cannot be left to chance. If we are to guarantee these atolls are left for future generations to visit and enjoy, ongoing scientific research is imperative to document the reefs' inhabitants, understand the ecological processes governing the reefs, and monitor that all is well. This research then feeds directly into the second essential component of maintaining the reef health—management. By ensuring that visitor numbers are kept low, boat and diver impact is kept to a minimum, and any fishing is limited and wholly sustainable, we will hopefully ensure that the Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve remains in its pristine state. And we're not doing this just for ourselves. As coral reefs continue to degrade worldwide at an alarming rate, the Rowley Shoals are our chance to show the world that reef conservation is achievable. Through careful management we can establish and maintain the Rowley Shoals as regional and potentially global benchmarks for coral reef biodiversity conservation—a pristine wilderness, if not untouched, then untainted. Something we can all be proud of.

John Huisman is a research scientist, currently holding a joint position with the Western Australian Herbarium and Murdoch University. He is an international expert on seaweeds and can be contacted by email (john.huisman@dec.wa.gov.au).

Suzanne Long was, at the time of the expedition, a senior research scientist with DEC's Marine Science Program. She has since taken up a position at the Reef and Rainforest Research Centre in Cairns, Queensland, and can be contacted by email (suzanne.long@rrrc.org.au).

For more information on the Rowley Shoals and Scott Reef, see the article 'Life in isolated oases' by John Huisman and Sue Morrison in *LANDSCOPE* Winter 2007, and visit DEC's website (www.dec.wa.gov.au).



Warlu Way

A new tourism initiative celebrates the rich Aboriginal culture of the Gascoyne, Pilbara and Kimberley. The Warlu Way self-drive trail is designed to encourage visitation to the area by linking national parks and towns in the region. It will also feature interpretive signage along the way to explain the historical tales and natural secrets of this ancient landscape.

by Samille Mitchell

The way of the warlu, or sea serpent, traverses an ancient and sacred land rich in natural beauty and enchanting Aboriginal stories. This 2,480-kilometre self-drive journey takes travellers through Western Australia's Gascoyne, Pilbara and Kimberley regions—areas resplendent with sapphire seas, soaring gorges, ancient Aboriginal art, rugged ranges and inland oases. Travellers will encounter interpretive signage as they travel, further opening their eyes to the secrets of this country and its historical, cultural and natural wonders.

Ocean to outback

Visitors start their journey on the shores of the Ningaloo Marine Park in the towns of Coral Bay and Exmouth. Here, visitors are encouraged to explore the dazzling underwater gardens of the Ningaloo Reef, visit the plunging canyons of Cape Range National Park and find out about the area's natural attractions at the Milyering Visitor Centre in Exmouth. The mighty whale shark—the world's biggest fish—is a major attraction here when populations of the harmless giant visit from about March to June each year.

From the coast the drive meanders inland to townships born from the riches of the State's mineral resources boom. Townsites like Tom Price, Newman and Paraburdoo have sprung up since the 1960s, supporting flourishing populations of people who work for mining companies that extract rich supplies of iron ore from the red earth.

Next on the agenda is one of Warlu Way's major attractions—the spectacular Karijini National Park. This park is famed for its plummeting gorges, sometimes thundering waterfalls and deep pools. At some places the gorges are so narrow you can reach out and touch their walls with both hands. At others they are yawning chasms of red rock, adorned with the gnarled plants clinging to sheer cliff face. Karijini is also rich in Aboriginal culture and history. Warlu Way travellers can learn much about this history, as well as the park's fascinating geology, at the Karijini Visitor Centre.

An ancient culture

From Karijini, Warlu Way returns west to Millstream-Chichester National Park (see 'Natural wonderland in the arid Pilbara', *LANDSCOPE*, Spring 2007). This park is truly an oasis in the desert. The mighty Fortescue River meanders through the landscape at Millstream and flat-topped, spinifex-cloaked hills form the Chichester Range. Millstream also features pools fed by an underground aquifer to create an enchanting environment of water lilies, dragonflies and birds.

The area is also of immense importance to the Yindjibarndi people who have lived here across the millennia. They would gather at the pools to camp near what became the Millstream homestead, and is today the visitor centre. Walk around Millstream today and you can still see flaked stone artefacts, grindstones, mollusc shells, rock art and trees from which boomerangs were cut many years ago.

Millstream is also of mythological importance for a pool on the Fortescue River called Deep Reach or Nhanggangunha. The waters here are home to the mighty warlu after which the drive was named (see 'The warlu – an almighty sea serpent' on page 28).

From Millstream, Warlu Way presses west to the coast at the industrial powerhouse of Karratha and the Burrup Peninsula. The Burrup and the nearby islands of the Dampier Archipelago are home to possibly the world's biggest collection of ancient Aboriginal art. Thousands upon thousands of rock carvings, known as petroglyphs, adorn the rocks here, and stand in stark contrast to the modern-day industrial development.

No-one knows exactly when these pictures were carved. Most estimates range from 6,000 to 20,000 years ago. The images provide clues to the region's first inhabitants and also show a hazy record of natural history, with images like the Tasmanian tiger acting as proof that these now extinct creatures once roamed here.

Previous page
Main Junction Pool in Karijini National Park.
Photo – David Bettini
Insets Joffre Falls Lookout, snappy gum.
Photos – Cathy Zwick/DEC

Left Aboriginal rock carvings, Burrup Peninsula.
Photo – John Kleczkowski/Lochman Transparencies

Above background Mount Nameless, Tom Price.

Right Four-wheel driving past the Hamersley Ranges.
Photos – Michael Pelusey

The art belonged to the Yaburara, a northern group of the Ngarluma Aboriginal people. These people believe ancestral beings created the artworks as a record of their laws—laws that oblige Aboriginal people to care for this sacred land. Should these areas become damaged or be treated with disrespect, the ancestral beings could unleash spiritual powers to punish the perpetrators.

The proposed Dampier Archipelago Marine Park has the most biodiverse waters in Western Australia. The waters here are home to more than 215 species of coral, dugongs that graze upon swaying meadows of seagrasses, more than 40 species of shorebirds and migratory waders which inhabit the saltmarshes and mangroves, and populations of hawksbill, flatback and green turtles that nest on the shores (see 'Science in the sea', *LANDSCOPE*, Autumn 2007).

Troubled past

Next, Warlu Way journeys north-east, en route to Broome. First it travels through Roebourne, home to an Aboriginal community becoming increasingly renowned for its art. However, this community has experienced troubled times in the past. Warlu Way signage and the fascinating Roebourne Old Gaol Museum tell the story of the town's beginnings.

While Roebourne has a large Aboriginal population today, this area wasn't traditionally an important place for the many Aboriginal groups who live here. It is the traditional country of the Ngarluma people but, through pastoral expansion, Aboriginal people of many different backgrounds were forced to settle here. These were dark days, a sad era when Aboriginal people were forced from the land that had nurtured their people for thousands of years.

With nowhere to go, the Aboriginal people lived in primitive conditions on

Top The historical town of Cossack.
Photo – Tourism WA

Above Karijini Eco Retreat.
Photo – Michael Pelusey

Above right DEC Ranger Maitland Parker guides a visitor in Karijini National Park.
Photo – Australia's North West Tourism

a reserve near Roebourne. People of the Ngarluma, Martuthumra, Yindjibarndi, Kurrama, Banyjima and more were expected to live side by side—akin to asking the British, French and Germans to live harmoniously together.

A mythological story tells of the struggle. Angered at the intrusion into the Ngarluma land, a great sea serpent conjured a mighty storm and flooded the landscape. The people from inland called on their freshwater serpent to protect them from the sea serpent's fury. A ferocious battle ensued in the skies above Roebourne as the serpents fought for their people. Eventually the freshwater snake drove the saltwater snake out to sea, and the inland people were free to remain at Roebourne.

The Warlu Way signage at Cossack reveals more of the atrocities committed against Aboriginal people during early European settlement. In the earliest days of pearling, for which Cossack was an important port, Aboriginal people were rounded up in their camps, chained by the neck, and forced to march across the land. Many were marooned on islands, awaiting sale to passing pearling luggers. They were then forced to skin dive for pearl shells, many drowning and some dying from shark attacks in the process.

Of course Cossack today is a far cry from the days of yesteryear. Today the township is a virtually uninhabited historical village, complete with extensive information about the area's colourful past.

It is also the site of an annual art competition during which Aboriginal art is displayed.

Further north-east at Port Hedland, Warlu Way travellers can learn about one of the most controversial industrial relations disputes in Western Australian history—the Pilbara strike of 1946. This strike is widely regarded as transforming Aboriginal rights in an era when these people were treated as grossly inferior. However, others lament it as the end of an era for Aboriginal employment on their homelands.

Before the strike, Aboriginal people

Right Aboriginal art at Cossack.
Photo – Australia's North West Tourism

Below right Sandpipers and other waterbirds wading and feeding in shallow waters south of Broome.
Photo – Jiri Lochman

were widely employed on Pilbara stations in roles as drovers, station hands, gardeners and cleaners. Many believe the pastoral industry owes its early success to this labour. However, the Aboriginal employees were rarely paid with money. Instead they received payments in flour, tea, clothes and occasionally meat.

Many Aboriginal people became upset at this treatment occurring on what was traditionally their own land and decided enough was enough. Secret meetings were held and a plan was hatched. They chose 1 May 1946 as the date for action.

Two Aboriginal men walked and cycled hundreds of kilometres across the arid Pilbara countryside, whispering plans of the pending industrial action. As most Aboriginal people then couldn't read or write, they were given calendars, some hidden on the back of jam tins, to mark off the days until the strike.

That day finally came and about 800 Aboriginal people abandoned the stations, trudging many kilometres to Port Hedland. Here they converged in camps and survived from bush meat and from money earned through collecting pearl shells or extracting minerals from the earth. However, some Aboriginal people stayed on the stations, happy to have work on their homelands. Some even hid from the strike organisers to ensure they could remain.

Some strikers soon returned to the stations on the promise of better conditions. But most of the strikers remained in the Port Hedland camps. A few gradually saved their money, eventually using it to buy back land from station owners and return to their traditional country. Most, however, never returned to the stations. But they say what they lost in employment they earned in respect and pride.

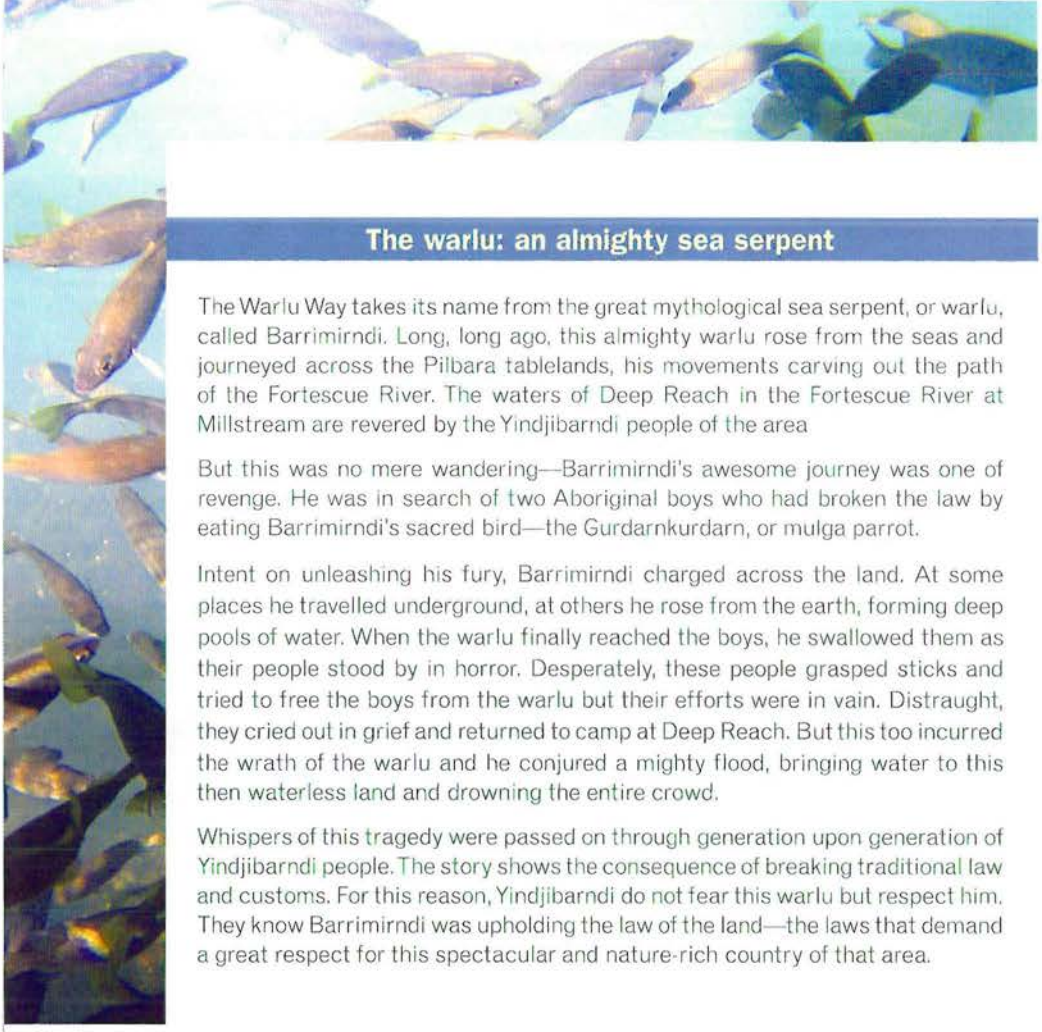
From here, there are options for a side journey to the north-east. Drivers can visit the historic town of Marble Bar—renowned as the hottest town in WA. Marble Bar was in fact misnamed after a jasper, not marble, outbreak which occurs by the Coongan River. It was founded on the hopes and dreams of gold discoveries in the late 1800s and retains its frontier feel today.

Top End

Warlu Way continues its journey north along nature-rich shores to Broome. It takes travellers to Eighty Mile Beach—the longest uninterrupted beach in WA. Its glistening shores stretch 220 kilometres between Cape Missiessy and Cape Keraudren (see 'Pilbara and Eight Mile Beach', *LANDSCOPE*, Autumn 2008).

Each year millions of migratory birds journey from the northern hemisphere with their mysterious autopilots set on Eighty Mile Beach shores. Some of these birds have flown more than 10,000 kilometres, without stopping, to reach here by springtime. They are said to fly at several thousands metres high and average 70 kilometres an hour on their journey.

They come here for the summer to feast on a buffet of marine invertebrates that live in the mudflats—millions upon millions of crustaceans, molluscs and worms. The birds feed over the exposed sand and mudflats at low tide and congregate on the narrowing beach at high tide in immense flocks, their sheer numbers creating a breathtaking viewing spectacle.



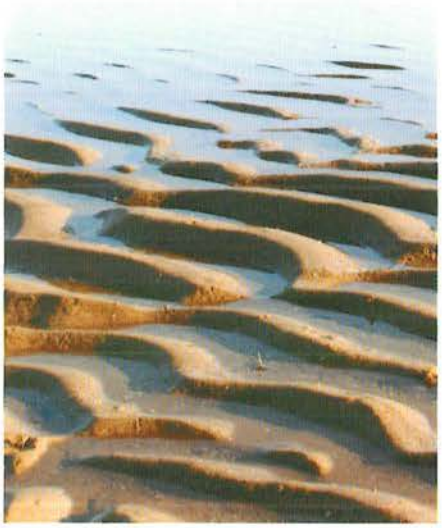
The warlu: an almighty sea serpent

The Warlu Way takes its name from the great mythological sea serpent, or warlu, called Barrimirndi. Long, long ago, this almighty warlu rose from the seas and journeyed across the Pilbara tablelands, his movements carving out the path of the Fortescue River. The waters of Deep Reach in the Fortescue River at Millstream are revered by the Yindjibarndi people of the area

But this was no mere wandering—Barrimirndi's awesome journey was one of revenge. He was in search of two Aboriginal boys who had broken the law by eating Barrimirndi's sacred bird—the Gurdarnkurdarn, or mulga parrot.

Intent on unleashing his fury, Barrimirndi charged across the land. At some places he travelled underground, at others he rose from the earth, forming deep pools of water. When the warlu finally reached the boys, he swallowed them as their people stood by in horror. Desperately, these people grasped sticks and tried to free the boys from the warlu but their efforts were in vain. Distraught, they cried out in grief and returned to camp at Deep Reach. But this too incurred the wrath of the warlu and he conjured a mighty flood, bringing water to this then waterless land and drowning the entire crowd.

Whispers of this tragedy were passed on through generation upon generation of Yindjibarndi people. The story shows the consequence of breaking traditional law and customs. For this reason, Yindjibarndi do not fear this warlu but respect him. They know Barrimirndi was upholding the law of the land—the laws that demand a great respect for this spectacular and nature-rich country of that area.



Above left background Fish in Fern Pool.
Photo – Cathy Zwick/DEC

Left Flatback turtle.
Photo – Jiri Lochman

Top Tidal flats near Cossack.
Photo – Michael Pelusey

Above Fig in rock crevices at Karijini National Park.
Photo – Cathy Zwick/DEC

But it's not only birds that visit this area. Between June and October, migrating humpback whales pass the coast on their mammoth journey from Antarctica to breeding grounds in waters off the north of the State. Dolphins are also regular visitors, as are flatback turtles, which come ashore between October and April to lay their eggs in the sand. These turtles hatch from about February to July and take to the oceans. Then, several decades later, females that have survived return to the very stretch of beach on which they were born to give birth themselves.

Finally Warlu Way reaches its end destination in Broome. Here travellers can learn about how this favoured tourist destination has transformed from a riotous and rollicking outpost to a resort town renowned for its glorious beaches, pearls and meeting of diverse cultures.

Samille Mitchell is a *LANDSCOPE* Editor and Department of Environment and Conservation (DEC) Publications Officer. She can be contacted on (08) 9389 8644 or by email (samille.mitchell@dec.wa.gov.au).

Warlu Way is an initiative of Australia's North West Tourism, supported by DEC.

A unique voyage for threatened plants

Research supported by an international partnership has resulted in seeds of the feather-leaved banksia making a special voyage to the United Kingdom before returning home to Western Australia as seedlings for planting that will enhance the survival of the species in the wild.

by Anne Cochrane

The feather-leaved banksia (*Banksia brownii*) is an iconic plant species from the south-west of Western Australia. It is listed as critically endangered and is declining due to the effects of *Phytophthora* dieback and too-frequent fires. It is highly possible that a changing climate may also affect the survival of this species. With this in mind, seeds of the feather-leaved banksia were collected from both coastal and mountain populations and, along with seeds of other species, taken to England in April 2007 for safekeeping under WA's partnership with the Millennium Seed Bank (MSB) Project at the Royal Botanic Gardens in Kew (see 'Our frozen future', *LANDSCOPE*, Winter 2001).

In collarboration with MSB Seed Ecologist Matthew Daws, experiments were established that aimed to understand temperature limitations on germination and growth of the banksia seed. Laboratory and glasshouse trials formed part of the preliminary experiments. Some interesting findings were made, but the most important point was the number of plants produced from the experiments. Traditionally, the germinated seeds would be recorded and the seedlings thrown away, but because of the threatened nature of the feather-leaved banksia it was considered wise to keep the seedlings and bring them home to be used in planned reintroductions this year.

Bringing the seedlings home

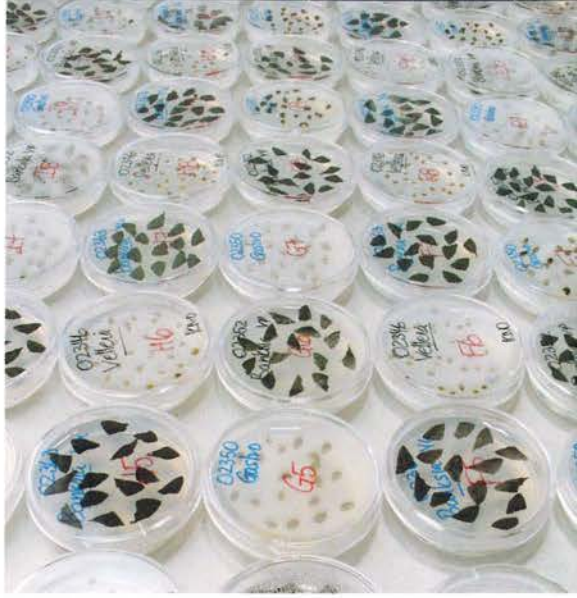
Stringent restrictions on the import of plant material into Australia meant a permit from the Australian Quarantine Inspection Service was required to bring the plant material back into Australia, despite the material being of Australian origin. To assure the Australian authorities that the plant material did not carry any 'foreign' pathogens, a phyto-sanitary health certificate was obtained from the British Government before re-entry into Australia. Although the Royal Botanic Gardens is a quarantine station, obtaining a health certificate for the seedlings was a precautionary measure. Due to international airline regulations for restricting liquids and gels to 100 millilitres, the seven small containers of seedlings growing in nutrient-free agar gel were not permitted on the plane as carry-on baggage. The seedlings were therefore required to travel in the hold of the plane. Though carefully packed in a small insulated esky made of polystyrene foam and wrapped well in plastic, there was some doubt as to whether the seedlings would return to Australia alive and in good enough shape to survive.

On landing in WA, the seedlings were taken to the Kings Park nursery in Perth for nurturing before they were large enough for planting back into the wild. Seedling survival was very high despite their long trip in the unpressurised hold of an aircraft. Of the original 165 feather-leaved banksia seedlings put on the plane in June 2007 in the United Kingdom, 86 of the mountain form and 70 of the

Previous page
Main Feather-leaved banksia seedlings growing in the glasshouse at the Millennium Seed Bank in England.
Photo – Anne Cochrane

Above Anne Cochrane with feather-leaved banksia seedlings for planting in a 'seed orchard' near the Stirling Range.
Photo – Sarah Barrett

Left The feather-leaved banksia growing in the wild.
Photo – Renee Hartley



Above left Feather-leaved banksia flower.
Photo – Renee Hartley

Top Feather-leaved banksia seeds from the Stirling Range species are assessed for temperature requirements for germination at the Millennium Seed Bank.
Photo – Anne Cochrane

Above Anne Cochrane plants a feather-leaved banksia seedling into a reintroduction site near Albany.
Photo – Meredith Spencer

coastal form survived until planting in May 2008. Meanwhile, since the initial arrival of the seedlings back 'home', Department of Environment and Conservation scientists had located two possible disease-free planting sites through the Western Australian Government's *Saving Our Species* initiative and through additional support from the Commonwealth-funded South Coast Natural Resource Management group. Plantings started in May this year and detailed demographic monitoring of the plants will be carried out to determine survival over time—information that is a vital part of any plant reintroduction.

World first in flora conservation

This has been the first attempt to repatriate whole plant material from the MSB back to its country of origin, marking a stepping stone in the global seed conservation partnership. Examples like this mean that research aimed at overcoming barriers to germination or understanding threats can be conducted on material held in the UK seed bank and the resultant seedlings can be sent back to the country of origin for reintroduction back into the wild. Many of the partner countries in the MSB collaboration do not have the capacity to conduct detailed research themselves so carrying out research in the UK is a feasible option. When threatened plants are involved it is comforting to know that seedlings from research programs can relatively easily return home. For the feather-leaved banksia, the increase in plants on the ground and knowledge of threatening processes associated with plant decline will increase the chances of the species' future survival.

Anne Cochrane is a senior research scientist working with the Department of Environment and Conservation (DEC) in Albany. She manages the Threatened Flora Seed Centre, DEC's seed conservation facility for rare, threatened and poorly known plant species. She can be contacted on (08) 9842 4500 or by email (anne.cochrane@dec.wa.gov.au).

Managing our stunning *south-west corner*

by Joanna Moore

A new draft management plan soon to be released for the parks of the Leeuwin-Naturaliste Ridge, Scott National Park and Gingilup Swamps Nature Reserve in Western Australia's south-west aims to manage the demands faced by this ever-popular region.

The iconic tourist destination of Western Australia's south-west corner boasts exceptional coastal scenery, beautiful forests, extensive wetlands and a wealth of nature-based recreational opportunities. Visitors with walking boots, binoculars, fishing rods, four-wheel drives, caving gear and boats abound in summer, and on long weekends throngs of leisure-makers make the trip 'down south' to enjoy the beach and bush delights of the region. Others prefer to wine and dine at the dozens of local wineries, breweries, restaurants and cheese and chocolate factories which can be found between the towns of Augusta, Margaret River and Dunsborough.

In this nature-rich region, the lifestyles of locals are shaped by the natural environment. Many feel a close affiliation with nature and the striking visual landscapes around them. A strong beach and surfing culture exists, local galleries feature work inspired by the forests and the varied coastlines, and natural areas are adorned with trails where hikers walk at one with nature.

The region has the most diversified economy of any in the State, based strongly on agriculture, horticulture, emerging aquaculture industries and extensive mineral wealth. With

an estimated 2.1 million visits to Leeuwin-Naturaliste National Park each year, tourism is also an important part of the economy. Viticulture has also experienced dramatic growth over the past decade.

Biodiversity hotspot

These intensifying land uses are putting increasing pressure on the wide range of natural values found in the area's conservation reserves. The Leeuwin-Naturaliste coast and inland forested areas feature many flora, fauna and threatened ecological communities that are listed as threatened or priority species in need of protection. The area sits within the internationally recognised south-west region which is classed as one of the world's 34 biodiversity hotspots and one of Australia's top 15. 'Hotspots' are biologically significant ecosystems that support large numbers of endemic species of plants and animals, and also face a high degree of threat to biodiversity.

High concentrations of endemic plant species are protected within Leeuwin-Naturaliste National Park, a narrow strip of coastal land running about 100 kilometres from Cape Naturaliste near Dunsborough to Cape Leeuwin near Augusta, and on the Scott Coastal Plain, which stretches 36 kilometres to the east of Augusta. The area contains more than 1,600 described species of vascular plants in 118 families, the largest being the pea, orchid, daisy, grass, sedge and eucalypt families. The region is also significant for species at their range limits, as it marks the northern limits for many south coast plant species, including karri, and the southern limit for several species of the Swan Coastal Plain, such as the chenille honey myrtle (*Melaleuca huegelii*). Cape Naturaliste is the only place where jarrah forest meets the coast.

As well as containing large numbers of bio-geographically significant flora, the south-west corner is the site of cave ecosystems, nationally important wetlands and invaluable remnants of vegetation, such as bushland on the Leeuwin-Naturaliste Ridge, an area which has been predominantly cleared due to the high demand for rural residential housing. There are also five threatened ecological communities in the south-west corner, including the Augusta microbial communities and Scott River ironstone community.

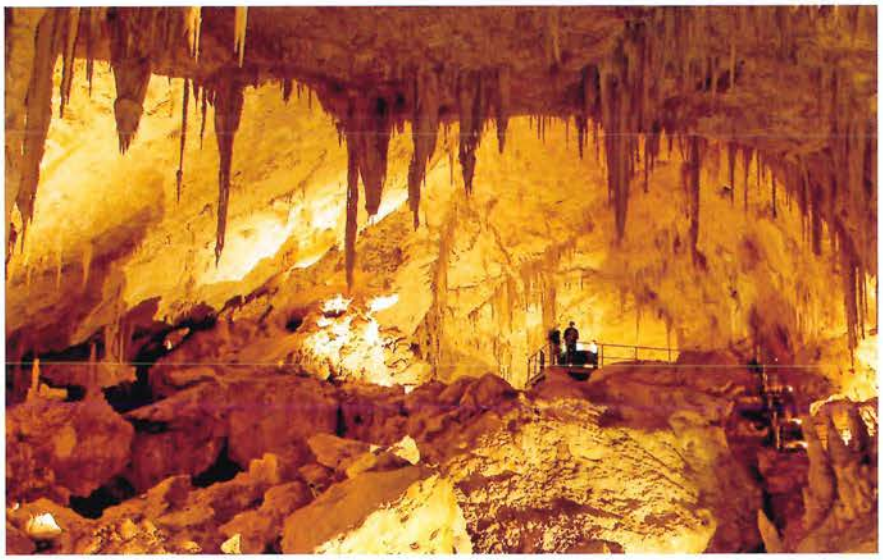
Wetlands

Further south and east, Scott National Park is particularly well recognised for its diverse vegetation, high flora conservation values and high

Previous page
Main Sugarloaf Rock.
Photo – Damon Annison
Inset Wildflowers.
Photo – Ann Storrie

Left Surfing at Boodjidup on the Leeuwin-Naturaliste coast.
Photo – Brett Dennis/Lochman Transparencies

Above Cape Leeuwin lighthouse, Leeuwin-Naturaliste National Park.
Photo – David Bettini



Right Calcite formations inside the large chambers of Mammoth Cave.
Photo – Samille Mitchell/DEC

flora species richness. More than 800 species of plant have been recorded there. Together with Gingilup Swamps Nature Reserve, these reserves comprise the largest remaining remnants of vegetation on the western side of the Scott Coastal Plain, and both are rich in wetland area and type.

The wetlands of the south-west corner, including those on the Scott Coastal Plain, are important for the maintenance of ecological processes and linkages between ecological systems. One site—the tributaries of the lower Blackwood River—is considered a wetland system worthy of nomination for inclusion on the Ramsar List of Wetlands of International Importance. The proposed nomination area provides critical habitat for the white-bellied frog (*Geocrinia alba*) and reedia swamps threatened ecological communities, both of which are critically endangered.

Special frogs and other animals

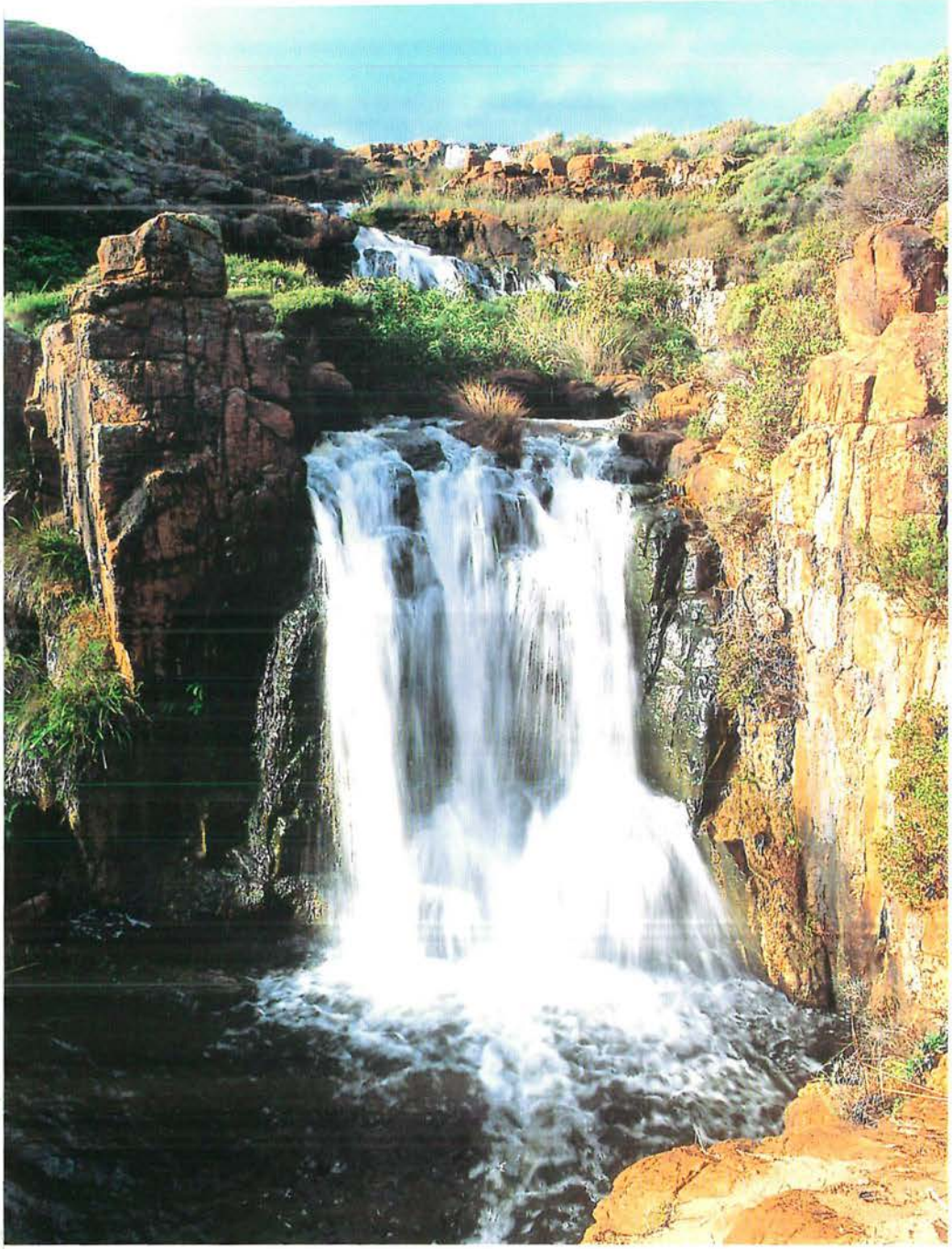
The white-bellied frog is one of 11 species of frog recorded in the south-west corner of the State, all of which are endemic to the area. This little frog lives within an area north and west of the Blackwood River between Margaret River and Augusta. In 1995, it occupied a range of just 190 hectares. Over the past 10 years this range has contracted further, mostly due to changing agricultural practices and the creation of large dams, leading to the disappearance of 25 per cent of known populations (see 'Fascinating frogs' on page 10).

Other species of specially protected and priority fauna found in the south-west corner include the forest red-tailed black-cockatoo (*Calyptorhynchus banksii naso*), chuditch (*Dasyurus geoffroii*), western ring-tailed possum (*Pseudocheirus occidentalis*), Dunsborough burrowing crayfish (*Engaewa reducta*) and Cape Leeuwin freshwater snail (*Austroassiminea letha*).

Caves

The Leeuwin-Naturaliste Ridge karst system is nationally and internationally significant and has several hundred karst features including caves, collapsed caves, solution pipes, root casts, subterranean drainage channels and some of the youngest but longest straw formations in the world. Caves are irreplaceable features of the landscape and support unique subterranean ecological communities of endemic aquatic invertebrate fauna.

Within the Leeuwin-Naturaliste Ridge karst system, there are four critically endangered aquatic root mat communities, most of which are under extreme threat as a result of declining rainfall and falling water levels in the caves. The karst system



Above Quininup Falls, Leeuwin-Naturaliste National Park.
Photo – Alex Bond

is also important for archaeology, palaeontology and recreation. Within the parks of the region, access to caves is strictly managed to minimise damage to these fragile systems.

Many uses

As well as being of high conservation importance, the area also offers many recreational pursuits, valued highly by the local community and visitors. The parks of the south-west corner are the most visited recreation destinations outside of Perth, with visitation to the Leeuwin-Naturaliste National Park increasing by 75 per cent over the past decade. The region is also experiencing significant residential growth with a focus on coastal areas. This popularity is putting increasing pressure on the natural spaces so treasured by both the local community and visitors who, ironically, often have little awareness of their high biodiversity values.

The parks of the Leeuwin-Naturaliste Ridge are fragmented and sit within a rapidly changing regional setting. Adjoining land uses such as viticulture, tree plantations and semi-rural developments shape the issues that land managers need to consider, such as fire, weeds, pest animals and visitor activities.

Improving management

The nature conservation and recreation values of the Leeuwin-Naturaliste area have been managed according to the Leeuwin-Naturaliste National Park Management Plan 1989-1999 for the past 18 years. A new draft management plan soon to be released will manage nearly 35,000 hectares of land including the Leeuwin-Naturaliste National Park along with the Yelverton, Bramley, Forest Grove and Scott national parks, the Gingilup Swamps Nature Reserve, several other small nature reserves, an unnamed national park and two timber reserves proposed to become forest conservation areas.

Many of these areas are now under increasing pressure and mis-use as tourist visitation increases and the residential population of the south-west continues to grow. The management plan will identify key actions required to protect and guide the use of these areas to ensure their value and function as conservation reserves continues into the future.

Adjoining the terrestrial parks is the proposed 'Capes' Marine Park. (See 'Capes coast beneath the surface', *LANDSCOPE*, Summer 2007-08.) The stunning marine environment is a major drawcard to the region. While popular activities such as surfing and fishing are based on the water, getting to one's favourite surf break or fishing spot can impact on the land. Managing this impact will be one of the challenges of the plan. Once the marine park is gazetted, the values of the marine and terrestrial reserves will complement each other.

Experiences, settings and users

Across its many settings, the area from Cape Naturaliste to Cape Leeuwin and inland provides a variety of experiences to a wide range of users. Bushwalking is a popular way to experience the bush and coastal scenery, especially for those seeking a remote nature-based experience. The Cape to Cape Track, which winds its way 135 kilometres down the Leeuwin-Naturaliste coastline, can be completed in five to seven days. Access points along its route provide a multitude of shorter walks for those with varying experience or time. A friends group has been formed to help develop and maintain the track and its collective assistance is an ongoing support to the Department of Environment and Conservation (DEC).

A section at the northern end of the Cape to Cape Track is being improved to enable 'access for more'. Here a 1.5-metre-wide bitumen and boardwalk surface enables people in wheelchairs, people with walking sticks or frames and parents with children in prams to experience the coastal vegetation and stunning ocean views. Two-thirds of this part of the track have been completed—about 2.3 kilometres—and when it is finished it will extend from the Cape Naturaliste lighthouse precinct to Sugarloaf Rock, where track users can be picked up by car.

These upgrades are part of improvements to create a high quality precinct at the Cape Naturaliste lighthouse that is accessible by as many people as possible—part of DEC's aim to accommodate visitors' wide-ranging needs when developing strategically selected high-use recreation areas. For those who prefer a wilder nature-based experience, away from the major recreation areas, the rest of the Cape to Cape Track will retain its rougher terrain and sense of remoteness.

Another site being upgraded is Hamelin Bay, a popular camping and fishing location about 70 kilometres south of Cape Naturaliste. To help cope with increasing usage, the day-use area has a new car park, new toilets and improved walks trails to the beach, which has also benefited from rehabilitation work. The access road to the beach, which used to run through Hamelin Bay's caravan park, has been re-routed, for several reasons including the safety and amenity of caravan park users. Additionally Lake Davies near the caravan park is a significant site to Aboriginal people and is listed on the Western Australian Aboriginal Heritage Site Register.

Left An 'access for more' path, Cape to Cape Track.
Photo – DEC

Below Canoeists picnic on the tranquil lower reaches of the Blackwood River.
Photo – Brett Dennis/Lochman Transparencies

How much development?

So will all the beautiful beaches, lookouts and historical sites eventually be developed to this degree? The new draft management plan determines that this will not be the case—rather the management of recreation areas will range from retaining places of minimal or no development to provide for remote experiences, through to highly modified areas that have been upgraded to cope with a higher-intensity use.

The vast numbers of visitors means that the really popular sites need to be able to handle mass tourism, especially during summer. Sites such as Canal Rocks, Ellensbrook Homestead, Redgate Beach, Sugarloaf Rock and Conto Camp Ground, which are well known and easily accessible, offer a full range of facilities such as toilets, sealed roads and information panels.

However, many sites simply cannot cope with high visitation due to their fragile environments or if they are to retain their special character. Putting in picnic areas and boardwalks can change the feeling of a place and as the recreation values of a site shift with upgrades, sometimes the very reasons that people once came to visit are lost. Therefore, minor sites need only minimal facilities—those that guide visitors to avoid negative impacts on the environment.

Local community-based recreation activities such as fishing, surfing, bush-walking and nature appreciation are long established and residents and special interest groups value being able to continue these activities in their favourite spots. Decisions about recreation development have also been influenced by the presence of sites with Aboriginal cultural significance, which are scattered along the coast.

By indicating that some sites will not be developed, the new draft management plan aims to ensure that the diversity of experiences which have been enjoyed by people visiting and living in the south-west will continue.

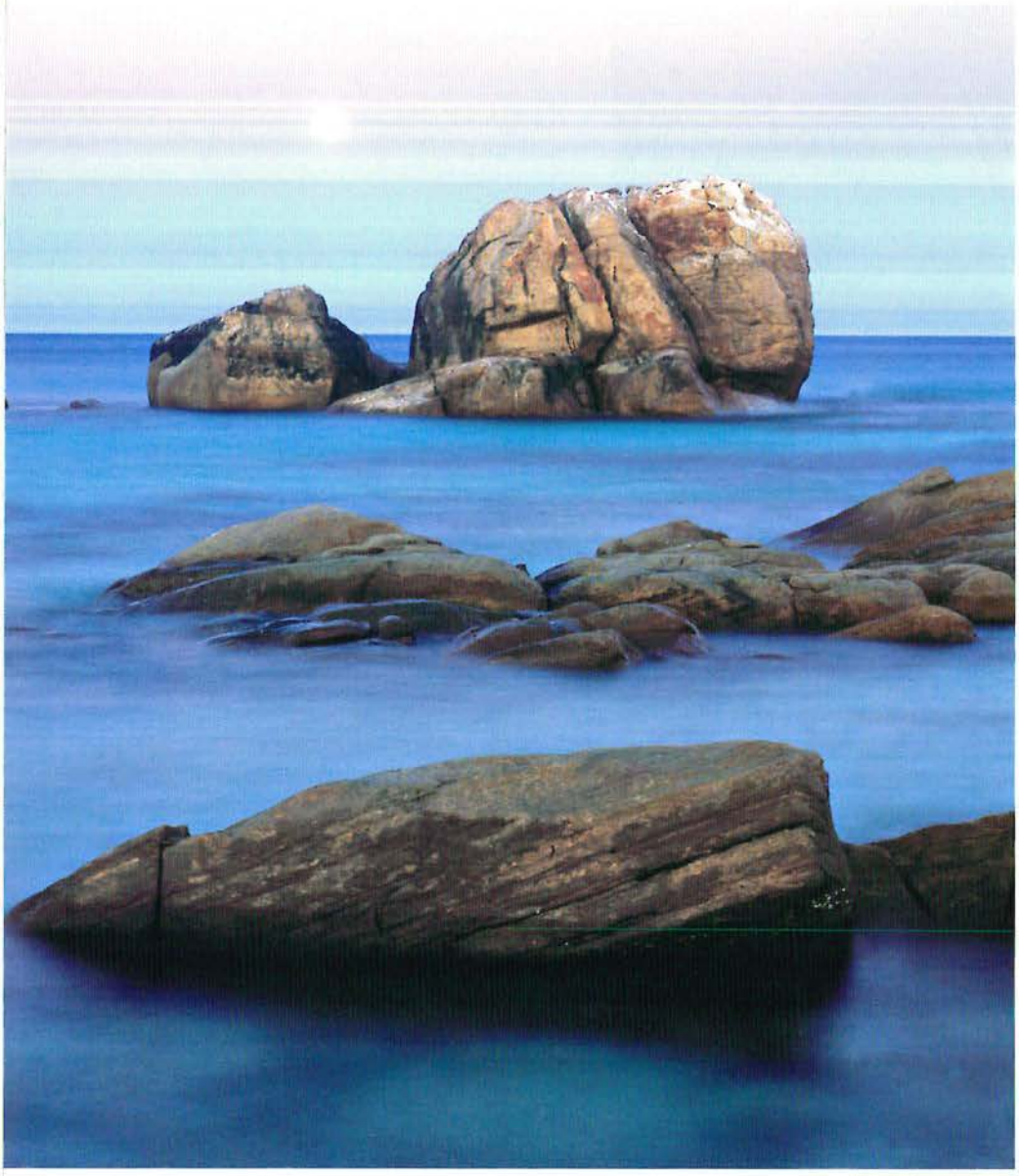
Indigenous cultural heritage

The Leeuwin-Naturaliste region was the tribal territory of the Wardandi people, essentially a coastal people based between Bunbury and Cape Leeuwin, and the Pibbelmen people, who lived around the lower Blackwood River. Sites of Aboriginal cultural significance in the planning area for the new draft management plan include middens and hearths, burial and ceremonial sites, mythological sites, paintings and engravings and artefact sites.

Artefacts are a valuable record of past Aboriginal life in the area and one significant location where many of these have been found is Devil's Lair. This cave site on the Leeuwin-Naturaliste Ridge contains animal remains and stone and bone artefacts which show the first human occupation in the area to be as early as 50,000 years ago, making it one of the oldest and most reliably dated early occupation sites in Australia. The management of Devil's Lair and other Aboriginal cultural heritage in the area will be guided by principles including their need for protection and the recognition that Aboriginal people are the primary source of information on the value and conservation of their heritage.

Telling the stories

An important aspect of improving and managing for recreational use is interpretation—information which reveals the natural and cultural values of a place to visitors. Interpretation enhances appreciation of park values,



Left Gannet Rock, Meelup.
Photo – Ann Storrie

leading to an increased understanding and support for their management. The diverse stories of the area—such as the dynamic coastline environment, the extensive wetlands of Scott National Park and Gingilup Swamps Nature Reserve, Aboriginal and historic sites, the stunning karri forest and its changing land uses and the merging of the Southern and Indian oceans at rugged Cape Leeuwin—shape the themed interpretation provided for visitors throughout the area.

While the name Caves Road hints at one story of the region, it may not be widely known that the primary reason for the original creation of the Leeuwin-Naturaliste National Park was its complex system of caves and other karst features. Cave overhangs were used as shelters by the Aboriginal people before intensive exploration began with colonial settlement from about 1850. From the turn of the 20th century, tourists travelled three hours by horse and carriage from the railhead at Busselton down the then Lake Cave Road to visit the caves that were at that stage the most significant tourist attractions in the area. Amateur explorers and, later, tour groups with little awareness of fragile cave formations caused significant damage to the caves.

The two tourist caves managed by DEC, Calgardup and Giants, and others such as Jewel, Mammoth, Ngilgi and Lake which are managed by local tourism associations, continue to be visited today. During the 18-year life of the previous management plan for the area, huge achievements were made in cave management. From access to caves occurring on an essentially random basis before 1989, the caves of the area are now some of the best-managed in Australia. The new draft management plan for the area will endorse the current permit system for the DEC-managed caves, which classifies caves as tourist (publicly accessible), adventure (appropriate for public access with an approved trip leader) or restricted access (only accessible for approved research).

Continuing inspiration

Hundreds of thousands of visitors spend time in the south-west corner each year, drawn by world-class recreational opportunities and exceptional scenery. Such a diverse and treasured area deserves the care of all who use it—whether for recreation, lifestyle or livelihood. With careful management and an increased awareness by visitors and the local community of the conservation values that surround them, the area can continue to support a wide range of sustainable nature-based recreation activities in its inspiring coast, forest, heathland and cave settings.

Above Cosy Corner Beach in the Augusta region of Leeuwin-Naturaliste National Park.
Photo – Alex Bond

Below An 'access for more' path, Cape to Cape Track.
Photo – DEC

Joanna Moore, a Communications Officer with the Department of Environment and Conservation, was born and raised in the south-west town of Dunsborough. She can be contacted on (08) 9389 8644 or by email (joanna.moore@dec.wa.gov.au).

Purnululu National Park

The towering domes of the Bungle Bungle Range entice visitors to the remote Purnululu National Park in the Kimberley.

Above Hiking through the Bungle Bungle Range.
Photo – Damon Annison

Opposite page
Left Flock of budgerigars.
Photo – Dennis Sarson/Lochman Transparencies
Right Rock ringtail dragon.
Photo – Babs and Bert Wells/DEC
Bottom right Rainbow bee-eater.
Photo – Rob Drummond/Lochman Transparencies

The towering rocky domes of the Bungle Bungle Range in Purnululu National Park have enchanted human beings with their majestic beauty since the beginning of time. Firstly Aboriginal people of the Kimberley lived near and among the soaring rock forms. They inhabited the region for thousands of years, eking out a living from the surrounding plains and living at one with the ancient landscape.

It wasn't until as recently as the 1980s that this now well-known icon of the outback shot to national fame with its first significant media coverage. This coverage sparked an avalanche of interest—where was this remarkable landform, people asked, and just how did Mother Nature come up with its stunning design?

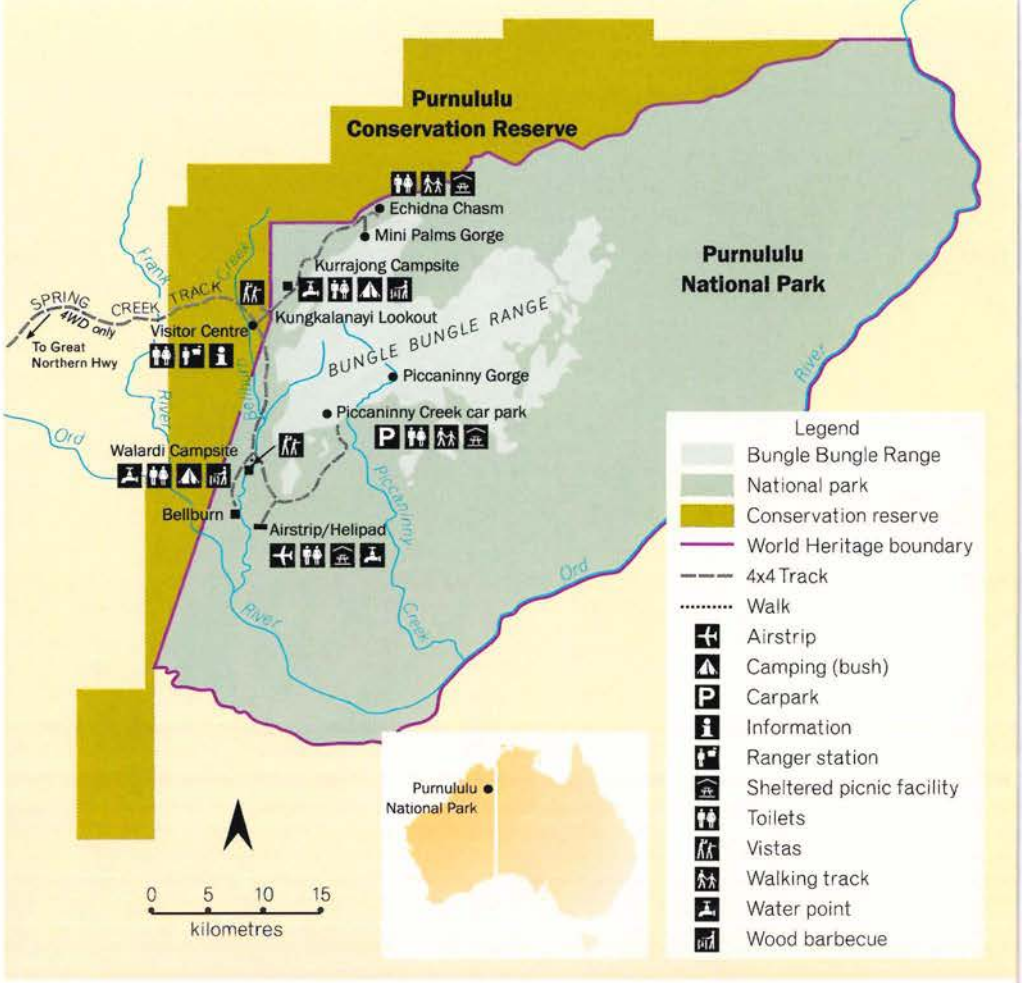
The geological attraction

Today, some 25,000 people travel to this remote part of Australia every year to experience the remote national park's astounding natural beauty. They are drawn by the wild assortment of gorges, canyons and towering rocky domes.

Still more people visit the area on a scenic flight from within the park, or from Halls Creek, Kununurra or Warmun. From the air you can truly appreciate the beauty and vastness of the range. The beehive-shaped domes soar more than 250 metres into the air and stretch to the horizon in an intricate maze of rusty red rocks. The towering gorges change colour, from brown to red, orange and gold, as the sun progresses across the sky. And all around majestic palms grow in striking green contrast to the deep orange of the range's rocks.

The sandstone which makes up the range's rocky domes was deposited some 360 million years ago. Then, over the past 20 million years, the natural forces of rain and water sculpted the range to the intricate network of domes seen today.

The stripy nature of the rocks came about thanks to a bacteria known as cyanobacteria. This dark algae grows on layers of sandstone where moisture



accumulates. The orange bands of colour come from different layers of rock, which dry out too quickly for the cyanobacteria to grow.

It is the geological marvel of the Bungle Bungle Range, and the natural beauty of the park, that has earned Purnululu a World Heritage Area title (see 'World Heritage: protecting the world's most treasured places' on page 6).

Experiencing the wonders

You can experience this geological wonderland in a variety of different ways. Flying above the range in a plane or helicopter is the best way to gain a perspective of the range's size and beauty. Otherwise, set out on foot on one of the many hiking trails.

While a hike may not give you the perspective you'll gain from the air, it may enable you to spot some of Purnululu National Park's animal life. Look out for charming rock ringtail dragons sunbaking along the trails or northern nailtail wallabies bounding across the rocks. If you're lucky you may see ghost bats or rockhole frogs hiding deep within crevices in the rocks. And you'll almost certainly delight in some of the prolific bird life. More than 130 bird species occur here, including rainbow bee-eaters and flocks of budgerigars.

The most popular of the walks is the easy hike to Cathedral Gorge. More adventurous hikers can spend two days exploring Piccaninny Creek and Gorge and camp overnight along the way. You can also camp at one of two designated camping areas to truly soak up the spirit of this enchanting place.

park facts

Where is it? The turn-off to the park is 250 kilometres south of Kununurra or 109 kilometres north of Halls Creek. The park access road is accessible only to four-wheel drive vehicles. The park is open only between April and December 31 (weather permitting).

Total area 239,723 hectares of national park and 79,602 hectares of conservation reserve.

What to do Hiking, photography, camping, nature observation, scenic flights.

Facilities Camping at Walardi or Kurrajong camps (both sites have toilets and water). Petrol and supplies available from Turkey Creek, also known as Warmun, which is on Great Northern Highway.

Nearest DEC office Kimberley Regional Office, Messmate Way, Kununurra 6743. Phone (08) 9168 4200.

HIDDEN BIODIVERSITY:
fungi and invertebrates

Biodiversity inventory surveys of the south coast of Western Australia are revealing fascinating new species of macrofungi and endemic invertebrates.

by Janet Newell, Katrina Syme, Melinda Moir, Mark Harvey and Deon Uber

Biodiversity is described as the 'variation of life at all levels of biological organisation'. The south-west of Western Australia is recognised as one of 34 international biodiversity hotspots for its high species richness, number of endemic species and its level of risk from various threats. Vascular plants and vertebrate fauna dominate our knowledge of the diversity and distribution of biodiversity. However, beneath this hides a taxonomic 'abyss' of fascinating but rarely seen life forms including ground-dwelling invertebrates such as spiders, millipedes, scorpions and velvet worms and a wondrous array of fungi including puffballs, earth stars and coral fungi.

On the south coast of WA, the regional Natural Resource Management (NRM) group, the South Coast NRM, is implementing the Biodiversity Inventory Program to target this area of poorly known and documented biodiversity. This program, implemented in partnership with the Department of Environment and Conservation's South Coast Region and the Western Australian Museum, extends from Walpole in the west to Cape Arid in the east.

The aim of the program is to conduct biological inventory surveys of poorly documented groups of biodiversity, starting with macrofungi and terrestrial invertebrates. The South Coast NRM strategy developed in 2004–05 identified these little-known areas of biodiversity as important pieces of the conservation puzzle that needed to be obtained. However, this is a massive task, as the number of species in these two groups alone is probably in the realm of tens to hundreds of thousands, of which only a relatively small proportion have been collected and formally described.

The inventory surveys conducted since early 2006 have collected data on terrestrial invertebrates and macrofungi. Already exciting discoveries have been made including new species, both to the region and to science. This program will lead to important insights into the evolutionary and ecological history of south coast ecosystems and will identify new species including some that are rare and possibly threatened.

Macrofungi

Fungi are an integral, though often undervalued, part of healthy functioning ecosystems, playing significant roles in the decomposition of organic matter and distribution of nutrients (see 'Perth's fungi forever', *LANDSCOPE*, Autumn 2007). The number of species of fungi that occur on the south coast is unknown, though it is estimated that less than 50 per cent of macrofungi species have been discovered or named. Although the first records of fungi from the south coast were made in the late nineteenth century, fungi were largely ignored in the region until the last quarter of the twentieth century.

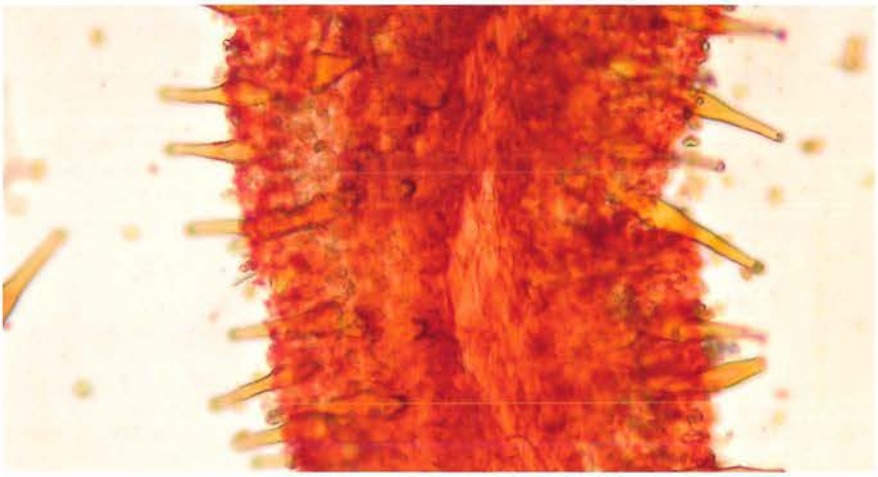
One reason that so little is known about fungi is their cryptic nature. The macrofungi's fine filaments, known as hyphae, spread throughout the soil and other organic matter, but identification of most species requires the examination of their fruiting bodies (e.g. mushrooms). This relies on being in the right place at the right time as, although the hyphae of a single species may cover many hectares, their fruiting bodies can pop up anywhere in that area. Most species only fruit when soil moisture content is high

Previous page
Main Orange fungi (*Dermocybe splendida*).
Photo – Ann Storrie
Inset Pill millipedes *Epicyliosoma sarahae* and *Cynotelopus notabilis*.
Photo – Melinda Moir

Above Janet Newell raking leaf litter in search of fungi at Corackerup Nature Reserve.

Left Fungus flies (*Tapeigaster* sp.) breed in fungi. This one is shown perched on the cap of *Pluteus lutescens* in the Walpole-Nornalup National Park.
Photos – Katrina Syme

Right The Australian oyster fungus (*Pleurotus australis*) is only recorded in Two Peoples Bay Nature Reserve.



Below right Seen at high magnification, the presence of metuloid cystidia—sterile cells on the face of the gills—help identify this collection as a species of *Inocybe*. Some spores are also visible.
Photos – Katrina Syme

and some only fruit every few years. Furthermore, most of these fruiting bodies are fragile, short-lived structures which are often present for only a few days before they decay.

Fungi forays

While conducting surveys (forays) over the past two years, mycologist Katrina Syme recorded 622 distinguishable species from more than 400 sites as part of the Biodiversity Inventory Program. More than 70 per cent of these species have not been formally named and many of the remaining collections are still to be identified. These fungi forays have increased the number of species known for the region by more than 40 per cent.

It is difficult to identify many fungi without the use of a microscope. The fruiting bodies that could not be identified in the field during the fungi forays were photographed, collected and given field names, such as 'brownish-maroon cap'. Katrina subsequently spent each evening describing and photographing each of these specimens which were then preserved by being sectioned and dried. Many hours were spent later peering through a microscope at the spores and cell structures of these specimens to confirm or aid accurate identification. The collections were then lodged with the Western Australian Herbarium.

Fungal discoveries

Fungi come in an amazing variety of forms, colours and lifestyles. Most of the fungi recorded during the inventory survey were growing in the soil and were mycorrhizal (forming beneficial partnerships with plants) or saprophytes (decomposers of organic matter such as dead wood, leaf litter and animal dung). A few macrofungi are parasitic, such as the Australian honey fungus (*Armillaria luteobubalina*), which is well known for causing disease and the death of many cultivated and native plant species.

The most commonly recorded species during the inventory surveys was the white dye-ball fungus (*Pisolithus albus*) which is a common and widespread species often seen along the hard-packed shoulders of roads—and sometimes even pushing through bitumen. Another commonly recorded species was the scarlet bracket fungus (*Pycnoporus coccineus*), which grows on dead wood. This easily recognisable species is a leathery, bright orange bracket that fades to a creamy pink colour.

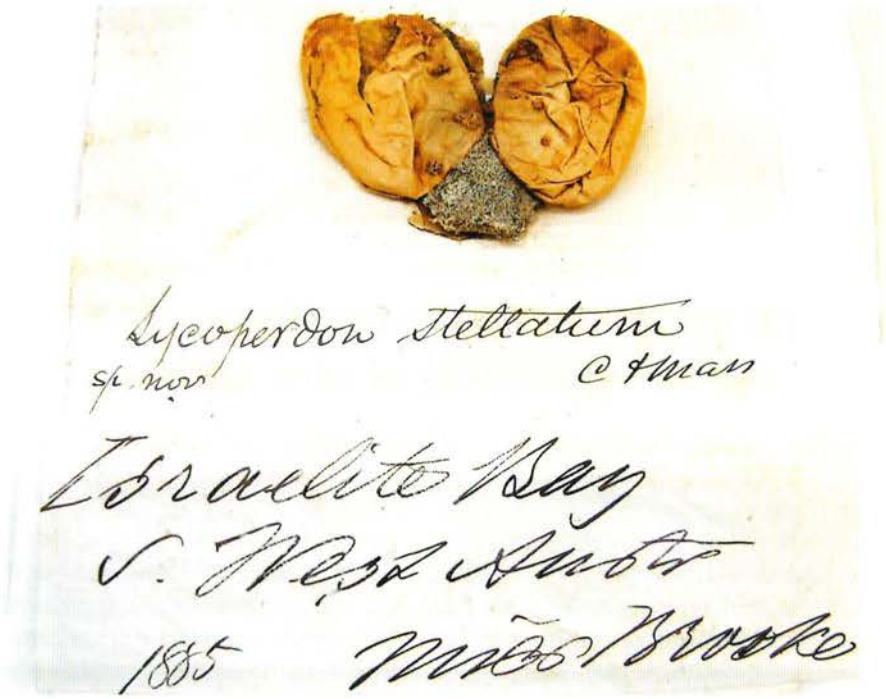
The surveys increase the known range of many fungi species within the south coast. For example, three collections of the toothed fungus (*Auriscalpium barbatum*) from near Hopetoun and north of Esperance, were the first collections made of this distinctive species since it was first recorded in Fitzgerald River National Park in the 1970s.

Some macrofungi species collected during the survey were found to have even broader ranges. For example, the grey-gilled porpoloma (*Porpoloma griseum* ms), which was found in dry woodland along the south coast, is otherwise only known from Mount Arapiles in Victoria, and a collection of a small waxcap (*Hygrocybe watagensis*) found at Denmark had only been collected once before in New South Wales.

The anemone stinkhorn (*Aseroe rubra*) was the first Australian fungus to be formally described by French botanist Jacques Labillardiére in the late eighteenth century. It is common throughout south-eastern Australia but was recorded for the first time in WA during this survey.

Above *Nothocastoreum cretaceum*, which fruits after bushfires. The spherical fruit body splits open to reveal the inner spore mass.

Left *Gastroboletus* sp., truffle-like relatives of boletes which were collected in the Stirling Range National Park, partly uncovered by foraging animals.
Photos – Katrina Syme



Below left The type specimen of *Lycoperdon stellatum*, collected at Israelite Bay by Sarah Theresa Brooks.
Photo – Jennifer Tonkin

The most cryptic fungi are the truffle-like species which form mainly underground fruiting bodies. Many of these species are important food sources for native animals and invertebrates, including the critically endangered Gilbert's potoroo (*Potorous gilbertii*), found in Two Peoples Bay Nature Reserve. About 32 species of truffles were collected during the inventory surveys, a group of which are unnamed species of *Gastroboletus* that were uncovered by looking where foraging animals had been digging.

Terrestrial invertebrates

The invertebrate fauna of the south coast have originated from three sources: the arid interior, species that have evolved since rainforests were replaced by the current *Eucalyptus*–proteaceous habitats, and Gondwanan relicts. Decreased rainfall in the south-west during the past 25 million years has extinguished the Gondwanan rainforests that once existed across southern Australia. Some Gondwanan species retreated and currently survive in refugial habitats such as deep gullies or mountain peaks, which have remained cooler and moister than the surroundings. These species are defined as 'short-range endemics', due to their restricted and isolated habitats. The size of the range of each of these species is limited by the small areas of suitable habitat and the limited ability of many of the species to disperse. The restricted distribution and the specialised requirements of the species put them at risk of extinction from disturbance.

The Biodiversity Inventory Program targeted the invertebrates most likely to be short-range endemics: millipedes, snails, spiders, scorpions, harvestmen and pseudoscorpions. Surveys were carried out by Melinda Moir of the Western Australian Museum at more than 200 sites throughout the south coast. These terrestrial invertebrates were found mainly by hand collecting and leaf litter sorting with the assistance of tullgren funnels—a device used to sort invertebrates from leaf litter.

Invertebrate discoveries

Melinda was especially interested in millipedes as, through the inventory surveys, 81 species of these extreme short-range endemic species were found to occur in the south coast. Most of these species are known from only a single mountain top, and many have never before been collected. A tiny (five-millimetre) millipede of a new genus of the order Chordeumatida was discovered from unburnt regions

on Mount Manypeaks, only the second species of its order recorded in WA. The first record for the south coast of the millipede family Haplodesmidae was uncovered from leaf litter in karri (*Eucalyptus diversicolor*) forest near Walpole. Several other species, including *Atelomastix albanyensis*, were rediscovered after not being recorded for decades. This species was recorded at both Two Peoples Bay Nature Reserve and Cranbrook for the first time since 1909.

Although pill millipedes, which resemble round pills when tightly curled up after being disturbed, are common in eastern Australia, only two species are known in WA, both of which Melinda recorded during the surveys. One of these species, *Epicyliosoma sarahae*, was found in both Cape Le Grand National Park and Cape Arid National Park, east of Esperance. The second species of the pill millipede, *Cynotelopus notabilis*, was found in the karri forests of the far south-west.

Pseudoscorpions are tiny harmless invertebrates that look superficially like scorpions without the 'tail'. More than 12 species were found during these surveys, including a species of *Sathrochthonius* in Torndirrup National Park, which was previously only known from Walpole-Nornalup National Park. All species of *Sathrochthonius* are restricted to Gondwanan regions (Australia, New Zealand and South America) and the sole Western Australian species is currently restricted to high rainfall regions of the south coast.

Many species of trapdoor spiders have extremely small ranges due to their limited ability to disperse. Two new populations of the ancient trapdoor spider family Migidae were found in gullies within Two Peoples Bay Nature Reserve and Waychinicup National Park. Although many other trapdoor spiders were collected during

Above The pink-headed millipede of the genus *Atelomastix* is found at Two Peoples Bay Nature Reserve and Mount Manypeaks.
Photo – Melinda Moir

Left Melinda Moir and Sarah Comer sampling for invertebrates by shaking the vegetation into a tray and sorting out the interesting specimens in Waychinicup National Park.
Photo – Janet Newell

Below The burrow of a trapdoor spider in Stirling Range National Park. The spider uses *Allocasuarina* needles as trip lines to detect its prey.
Photo – Melinda Moir

Left *Bothriembryon glauerti*, an endangered snail, from the Stirling Ranges.

Below A rock spider (Selenopidae family) found under rocks along the south coast. Note the small pseudoscorpion, *Synsphyronus callus*, to the left which is sharing the same rock. *Photos – Melinda Moir*

these surveys, most were females, which could not be accurately identified as the main taxonomic features are found in males. Future research at the Western Australian Museum will be aimed at using molecular sequence data to accurately identify female and juvenile specimens.

Bugs, insects with sucking mouthparts, were not generally a target during these surveys. However, an astonishing new genus of bug was found living with ants near Ravensthorpe. Although ants are known to share nests with other taxa such as beetles, this is the first known recording in the world of a member of the bug family Flatidae co-habiting with ants.

More to uncover

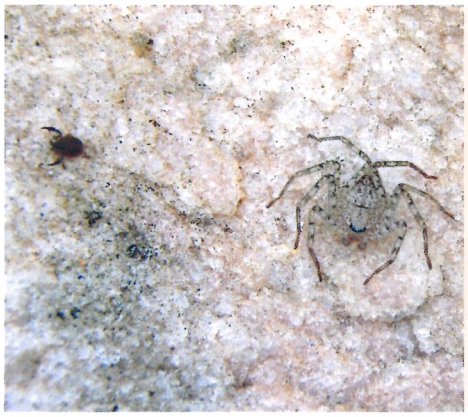
These inventory surveys have made a start at improving our current knowledge of the distribution, taxonomy and conservation status of poorly known biodiversity throughout the region. To date from these surveys, two new species and a new genus of invertebrate, plus one species of macrofungi are in the process of being described, with numerous others to follow. One of the new species of invertebrate, the millipede *Epicyliosoma sarahae*, has been nominated for State conservation listing.

These inventory surveys have raised awareness among south coast land managers and the general public of the existence of these components of biodiversity and the importance of their conservation. The surveys have also helped to identify areas of high biodiversity and special interest. For example, Cape Le Grand National Park east of Esperance contains seven species of millipede, five of which are found nowhere else.

Yet this is only a first step towards understanding these components of biodiversity. For example, more than 60 per cent of the recorded fungi species were only collected from one location, demonstrating the urgent need for more on-going surveys in understanding the distribution and diversity of such species. And within that taxonomic 'abyss' there are still other groups, such as other invertebrates, mosses, liverworts and hornworts, which are similarly poorly known and documented.

As for our well-known flora and fauna, these poorly known components of biodiversity are under threat from habitat disturbances such as land clearing, weed incursions, *Phytophthora* dieback, inappropriate fire regimes and predicted climate changes, due to the small ranges and specific habitat requirements of many of these species.

South Coast NRM will use the findings from the Biodiversity Inventory Program to guide future investment through the Australian Government's new Caring for Our Country program and other funding sources which will support further surveys and management of our hidden biodiversity, including macrofungi and short-range endemic invertebrates.



Janet Newell is a technical officer for the Department of Environment and Conservation (DEC) working on the South Coast Natural Resource Managment (NRM) Biodiversity Inventory Program. She can be contacted by email (janet.newell@dec.wa.gov.au).

Katrina Syme is a mycologist and botanical artist based on the south coast, where she has been learning about, documenting and painting fungi since 1982.

Dr Melinda Moir worked for the Western Australian Museum on the Biodiversity Inventory Program short-range endemic invertebrate surveys. She is now a researcher with the University of Melbourne.

Dr Mark Harvey is a Senior Curator at the Western Australian Museum specialising in the systematics of invertebrates.

Deon Utber is DEC's Regional Biodiversity Facilitator for South Coast NRM.

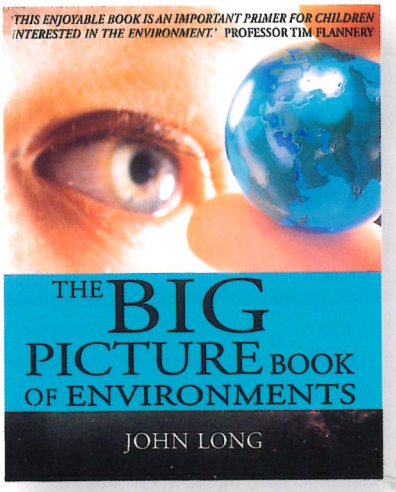
bookmarks

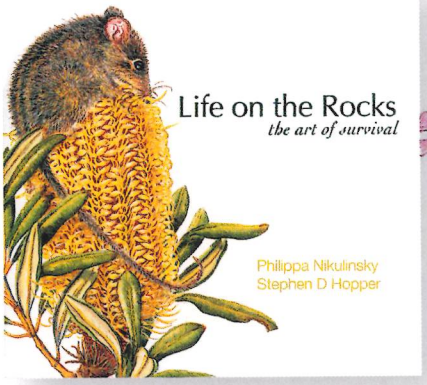
by Samille Mitchell

The Big Picture Book of Environments

Author: John Long
Publisher: Allen & Unwin
48 pages, hard cover, full colour
ISBN: 978 1 7417 5460 5
RRP: $32.95

Using stunning images and child-friendly text, this book introduces children to the issue of climate change and its effects on environments around the world. In the process the book opens children's eyes to the sheer diversity of environments, from deserts to rainforests, polar regions to great rivers and oceans to lakes. It begins with an explanation of the Earth's past, including information on dinosaurs, ice ages and changing climates and continues with an examination of the Earth today. Finally, it concludes with two differing predictions about life in 2080—one if we do nothing to combat climate change and the other if we act now to avoid it.





Life on the Rocks: the art of survival

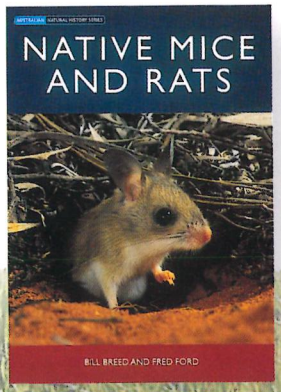
Author: Stephen Hopper
Illustrator: Philippa Nikulinsky
Publisher: Fremantle Press
191 pages, hardcover, colour illustrations
ISBN: 978 1 9213 6128 9
RRP: $35.00

The second edition of this beautiful book features the illustrations of Perth artist Philippa Nikulinsky, whose artwork regularly graces *LANDSCOPE* covers, and the words of eminent conservation biologist Stephen Hopper, who led conservation works in the south-west of Western Australia and currently works as Director of the Royal Botanic Gardens in Kew, United Kingdom. The book combines scientific precision with personal observations, allowing the author's and illustrator's love for their work to shine through. This, combined with the fusion of art and science, provides a beautiful perspective on the fascinating flora and fauna that inhabits Western Australian granite rock environments.

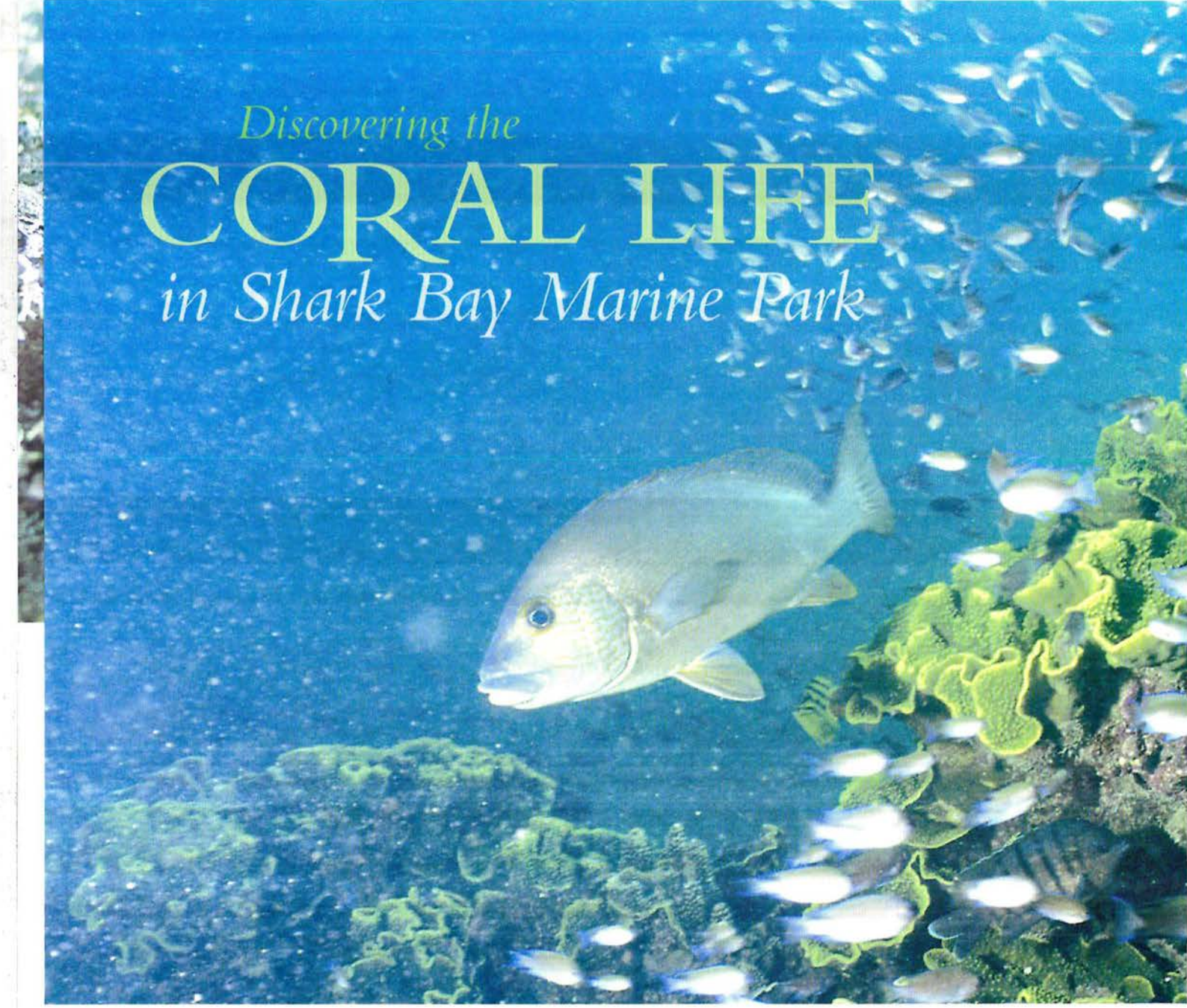
Native Mice and Rats

Authors: Bill Breed and Fred Ford
Publisher: CSIRO Publishing
200 pages, paperback, colour photographs
ISBN: 978 9 6430 9166 5
RRP: $39.95

This scientific publication delves into the work of Australia's most ecologically diverse mammals—native rats and mice. It covers 60 living species which range from the tiny delicate mouse to the large tree rat and carnivorous water rat. The book covers diversity, distribution, evolution, reproduction, diet, populations, social organisations, behaviour, parasites, disease and conservation. Information on the historical records of mice and rats is particularly interesting, with many references to the journals of early explorers and biologists.



Discovering the CORAL LIFE *in Shark Bay Marine Park*



Located at the most western point of the Australian coast, Shark Bay is one of the most isolated and beautiful locations on Earth. But it is much more than this, having been inscribed on the World Heritage list as a place with four outstanding values: it displays the major stages in the Earth's evolutionary history, it has outstanding examples of significant ongoing ecological and biological processes, it has superlative natural phenomena and it contains important and significant habitats for conserving biological diversity (see 'World Heritage: protecting the world's most treasured places' on page 6).

For more than 10 years, marine scientists from the Department of Environment and Conservation's (DEC's) Marine Science Program and its predecessor, the Department of Conservation and Land Management's Marine Conservation Branch, have undertaken research and monitoring in the Shark Bay Marine Park.

Shark Bay Marine Park is well known for having the world's biggest temperate seagrass meadows and the most seagrass species recorded in one place. It supports more than 10,000 dugongs, a large population of tiger sharks, humpback whales and the famous bottlenose dolphins of Monkey Mia. The park's bays, inlets and islands support a profusion of turtles, prawns, scallops, sea-snakes and sharks as well as colourful communities of corals, sponges and other invertebrates, together with a unique mix of tropical and temperate fish species. However, little is known about the distribution of coral reef communities and their importance as a habitat in the Shark Bay Marine Park.

Reefs of life

Coral reefs are the major structural and biological components of shallow water tropical marine systems. Shark Bay lies in the transition zone between temperate and tropical areas in Western

Corals have been described as the ocean's rainforests, breathing life into the marine world. Department of Environment and Conservation staff surveyed the coral communities of Shark Bay Marine Park and made some surprising and delightful discoveries.

by Kevin Bancroft

Above Areas of cabbage corals (*Turbinaria* species) support an abundance and diversity of fish in the Shark Bay Marine Park.
Photo – Eva Boogaard/DEC

Australia and, relative to oceanic waters, the waters of Shark Bay are warmer in summer and cooler in winter. The ecosystem of the Shark Bay Marine Park is largely driven by seagrasses. However, its waters support some very attractive patches of coral reef in several areas. At least 80 coral species are known to exist in the park.

There are two major groups of corals (class Anthozoa)—hard corals (subclass Zoantharia) and soft corals (subclass Alcyonaria)—which are distinguished by the way in which they lay down their skeletons. Only hard corals build reefs. The basic component of a coral reef is the coral polyp. These anemone-like creatures consist of a stomach and a mouth surrounded by tentacles. The tentacles have stinging cells that are used to capture prey such as plankton and also serve as a defence mechanism. Some coral species exist as a single polyp but most form colonies which live together as a single entity. Most corals feed at night and the polyps remain contracted during the day, but some species are occasionally seen with polyps extended and feeding during the day.

Hard corals, though they are animals, have single-celled algae known as zooxanthellae living inside them, converting sunlight into energy in much the same way that trees do in a rainforest. These minute plants find a safe haven in the living tissue of reef-building corals and help corals to extract calcium carbonate from the surrounding water. The calcium carbonate is used to build the coral's skeleton, which eventually forms part of a reef. In shallow waters such as those found throughout much of Shark Bay Marine Park, the coral is both predator and prey, consuming tiny creatures and being eaten by others.

The world's coral reefs are at serious risk from ocean warming caused by climate change (see 'Corals in crisis', *LANDSCOPE*, Winter 2008). A relatively small increase in ocean temperature has the potential to cause the extinction of many species of corals and the marine life they support.

Underwater survey

There was little information about the diversity and distribution of coral reef communities in Shark Bay before the latest underwater inventory of coral reefs. So, in late February this year, the then Shark Bay Marine Park Coordinator Tim Grubba, Shark Bay Marine Park Ranger Wayne Moroney and I, left Denham to carry out seafloor mapping and explore the bay's coastal waters. We conducted the work from aboard DEC's patrol vessel *Sirenia II*, equipped with camera gear, eskies, jerry cans of fuel and water, swags, food and a generator set for charging batteries.

Anecdotal information from DEC staff, charter vessel operators and recreational fishers, as well as aerial photographs and existing habitat data collected by DEC and the Department of Fisheries provided information for the first survey sites.

Using a combination of submersible video cameras in deeper areas and snorkelling in shallower sites, we documented the extent and characteristics of coral communities at each site. The data recorded included live hard coral, live soft coral, recently dead hard coral, several types of seagrass and seaweeds, sponges, filter feeders, and silt, mud and sand.

Discovering gardens

As we surveyed the seafloor through the western gulf of Shark Bay Marine Park, we discovered a treasure trove of brilliant yellow, white, pink, purple and green corals in discrete patches in the shallow waters: staghorn, bushy, vase, plate and brain corals. Such magnificent coral gardens were a pleasant find.

Top left Sea urchins graze on limestone reef at Monkey Rock off Steep Point.

Centre left Kevin Bancroft at work in the Shark Bay Marine Park.
Photos – Marine Science Program/DEC

Left Shark Bay Marine Park is well known for its expansive seagrass meadows. The temperate seagrass *Amphibolis antarctica* is one of the many species found there.
Photo – Ann Storrie

The extent of the coral communities was greater than anticipated and coral communities occurred in places where we did not expect to find them.

The Surf Point Sanctuary Zone at the southern end of Dirk Hartog Island—a pastoral lease that is being purchased by the State Government with the aim of establishing a national park—was the first stop of the trip. Initially, we towed the underwater camera and equipment northwards for five kilometres along the island's western side, which revealed wave-cut platforms covered with turf algae. This coastline is exposed to massive swells built up over vast unbroken stretches of ocean. We then returned to Surf Point and Monkey Rock, near Steep Point, on the east side of South Passage. Both these areas were exposed to swells and quite turbid and we found small robust bushy or dome-like coral communities with a mix of soft corals and turf algae on the reef 'pavement', with some areas deeply scarred by grazing sea urchins.

Camping on the small *Sirenia II* was cosy to say the least. With equipment and provisions there was not a lot of spare space and we worked beside the constant hum of the generator which charged cameras, laptops and other electronic equipment. Finding somewhere to cook, take notes and enter data was a challenge, as was finding somewhere dry to sit.

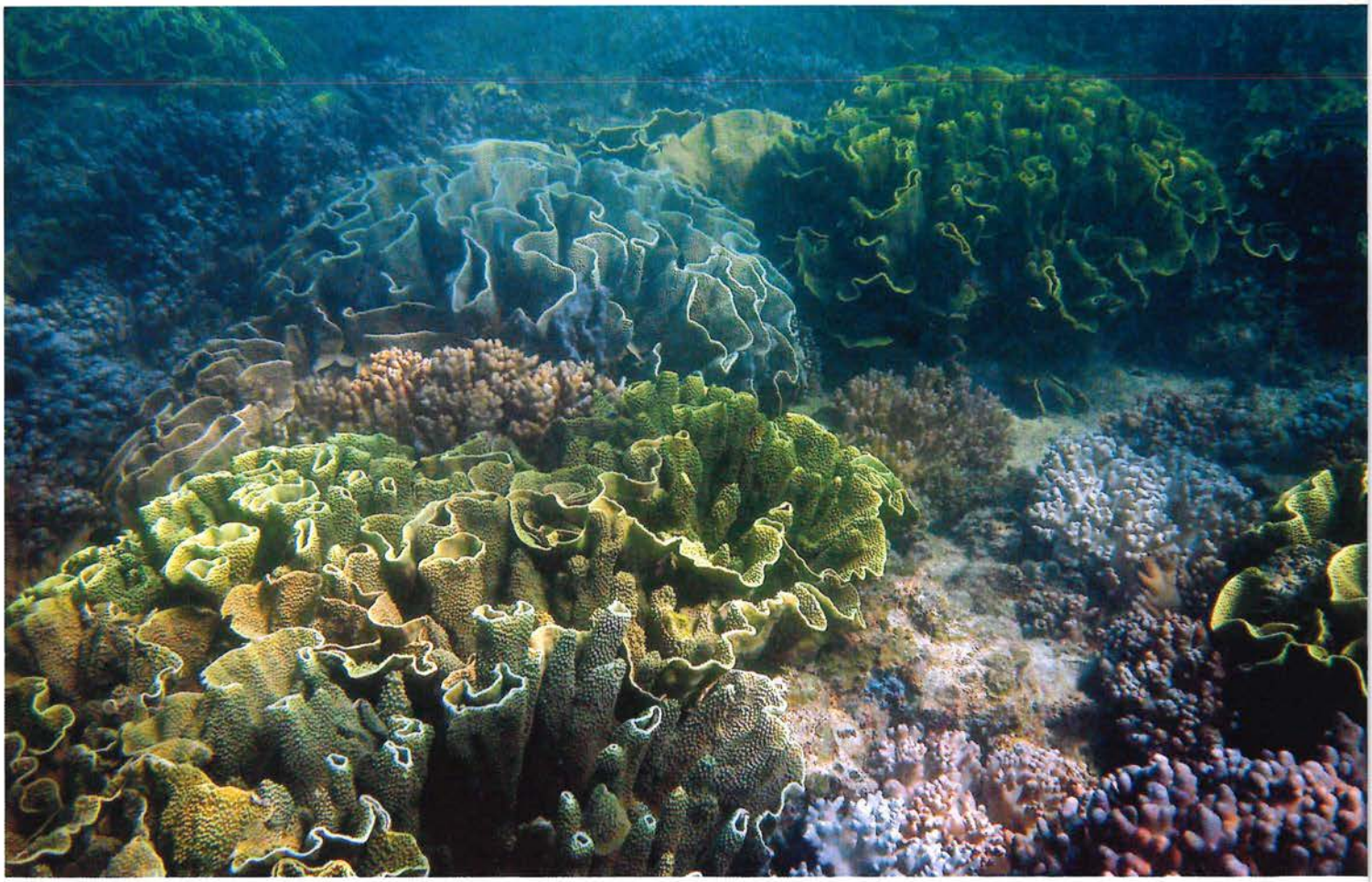
Left DEC patrol vessels such as *Sirenia II* are essential for marine park management including research and monitoring.

Below Vase-like *Turbinaria* corals interspersed with *Pocillopora* coral and soft corals were typical of the central part of the east coast of Dirk Hartog Island.
Photos - Marine Science Program/DEC

Vases and shawls

On the second day we worked our way up the eastern coast of Dirk Hartog Island to a bay that was sheltered from the southerly wind, where we found dense patches of the large seagrass, southern wireweed (*Amphibolis antarctica*). In the next sheltered bay we found our first large expanse of corals, a two-hectare patch of impressive vivid yellow vase-like and shawl-like corals, almost all of them *Turbinaria* species. These species often occur in turbid waters and, as water visibility was poor, it was not surprising to encounter them here.

A little further on we found some small patches of less healthy *Turbinaria* coral colonies, before calling in to the Dirk Hartog homestead for a late morning tea with caretakers Dave and Jenny Evans, who had been in the job for several years. As we sipped our tea and



discussed the survey, several medium-sized sharks, manta rays and schools of fish cruised past the front door, highlighting the incredible diversity of wildlife found in this marine park.

Following Dave and Jenny's instructions we headed to a popular fishing spot further up the coast and located another large patch of *Turbinaria* corals. This coral community provides ideal habitat for many fish species and is a popular fishing spot. By the way the fish bubbled at the surface to greet the boat, possibly anticipating a feed, we knew that this area had been frequented regularly.

Staghorns and brains

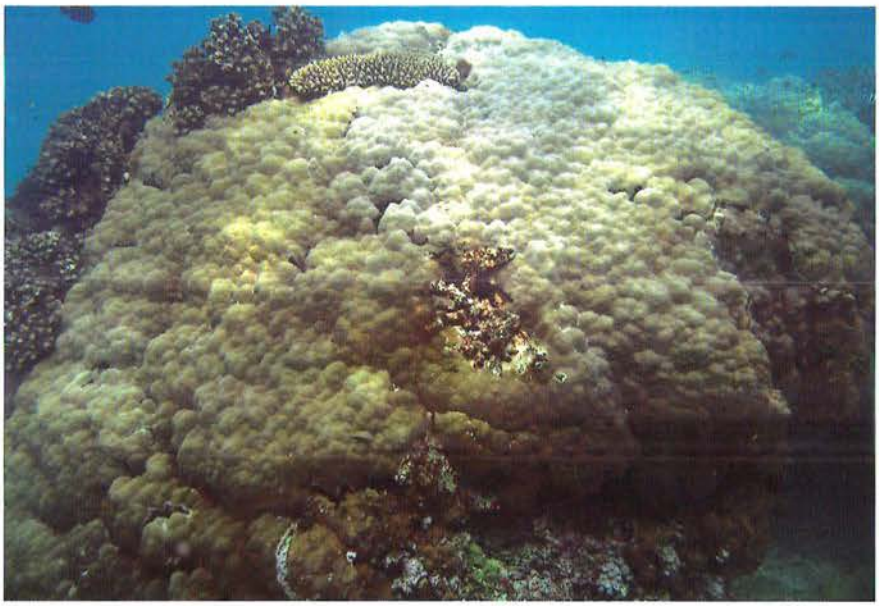
Further north, as the water clarity increased, the patch reefs were less dominated by vase and shawl-like corals, being replaced with more soft corals, staghorn and plate corals (acroporid species) and small brain corals (faviid and poritid species). These coral types are the most common corals on reefs throughout the Indo-Pacific region.

Sirenia II refuelled in Denham and returned to Dirk Hartog Island with a Murdoch University turtle researcher and her volunteers aboard. They were planning to stay a month to monitor the health and survival rate of loggerhead turtle hatchlings at several beaches in Turtle Bay.

Towards the end of the trip the wind picked up, making the task of surveying the seafloor even harder. We were surprised to discover several reefs dominated by fragile branching and plate corals growing across several hectares. At some point they had begun to die on the western edge but, as reefs do, smaller corals have started to colonise the dead reef.

We moved towards Cape Levillain on the north-eastern tip of Dirk Hartog Island to find large dome-like, long-living massive coral bommies (*Porites* species) up to three metres high and two and a half metres in diameter, suggesting that some colonies are likely to be several centuries old. Like trees, many coral species have annual growth 'rings' which provide records of climatic and environmental changes. Earlier this year, with researchers from the Australian Institute of Marine Science, I took part in a survey of massive coral bommies in the Montebello/Barrow Islands marine parks and reserves, Ningaloo Marine Park and a few west Pilbara islands. We identified those colonies that could be cored to tap centuries of information about their growth and ability to cope with different environmental and climatic conditions. The Shark Bay *Porites* would also have a story to tell.

One of our final stops was historic Turtle Bay. With its tall cliffs, offshore winds and calm sea, it was like another world. Turtle tracks dotted the beach and we could see the turtle nests that had been marked by the Murdoch University researchers. We dropped off our spare fresh water at the researchers' field camp at the old lighthouse keeper's quarters on top of the cliff, but were driven back to the boat by masses of persistent flies and mosquitoes. There



Above left *Porites* bommies may hold the answer to how coral reefs will cope with climate change.

Left Fragile staghorn (*Acropora*) coral reef occur in the sheltered, less turbid areas along the northern section of the east coast of Dirk Hartog Island.
Photos – Marine Science Program/DEC

Above An encrusting coral provides habitat for racoon butterflyfish, ring-tailed cardinalfish, scissortail sergeants and southern drummers.

Right Landscapes like Cape Tumbledown on the east coast of Dirk Hartog Island provide shelter from the persistent southerly winds.
Photos – Marine Science Program/DEC

were no significant coral formations in this area, so the trip soon drew to a close.

Results

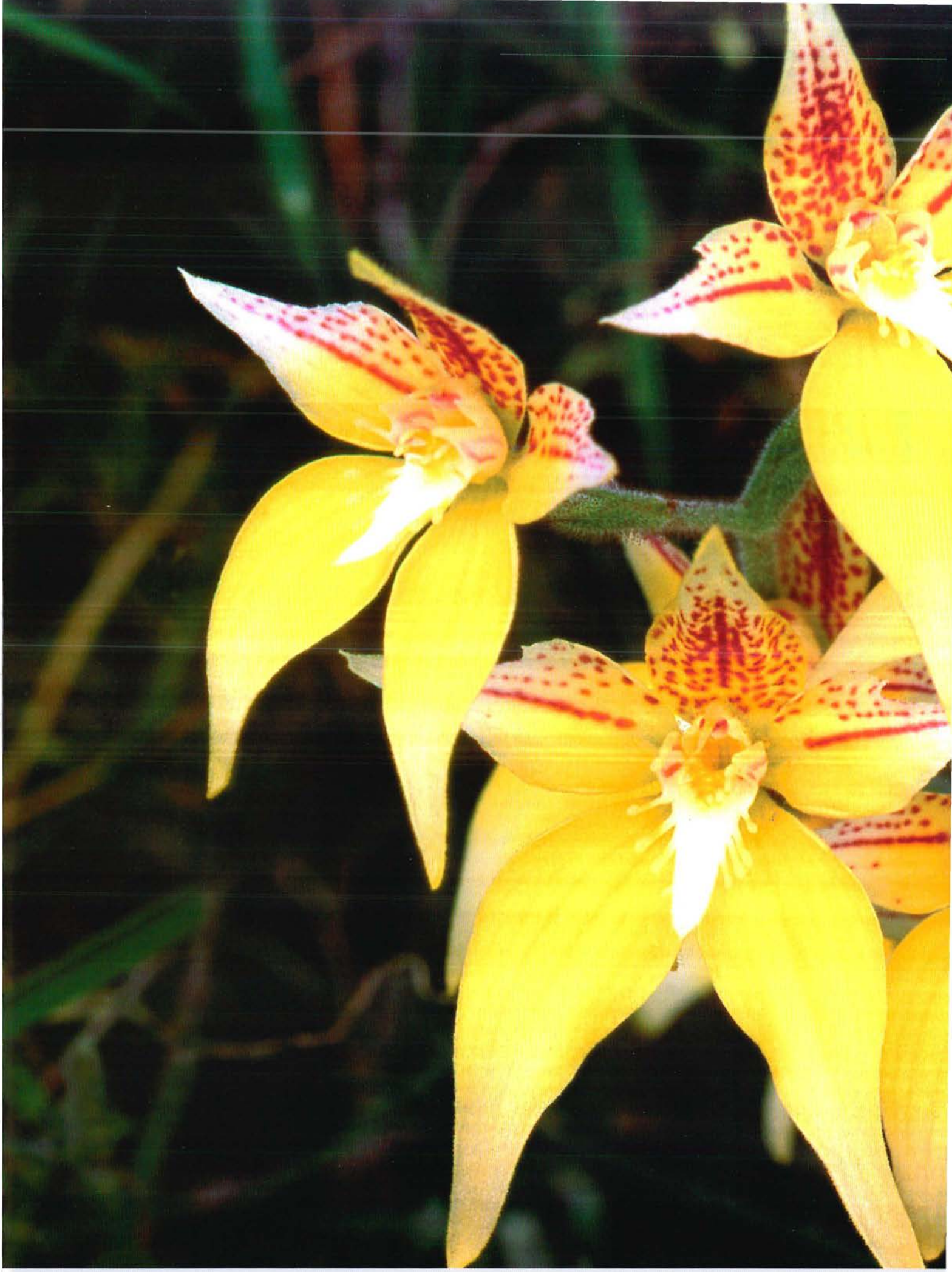
During the survey, we were delighted to have found a diversity of coral reefs comprising corals from five different coral families: Acroporidae, Pocilloporidae, Dendrophylliidae, Faviidae and Poritidae. Our observations revealed that these areas support diverse and highly abundant marine life. Several coral samples gathered during the trip are now at the Western Australian Museum for identification.

Information gleaned from the survey will be vital in determining how we conserve these coral communities and manage the risks that may affect them. An understanding of the diversity, pattern and distribution of the coral communities in Shark Bay will be important information for marine park managers. Detailed information from the study will be used in the Shark Bay Terrestrial Reserves Management Plan (for instance, by ensuring that visitor access points to the proposed Dirk Hartog Island National Park are located away from fragile staghorn coral communities) and will be incorporated into the proposed revision of the Shark Bay Marine Reserves Management Plan.

This survey, in conjunction with newly acquired aerial photographs and satellite imagery, will assist in creating maps to show the distribution and diversity of coral reef communities in the very special Shark Bay Marine Park.

Although coral reef communities are not the most abundant marine habitat found in Shark Bay, they are the most southern occurrence of significant near-shore tropical coral reefs along the Western Australian mainland, making them a small but significant habitat in this World Heritage Area.

Kevin Bancroft is a Department of Environment and Conservation research scientist working in the Marine Science Program. He has carried out research at the Shark Bay, Ningaloo, Montebello Islands, Barrow Island, Marmion and Jurien Bay marine parks and in the proposed Dampier Archipelago, 'Capes' and Walpole and Nornalup inlets marine parks. He can be contacted by email (kevin.bancroft@dec.wa.gov.au).



Bound by a love for flora

by Bronwen Keighery, Brian Moyle and Ann Gunness

A special group of volunteers and professional botanists has spent 20 years surveying the kaleidoscope of flora in Western Australia's south-west.

Twenty years ago this year a group of professional botanists, amateur botanists and interested people came together, bound by their love for Western Australia's wildflowers. Together the group, under the lead of the already formed Wildflower Society of Western Australia, started surveying the incredible wealth of plant species found throughout the south-west. Over 20 years they have built up a comprehensive picture of flora biodiversity, discovered new species and found populations of some of our rarest plants. Most people in the group are volunteers who pay their own way and donate their time to better understanding south-west flora—people driven by a thirst to learn more about the area's floral wonders.

The early years

The Wildflower Society of Western Australia's 20-year bushland plant survey was born through a federally funded project—the Moore River to Jurien Sandplain Survey. While there have been other successful flora-based volunteer projects, two features distinguished this project from others—the emphasis on plant communities as opposed to individual plant species, and the use of botanists to support the volunteer groups. Three botanists, Ted Griffin, Bronwen Keighery and Malcolm Trudgen, led seven groups formed from the 79 volunteers registered with the survey. This initial project was considered a success and fired the passion of volunteers, who expressed an interest in being involved in future surveys. The groundwork for long-term surveying was set.

In the early 1990s the Wildflower Society of Western Australia received funding to continue the bushland survey work as part of a regional floristic survey of the Swan Coastal Plain. This enabled the program to be established on sound principles in keeping with the approach that was so successful in the first survey. Important features of the program included establishing a confidential register of volunteers, advertising, running a yearly program and developing a vegetation-survey package.

The Wildflower Society used the survey techniques developed and trialled in the early years of the survey to form the basis of a book published in 1994. The book, *Bushland Plant Survey —A Guide to Plant Community Survey for the Community*, was developed from established methods and adapted for community use. Hundreds of copies of the guide have been sold to amateurs and professionals involved in bushland plant surveys. The guide outlines a structured field-survey approach that does not require each participant to have a strong knowledge of botany. It also forms a base for many of the society's workshops.

Bushland surveyed

Since its beginnings, the survey program has visited bushland areas from Eurardy Station, north of Kalbarri, east to Bodallin, west of Southern Cross, and south to Denmark. More than 70 bushland areas have been surveyed and these have ranged from a few hectares, like Coolbinia School bushland in Perth, to thousands of hectares, like Eurardy Station.

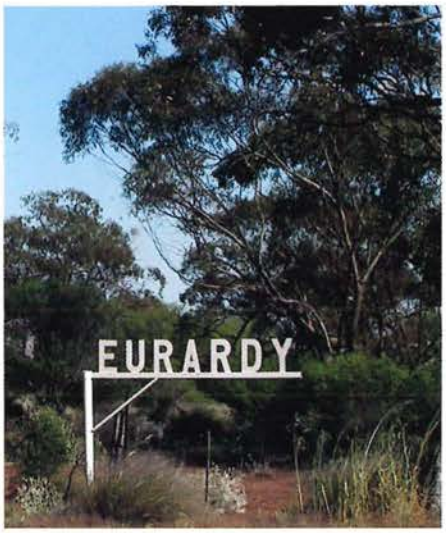
Surveys have been conducted on private and public lands with the permission and invitation of the land holder or manager. The public lands surveyed have included Yanchep, Walyunga, Yalgorup and Whicher national parks, Bullsbrook, Ellen Brook, Cardup and Capel nature reserves, Blackwood and Boyanup State forest, Dardanup Conservation Park and local government reserves in Victoria Plains, Swan, Merredin, Wickepin, Quairading and Busselton. The survey on private lands focused on farms in the Wheatbelt but has included a farm in the Perth metropolitan region and another in the Margaret River area.

Records for tens of thousands of common and not so common plants have been made during the surveys. Participants are fascinated by the stunning variety of plants discovered, particularly the tiny herbs, grasses and grass-like plants. Exciting discoveries include plants not expected in the area, new rare flora populations, plants new to science and new records for the State.

Reports detailing conservation values have been produced for about

Previous page
Main Cowslip orchids (*Caladenia flava*), one of the beautiful small plants found in many quadrats.
Photo – Sallyanne Cousins
Insert Volunteers and a botanist working on a quadrat in wandoo woodland in Mogumber Public Reserve on the Moore River.

Left Argyle platytheca, a new species of *Platytheca* located on the Whicher Scarp near Capel.
Photos – Mark Brundrett



Above The most northern survey was on Eurardy Station in spring 2003.
Photo – Nina McLaren

Above right Working on the 1988 Moore River to Jurien Sandplain Survey.
Photo – Greg Keighery

Right Summer flowering morrison (*Verticordia nitens*) in Moore River National Park.
Photo – Sallyanne Cousans

Wildflower Society of Western Australia celebrates 50 years

The Wildflower Society of Western Australia celebrates its fiftieth anniversary this year. Inspired by the formation of the Society for Growing Australian Plants in Melbourne in 1957 and a visit to WA by the founder AJ Swaby, a south-west regional council of the 'Society for Growing Australian Natives' was formed on 18 March 1958. Now called the Wildflower Society of WA, this group of more than 1,000 members is a key conservation group in WA. The society aims to understand our native plants, to share information on how to recognise them, to protect the bushland in which they grow and to propagate and grow them. For more information visit the website www.members.ozemail.com.au/~wildflowers/.

50 of the surveys. A list of reports is provided on the society's website and reports are available from the society or from the Department of Environment and Conservation's (DEC's) Science Library. Field herbaria have been compiled for many projects. These are presented to the landholder or community group and are also kept by the society. Quadrat information collected is incorporated in the DEC plant community database and more than 3,000 specimens have been lodged at the Western Australian Herbarium.

Keeping the plot

Fieldwork conducted for the surveys revolves around establishing and recording vegetation and flora information for 10-metre by 10-metre plots or quadrats. Focusing on quadrats is essential as it establishes a systematic procedure for the collection of information. This technique focuses on sampling all plant species in the quadrat area and therefore helps to avoid concentration on only the common and conspicuous species. Although time consuming, this method ensures information is collected carefully and systematically in a repeatable way. After analysing a quadrat, volunteers often leave amazed at the diversity of plants discovered in a single 100 square metres.

The field surveys yield a collection of specimens for identification, including some of importance for pressing and labelling at the Western Australian Herbarium and for compiling of field herbaria. At least one identification workshop is held at the herbarium following each survey, led by the survey botanist. A band of dedicated volunteers meets regularly at the herbarium to help carry out this work and initiate and complete further survey projects.

The volunteers

Hundreds of people have registered as volunteers with the survey. A core of seven volunteers—Mary Bremner, Anne Bellman, Margaret Lark, Diane and Gary Matthews, Dorothy Perret and Margaret Pieroni—have been involved since 1988. Many other volunteers have been involved for more than 10 years.

Above Identifying specimens during a spring 1995 weekend in Bunbury.

Above right A small daisy *Waitzia suaveolens* from Bullsbrook Nature Reserve.

Right A rattlepod *(Daviesia physodes)* from bushland surveyed near Busselton. *Photos – Bronwen Keighery*

Many volunteers are botanists including botanists from DEC's Science, Nature Conservation and Strategic Policy divisions. Interestingly, all of the 15 botanists employed on the surveys have worked in the program as volunteers at some time.

Volunteers from the Wildflower Society manage the program and form most of the ongoing participants. Survey participants range from interested public with no previous experience to experienced botanists. Volunteers participate in the survey completely at their own cost.

During the life of the project, all sessions have been filled to capacity. The initial program in 1988 was broadly advertised within the Wildflower Society and to kindred community groups. However, once a base register of volunteers was established, the initial yearly post-out to registered volunteers became the key recruiting tool. A steady number of enquiries is generated by word of mouth and the survey training workshops. These have become the chief source of new participants. When a survey is focused on a specific locality, local land care and conservation groups are informed of the planned survey and invited to take part.

Based on feedback from volunteers, landholders and community participants, the program has been well received. Key to its success is the passion of volunteers and the use of a dedicated volunteer coordinator to communicate with volunteers and organise the program. Four coordinators have worked on the program: Bronwen Keighery, Ann Gunness, Karen Clarke and Vanda Longman, who currently holds the position. The timing of field and workshop sessions on weekends and on evenings has also been acknowledged as part of the program's success, as has the opportunity to be involved in 'hands on' activities, often on land that these people would not otherwise be able to access.

Participants have also expressed appreciation for the opportunity to get out among like-minded people, to meet people, to make good friends and to be part of improved communication and a link between scientists, landholders and the community. They have also given positive feedback on the scientific nature of the program and the commitment of professional botanists who share their knowledge and expertise with volunteers both in a paid and volunteer capacity.

Support

The integration of a substantive number of surveys with research projects has been a strength of the project. Volunteers appreciate that their work contributes to the conservation and management of bushland. Government departments have supported the survey by supplying equipment and transport, access to the Western Australian Herbarium and direct research staff involvement.

In 1993 the survey was registered jointly with the Wildflower Society and with what was then the Department of Conservation and Land Management's (now DEC's) Community Involvement

Above Banksia woodland in the Talbot Road Bushland becomes bright with the white common smoke bush (*Conospermum stoechadis*) in spring.

Above right background Marri woodland in the Talbot Road Bushland.
Photos – Greg Keighery

Talbot Road Bushland

(Bush Forever site in the Shire of Swan)

The Talbot Road Bushland site demonstrates the value of surveying areas. This area of bushland lies on the eastern margin of the Swan Coastal Plain north-east of Midland and, while some people had recognised its flora values, it had never been systematically documented and described. As such, the Talbot Road Bushland became the location of the first session of the bushland plant survey in the Perth metropolitan region. A hardy band of 31 volunteers met in the bushland on 28 October and 9 December 1990. Eleven quadrats were located in the 92-hectare reserve over the two sessions. The first session focused on training and became the primary source of the material used in the *Bushland Plant Survey—A Guide to Plant Community Survey for the Community.*

A report on this work published by the Western Australian Wildflower Society in 1993 described the outstanding flora values of the bushland, including more than 360 native plants, a number of rare and restricted plants and eight plant communities. Results from the study were included in a regional floristic survey of the Swan Coastal Plain, which led to the recognition of two threatened ecological communities in the bushland. Thanks to the survey work, the Talbot Road Bushland is now recognised as a regionally significant bushland area and a vital reserve in conserving Perth's biodiversity.

Program. Registration with the program gives the volunteers insurance cover during their participation and a degree of formal recognition.

The program has been funded from various sources and to variable degrees since its inception. The fundamental reason for funding is to provide support for the coordination of the program and to have survey projects led by botanists.

The Department of Conservation and Land Management started supporting the project in 1988, and the Department of Environment came on board in 1994. These agencies merged to become DEC in 2006 and the new agency has continued to support to the project. The project has also been bolstered by grants of various amounts from the Australian Heritage Commission under the National Estate Grants Program (1991–92), the National Landcare Program, Save the Bush and the Natural Heritage Trust (1995–2002).

In addition, some projects have been funded by the Wildflower Society as well as by local groups such as conservation and land care groups. In some years projects have proceeded without funding, relying on volunteers to run all aspects of the project.

A happy outcome

All participants in the program have gained a richer understanding of the values of the bushland. There is always a wonderful sense of surprise when people are made aware of the wealth of plants in any piece of bushland—a recurring reaction from new volunteers, landholders and community participants alike. This sense of wonder is heightened by the enthusiasm and passion of volunteers involved.

The camaraderie of the group is a very significant part of the program. Volunteers, botanists, coordinators and landholders alike have enjoyed the opportunities presented over two decades of surveys. They have been drawn back time and time again by the opportunity to work in the beautiful, wild places of the south-west as part of a motivated and supportive group while contributing positively to the conservation of WA's bushland.

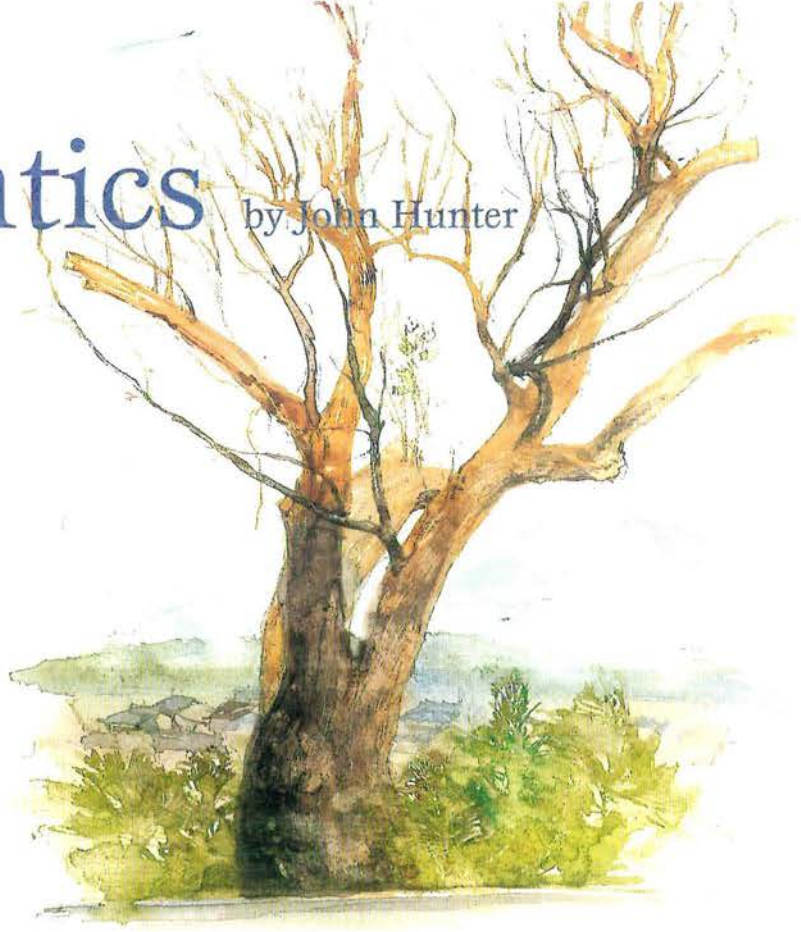
Department of Environment and Conservation botanist Bronwen Keighery works on botanical survey and conservation planning on the Swan Coastal Plain. She has been involved with the bushland plant survey since it began in 1988 and has participated through the program's 20 years.

Brian Moyle is a past president and an honorary life member of the the Wildflower Society of Western Australia. He has been involved in the bushland plant survey since 1991, attending most field survey sessions and serving on the program's management committee.

Ann Gunness has been involved with the Wildflower Society bushland plant survey since 1997. This included time as the program coordinator for projects in the Wheatbelt. She now lives in Geraldton and continues to pursue botanical interests.

urban antics

by John Hunter



Dead wood

For years, the huge, dead, limb of a tuart hung precariously at right angles over the nature reserve fence and out into the air space of the busy urban road. At 100-something-years of age, the tuart tree had been attacked in the past by fire, little boys with tomahawks and hundreds of other species of Earth dwellers that regularly use it as prime habitat. Because of its age and size, its presence in the shire conservation reserve was imperative to the visual enhancement and conservation integrity of the surrounding bush.

During a storm in June, the lower limb succumbed to centrifugal and other forces and plunged harmlessly onto the street verge. It was a lucky result but a frightening experience even though the formed footpath was on the opposite side of the road. The event could have been avoided with some pre-planning and pruning. What happened next was a typical human knee-jerk reaction and the reason for this peasant's proverbial 'spitting of the dummy'.

For years it has been in the forefront of government programs and all local land care initiatives to preserve, where possible, icons of conservation habitat value. At the behest of earning a 'quid' and within a couple of hours of the 'fall', little council people in work clobber oozed onto the scene like termites from an upturned plank. Now, I wasn't privy to the investigation, if any, but the three remaining trunks that did not protrude beyond the fence line, including one which sported a tuft of greenery high up, were set upon and demolished at ground level. John Williamson's song 'Rip Rip Woodchip' was alive and well.

As reported by neighbours, three species of parrot protecting some six nest holes screamed incessantly during the procedure and hung on violently as they rode the entire tree nearly to the ground. No-one mentioned the geckoes, skinks and insects that succumbed under the buckled bark.

At some 20 metres high and on a hill reserve, the tree was a navigation point for passing Carnaby's black-cockatoos that regularly come through the lower valley to rest on the prime stag heads and reconnoitre the distant office towers of Perth city before heading south.

Most times these days it seems to be necessary to remind those who like to be seen to be earning their stripes with strength and flair, that there is a need to also think before acting, especially in relation to environmental matters.

At the risk of preaching to the converted once more, this grizzle is not aimed at you, the supporter of this magazine and urban gardener, but it is a reminder for those of us with big, old trees down by the back fence. Before removal, the question must be asked, can they be pruned? Can they be used for nest holes or boxes? Can they really be left as part of the web of nature?

We are all the custodians of the environment within our small lots in suburbia and while it can be hazardous to accumulate logs and ground refuse for reptile habitat, we sure can do something better in this 'urban desert' by planting native vegetation and looking after trees of known habitat value.

DID YOU KNOW?

- The values of tuart woodlands include conserving biodiversity, protecting ecosystem function and providing connectivity between remnant vegetation.
- A dead tuart tree pruned for safety, but with a few nesting hollows and draped in native wisteria vine, is an absolute bonus in your backyard, aesthetically and as wildlife habitat.
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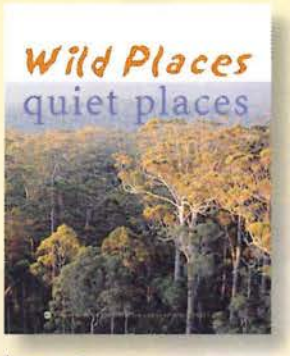

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