WA's conservation, parks and wildlife magazine

LANDSCOPE

Volume 24 Number 3 AUTUMN 2009 $6.95

Caves of Western Australia

Two Peoples Bay Nature Reserve

Baselining the Avon

Pint-sized penguins **Karakamia Wildlife Sanctuary** Marine debris

Making a world of difference since 1992

LANDSCOPE Expeditions

Kevin Coate and *LANDSCOPE* expeditioners investigating an osprey nest on Pelsaert Island in the Houtman Abrolhos Archipelago.
Photo – Ron Johnstone/Western Australian Museum

Desert Tracks – Plants and animals of the Canning Stock Route

Canning Stock Route 19 – 31 July 2009

Experience the true Australian outback while conducting important research into desert ecology and biodiversity. For scientists, the Canning Stock Route represents one long biodiversity transect through several different biogeographical regions. Discover local fauna and flora, map fire scars and search for evidence of introduced predators while experiencing the magnificent Australian desert. Tag-alongs are welcome on this expedition. (UWA Extension code 096100)

An Astronomical Odyssey – Exploring sites of astronomical significance in Western Australia

Midwest and Gascoyne Regions 23 – 30 August 2009

Join a journey through the Western Australian outback for an intimate look at some of its natural, historical and modern-day sites of astronomical significance. Visit the Dalgaranga Meteorite Crater, the site of temporary observatories in Shark Bay established by French astronomers on Baudin's 1801 voyage of discovery to Shark Bay, the Learmonth Solar Observatory and many more significant locations on this special expedition celebrating the International Year of Astronomy. (UWA Extension code 096101)

A Brush with Nature – The art of the flower hunters

Karara Station 14 – 23 September 2009

Discover the art of botanical painting with botanical artist Katrina Syme at Karara, a former pastoral lease being managed for its conservation values. You will also help scientist Daphne Edinger establish flora monitoring quadrats and compile a field herbarium for the area. This is a rare opportunity to combine scientific research and botanical observation with the tradition of botanical illustration in an area famous for its wildflowers. (UWA Extension code 096102)

Sanctuaries of the Sea – Wildlife of the Montebello Islands

Montebello Islands 5 – 12 October 2009

The Montebello Islands are home to many native animals severely affected by introduced predators. DEC has removed these threats to allow the recovery of native species. Join scientists in searching for boodies, mala, golden bandicoots and Shark Bay mice and discover the history of this magnificent marine sanctuary. (UWA Extension code 096103)

Wonders of the Dundas Woodlands – Wildlife of the Dundas Nature Reserve

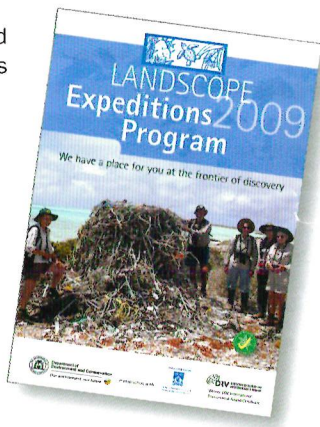
Dundas Nature Reserve 19 – 27 October 2009

The 780,000-hectare Dundas Nature Reserve lies east of Norseman in Western Australia on the western edge of the Nullarbor Plain. The remoteness and size of the reserve and its variety of vegetation types makes it an exciting location in which to undertake biological research. Join an expedition with scientists into one of the State's biggest nature reserves to study the plants and animals that inhabit this richly diverse area. Tag-alongs are welcome on this expedition. (UWA Extension code 096104)

Seabirds and Shipwrecks – An exploration of the Houtman Abrolhos Archipelago

Houtman Abrolhos Islands 4 – 10 January 2010

The Houtman Abrolhos Archipelago off the Midwest coast of WA supports the most species-rich assemblage of seabirds in the Indian Ocean. Lying in the path of the warm Leeuwin current, the islands and the surrounding waters form a unique marine area where tropical and temperate sealife meet.
Join an expedition with Kevin Coate and Ron Johnstone to these islands to record seabird, shorebird and bush bird species at the peak of the breeding season. (UWA Extension code 096105)



Send for your copy of the *LANDSCOPE* Expeditions 2009 brochure.

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Doug Coughran


Jiri Lochman

contributors

Doug Coughran joined the Western Australian Department of Fisheries and Wildlife in 1979 and was transferred to the newly formed Department of Conservation and Land Management (now Department of Environment and Conservation—DEC) in 1985. Doug specialises in marine wildlife protection and has extensive experience in marine mammal incident management. He trains local and interstate colleagues how to manage risks during large whale disentanglement operations. Doug is part of an international network of experienced operation team leaders sharing and contributing to the ongoing improvement of the management of marine mammal incidents, including oil spill-affected wildlife.

editor's letter

One of my favourite things to do is to grab a good book or magazine, find a quiet and comfortable spot somewhere, and then just immerse myself in good writing. Often, it is nature writing.

Writers such as Barry Lopez, author of such seminal works as *Of Wolves and Men* and *Arctic Dreams: Imagination and Desire in a Northern Landscape*, *Pilgrim at Tinker Creek* author Annie Dillard, and our own *Urban Antics* essayist John Hunter, have all given me insights into my own experiences with nature through their exploratory and reflective writing.

Wikipedia (where else would you turn to for a quick fact?) says nature writing is generally defined "as nonfiction prose writing about the natural environment. Nature writing often draws heavily on scientific information and facts about the natural world; at the same time, it is frequently written in the first person and incorporates personal observations of and philosophical reflections upon nature".

My own observation is that nature writing is often positive, reflecting the hope that is inherent in the world—a pink mulla mulla growing out of the rock at Temple Gorge in the Kennedy Range National Park (see August in the 2009 *Western Australia Calendar* presented by this magazine), humpback whales leaving Antarctica each autumn to migrate northwards to their tropical calving grounds along the west and east coasts of Australia, or native plants resprouting and flowering within months of an intense wildfire.

In this edition of *LANDSCOPE*, some of our own very good nature writers take a look at new discoveries, cover some of the important conservation management issues being tackled in Western Australia, and journey to some of our State's special places.

South-west Australia is an internationally recognised biodiversity hotspot for flowering plants and Perth is central to this region. In 'New plant discoveries in Perth's backyard', Bronwen and Greg Keighery chronicle new plant discoveries and provide an insight into why the Swan Coastal Plain and the adjacent Darling Scarp make the area around Perth a hotspot of plant species richness.

Karakamia Wildlife Sanctuary in the northern jarrah forest near Chidlow has been offering refuge for Western Australia's native mammals for 17 years. In 'Bringing back the animals', Jacqui Richards, Martin Copley and Trish Gardner detail the results and management programs of this privately-funded wildlife sanctuary, and explore how success involves a lot more than just erecting predator-proof fencing.

Two Peoples Bay lies between the massive granites of Mount Gardner and Mount Manypeaks, east of Albany on the far south coast of WA. In 'Two Peoples Bay Nature Reserve', Anne Cochrane takes a detailed look at this natural wonderland that harbours some of the world's most threatened animals.

Enjoy the read and we'll see you again in winter.

Ron Kawalilak
Executive Editor

Jiri Lochman, a Perth-based professional photographer, has regularly contributed photographs to *LANDSCOPE* for 23 years, his photographs featuring in 92 out of 95 published issues. Apart from *LANDSCOPE* magazines and *LANDSCOPE* calendars, Jiri's photos also appear in Bush Books and other books, brochures and displays produced by DEC. Jiri is also an author and co-author of several books, among them *Australia's Unique Wildlife* and *Wildflowers of Western Australia*. In 1986 Jiri and Marie established the photographic agency, Lochman Transparencies, which they continue to run in between expeditions and photographic assignments. With his wife Marie, Jiri is a recipient of the coveted Australian Geographic Society's Award for Excellence in Photography.

Kate Fitzgerald is a research assistant for the Australian Institute of Marine Science (AIMS) and is involved in studies of corals at Scott Reef off the north-west Australian coast. Before her appointment to AIMS in 2007, Kate was a marine education officer with DEC, during which time she implemented marine education programs around the State. She has also lived in Cambodia where she raised a sun bear cub at the Free the Bears Fund Sanctuary and has been a committee member of the fund since 2004.

Anne Wood has worked as a caves manager in DEC's Blackwood District for 10 years. As well as managing Calgardup and Giants caves, she administers the cave and abseil permit system which controls access to all cave and abseil sites in the Leeuwin-Naturaliste National Park, runs the Cave Leader Course, assists in karst-related research, carries out visitor risk management and undertakes monitoring of karst sites. A love of caves (she was a recreational caver before working in this field) and the natural environment attracted her to the position with DEC.


Kate Fitzgerald

Also contributing...

Jeff Richardson, Joanna Moore, Greg Keighery, Bronwen Keighery, Anne Cochrane, Jacqui Richards, Trish Gardner, Martin Copley, Carolyn Thomson-Dans, Ryan Scott, Andrew Brown, John Hunter and Samille Mitchell.


Anne Wood

Features

Cover illustration by Philippa Nikulinsky
The cut-leaf banksia (*Banksia praemorsa*) is a striking species of the *Banksia* genus that occurs only on the south coast of Western Australia, between Albany and Bald Island. It flowers from August to November producing cylindrical red-maroon flower heads up to 27 centimetres long. The tree grows to four metres tall and features serrated leaves and hard woody fruits typical of banksias.

Back cover photo by Damon Annison
Two Peoples Bay Nature Reserve.

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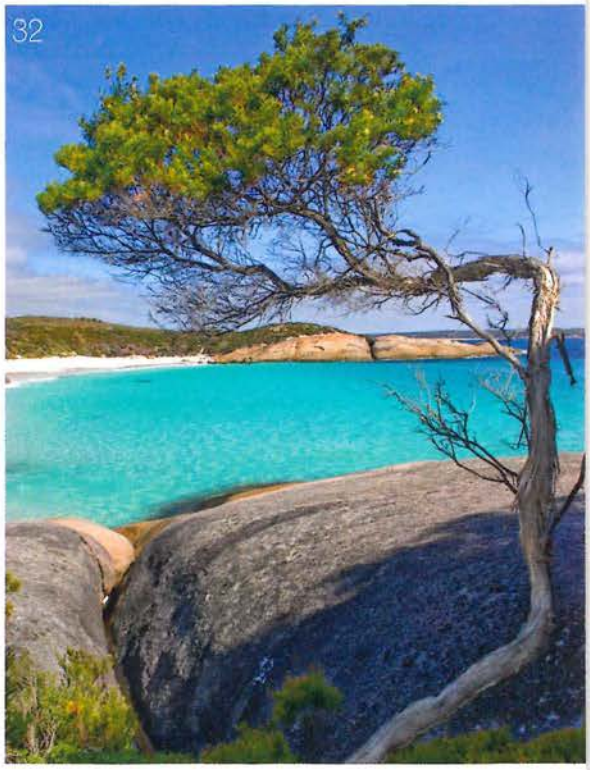


Primitive flowering plants

A seemingly insignificant flora family has surprised botanists, with new research showing it to be a primitive form of flowering plant.

by Greg Keighery

Western Australia is home to many strange, showy and wonderful plants, including the Albany pitcher plant (*Cephalotus follicularis*), the sundew family (*Drosera*), kingias, the everlastings, the banksia family and the southern heaths. But equally intriguing are the almost unknown tiny plants that inhabit many of our wetlands—members of the Centrolepidaceae, Hydatellaceae and Juncaginaceae families. These plants have ancient lineages stemming from deep in the past, when Australia was joined with other continents as the supercontinent Gondwana. Traditionally, these fascinating pygmy plants have been placed close to the grasses in their taxonomic classifications. But new research has revealed them to be more closely related to primitive flowering plants like the waterlilies.

Small but significant

Despite being wetland plants, these tiny plants are supremely well adapted to our dry climate. They are tiny and able to grow fast and furious in very ephemeral wetlands on granite rocks, seeps on salt lakes and clay pans. Most of these highly reduced species are wind pollinated (a few are water pollinated), with very simple flowers consisting of a single anther or ovary and no petals. Their dry pollen is usually held up to the wind and they have feathery stigmas to catch the pollen. Often the flowers and the whole plant are red in colour—a sunscreen to protect their delicate leaves and flowers. Because of their size and rather characterless flowers, few people notice these plants and their true relationships have long remained obscure.

The Hydatellaceae are a small southern hemisphere family of 10 species in the genus *Trithuria* (five in southern WA, one in New Zealand and one in India), with 80 per cent of species found in southern WA confined only to the area.

Until recently they were included in the family Centrolepidaceae—itself a southern hemisphere family of 33 species in four genera (*Aphelia*, *Brizula*, *Centrolepis* and *Gaimardia*). This family also has many species in southern WA, with 65 per cent of them endemic, normally dampland annuals. Some species have bristly fruits and are distributed on fur or feathers, some hold their seeds on the parent plant during summer but most shed them into the drying mud.

Defining the difference

In 1976, species of the Hydatellaceae family were segregated from the Centrolepidaceae family because of differences in their pollen, anther structure, embryological differences and seed anatomy. They also differ in many aspects of their biology from other members of the Centrolepidaceae. The Hydatellaceae are normally submerged aquatics, with thin soft leaves that often lack gas-exchanging openings called stomates. They shed their seeds into the drying mud and appear to have no specialised dispersal systems. Nearly half of the species have the sexes separated on different plants. However, some plants classed as wind-pollinated members actually appear to use water and several appear to be able to set seed without fertilisation.

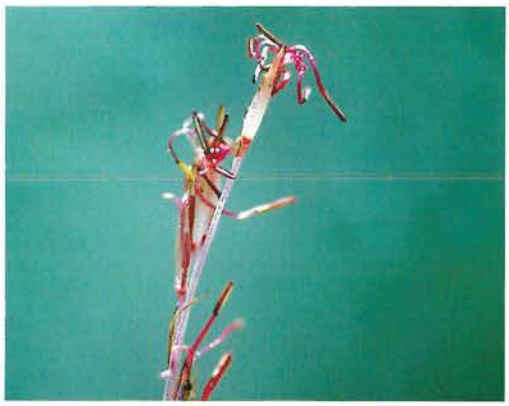
Since being separated in their classification, the relationships of this small family have remained obscure, with numerous possible relationships proposed. But recently, using DNA studies, the Hydatellaceae has become regarded as a very primitive group

Above The female form of common trithuria (*Trithuria austinensis*), flowering in a granite pool in Cape Arid.

Right The male inflorescence of common trithuria.

Far right Claypan trithuria (*Trithuria bibracteata*), a bisexual plant, in flower.

Below The inflorescence of pointed centrolepis (*Centrolepis aristata*), showing pollen held in boat-shaped anthers.
Photos – Greg Keighery/DEC

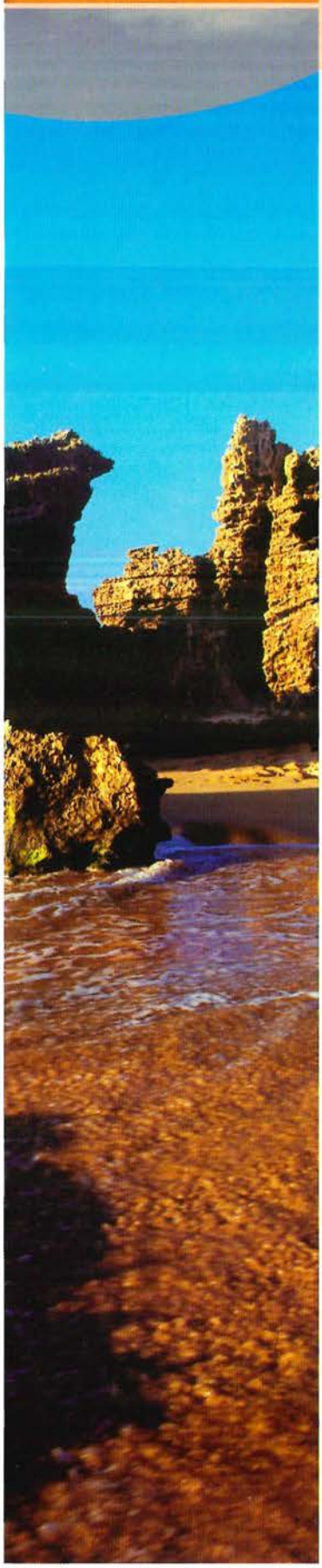


of flowering plants, more closely related to basal flowering plants such as the waterlilies, rather than other monocotyledons, such as grasses or lilies. A very recent study suggests that they even nourish their embryos externally, more like a conifer than a flowering plant.

Despite being inconspicuous in flower and stature, *Trithuria* in the Hydatellaceae family has hit the scientific press with stories of its unusual nature and new classification. It again clearly demonstrates that small can be very significant.

Greg Keighery is a Department of Environment and Conservation senior principal research scientist based at Woodvale. He can be contacted on (08) 9405 5142 or by email (greg.keighery@dec.wa.gov.au).

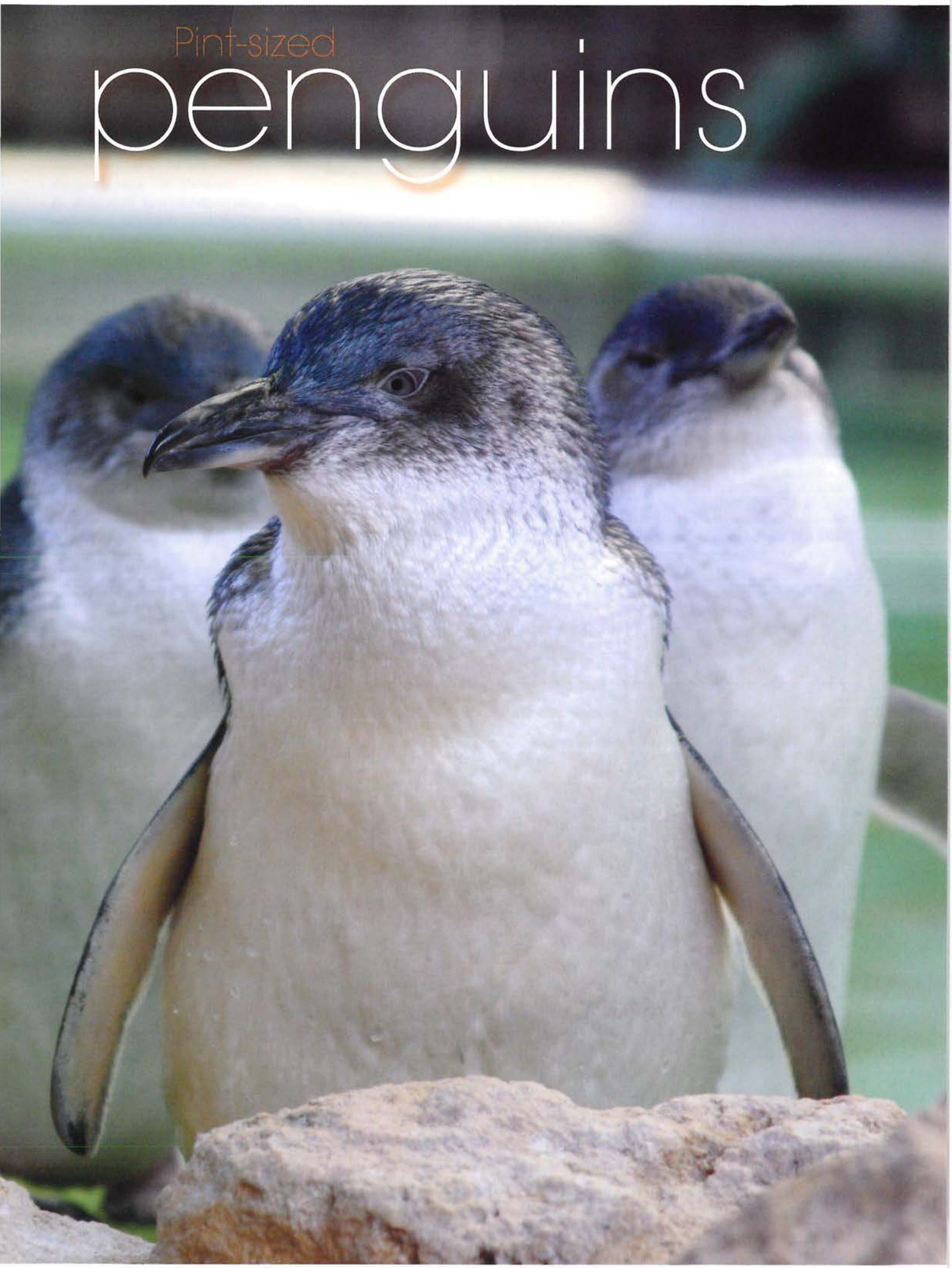
by Samille Mitchell



The little penguins in the discovery centre on Penguin Island delight visitors with their antics. But how is the wild penguin population faring? Study into the penguins, which rely on the surrounding Shoalwater Islands Marine Park for their survival, is revealing information about their lifestyles and possible threats they are facing.

Pint-sized

penguins



There's a rustle in the bushes at Penguin Island, a flash of khaki trousers and Murdoch University scientist Belinda Cannell emerges from underneath the low scrub. Dusting herself off, she gets up, grabs her tool box and marches on to the next site where she drops to her knees and again pokes her head out of sight under the brambly growth.

Belinda is conducting her fortnightly check of the little penguin (*Eudyptula minor*) nesting boxes on Penguin Island, recording the presence of adult penguins, chicks and eggs and taking samples of the chicks' fluffy covering of down. An assistant takes notes of the site number, the weight of the bird if encountered, its approximate age and whether it has been marked with a micro-chip.

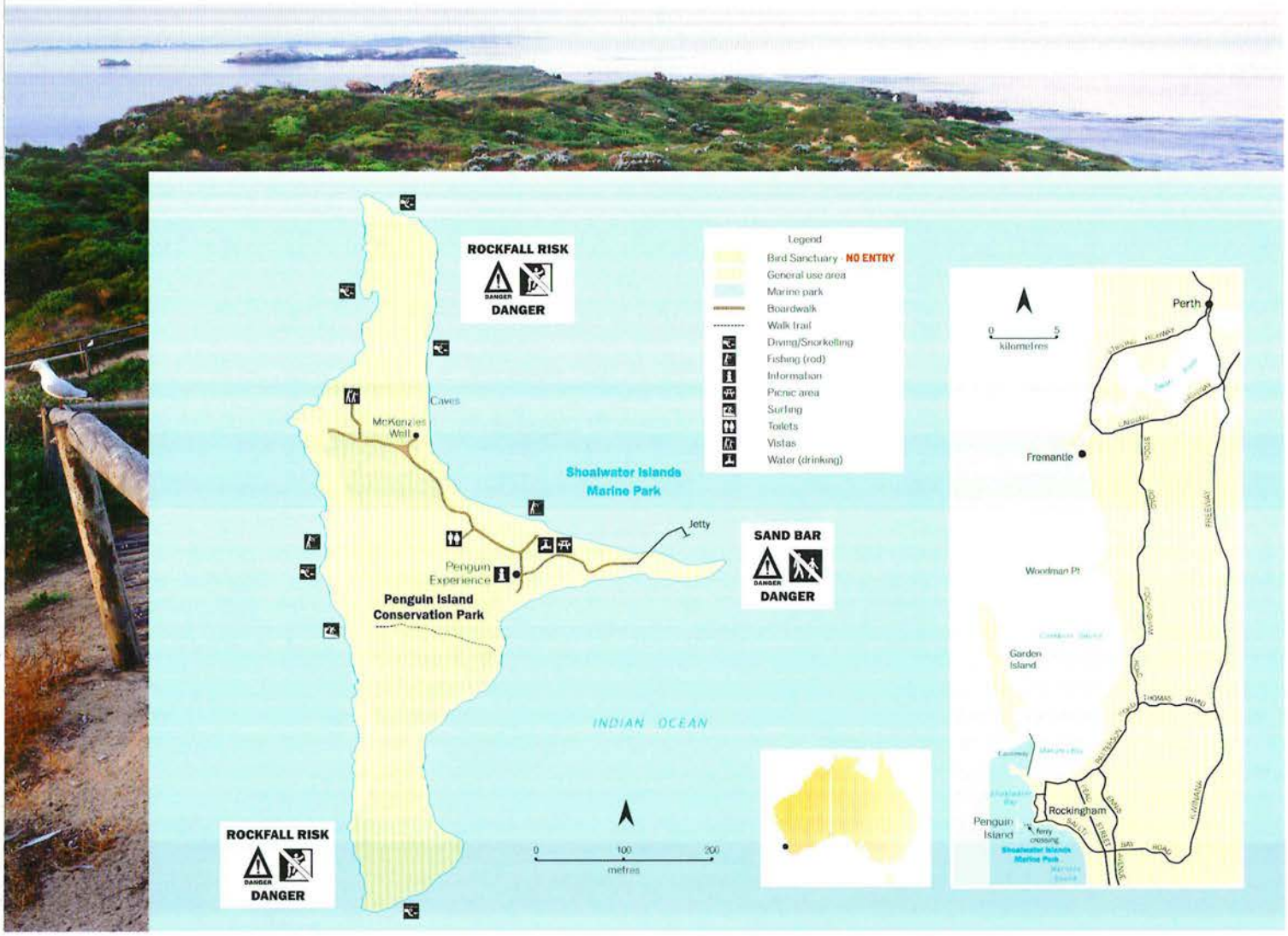
It's a repetitive task that takes most of the day but Belinda tackles the task with enthusiasm. She's continuing a project that started more than 20 years ago and aims to understand more about these delightful creatures. Despite years of study, much about these birds remains unknown. And recent trends suggest the Penguin Island population could face decline if their food sources dwindle and boat traffic increases.

Penguin Island

The 12.5-hectare Penguin Island Conservation Park lies just 600 metres off the mainland coast near Rockingham. It is completely surrounded by the waters of the Shoalwater Islands Marine Park, which features a combination of shallow waters, rocky reefs, islands and seagrass meadows—a diverse range of habitats that are important for little penguins and other seabirds and shorebirds as well as bottlenose dolphins, Australian sea lions and other marine life.

Penguin Island itself is home to Western Australia's biggest colony of little penguins, sometimes called fairy penguins or blue penguins. It is the northern-most little penguin colony in WA and the western-most in the world. Aside from small populations on Garden Island and Carnac Island, the next closest colony is at Albany in the south, though they have also been recorded at other destinations in the south-west. Despite Penguin Islands' position within a protected marine park, it lies in reasonably close proximity to heavy industry at Cockburn Sound.

Previous page
Main Little penguins at the Penguin Experience Island Discovery Centre.
Photo – Michael Pelusey
Inset and this page below Penguin Island.
Photos – Michael James/DEC



The colony of little penguins on Penguin Island has been given the highest conservation status of the 256 major colonies of little penguins around Australia. This status was awarded after considering the population size, location, vulnerability and history of scientific research.

So why do little penguins favour Penguin Island and not other coastal habitats? The penguins remain close to the coast, rarely travelling more than 10 kilometres from the shore. Radio-tracking and satellite tagging of the Penguin Island penguins have revealed they mostly stay within the Murray Reef System, which lies roughly 10 kilometres from the coastline. They also need to be within 20 to 30 kilometres of a reliable food resource, to have few predators, and be exposed to few threats.

While the penguins face several threats, Belinda and her fellow researchers at Murdoch University and the University of New South Wales can only determine whether populations are stable, increasing or in decline if they know the size of the population. It is difficult to accurately determine the population of Penguin Island penguins because it is impossible to locate and check every natural nest on the island without damaging or destroying the tangled undergrowth in which the nests are made. However, one way of estimating the population is to mark the penguins, release them and see how many times they are recaptured. Penguins will often re-use the same nest site from year to year so the information gleaned from monitoring nest sites helps make population estimates. In addition, Belinda and her team conduct night beach counts at four different sites on the island, one site per night, and repeat this four times a year. They set up a temporary fence at a beach site that penguins use for arriving back at the colony.

Top right The urban spread of Rockingham with Penguin Island in the foreground.
Photo – Dennis Sarson/Lochman Transparencies

Right box inset A little penguin.
Photo – Michael James/DEC

The little penguin

Little penguins are aptly named—they are the smallest of all penguins, growing to just 330 millimetres tall. They are also the only penguin to breed in Australia and the only one to wait until dark before returning to their colony. In the evening, they form groups and cross the beach to the sand dunes where they nest in crevices and burrows. On Penguin Island, the soft sand means burrows often collapse so they nest under the thick scrub instead. They signal time for the morning return to the oceans with a 'yap-yap' call before they regroup and waddle down paths to the beach and the sea.

Little penguins usually live for about six or seven years but have been recorded to live for up to 20 years. They reach sexual maturity at two years and choose their mate after a ritualised courtship.

Adults share incubation duties, one parent sitting on the eggs while the other feeds at sea. Eggs hatch after five weeks, after which the chicks grow rapidly. They are left by themselves at about two weeks old while both parents spend the day at sea catching enough food for their offspring. The young penguins leave the nest at eight weeks old. At Penguin Island, they take to the seas, only to return to their Penguin Island homes after at least one year. No one knows where they travel during this time. The adult penguins can lay two sets of eggs in a year, and depending on food availability, may raise both clutches. This ability to reproduce is important, especially as up to 70 per cent of the chicks die within the first year

These superb swimmers 'fly' through the water using their modified wings, or flippers. They lie belly down on the surface of the water when at rest. The Penguin Island birds dive to depths between one and 20 metres, with a dive duration of about 10 to 30 seconds. Their dives here seem to be limited by the depths of water they are in, as little penguins elsewhere can dive up to 70 metres. These hard-working little birds can dive 150 times an hour in their search for food—a feat recognised in their scientific name, *Eudyptula*, which is Latin for 'good little diver'.

As the penguins come ashore they are corralled, marked, weighed and released. Information from this study over three years will help better assess the numbers of penguins which inhabit the island annually.

In addition, the Department of Environment and Conservation (DEC) has installed a video camera which records one of the beaches at night, enabling penguins to be counted as they come ashore. Data gleaned from the camera will help with any future studies into the Penguin Island population.

Research

The Penguin Island study—funded by DEC, Australian Research Council Linkage, Fremantle Ports, Department of Defence, Tiwest and Winifred Violet Scott Trust—involves fortnightly checks of 126 man-made nest boxes and 58 natural nest sites on Penguin Island and 13 nest boxes on Garden Island. The nest boxes are particularly useful as they enable researchers to easily observe the penguins, eggs and chicks and access them to weigh and mark them for future identification. The penguins are marked by inserting a grain-sized micro-chip under the penguins' skin—the same way that dogs and cats are micro-chipped. The penguins are then simply scanned for identification. By monitoring nests with known individuals, Belinda and her team can determine when the penguins are breeding, how successful they are at raising chicks, how much weight the adults gain or lose during the breeding season and how well the chicks are growing.

Twenty years of study on Penguin Island and eight years on Garden Island has helped Belinda work out differences between years and potentially the cause of differences. For example, a late start to breeding, coupled with lower than average body weight or poor breeding success, is likely to indicate that fish abundance is lower than normal.

Top left Juvenile little penguins in a nest box.

Centre left Little penguins nest in thick scrub on Penguin Island.

Left Murdoch University scientist Belinda Cannell monitors and studies the Penguin Island penguin population.
Photos – Jiri Lochman

Above Penguin Island.
Photo – Samille Mitchell/DEC

Last year's research may reveal a troubling trend. It showed a much lower number of breeding birds (only 112 eggs were laid in the Penguin Island nest boxes in 2008, compared with 173 in 2007). However, as about 60 new boxes were added in 2006 and penguins are less likely to use the boxes immediately, these figures cannot be compared against longer-term averages. Belinda has also recorded greater fatalities in the past year, birds weighing less than average and moulting occurring much later than usual. Little penguins must reach a certain weight before moulting begins. These factors suggest the penguins may be eating less.

The argument that this is caused by a scarcity of food is lent further weight by satellite tagging of 30 birds over two years. During incubation, one of the parent birds usually leaves the nest for three to five days in search of food while the other parent incubates the eggs. When one parent returns, they swap roles, allowing the other parent to forage for food before returning to the nest. But recent tagging has shown the parents to be away from the nest for much longer than the usual three to five days—up to 13 days. This suggests the penguins may have to hunt longer and harder to find food, leaving their mate literally starving on the nest while they await their partner's return.

So what is causing the apparent demise in their food source?

Penguin diet

Past examinations of little penguins' stomach content has revealed they feed primarily on whitebait, pilchards, anchovies, garfish and blue sprat, with whitebait forming 60 to 80 per cent of the diet. So if penguins are failing to gain weight, it is likely that these species, particularly whitebait, may be less abundant.

However, determining what could be affecting these species is difficult. Department of Fisheries research showed an increase in juvenile salmon numbers last year. As older salmon eat smaller fish like whitebait, this could be having an effect on penguins. Past research has also shown a correlation in a strong Leeuwin Current and penguins weighing less than usual. However, while there are theories why the current and its warming, south-ward flowing waters have this effect, at this stage Belinda says there's no definitive answer.

Conservationists have expressed concerns that plans for a new boat ramp at Port Kennedy may further threaten penguin food sources. The proposed ramp is positioned near a whitebait nursery, potentially threatening whitebait populations—a major food source for the little penguins.

A precarious existence

Declining fish stocks are not the only threat facing little penguins. Like other marine creatures, they are prone to entanglement in fishing line and other debris (see 'Don't rubbish our marine wildlife' on page 40). Their tendency to make shallow dives and to rest on the surface of the water also makes them prone to boat strikes. Studies have revealed that some penguins spend almost 70 per cent of their time at sea in the top one to two metres of water. Belinda has reports of many penguins that have been killed or wounded from boat propellers. In fact, 30 per cent of the dead penguins Belinda studies have evidence of injury likely to have been sustained from watercraft. This problem is exacerbated in the Rockingham area as it is reported to have the second highest boat ownership per capita in WA—a trend that is increasing.

Water pollution may also be harming penguins. However, no study has been made into the effects of water quality on penguins. Oil spills and damage to nesting sites through storms or erosion also threaten little penguins and their habitats.

Left Beach renourishment program work on Penguin Island.

Below left Belinda Cannell checking one of the penguin nesting boxes.
Photos – Samille Mitchell/DEC

Protecting penguins

Despite the threats facing these delightful creatures, ongoing study is providing guidance for management to protect the penguins on Penguin Island. DEC, which manages Penguin Island Conservation Park and the surrounding marine park, regularly consults with Belinda and other researchers when it conducts work on the island. It has installed boardwalks across the island to enable visitors to explore, without damaging the nests of penguins and other seabirds that are nestled in the undergrowth. In 1995, the Department of Conservation and Land Management opened the Penguin Experience Island Discovery Centre. The centre features a central enclosure which houses a small colony of penguins that have been rescued and nursed back to health. An army of dedicated volunteers and DEC staff mans the enclosure and related interpretive displays and provides visitors with information about the penguins and their biology. By allowing the public to see and learn about the penguins here, they are discouraged from trampling across the island's fragile vegetation in an attempt to find the secretive birds themselves.

DEC has undertaken a beach renourishment program on the south side of the island, adding some 10,000 cubic metres of beach sand on the beach in attempt to reduce erosion. Continued erosion was endangering the infrastructure on the island as well as the arrival point that some penguins use to access their nests. A combination of storms and high tides in 2007 resulted in a vertical wall of sand that the penguins could not climb up to get to their nests. Sand bags were originally put in place to help the penguins access their nest sites—a move which helped one satellite-tagged penguin to find its mate. Another penguin, however, spent five nights returning to the island but could not find its way to its nest and eventually gave up. Since the addition of the sand to the beach, consequent study has found that although penguins must travel over wide stretches of beach, they have successfully accessed the shore and their nests.

Penguins and people

Despite 20 years of study, much remains to be learned about these endearing birds. However, funding for the current study ends in September 2009. Further study would unlock more of the secrets about little penguins—information like where they go after they leave the nests and just how threatened they are. Stopping briefly near the azure waters of the Shoalwater Islands Marine Park that surround Penguin Island, Belinda speaks of her hope to learn more about these enigmatic birds.

"They need someone to be an advocate for them," she says.

"With increasing urbanisation comes increasing threats. We humans recreate in the same waters the penguins rely on for survival. Without more information, we won't be able to offer them the protection they deserve."

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

Thanks to Dr Belinda Cannell from Murdoch University for her assistance with this article. Until September 2009, Belinda can be contacted on (b.cannell@murdoch.edu.au).

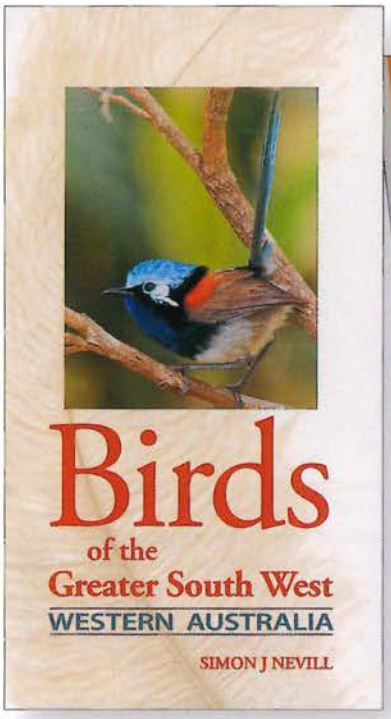
bookmarks by Samille Mitchell

Birds of the Greater South West Western Australia

Author: Simon Nevill
Publisher: Simon Nevill Publications
304 pages, soft cover, full colour
ISBN: 978 0 9803 4812 5
RRP: $34.95

This delightful full-colour field guide helps bird watchers to identify the myriad of bird species that occur from Carnarvon in the north to Kalgoorlie and Esperance in the south-east. The first section of the book focuses on the region itself, habitat types and provides tips for people who are new to bird watching.

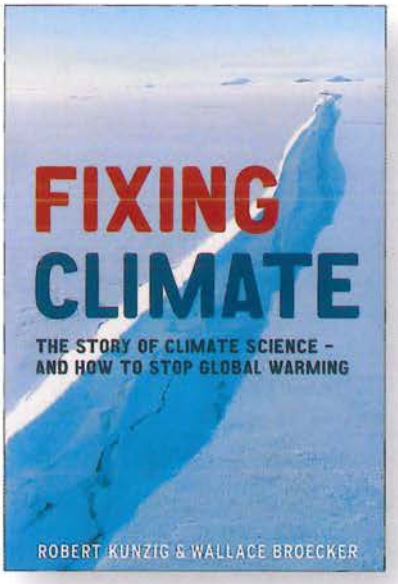
The bulk of the book is dedicated to individual bird species, with information on their description, status and where to find them. Each species entry features a distribution map and colour photographs.



Fixing Climate: The story of climate science and how to stop global warming

Authors: Robert Kunzig and Wallace Broecker
Publisher: Profile Books
ISBN: 978 1 8466 8860 7
288 pages, soft cover
RRP: $29.95

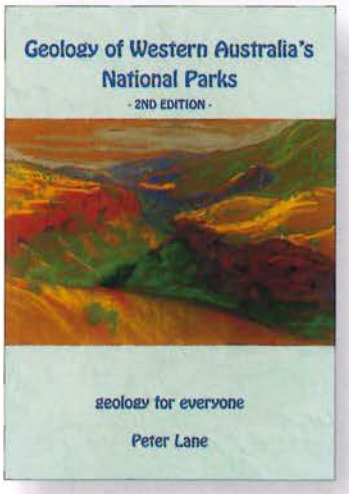
Wally Broecker—one of the first scientists to recognise global warming (he is said to have coined the term)—joins forces with science writer Robert Kunzig to produce this look at the Earth's volatile climate history. The book deals with ice ages, planetary orbits and more —all written in a popular history style. It concludes with some wild ideas to combat climate change, including artificial trees and underground storage.



Geology of Western Australia's National Parks 2nd Edition

Author: Peter Lane
Publisher: Peter Lane
ISBN: 978 0 6464 8217 0
108 pages, soft cover, full colour
RRP: $29.95

The second edition of this book makes the often complicated science of geology accessible to the layman. It provides easy-to-understand descriptions of geology in many national parks across the State. You can learn fascinating facts like how the south coast is the remains of an alpine mountain range, how Kalbarri National Park shows signs of the first life to have emerged from the oceans, how Karijini National Park may hold clues to some of the earliest bacterial life on the planet, and more.



Intriguing underworlds: caves of Western Australia

Caves fascinate visitors with their dazzling forms and contain evidence of early human and animal life in Western Australia.

by Samille Mitchell and Anne Wood

Caves hold an almost primal fascination to visitors. It's simply enthralling to explore their dark reaches, marvel at their jewel-like forms and guess at the people or animals who have used them over the millennia. You may be in a cave steeped in Aboriginal legend, one that is home to prehistoric fossils or you may be somewhere that harbours bizarre life forms found nowhere else in the world.

Western Australia is home to thousands of caves ranging from yawning caverns complete with dazzling crystal-like formations to tiny tunnels wending deep within the earth. Many come adorned with underground streams or mirror-like lakes, further adding to their beauty. The south-west is particularly rich in enchanting caves open to tourists.

Cave formation

Caves are mostly formed within areas of limestone, which is partially soluble and therefore prone to dissolution into features like caves and gorges. These landscapes, formed mainly by the dissolving of rock, are known as karst landscapes. In addition to caves, karst features include such formations known as limestone pavements, closed depressions known as dolines and the Pinnacles in Nambung National Park near Cervantes.

But what exactly is limestone and how does it form? Limestone is a sedimentary rock containing at least 50 per cent calcium carbonate. Most limestone was formed in ancient seas by marine animals, plants and micro-organisms that made use of the calcium carbonate from the sea water in the construction of their shells, skeletons and other structures. The main areas of limestone in WA occur in the south-west, Nullarbor, Cape Range near Exmouth and Kimberley.

Limestone is not very soluble in pure water, however, ground water is usually slightly acidic due to the presence of carbon dioxide from plant decay. This forms weak carbonic acid which, over great periods of time, can dissolve away the rock to form caves. Most caves were formed by water moving slowly through the zone below the water table, mainly at the top of the saturated zone. Cave passages may form along cracks and fractures in the limestone.

Nature's crystal wonderland

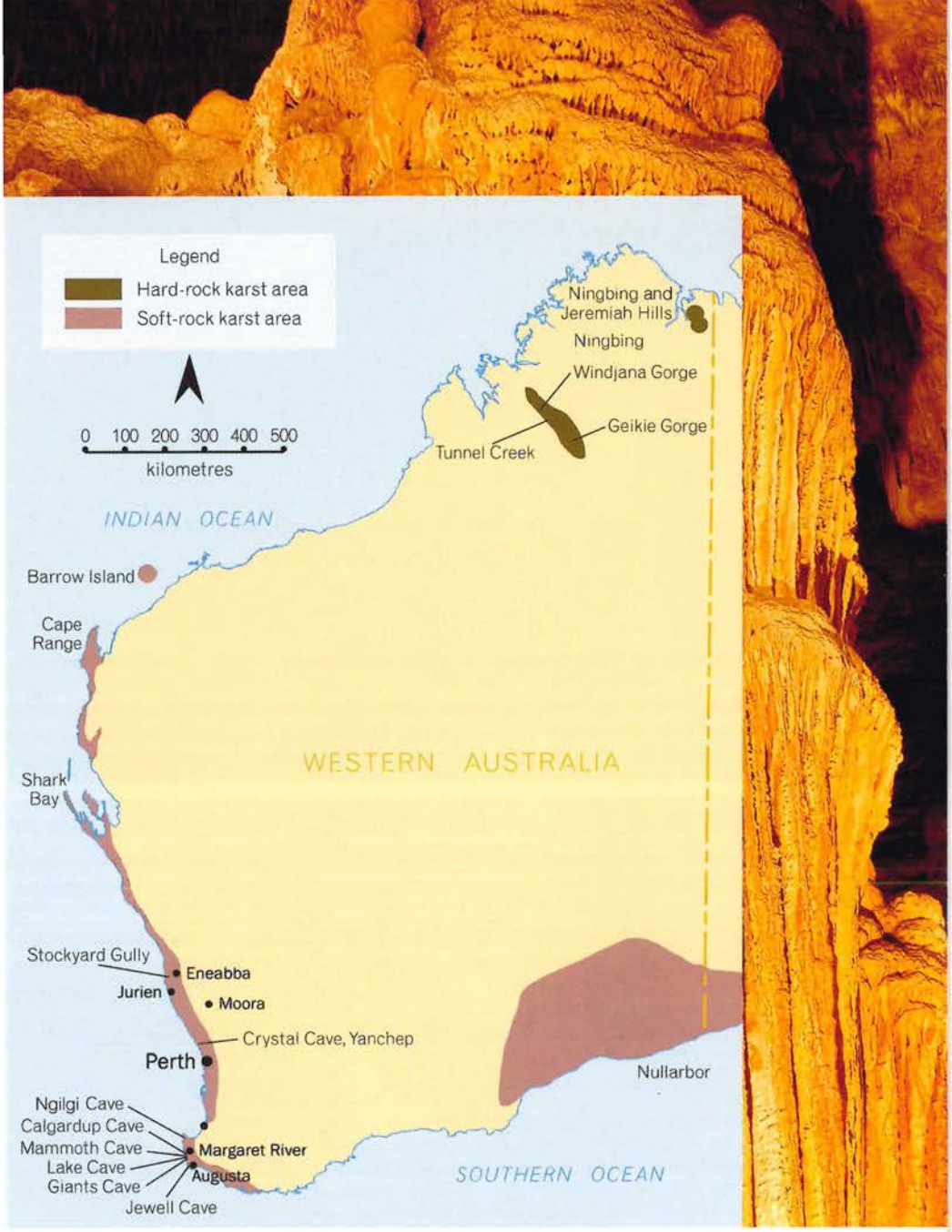
The most spectacular caves are home to decorations known as speleothems. These natural formations form an underworld of dazzling beauty and intrigue. They shine like jewels, hang like daggers and adorn cave walls, ceilings and floors with weird and wonderful forms. They range in size from minute helictites, only a few millimetres long, to large pillars and flowstones weighing several tonnes. There are also stalactites, stalagmites, shawls, columns and straws. But what exactly are these weird formations and how do they form?

The speleothems typically found within caves come from a secondary deposition, usually of calcite (calcium carbonate crystal). Other depositions found in WA are halite (sodium chloride or common table salt) and gypsum (calcium sulphate). Cave decorations usually take many thousands of years to form and are therefore non-renewable in human lifetime scales.

Speleothems are created when slightly acidic water seeps down through the limestone bedrock and dissolves calcium carbonate. When the solution reaches an air-filled cave, a discharge of carbon dioxide may alter the water's ability to hold these minerals in solution, causing its solutes to precipitate. Over time, the accumulation of these precipitates may form speleothems. The rate of speleothem growth depends on the amount of carbon dioxide held in solution, rainfall, surface vegetation, density of the limestone, temperature, and other factors. Different combinations of factors create different speleothems.

Previous page
Main A cave in the Boranup Forest in Leeuwin-Naturaliste National Park near Margaret River. Some caves are so fragile that specially permitted visitors must remove their shoes.
Photo – Ross Anderson
Inset Yanchep National Park cave.
Photo – DEC

Left Lake Cave.
Photo – Samille Mitchell/DEC



Top left Pendulites.
Photo - Brian Combley

Above left Helictites.

Background above Diverse cave formations.
Photos - Samille Mitchell/DEC

Ancient animals

Caves can act as windows to the past—virtual museums of treasures that provide clues to ancient animals which once roamed the Earth, early human inhabitants and climate from days long past.

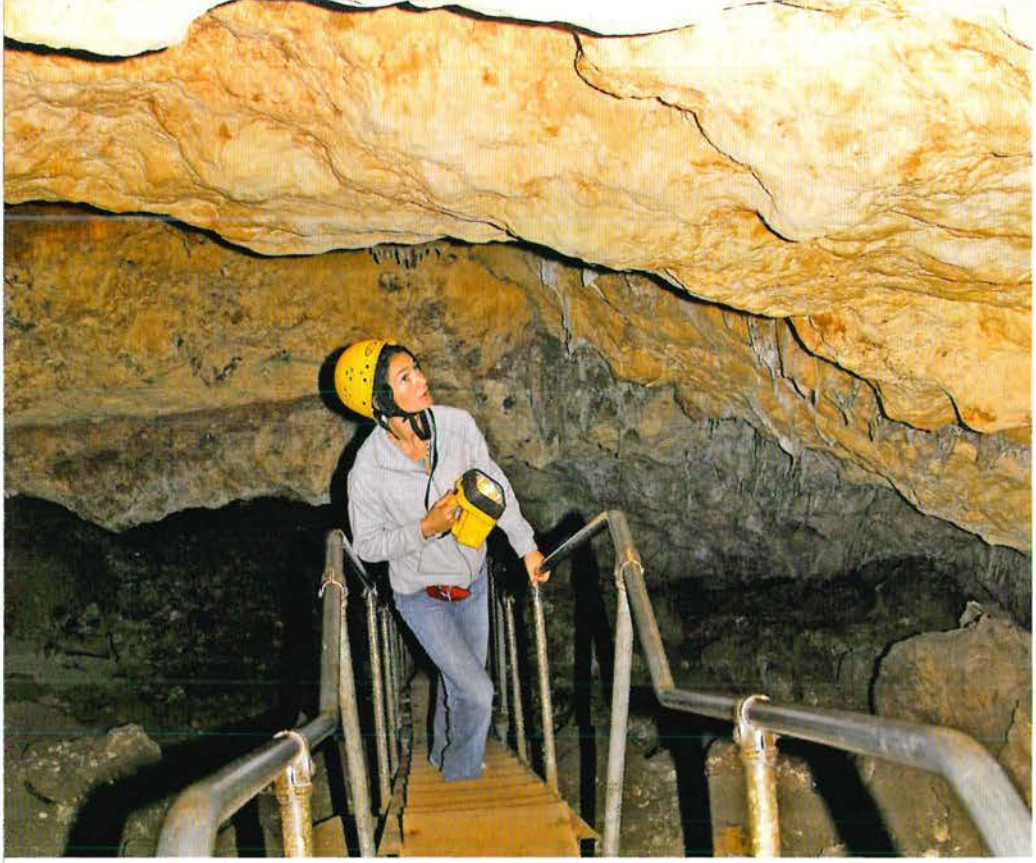
A cave's constant conditions, alkaline environment and protection from disturbance means they are ideal for preservation of fossil and sub-fossil material. As such, caves are often home to fossilised remains of animals that may have fallen into caves, animals that may have used the cave as a lair or bones that have washed into caves.

Several caves in the south-west are particularly well known for their megafauna, which are animals weighing more than 45 kilograms that became extinct about 45,000 years ago.

For example, Mammoth Cave in the south-west has remains of long-extinct animals like a giant marsupial called *Zygomaturus trilobus*, that was the size of a small hippopotamus and may have lived like a marsupial version of a hippo, inhabiting swampy regions and feeding on plants. A partial skeleton of a giant echidna sized one-metre long and called *Zaglossus hacketti* was also discovered here—the biggest known monotreme ever discovered. And two species of the now extinct short-faced kangaroo were also discovered in Mammoth Cave, preserved deep below the earth.

In the Kimberley, Windjana Gorge in Windjana Gorge National Park holds the bones of *Diprotodon* (another long-extinct, hippo-like creature), the teeth of an extinct giant crocodile and scant remains of a thylacine, more commonly known as a Tasmanian tiger.

Mummified thylacine remains were also discovered in Thylacine Hole in the Nullarbor and dated at 4,500 years old. Nullarbor caves also have complete skeletons of the marsupial lion (*Thylacoleo carnifex*), skeletons of three species of short-faced kangaroos and bones of a giant wombat (*Phascolonus gigas*), a giant kangaroo (*Procoptodon goliah*), extinct species of wallaby and



more. These remains are dated from the Pleistocene epoch, from 180,000 to 11,550 years ago, and are the best preserved examples found in Australia.

Early humans

Ancient human occupation has been revealed from the depths of Western Australian caves. The cave called Devil's Lair, in the south-west, has stone and bone artefacts, intact campfire ash-beds and enormous quantities of mammal and other bones which show Aboriginal people used the area some 50,000 years ago. Some of the stone artefacts were used as tools—proof the caves were used for preparing food, making wooden implements and carrying out other camp activities. The discovery of teeth from young children suggests family groups visited the cave. However, occupation seems to have been very occasional, perhaps taking place only during cold or wet weather.

Other caves in the region show food remains, identified as such because they are charred and occur in beds of long-dead campfires, and many of the bigger mammal bones had been deliberately smashed, offering further proof of human occupation.

Caves closer to the coast are home to more camp fire beds, quartz artefacts, vertebrate remains (including fish) and marine and freshwater mollusc shells. They are dated at 800 years old and provide evidence that these caves were used as overnight and meal camps.

Caves in other areas have revealed fragments of burnt emu eggshell, indicating Aboriginal people ate emu eggs when available, and one site contained many kangaroo jawbones without front teeth, possibly because the teeth were removed to make tools or ornaments.

Top left Giants Cave.
Photo – Samille Mitchell/DEC

Centre left Cave spider.
Photo – Anne Wood/DEC

Left Calgardup Cave.
Photo – Michael James/DEC

Above left Bride Cave is a popular abseil site in the Leeuwin-Naturaliste area.
Photo – Marie Lochman

Above Giant limestone caves are common in the Nullarbor.
Photo – Ross Anderson

Cave life

The dark reaches of caves offer too little light for plant growth and are therefore not associated with the number and variety of life forms found in surface habitats. But these intense black habitats are sometimes home to communities of bizarre creatures —many of which live nowhere else in the world but their own cave.

Troglobites are species that spend their entire lives in subterranean habitats, and can't survive elsewhere. They live an amphibious or terrestrial lifestyle. They usually have reduced or totally missing eyes and pigmentation. They often have elongated appendages such as antennae and legs. Troglobites are adapted to a very narrow range of environmental conditions such as temperature and humidity and so are particularly sensitive to change.

Some animals (troglophiles) may live their entire life within caves, but can also be found living in suitable surface habitats. Yet others (trogloxenes) may live part of the time in caves, and part outside. Cave-dwelling bats are an example of this. They shelter within suitable caves but must leave periodically to find food.

Stygofauna are creatures which live fully in water. They include cave-dwelling crustacean species such as remipedes, amphipods, copepods and ostracods. Given the dark environments in which they live, most of these creatures are without pigmentation and eyeless, or have only residual eyes.

Cape Range National Park near Exmouth is home to one of the most significant cave fauna areas on Earth. The terrestrial fauna is a relict of a much wetter past, but the present day arid climate has resulted in the extinction of related surface-dwelling species. The aquatic fauna includes Australia's only two troglobitic fish, the blind gudgeon and the blind cave eel.

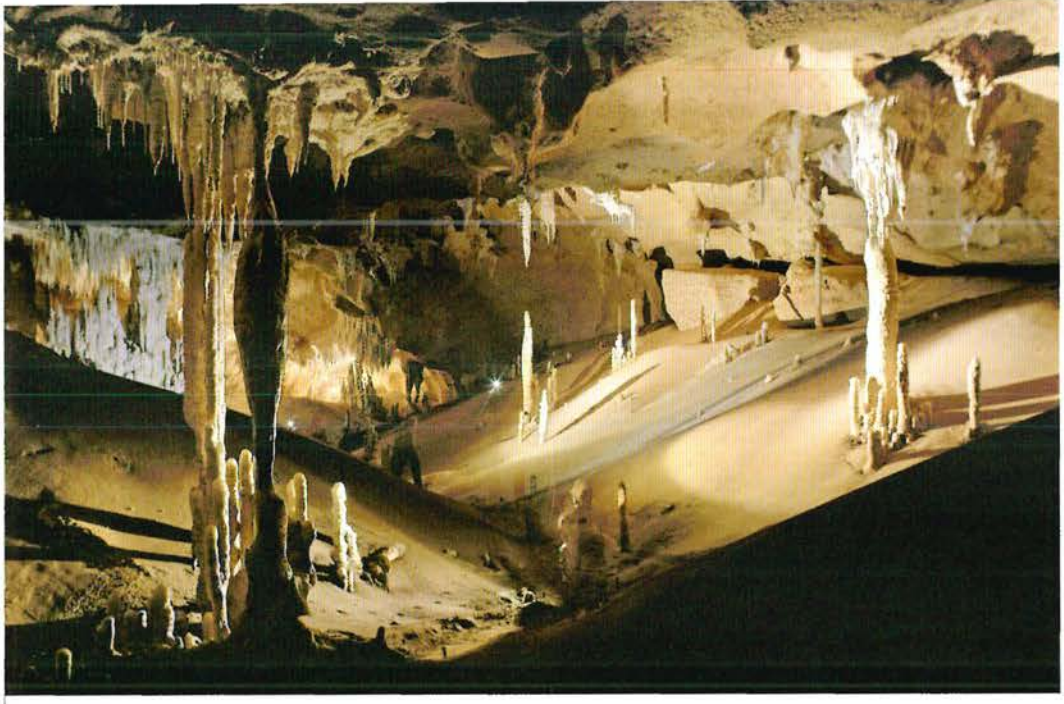
Caves that feature mats of roots from trees growing above, such as some at Yanchep National Park and in the Leeuwin-Naturaliste Ridge, may harbour many aquatic cave animals. The root mats provide food and shelter for these animals, which include invertebrates and some night fish. Some of these species are ancient. And some of the root mat communities are listed as critically endangered due mainly to their limited distributions and falling water levels.

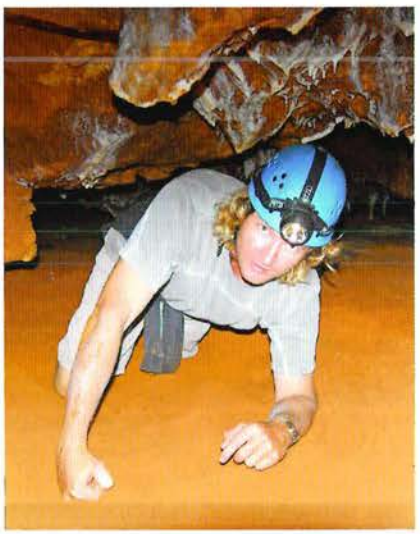
Cave hotspot

The Leeuwin-Naturaliste Ridge in the south-west is the biggest area of coastal limestone in WA and features the most easily accessible and stunningly decorated caves. The Department of Environment and Conservation (DEC) manages two of these caves —Calgardup and Giants. Calgardup Cave is unlit and self-guided, providing the opportunity to explore at your own pace. It is fascinating to run the beam of your head or hand torch over the cave walls and see what formations appear in the light. It's also enjoyable to sit on one of the several seats in the cave and soak up the enchanting atmosphere. In addition to beautiful crystal formations, Calgardup Cave contains a stream that trickles through the cave all year around, carrying nutrients to the tiny cave creatures that inhabit the water and many tree roots that can be seen dangling from the roof and trailing into the water.

Calgardup Cave is also an information centre for the Leeuwin-Naturaliste National Park and the booking centre for the cave and abseil permit system that manages access to the adventure caves and wild caves in the area.

Giants Cave is one of the biggest and deepest caves on the Leeuwin-





Above A cave in the Eneabba area.
Photo – Ross Anderson

Above right Adventure tours are popular at Ngilgi Cave near Yallingup.
Photo – Samille Mitchell/DEC

Naturaliste Ridge. It is entered via a spectacular collapsed doline almost 100 metres in diameter, and plunges 86 metres into the earth. You can explore its dark reaches on a self-guided tour, scrambling up ladders, squeezing through tunnels and meandering through enormous caverns. The infrastructure is minimal, meaning you feel like an early explorer discovering this underground wonder.

Further north near Yallingup is the stunning Ngilgi Cave, managed by Geographe Bay Tourism Association. Ngilgi was the first cave in WA to be opened to tourists. It has enchanted visitors with its dazzling forms for more than a century, and also features in the legends of the local Wardandi Aboriginal people.

You can join a semi-guided cave tour which provides information about the cave but also gives you time to explore yourself. Adventure tours with hard hats and head torches are also available for those wishing to witness the cave's deepest reaches—an exhilarating way to explore.

Caveworks runs another three caves open to tourists on Caves Road—Mammoth, Lake and Jewell. Mammoth Cave is one of the south-west's biggest and most spectacular caves. Its enormous caverns are thickly encrusted with exquisitely beautiful forms. Mammoth Cave is also a natural time capsule—home to ancient fossil remains of extinct animals.

Lake Cave's watery entrance makes this cave particularly stunning, as it reflects the strikingly lit formations that encrust the ceiling and walls. In fact, this cave has one of the most impressive and beautiful entrances of all the Western Australian tourist caves. It occurs at the bottom of a huge closed depression, and is so named because of an underground lake, which is formed by a stream flowing through the cave.

Jewel Cave is a treasure chest of lavish cave formations that range from tiny, crystal-like clusters to enormous flowstones that glow gold in the artificial light. The cave is named after the Jewel Casket, a small formation in the lower section of the cave. As you enter the cave, you'll encounter a huge chamber and several tree roots spiraling down from the roof. These are the roots of karri and marri trees seeking moisture far below.

Protecting caves

Many coastal towns, farms and even suburbs of Perth are situated on karst. This makes these areas prone to problems like sinking, collapse, and pollution of groundwater. Groundwater moves rapidly through karst areas with little opportunity for filtering. As such, to protect karst areas it is necessary to consider and protect the entire catchment area.

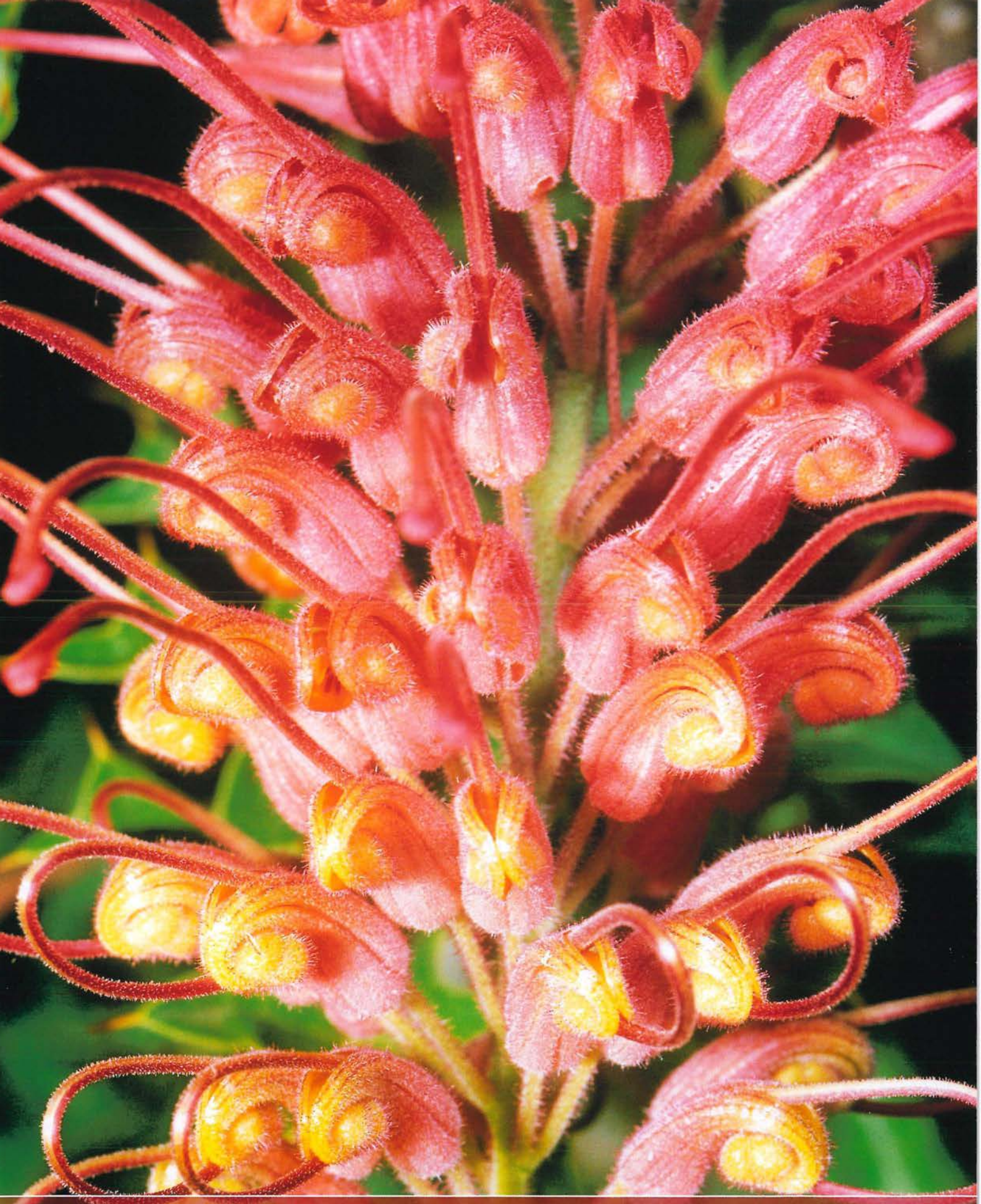
Sinkholes and collapses in karst areas can occur spontaneously but are often the consequence of changing land use and drainage on the surface. For example, burst water pipes have been responsible for several land collapses in karst areas—a major problem if houses or infrastructure are situated nearby.

When visiting caves it is important to remember that they are sensitive to environmental impacts. Caves are usually very stable environments where any change can have an adverse effect. Visitors should move carefully, disturb as little as possible, and leave nothing behind. Any damage must be considered irreversible in human lifetime scales. For this reason, DEC and other cave managers restrict access to caves to ensure visitors remain on boardwalks and designated paths. By doing so, they prevent damage to the fragile decorations that visitors have come to admire.

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

Anne Wood is DEC caves manager and can be contacted on (08) 9757 7035.

Information in this article is based on the newly released book *Discovering the Caves of Western Australia*. The book is available for $6.50 from bookshops and tourist outlets, by phoning WA Naturally Publications on (08) 9334 0437, by ordering online at www.dec.wa.gov.au/shop or using the order form between pages 40 and 41.



by Bronwen Keighery and Greg Keighery

New plant discoveries in Perth's backyard

New species of plant are continually being discovered on Perth's doorstep. Who knows what else is still out there waiting to be found?

During the past 12 months, television and print media have reported on expeditions discovering new species of plants on remote peaks in exotic locations like New Guinea and South Africa. In the meantime, continuing detailed studies of our bushland routinely uncover new plants on Perth's doorstep that go completely unreported.

Such discoveries should perhaps not be unexpected since south-west Australia, the area west of an imaginary line stretching from Shark Bay to Israelite Bay, is an internationally recognised biodiversity hotspot for flowering plants and Perth is central to this region.

Flora hotspot

About 8,000 species of flowering plants occur in the south-west of Australia and about 6,000 of these are only found here. It has also long been known in botanical circles that plants are not distributed uniformly across the south-west, but rather concentrate in a variety of nodes of high species richness and local endemism. Some of these nodes are large, like the southern (Albany to Esperance) and northern (Jurien Bay to Kalbarri) sandplains. These sandy soils are remarkable for both species richness and endemism in a range of shrubs from the banksia, myrtle, pea and heath families. Conversely, the wet forests of the south coast are diversity centres for herbaceous groups such as the sedges, trigger plants and a wide variety of endemic species such as the tingle trees and Albany pitcher plants, whose ancestors hark from ancient times.

Within these broad nodes there are smaller areas that are centres of locally endemic species—places like Stirling Range, Fitzgerald River and Lesueur national parks. Groups of plants also show different centres of species richness within the south-west, including the eucalypts in the Goldfields and the wattles in the north-eastern Wheatbelt.

Perth regional hotspot

While many of these areas have been long recognised and well documented, nearly two decades of detailed survey work on the Swan Coastal Plain and adjacent Darling Scarp has revealed that the area around Perth is itself a local hotspot of species richness and, to a lesser extent, endemism.

Many people have been involved in these decades of discovery. However, pivotal studies were the Southern Swan Coastal Plain Survey between 1992 and 1994 and the documentation between 1995 and 1998 of all of the plants in more than 70 bushland areas in the same area of the Swan Coastal Plain.

The Southern Swan Coastal Plain Survey focused on systematically comparing more than 500 fixed sites (in 10-square-metre quadrats) in the different plant communities on the

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Main Fuchsia grevillea (the Darling Range and scarp subspecies of *Grevillea bipinnatifida* subsp. *bipinnatifida*). *Photo – Jiri Lochman*

Above One of the new soon-to-be-described species from within the *Melaleuca systena* complex, growing on the Muchea limestones near Bunbury. *Photo – Bronwen Keighery*

Left Another new species soon to be described from within the *Melaleuca systena* complex growing on one of the Tamala limestone ridges north of Perth. *Photo – Greg Keighery*

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Right The newly recognised swamp tribonanthes growing in a clay pan on the Pinjarra Plain.

Far right One of a series of new *Eryngium*, the swamp devil, from a clay pan or vernal pool on the Pinjarra Plain. Vernal pools in California support a diversity of plants in the same genus.

Below right A spiky blue devil from a clay pan on the Pinjarra Plain. As the name describes, this new devil has prickly leaves and heads of blue-tinged flowers.
Photos – Bronwen Keighery

plain and involved scientists from government and the community as well as other members of the general public. The study provided data on the distribution and patterning of more than 1,400 plants and found 15 previously unknown species, three presumed extinct species and new populations of 10 declared rare plants. It also documented a series of rare plant communities, most listed as threatened (see 'Threatened plant communities of the Swan Coastal Plain', *LANDSCOPE*, Spring 1996).

The work on fixed sites and bushland area inventory continues today (see 'Bound by a love of flora', *LANDSCOPE*, Spring 2008). More than 1,500 quadrats are now included in these studies and more than 100 inventories of bushland areas have been made. The studies are helping with conservation planning north and south of Perth. The conservation planning projects include the update of the System Six report (the 1983 conservation plan for the Swan Coastal Plain), *Bush Forever* (the conservation plan for Perth's Swan Coastal Plain) and the Swan Bioplan Project, which is the current conservation planning project for the Swan Coastal Plain south of the Perth Metropolitan Region.

This work has raised the number of known flowering plant species recorded for the Swan Coastal Plain to more than 3,000, of which 1,700 are from the Perth Metropolitan Region alone.

The diversity is a result of the juxtaposition of major geological features like the granites of the Darling Scarp and sands of the plain as well as highly diverse wind, water and erosional-deposited soils, limestones and ironstones. The area is also home to diverse wetlands, especially the clay-based vernal pools (seasonal pools that fill up in spring) which have very high species richness and local endemics. The big variation in rainfall across the area further contributes to species diversity.

New plant discoveries

New plants continue to be uncovered during this work. There have also been significant rediscoveries of species not seen for long periods. Most of these discoveries are found in highly restricted and, until recently, poorly studied habitats.

One of these habitats is the limestone hill landscapes which line the coast north of Perth. This habitat is listed as a threatened ecological community and supports both the current widespread shrub *Melaleuca systena* and a new species related to this. The two species differ mainly in leaf characteristics, and were considered as local variants of the widespread but variable *Melaleuca systena* in the recent revision of the genus. However,

a new study has revealed both species growing together in several locations with no signs of hybridisation, or intergradation—a very good indication that these are two separate species.

Perhaps the most surprising new plants are a series of new grasses, recently included in a new grass classification. One of these is a salt-tolerant annual grass originally collected from the Vasse Estuary and identified as the widespread *Puccinellia stricta*, which was rediscovered after 70 years on the Leschenault Estuary. In 2007, Alex Williams, an expert in grasses who volunteers at the Western Australian Herbarium, named this as a new species—the Vasse puccinellia (*Puccinellia vassensis*).

Coincidentally, also in 2007, a new annual tumbleweed grass (*Lachnagrostis nesomyrtica*) was described by a Melbourne botanist. Allied to species normally growing in freshwater swamps, this new species had three subspecies described, one locally common upland grass restricted to Garden Island and two others restricted to seeps and woodlands on Rottnest Island.

The eastern alluvial flats of the Swan Coastal Plain, called the Pinjarra Plain, support a series of diverse wetland communities. The most diverse of these communities are associated with clay flats and depressions, also known as clay pans or vernal pools. It is on these habitats that more than 10 plants new to science have been recognised. These include the sedge Keighery's spikerush (*Eleocharis keigheryi*); the herbs Gibson's blue squill (*Chamaescilla gibsonii*),

Top left Two entities of the common hovea from the Bullsbrook Nature Reserve, soon to be recognised as different species.
Photo – Greg Keighery

Centre left The beautiful Bronwen's grevillea from the Whicher Scarp.

Left Graceful jacksonia (*Jacksonia gracillima*), recently described in a revision of the genus, was first recognised in the wetlands of the Jandakot area.
Photos – Bronwen Keighery

Right background The leaves of *Grevillea bipinnatifida* subsp. *pagna*.

Below right The golden flowered variety of *Lambertia multiflora* in the Talbot Road Bushland.
Photos – Bronwen Keighery

Understanding plant classification

All plants (and animals) are grouped and then named (classified) in a basic hierarchy of genus and species. The genus reflects their shared features and past histories while the species gives the particular features of that species. This is the binomial system established by Linnaeus that enables biologists throughout the world to immediately see what is related to what.

A genus is a group of species that share similar characters and are genetically related. For example the native honeysuckle genus, *Lambertia*, is a group of shrubs with small heads of honey suckle-like flowers much loved by honey eaters.

A species is a group of populations with common characteristics and are usually capable of mating with each other to produce vigorous fertile offspring. For example the prickly honeysuckle or prickly lambertia (*Lambertia echinata*), grows in the south-west on Cape le Grand, around Albany and near Busselton. This level is the basic unit of classification.

A sub-species is a group of populations less distinct than a species, but based on readily identified characters and normally occupying a discrete geographical range. For example the ironstone lambertia (*Lambertia echinata* subspecies *occidentalis*) has yellow flowers and long narrow floral bracts and is confined to one population on the Busselton ironstones.

Varieties differ in minor ways from other populations. The golden lambertia (*Lambertia multiflora* var. *darlingensis*) with yellow flowers is distinguished from the red lambertia (*Lambertia multiflora* var. *multiflora*) with red flowers.

So the classification system is always ordered genus-species-subspecies-variety.

swamp devil (*Eryngium pinnatifidum* subsp. *palustre*), spiky blue devil (to be named as *Eryngium ferox*), swamp tribonanthes (*Tribonanthes uniflora*) and a tiny *Samolus*; and several shrubs, one *Astartea* species and one *Hakea* species. The surveys have also found that the highly restricted spider net grevillea (*Grevillea thelemanniana*) is composed of two separate forms, one in the Perth area and the other in the Coojarloo area. These are being described as separate subspecies, which will result in the southern subspecies being again confined to a few wetlands in the Perth area.

Another strange habitat on the Pinjarra Plain is the Muchea limestone. Associated with this limestone is a series of disjunct populations of many species characteristic of the coastal limestones. Because of its unique composition and the very few areas remaining, the vegetation of this habitat is a threatened ecological community and, on closer examination, it looks like some of these separated plants are unnamed species. These include two tussocky speargrasses, both initially placed with the coastal *Austrostipa flavescens*, which are now being recognised as separate species, one in Gosnells and Bunbury and the other only known from near Bunbury. These species are more closely allied to inland salt lake species. Other examples of new species in this habitat are a *Hibiscus* and a *Melaleuca*. The *Melaleuca* is another related to *Melaleuca systena*. It is expected that more new plants will be distinguished as studies continue.

Another interesting habitat is the foothills of the Darling Scarp. The well-known *Grevillea bipinnatifida*, one of the parents of the widely cultivated grevillea Robyn Gordon, has also been found to contain two separate subspecies, one confined to the foothills between Harvey and Serpentine. New surveys along the southern foothills have uncovered a new very restricted triggerplant (*Stylidium korijekup*) in a small area at Harvey. Because this is the only known remaining remnant of this vegetation it is difficult to reconstruct this species' original range.

Species groups

These examples show a common feature of our rich and diverse flora. Detailed ecological and taxonomic studies are showing that many widespread species, previously considered to show continuous variation across their ranges, contain very discrete forms that are best

Above The beautiful red flowered variety of *Lambertia multiflora* from bushland in the Badjingarra area.

Left Wendy's logania is only found growing in a small area of the northern Whicher Scarp.
Photos – Bronwen Keighery

considered as a complex of closely related species. The newly segregated species can be very rare.

As an example, these include such well-known species as common hovea (*Hovea trisperma*) and common brown pea (*Bossiaea eriocarpa*). Despite being subject to recent excellent taxonomic revisions, these species contain populations that differ in morphology, habitats and fire responses, that are difficult to elucidate in a broader study.

Currently considered a widespread variable subspecies, common hovea contains at least three entities on the Swan Coastal Plain, several of which co-occur. In Bullsbrook Nature Reserve both the very large flowered *Hovea trisperma* var. *grandiflora* and the coastal plain form of common hovea grow together, with no sign of hybrids or intergradation. Both of these forms re-sprout from a tuberous rootstock. At the base of the Whicher Range near Busselton the 'true' common hovea (a very small-flowered partially tuberous form, common through the jarrah forest from Perth to Albany, where the species was named) co-occurs with the coastal plain form.

New hotspots

Not only are new plants being routinely uncovered but so too are new potential biodiversity hotspots. Past surveys have shown that the Perth area constitutes a biodiversity hotspot, and current work continues to uncover areas that deserve this ranking. People working on the Swan Bioplan Project have examined areas not covered by previous studies to ensure a more complete picture of the region. The surveys have focused on the Dandaragan Plateau (north of Perth) and the Whicher Scarp (east and south of Busselton).

Previously, surveys in the 1990s around Whicher National Park had uncovered a series of local endemics, such as the Whicher flannel flower (*Actinotus whicheranus*), Bronwen's grevillea (*Grevillea bronwenae*) and Whicher gastrolobium (*Gastrolobium whicherense*). Imagine the surprise when quadrat-based surveys of the

Right Star angianthus (*Angianthus drummondii*) is another of the many new plants found growing in clay pans on the Pinjarra Plain.

Below Female plants of the Whicher lomandra (*Lomandra* species) have male and female flowers on separate plants. It took years to find flowering male and female plants of this new species. *Photos – Bronwen Keighery*

northern section of the Whicher Scarp uncovered a new series of local endemic species—Whicher lomandra (*Lomandra whicherensis*), Wendy's logania (*Logania wendyae*) and two new *Platytheca* species.

The subsequent report on the flora of the Whicher Scarp shows the area deserves to be considered as a separate biodiversity hotspot in itself. There are very high levels of species diversity (more than 90 species in 100 square metres) in some of the banksia woodlands, which is comparable to the northern and southern heathlands. This small area contains more than 900 species of flowering plants.

The report documented that the area has more than 40 endemics and 240 species of conservation significance (100 disjunct populations, 81 species at their range ends and 60 rare species). Of particular interest is the fact that several of these highly disjunct populations (*Lambertia rariflora* subsp. *rariflora* and *Lambertia echinata* subsp. *occidentalis*) are already formally described as separate entities from the main species populations. Preliminary estimates are that another 25 require genetic and taxonomic study. These include the now very rare populations of *Dryandra baxteri* (threatened by *Phytophthora* dieback), which needs urgent management, the already rare *Dryandra mimica* and the Sabina River form of showy dryandra (*Dryandra formosa*), all of which may prove to be separate entities.

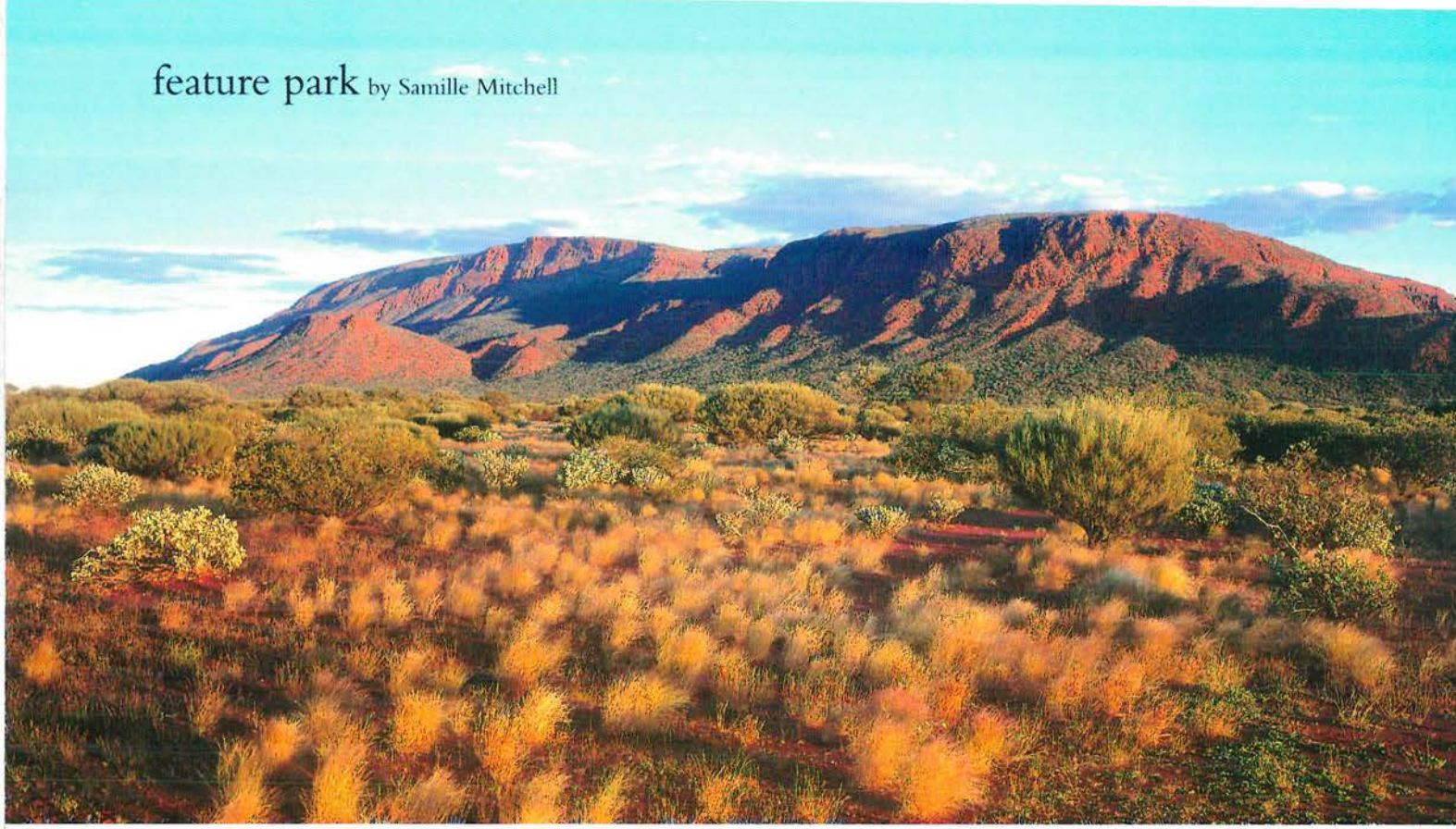
Outcomes and the future

The major aim of these detailed studies is to use the results to improve the reservation and conservation for many threatened communities and species on the Swan Coastal Plain. These improvements are reflected in the fall in the number of plants on the Swan Coastal Plain that were not protected in reserves from 261 in 1999 to 115 by 2005; and that most critically endangered communities have had habitat purchased and reserved.

Many of these previously unknown taxa are highly restricted and could have easily been lost forever without being recorded if their remnant habitat had been cleared, given the development pressures in the study area. It is a reminder that in a mega-diverse region of flowering plants on a world scale, there is no substitute for continuing careful survey of our flora both in the wild and in the laboratory. Accepting the current state of knowledge as complete will surely result in the loss of rare components of our unique biodiversity. We know there are many new plants still awaiting discovery in our bushland and segregation in the Western Australian Herbarium. The thrill of discovery still awaits a new generation of botanists if we keep the 'bush forever' in our city and surrounds.

Greg Keighery is a Department of Environment and Conservation (DEC) senior principal research scientist based at Woodvale. Greg has worked on the plants of the Swan Coastal Plain and adjacent scarps since he began work as a botanist more than 30 years ago. He can be contacted on (08) 9405 5142 or by email (greg.keighery@dec.wa.gov.au).

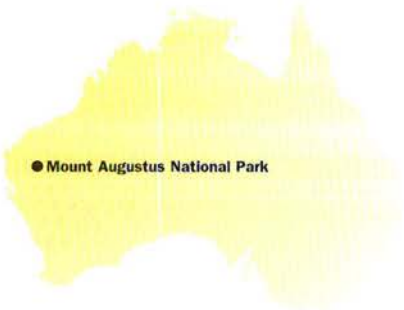
Bronwen Keighery is a DEC senior environmental officer. Bronwen has been working on the plants of the Swan Coastal Plain for the past 20 years. She can be contacted on (08) 9405 5136 or by email (bronwen.keighery@dec.wa.gov.au).



Mount Augustus National Park

Mount Augustus dominates the landscape in the eastern Gascoyne and lures visitors from afar.

The towering hulk of Mount Augustus soars 715 metres above the surrounding plain deep within the red heart of the Gascoyne. You can see it from afar, a slumbering geological giant which changes hues with the path of the sun, from shades of purple at dawn through to greens, browns and brilliant red in the late afternoon light.



History

The mount and the surrounding Mount Augustus National Park are rich in Aboriginal history and significance. The local Wajarri people know the mount as Burringurrah in reference to a Dreamtime story. During this mystical age, a young boy called Burringurrah escaped the rigours of his tribal initiation only to face the consequent wrath of his tribesman. They tracked him down and speared and clubbed him to death. The Wajarri people say the shape of the mount is the boy lying on his belly with his left leg bent up beside his body. The rock formations to the west of the mount show his wounds.

Ancient Aboriginal art adorns many of the mount's caves. Some of the art is so old its meaning has been lost to time. Wajarri believe a spirit continues to live on the mount today. As such, they treat it with great respect and advocate that others do the same.

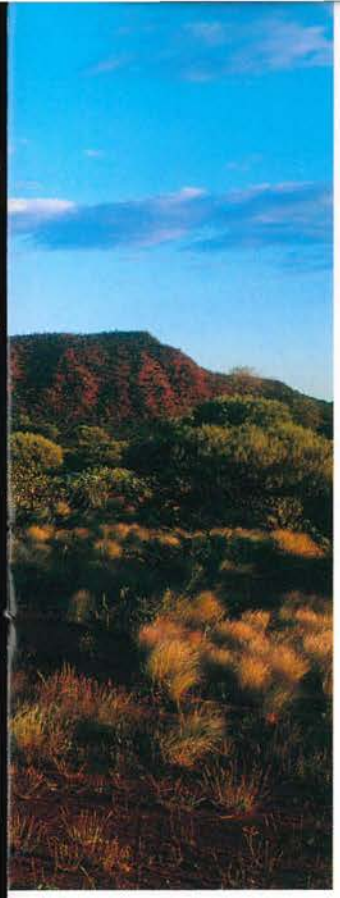
The mount earns its European name from explorer Francis Gregory who scaled it in June 1858 and named it after his brother, Augustus.

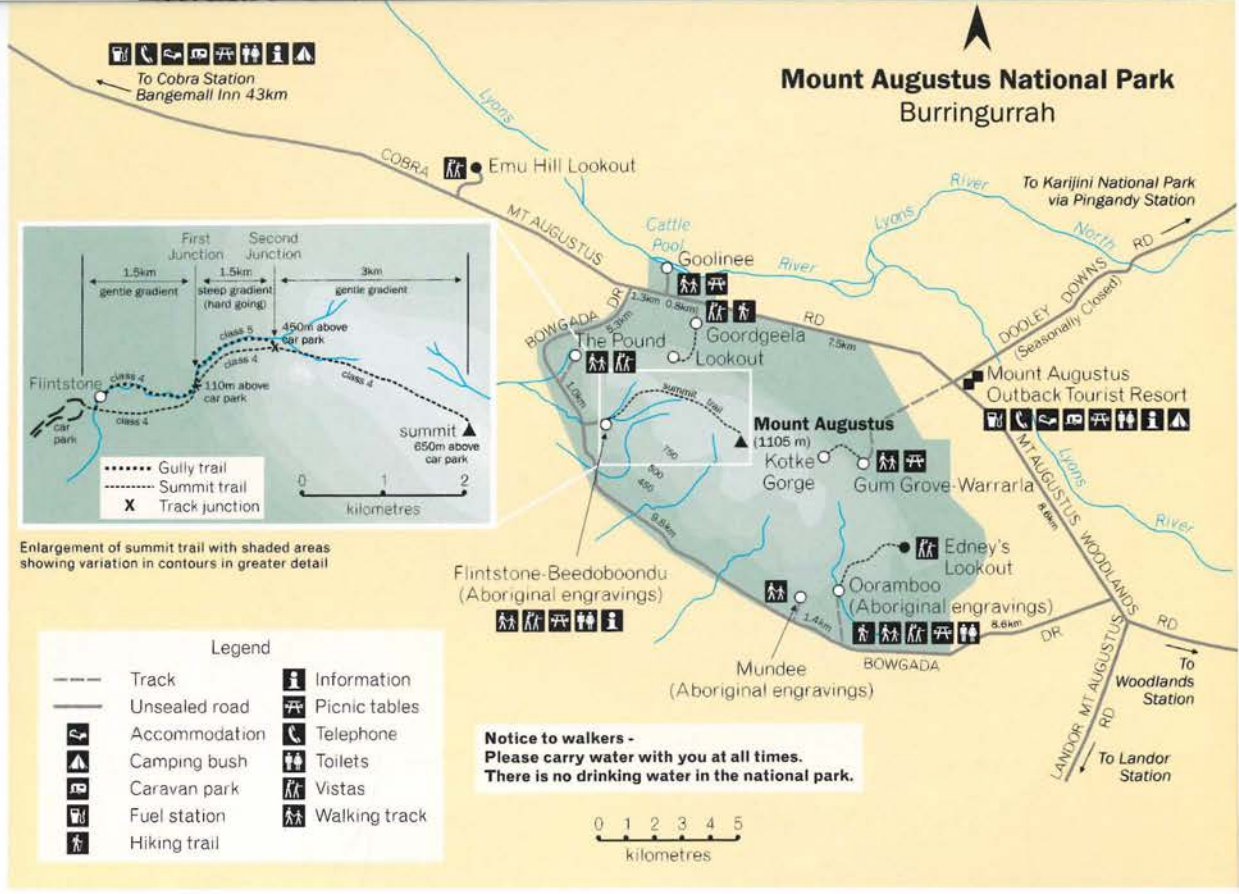
Natural attributes

Mount Augustus is often marketed as being the biggest rock in the world—twice the size of its famous cousin Uluru. But Mount Augustus is not a rock, as such. It's a sandstone and quartz massif with the rather unwieldy geological title of an asymmetrical anticline. This refers to the rock layers that have been folded into an arch-like

Above Mount Augustus.
Photo – David Bettini

Opposite page
Right Aboriginal engravings.
Photo – Rob Olver
Far right A stream cascades down through Kokte Gorge on Mount Augustus.
Photo – Brett Dennis/Lochman Transparencies





structure, which Mount Augustus was about 900 million years ago, before erosion created its current form.

The mount stretches about eight kilometres along its uppermost ridge and covers an area of 4,795 hectares. Water drains from the rock and seeps beneath the surrounding sands to feed groves of white-barked river gums while elsewhere mulga, myall, gidgee and other wattles adorn the red sandplain.

Animal life is varied, ranging from prehistoric-looking goannas to red kangaroos, euros and birds of prey circling on the thermals above. Nearby Cattle Pool is a bird watcher's paradise. Here riotous flocks of budgerigars explode from the branches of trees, and water birds such as black cormorant, swans and ducks adorn the permanent waters.

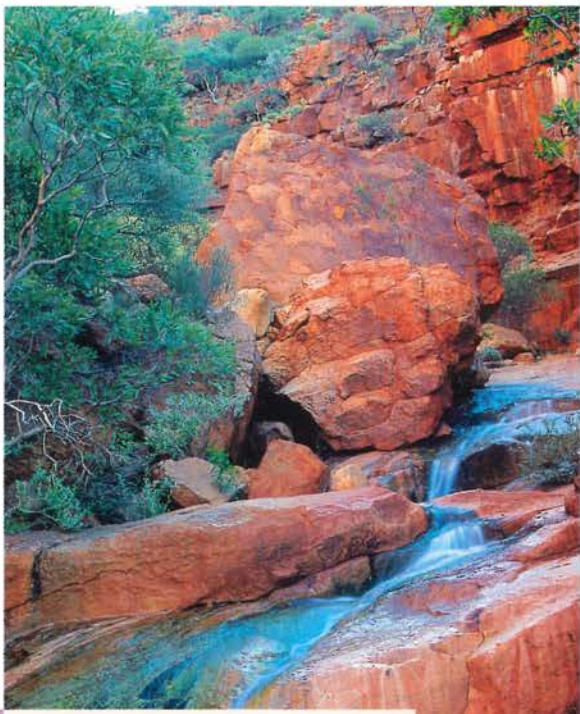
Exploring the park

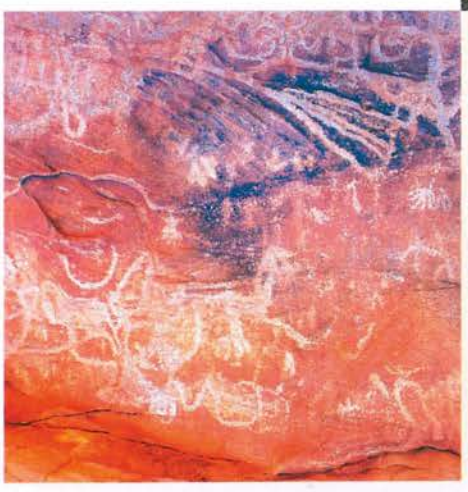
One of the best ways of viewing the changing faces of Mount Augustus is setting out on the 49-kilometre circuit drive. This drive takes in rocky creek gorges, caves, Aboriginal rock engravings, picnic sites and walk trails.

Hikers will find an extensive selection of walk trails, ranging from 250-metre trails to picnic areas and gorges to the challenging 12-kilometre return walk to the mount summit.

About five kilometres west of the park boundary is Emu Hill Lookout—the ideal spot for taking photos of the mount at sunset. Cattle Pool, also known as Goolinee, is also well worth the visit. This permanent pool on the Lyons River is home to a riot of birds and is revered by the Wajarri people for its spiritual value.

There is no camping within the park but accommodation is available at the nearby Mount Augustus Outback Tourist Resort. Accommodation is also available at the historic Bangemall Inn located on Cobra Station, a former pastoral lease now managed by the Department of Environment and Conservation for its conservation values.





park facts

Where is it? 850 kilometres north-east of Perth, 490 kilometres east of Carnarvon via Gascoyne Junction and 360 kilometres from Meekatharra.

Total area 9,168 hectares.

What to see and do 49-kilometre circuit drive trail, Emu Hill Lookout, Cattle Pool, walk trails, Aboriginal art engravings.

Facilities Picnic areas, walk trails, interpretive signage.

Relevant DEC office Carnarvon, 59 Olivia Terrace, Carnarvon, ph (08) 9941 3754.

Two Peoples Bay Nature Reserve

This natural wonderland near Albany harbours some of the world's most threatened animals.

by Anne Cochrane

Two Peoples Bay lies between the massive granites of Mount Gardner and Mount Manypeaks, 35 kilometres east of Albany on the far south coast of Western Australia. The high rocky hills around Mount Gardner (408 metres above sea level) form a headland on the south side of the bay, protecting it from heavy Southern Ocean swells.

The granite coastline to the east, north and south of Mount Gardner is very steep and deeply incised to form streams that descend to the sea. The islands that surround the coast are the crests of drowned granite hills. The area is underlain by rocks of the Albany-Fraser Orogen formation created 1,200 to 1,400 million years ago. These rocks are ancient sediments that were intruded by bodies of granite. The undisturbed coastline and diversity of landscape features, such as the shoreline, cliffs, beaches, reefs, offshore islands, headlands, mountain peaks, dunes, lakes and various vegetation associations, contribute to the area's spectacular scenery.

History

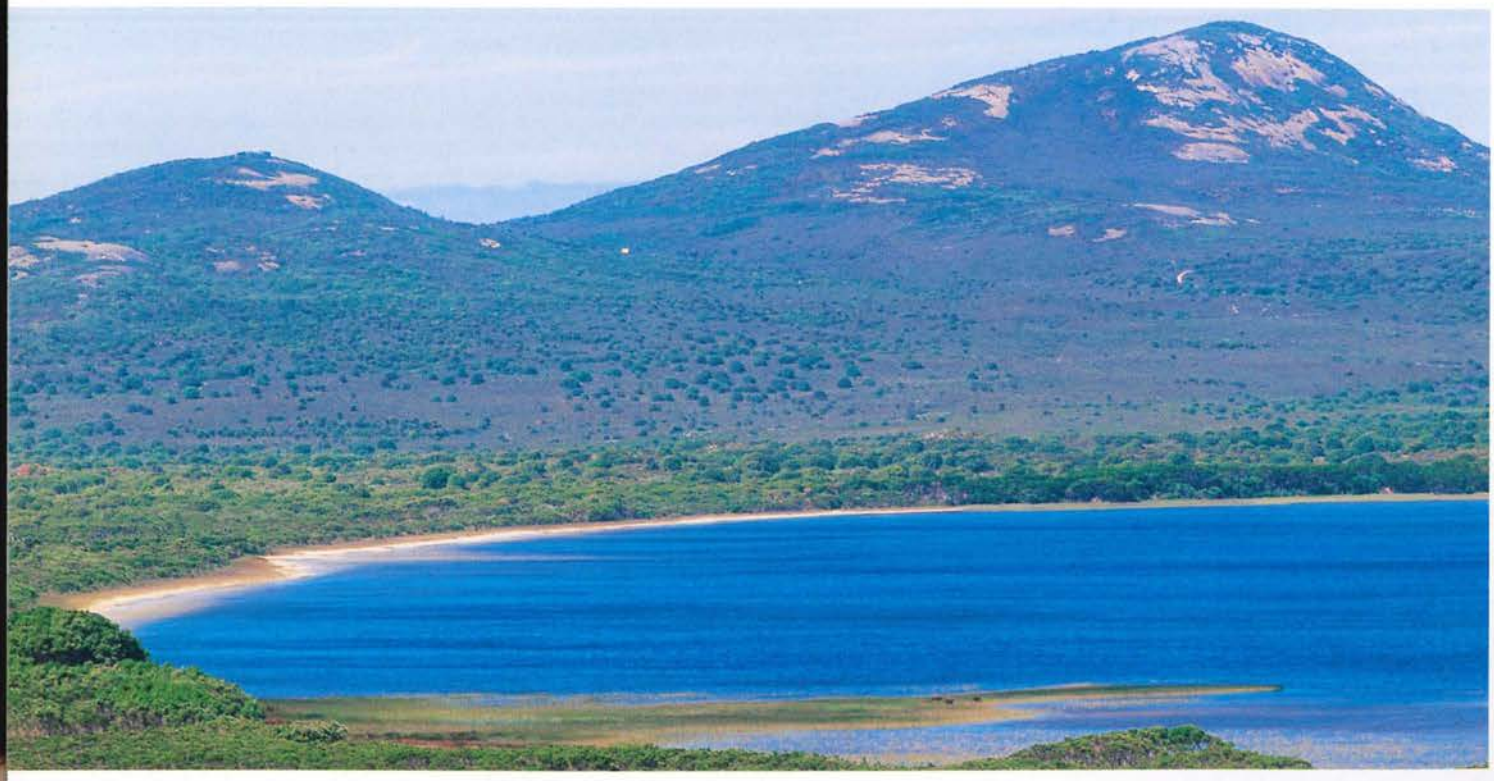
Although the land around Two Peoples Bay was occupied by the Minang Aboriginal people, the name of the area came about through a chance meeting in 1803 between Captain Nicolas Baudin's ship the *Geographe* and the sealer brig *Union* under the command of Captain Isaac Pendleton. The French and American meeting on the far side of the world was commemorated by white settlers in the name *Baie des Deux Peuples*, or Two Peoples Bay. Due to the rich marine life and availability of fresh water, the bay and adjacent areas became an early focus for sealing and whaling activities in the first half of the nineteenth century.

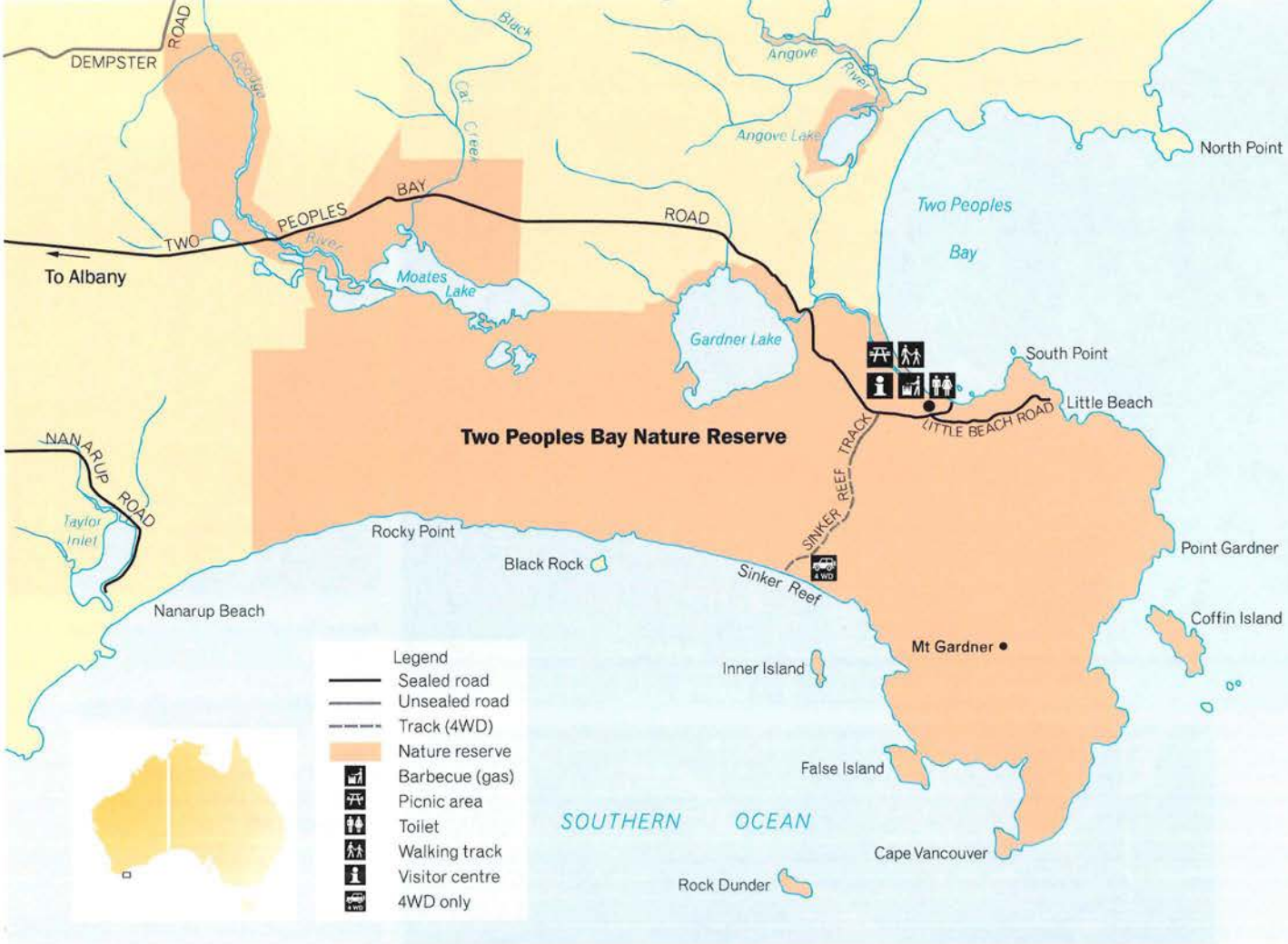
Previous page
Main Two Peoples Bay.
Photo – Damon Annison

Left Nosiy scrub-bird.
Photo – Jiri Lochman

Below Mount Gardner.
Photo – Jiri Lochman

For many years, Two Peoples Bay was used by commercial fishers and became a popular recreation area for Albany residents with picnics and fishing being the main activities. Shacks were first erected in the early 1930s and a small reserve for camping and recreation was set aside. Increased interest in the bay as a holiday resort and private applications for dwelling sites prompted the Department of Lands and Surveys to consider declaring a town site at the bay. The resultant Casuarina town site was formally gazetted in March 1961. But by this time, the rediscovery of a small brown bird, the noisy scrub-bird (*Atrichornis clamosus*), not officially sighted for more than 70 years (see 'Two Peoples Bay: a haven for the lost and found', *LANDSCOPE*, Winter 1996), had conservationists from around the world clamouring to protect the bird's habitat. After several years of debate and discussion it was agreed that the Casuarina town site plan should be cancelled and a reserve created for the conservation of fauna instead.





The Two Peoples Bay Nature Reserve was formally gazetted in 1967 and covers the entire headland, the adjacent islands and the short isthmus connecting to a wetland system of lakes, streams and swamps—remnants of an estuary in the Pleistocene era.

Floral diversity

The landforms and soils support a diversity of vegetation associations, with more than 30 plant communities identified. Tree-dominated communities classified as low forest are prominent to the north of Moates Lake, but also occur on the margins of the lakes and along the major streams of the wetland system, around the picnic area and in small pockets in deep gullies on Mount Gardner. Woodlands are found to the north of Moates Lake as well as on the dunes between Moates and Gardner lakes and the north-eastern slopes of the Mount Gardner headland.

Low heath and shrublands dominate the isthmus area on limestone and calcareous sands and extend to the deeper sands at higher levels around the headland. Dense scrub and thicket dominate much of the headland occurring in gullies and on the slopes.

Above Velvet rush.
Photo – Anne Cochrane/DEC

The 622 vascular plant species recorded in the reserve reflect the great floristic richness of south-western Australia. The reserve is comparatively rich in species of Orchidaceae and Liliaceae. Other important families include Proteaceae, Myrtaceae, Papilionaceae and Epacridaceae. The genera with the largest representation are triggerplants (*Stylidium*), beard heaths (*Leucopogon*), spider orchids (*Caladenia*), wattles (*Acacia*), *Banksia* and *Hakea*.

The reserve has three declared rare species: the pine-leaved andersonia (*Andersonia pinaster*), the grand spider orchid (*Caladenia huegelii*) and the granite banksia (*Banksia verticillata*). A number of priority conservation-

Above Two Peoples Bay andersonia.
Photos – Andrew Brown/DEC

Above left Two Peoples Bay moss.
Photo – Sarah Barrett/DEC

Left The western bristlebird.
Photo – Simon Nevill/Lochman Transparencies

listed flora species also occur within the reserve, including a small moss (*Pleurophascum occidentale*), the showy flame pea (*Chorizema reticulatum*), the Plantagenet triggerplant (*Stylidium plantagineum*), James' paperlily (*Laxmannia jamesii*), a wax flower (*Chamelaucium forrestii* subsp. *orarium*) and *Eucalyptus* x *missilis*, a small hybrid mallee gum tree. The major flowering period for the flora is October.

Noisy scrub-bird haven

In addition to the threatened noisy scrub-bird, the reserve has an unusually rich bird life. Some of the 188 species recorded are sea birds, like the great-winged petrels (*Pterodroma macroptera*), flesh-footed shearwaters (*Puffinus carneipes*) and little penguins (*Eudyptula minor*), which breed on Coffin Island. Others are trans-equatorial waders or nomadic species of honeyeaters, lorikeets and pardalotes, which appear in response to seasonal blossom. The majority, however, are residents that breed within the reserve. For the noisy scrub-bird, the management of habitat and a long running translocation program have seen breeding populations of scrub-birds established between Two Peoples Bay and Cheynes Beach, with a number of birds also found on Bald Island. Wildfire is a key threat to the survival of these mostly ground-dwelling birds and, in recent years, more than half of the population was lost in a single wildfire on nearby Mount Manypeaks. In addition, the presence of the western bristlebird, the heath sub-species of the western whipbird and the Australasian bittern further increase the reserve's status for bird conservation.

Mammal refuge

The nature reserve is also a haven for a number of rare and uncommon mammals. A total of 28 mammals have been recorded. Twelve of these are native marsupials, 10 are other native mammals and six are introduced species. The mammal fauna is typical of the wetter areas of the south coast with many species at or near the eastern limit of their range. The quokka (*Setonix brachyurus*), relatively scarce on the mainland, is of note at Two Peoples Bay. The honey possum (*Tarsipes rostratus*) is present in heaths and scrub despite the reduction of many of its preferred food sources as a result of the plant pathogen, commonly referred to as *Phytophthora* dieback. The diggings of the quenda or southern brown bandicoot (*Isoodon obesulus*) are widespread and individuals are often seen during the day crossing roads and tracks within the reserve. Western ringtail possums (*Pseudocheirus occidentalis*) are occasionally seen in the low forest trees on Mount Gardner. Sightings of mammals in the reserve have increased since foxes have been

Right Gilbert's potoroo.
Photo – Jiri Lochman

Below South western carpet python.
Photo – Alan Danks/DEC

Below right Banjo frog.
Photo – Andy Ballard

controlled under the Department of Environment and Conservation's wildlife recovery program *Western Shield*. Among the marsupials, Gilbert's potoroo (*Potorous gilbertii*) is of major importance and, until 1994, had been officially proclaimed extinct (see 'Lost and found: Gilberts potoroo', *LANDSCOPE*, Autumn 1995) and had not been officially sighted in 125 years. The population comprises fewer than 40 animals and the species is regarded as Australia's most threatened mammal. Steps taken to ensure the ongoing survival of this small mammal include a comprehensive demographic monitoring program that involves radio tracking and trapping animals, cross fostering of animals (see 'Cross-fostering Gilbert's potoroo', *LANDSCOPE*, Autumn 2008), translocation of individuals to a nearby island, away from foxes and cats (see 'Bald Island getaway for Gilbert's potoroo', *LANDSCOPE*, Spring 2005) and the establishment of a new fenced mainland population.

Other life

The freshwater systems of the reserve appear to be at the western or eastern limits of a number of endemic fish species, including the threatened trout minnow (*Galaxius truttaceous*), known from only a few locations in the Albany area. Several frog species have been recorded from the reserve including the moaning frog (*Heleioporus eyrei*), the motorbike frog (*Litoria moorei*), the banjo frog (*Limnodynastes dorsalis*) and the slender tree frog (*Litoria adelaidensis*). Reptiles found in the reserve include oblong turtles (*Chelodina oblonga*), marbled geckos (*Christinus marmoratus*), King's skink (*Egernia kingii*), carpet pythons (*Morelia spilota* subsp. *imbricata*), bobtails (*Tiliqua rugosa* subsp. *rugosa*) and southern heath monitors (*Varanus rosenbergi*). Many of these reptiles can be either seen or heard when walking at Two Peoples Bay. In recent years a population of the trapdoor spider 'Moggridgea' was found in a gully on Mount Gardner. This spider's ancestors occurred at the time of the super-continent Gondwana.

The sea adjacent to the reserve also has high conservation value and provides feeding areas for many marine mammals. Marine mammals recorded off Two Peoples Bay include the

Left Looking towards Mount Manypeaks from the east.
Photo – Michael Pelusey

Below Yellow navel.
Photo – Neale Bougher/DEC

common dolphin (*Delphinus delphis*), the bottle-nosed dolphin (*Tursiops truncatus*), which is often recorded in schools of 20 or more, southern right whales (*Eubalaena australis*), which are regular visitors with females and calves sometimes present during the calving season, humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*) and killer whales (*Orcinus orca*).

The reserve also has a very rich and varied fungal flora, particularly in the long-unburnt areas of heath and woodlands. Extensive surveys have revealed 441 species, the majority undescribed. Some of the more visible and highly colourful species found in early autumn to early spring include the orange fan (*Anthracophyllum archeri*) and the yellow navel (*Lichenomphalia chromacea*) fungi. The abundance of fungal species is associated with the exclusion of fire resulting in the accumulation of organic matter in and on the soil. Gilbert's potoroo is heavily reliant on underground fungi or truffles for food.

Deadly dieback

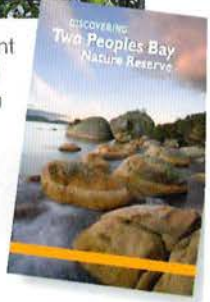
Dieback caused by the plant pathogen *Phytophthora cinnamomi* has been present in the reserve for a long time and has had a major effect on the vegetation. The consequent loss of banksia from much of the isthmus and granite hill areas may have resulted in a change from open woodland to open heath. The rare Albany banksia (*Banksia verticillata*) has become extinct from the reserve due to the pathogen.

Dieback is currently affecting hakea and banksia-dominated scrub and thicket on Mount Gardner, leaving more open sedge-dominated communities. Walkers in the area are advised to keep to established tracks and should be mindful of walking in the bush in wet soil conditions. Keeping walking boots clean of mud and soil will help prevent spread of the disease to other sites. Fire may also alter the structure of the vegetation over time and the long period since fire is unusual for comparable areas of coastal vegetation. The changes occurring in the vegetation after fire and the effects of dieback have implications for the conservation of many of the reserve's unique species.

Exploring Two Peoples Bay

Two Peoples Bay is an important area for scientific study but still provides opportunities for public recreation and enjoyment. More than 55,000 visitors a year are attracted to the area, a relatively high number of visitors for a nature reserve. Due to the rare fauna species found at Two Peoples Bay, public recreational activities are kept to a minimum, with low-impact recreation such as nature pursuits favoured. The beaches of Two Peoples Bay are clean and white and the waters cool and clear. In particular, the calm protected waters of Little Beach, nestled between lichen-covered granite headlands, are ideal for swimming. Crystal clear waters make diving a popular activity and the fish life is outstanding, drawing recreational fisher folk. Due to the rich diversity of marine species in the area, the waters off Two Peoples Bay are set to become a marine reserve to conserve marine plant and animal life. A short stroll on the Two Peoples Bay Heritage Trail leads you over the headland and along the beach, taking in interesting vantage points providing fantastic views of the coastline and intersecting several different vegetation communities. Gas barbecue facilities and a grassed picnic area can be found near the main beach and a visitor centre is located nearby.

Anne Cochrane is a senior research scientist working with the Department of Environment and Conservation (DEC) in Albany. She can be contacted on (08) 9842 4500 or by email (anne.cochrane@dec.wa.gov.au). Information in this article is based on DEC's new publication *Discovering Two Peoples Bay Nature Reserve*. The book is available for $6.50 from bookshops and tourist outlets, by phoning WA Naturally Publications on (08) 9334 0437, by ordering online at www.dec.wa.gov.au/shop or using the form between pages 40 and 41.



endangered by Andrew Brown

Woolly lysiosepalum

A member of the *Sterculiaceae* family, *Lysiosepalum* is a small genus of five species endemic to the Albany–Geraldton area of Western Australia. All are shrubs to 1.5 metre high with attractive pink or pink–mauve, star-shaped flowers. Petals are reduced to scales or are absent, and the six sepals are petal-like. The name *Lysiosepalum* is derived from the Greek *lysios*, meaning loosening, and the Latin *sepalum*, meaning sepal, in reference to the divided sepals found in all species.

While three *Lysiosepalum* species are relatively common, the other two, pepper-scented lysiosepalum (*Lysiosepalum aromaticum*) and woolly lysiosepalum (*Lysiosepalum abollatum*), are rare, with the former known from one population near Highbury and the latter from one population near Wongan Hills.

Described by Carol Wilkins in 2001, woolly lysiosepalum is a dense shrub to 1.5 metres high by 1.5 metres wide with stems and leaves covered in distinctive, white, woolly hairs—hence the species' common name. Its leaves are mid green in colour, and 10 to 16 millimetres long by two to three millimetres wide. Up to eight pink, or pink–mauve flowers, 16 to 30 millimetres across, are borne on inflorescences 40 to 90 millimetres in length. Flowers appear between August and September.

Woolly lysiosepalum is similar to wrinkled leaf lysiosepalum (*Lysiosepalum rugosum*) in having an upper leaf surface that is wrinkled rather than smooth, but is distinguished by its shorter leaf stalks, and leaves with large, long-stalked hairs, rather than small, stalkless hairs.

In the single-known locality, the species grows in red and orange-brown sandy-clay soil with York gum (*Eucalyptus loxophleba*), sandplain mallee (*E. ebbanoensis*), and *Acacia*, *Grevillea* and *Hibbertia* species.

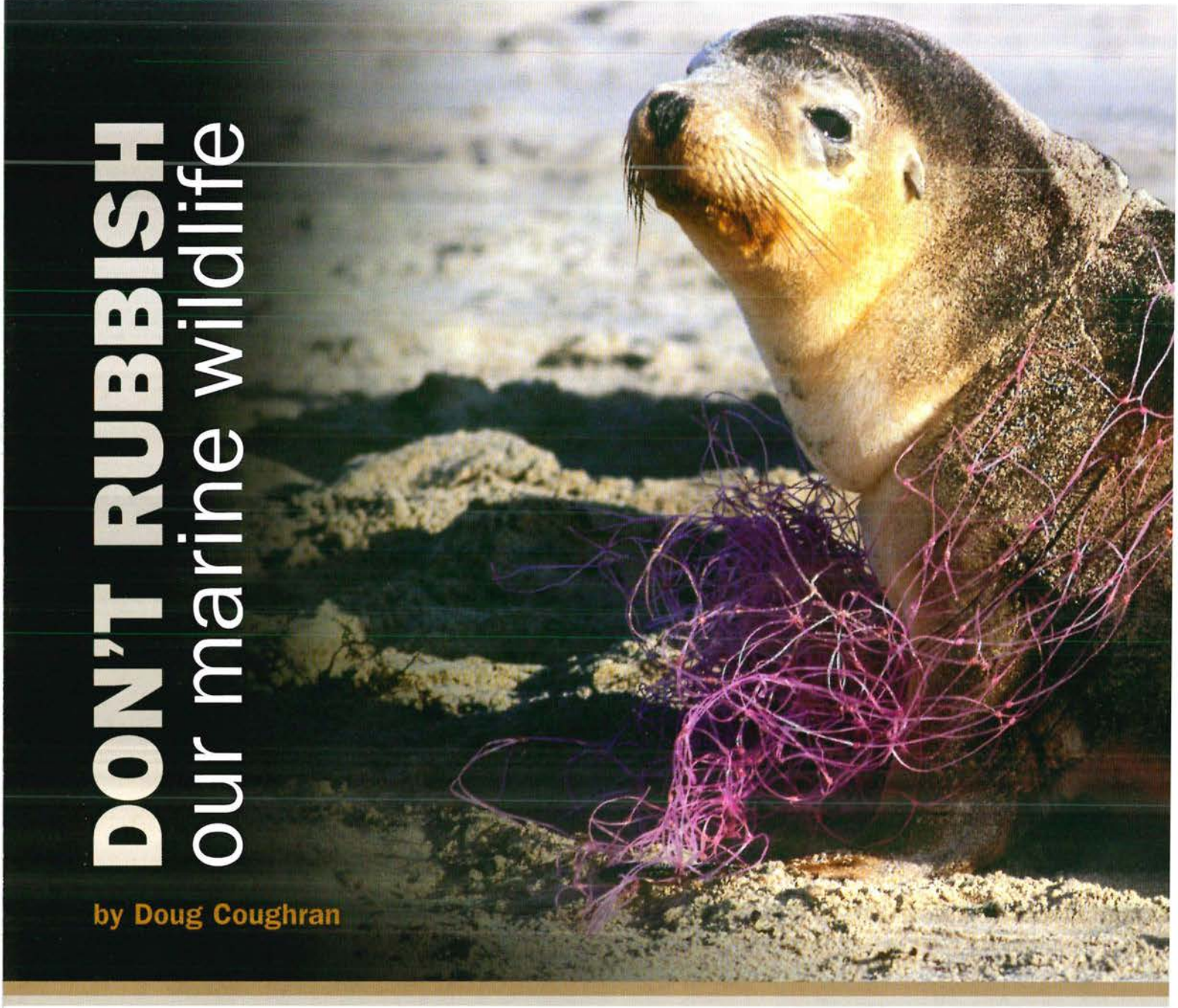
Woolly lysiosepalum was first collected in 1976 and, despite numerous surveys since, has not been found anywhere else. Just 129 plants are known and, due to restricted habitat and threats associated with low population size, poor recruitment and drought, the species is currently declared as rare flora under the Western Australian *Wildlife Conservation Act 1950* and ranked as critically endangered. The species is not currently listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The Department of Environment and Conservation's (DEC's) Avon-Mortlock District Threatened Flora Recovery Team is implementing an interim recovery plan for the species. Recovery actions include fencing to exclude stock and other herbivores, seed collection and propagation of additional plants.

It is possible that there are more populations of woolly lysiosepalum in the Wongan Hills area. If you think you have found this species, please advise DEC.

Photos by Sonya Thomas

DON'T RUBBISH our marine wildlife



by Doug Coughran

In 2005, Phil Coulthard, from the Bunbury Dolphin Centre, photographed a baby dolphin with a recreational fish hook and rig under its eye that had opened up the flesh. In 2000, an autopsy on a Bryde's whale that died in Trinity Bay near Cairns revealed that it had tightly packed plastic in its stomach. Supermarket bags, food packages, bait bags, sheets of plastic and remnants of garbage bags had all been ingested, but no food was found. Sadly these kinds of incidents are becoming more and more commonplace.

Go for a stroll on any remote island anywhere in the world and you will find plastic litter on beaches. For example, Mystery Bay on Dirk Hartog Island, one of the most remote beaches in Western Australia, is literally covered in ropes, polystyrene floats and plastic rubbish. Where is all this junk coming from? Historically, both the shipping and fishing industries have played a large part in causing the problem, sometimes inadvertently. Plastic is either lost from ships or deliberately dumped. Even plastic dumped on land can be blown for long distances or carried along waterways, eventually ending up in the ocean. Because it takes years to break down, this waste can spend decades riding the world's ocean currents before being dumped on a 'wreck trap' like Mystery Bay.

Turning turtle

The rubbish itself is one problem, but the real damage occurs when marine animals confuse plastic bags, balloons, bait packets, lolly wrappers and rubber with prey and eat them. Many species of turtle feed on jellyfish. To a turtle's senses, floating plastic bags are indistinguishable from food. Sea birds eat polystyrene balls and plastic buoys, after confusing them with fish eggs and crustaceans. Baleen whales such as blue whales, humpback whales, southern right whales and the Bryde's whale mentioned before take big gulps of water to feed on krill that they filter through their baleen, and may accidentally swallow plastic rubbish when feeding.

Ironically, starvation is the major cause of death for birds or mammals that ingest plastic. It is indigestible and can fool the animal into believing its stomach is full of food, as well as preventing proper digestion or elimination of any food that is eaten. Sea birds caught in marine debris may

Plastics are the most common man-made objects sighted at sea, with 18,000 pieces of plastic litter floating on every square kilometre of the world's oceans. Six million tonnes of debris enters the world's oceans every year. According to one source, plastic marine litter is killing up to a million sea birds and 100,000 marine mammals, such as dolphins, whales and seals, every year around the world. What is being done to keep the sea plastic free?

Main Juvenile sea lion entangled in fishing net.
Photo – Nick Gales/Lochman Transparencies

Right A rope in the mouth of a minke whale caused it to starve and strand at Dunsborough.
Photo – DEC

also be prevented from moving quickly through the water, reducing their ability to catch prey and avoid predators. They can also suffer constricted circulation, asphyxiation and subsequent death.

A 2007 study in Queensland found that plastic bags were the leading cause of death of marine turtles, with 23 per cent killed by the ingestion of marine rubbish.

Entanglement

Entanglement is another problem associated with marine rubbish and is also increasing in frequency, especially as populations of threatened whales that migrate along our coast recover in numbers. If animals become entangled in lines, nets, ropes or plastic, it can restrict their movement and lead to starvation, infection, amputation and drowning. Turtles, whales, sea lions, sea birds and dolphins may be severely injured and even die if they become entangled.

In March 2005 a southern right whale had to be rescued from waters between Albany and Denmark after it was sighted dragging heavy 60-millimetre ropes and large floats consistent with those used in deep ocean fishing in international waters. More recently, a 10-metre Bryde's

Left DEC's Doug Coughran disentangling a leatherback turtle off Scarborough.
Photo – Fisheries WA

Centre left This sea lion was eventually captured 10 months after it was first sighted and DEC staff were able to successfully remove the rope. The sea lion survived.
Photo – Kevin Crane/DEC

Centre right Hooks and line embedded in a bottlenose dolphin calf's face.
Photo – Phil Couthard

Below DEC team successfully disentangling ropes from a humpback whale off Scarborough in 2004.
Photo – Pauline Goodreid/DEC

whale entangled in ropes off the Western Australian coast at Cervantes was freed on 20 March 2008 by the crew of the Department of Fisheries patrol vessel *Hamelin*, supporting Department of Environment and Conservation (DEC) rescue efforts. On arriving at the site, the crew found the whale was in very poor condition and starting to drown. Because the whale was small and very lethargic, a decision was made to cut some of the ropes which fortunately enabled the whale to swim away.

An upsetting worst case involving entanglement in marine debris was experienced by DEC staff on 29 March 2007 when a minke whale was found stranded in shallow water at Meelup Beach, Dunsborough. The whale was entangled in rope debris, was severely emaciated and starving. Its shocking condition was caused by a loop of rope through the mouth which prevented it from feeding. The entanglement was probably carried by the five-to-six-metre minke whale for more than 12 months. Sadly, the whale did not survive.

DEC has formed a specialised marine mammal disentanglement team that is at the forefront of developing techniques to safely rescue and disentangle whales and other marine animals. In WA, the fishing industry is also very proactive and supportive of efforts to reduce the probability of large whale entanglements and has adopted world's 'best practice' in making changes in the way it operates

and recovers any discarded fishing gear when found, returning it to shore for appropriate disposal.

Keeping the sea plastic free

Governments, non-government organisations and local communities everywhere are taking action to reduce litter in our oceans and raise public awareness. The Commonwealth Department of the Environment, Water, Heritage and the Arts conducts a 'Keep the sea plastic free' campaign to raise public awareness about the consequences of marine litter (it estimates that more than 70 per cent of rubbish in our oceans is plastic).

Marine park rangers from DEC help educate boat users and other marine park users about disposing of plastic bags and other rubbish thoughtfully. DEC has recently developed a website for primary school students (www.marineparks.wa.gov.au) which includes pages on the effects of litter on marine wildlife (see 'New marine parks website a hit with kids' on page 51). It is also developing a teachers' resource on marine parks for secondary school students that includes a field trip to collect and analyse marine debris found on local beaches.

Last year, the Western Australian town of Exmouth, which is the nearest large town to Ningaloo Marine Park, made a huge leap forward, becoming a 'plastic bag free' town. The local Cape Conservation Group has run a six-year 'No plastic fantastic!' education campaign to make the community aware of the problem with plastic bags and to persuade the community and tourists to use reusable bags. On 1 November 2008, both the local supermarkets stopped putting people's shopping in plastic bags, which are no longer available.

Above all, public education is vital. All the policing in the world will do no good until individuals and industry realise the impact of plastics on the marine environment. It may once have seemed fairly harmless to toss bait bands or lunch bags overboard. One look at a sea lion slowly dying must surely convince you otherwise.

Above Dolphin Discovery Centre and DEC staff have been working to cut away knotted fishing line embedded in the beak of a dolphin calf in Bunbury.
Photo – Dave and Fiona Harvey

Above box background Ocean debris accumulation at Mindarie Keys marina.
Photo – Len Stewart/Lochman Transparencies

Right Marine animals can mistake floating plastic bags for jellyfish.
Photo – Eva Boogaard

FACTS ABOUT MARINE LITTER

Do you know how long it takes for litter to break down in the ocean?

- Paper bus and parking tickets: two to four weeks.
- Orange and banana peel: up to two years.
- Cigarette butts: one to five years.
- Plastic bags: 10 to 20 years.
- Foam cups and tin cans: 50 years.
- Aluminium cans: at least 80 years.
- Plastic bottles: 450 years.
- Fine fishing net: at least 600 years (much longer for heavier nets).
- Glass bottles: one million years.

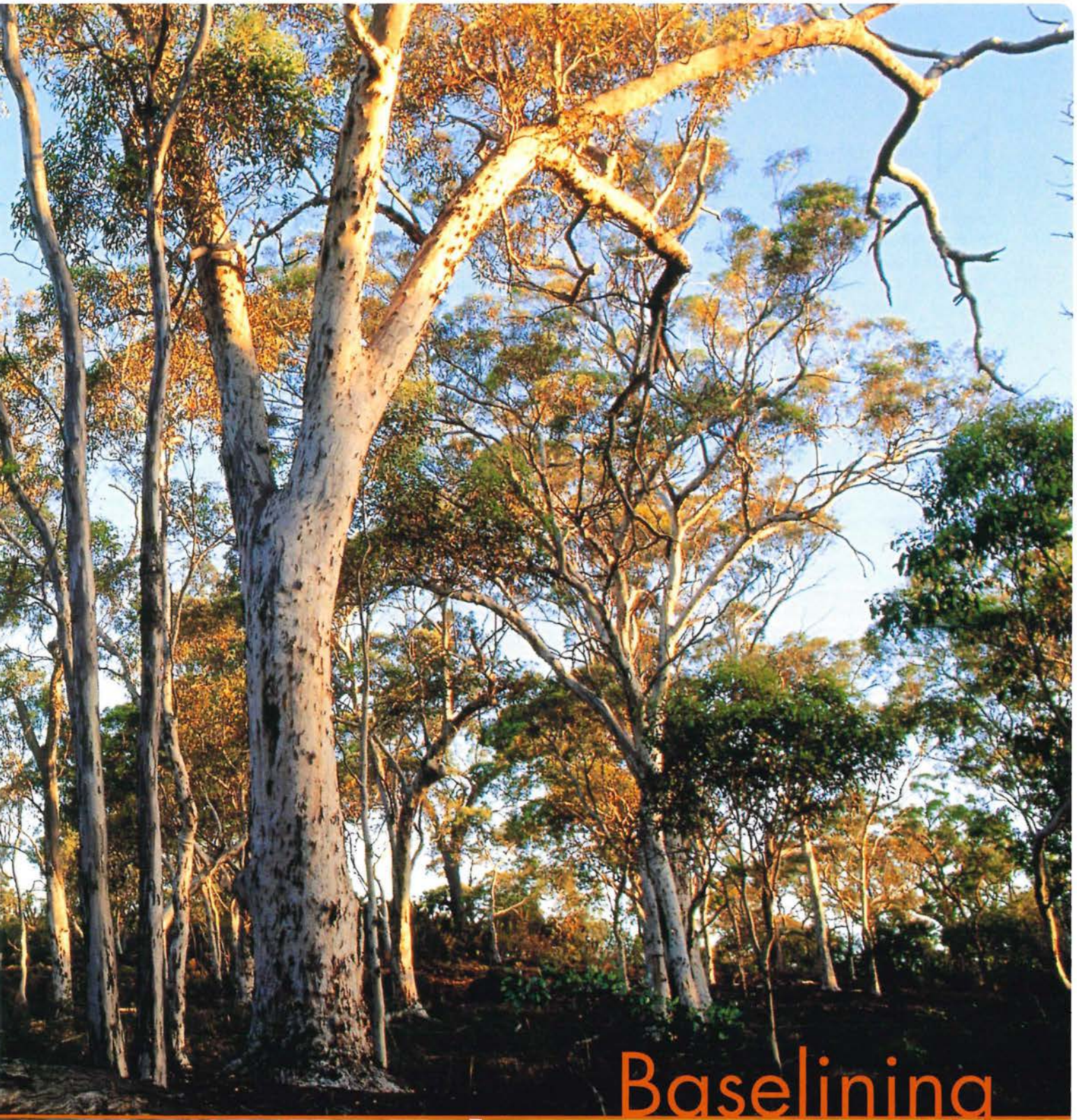
More than 260 animal species worldwide have been recorded entangled in or having consumed fishing line, nets, ropes and other discarded equipment.

An astounding 86 per cent of all marine turtles are affected by marine debris.

Every day ships throughout the world discard 5.5 million pieces of rubbish into our oceans.

Australians use more than four billion plastic bags per year—if these were tied together they would stretch around the world 42 times!

Doug Coughran is a Department of Environment and Conservation senior wildlife officer specialising in marine wildlife incident management. He leads efforts to disentangle marine animals trapped in debris. He can be contacted on (08) 9334 0339 or by email (douglas.coughran@dec.wa.gov.au).



Baselining the Avon

by Jeff Richardson and Joanna Moore

Straddling Australia's only globally recognised biodiversity hotspot is the Avon Natural Resource Management Region—an area of extraordinary species diversity. Who would think that this largely cleared and primarily agricultural region contains more than 25 per cent of Australia's and more than 1.5 per cent of the world's flowering plant taxa? This is only one of the reasons for the development of a project aimed at determining the natural values of the region.

Nature conservation is a challenging task, especially in a place as diverse as the south-west of Western Australia where the natural assets are diverse, poorly known and suffer numerous threats. To help fill the gaps in knowledge, the Avon Natural Diversity Alliance (ANDA) has developed a project called Avon Baselining to measure, or 'baseline', the area's natural values. Information gleaned from the wide-ranging project will be used to support many other projects aimed at conserving the natural diversity of the Avon Natural Resource Management (NRM) Region—a primarily agricultural region within the south-west of WA. In the process, Avon Baselining has revealed an extensive suite of plants and animals and highlighted areas in need of further protection and study.

Project parameters

ANDA is a partnership between government and non-government organisations that tackles nature conservation in the 13-million-hectare Avon NRM Region. The region stretches from just behind the Perth metropolitan area, through the central and southern Wheatbelt and beyond the agricultural region to about halfway between Southern Cross and Kalgoorlie—an area twice as big as Tasmania. Country towns including Wongan Hills, Mukinbudin, Northam, Merredin, Lake Grace, Kondinin and Beverley lie within the area.

The Avon NRM region straddles what is known as the South West Botanical Province of Western Australia, one of the world's biodiversity hotspots. This hotspot title recognises the region's high diversity of species—the Avon is home to more than 5,000 different types of plants, of which more than 400 are confined to the Wheatbelt—and the high level of threat to this biodiversity. Threats include vegetation clearing, pest animals, salinity and climate change. The south-west of WA is ranked as one of the six world biodiversity hotspots most vulnerable to climate change.

Vegetation clearing in the area has occurred from the beginning of European settlement in WA. Within the agricultural area, which makes up most of the region, 16 per cent of the vegetation is left, or about 1.3 million hectares. Agriculture has led to patchy remnants of native vegetation—about 110,000 patches across eight million hectares of agricultural land.

Previous page
Main Wandoo woodland in the southern Wheatbelt.
Photo – Marie Lochman
Insets from left Carnaby's black-cockatoo.
Photo – Babs and Bert Wells/DEC
Grevillea scapigera.
Bindoon starbush (*Asterolasia nivea*).
Photos – Andrew Brown/DEC
Western spiny-tailed skink near Koorda.
Photo – Rowan Inglis/DEC

Above Salinity-affected land.
Photo – Jiri Lochman

Above Biodiversity of flora in the Wheatbelt region.
Photo – Marie Lochman

Right Wongan Gully wattle (*Acacia pharangites*).
Photo – Luke Sweedman

ANDA is supported by the Avon Catchment Council (funded through the State and Commonwealth governments' Natural Heritage Trust and National Action Plan for Salinity and Water Quality) and includes a range of government and non-government organisations which have come together to conserve the natural values of the region. Greening Australia WA, WWF-Australia and the Western Australian Government departments of Environment and Conservation (DEC) and Water are members of ANDA. Run by DEC, the Avon Baselining project was conceived by ANDA with the intent of informing the alliance's five other conservation projects about the natural attributes of the area.

Where do we start?

Collating data across an area as large as the Avon NRM region was a significant task. It involved gathering existing data from a range of sources in each of three broad areas: natural assets, threats to these assets and current or historic conservation programs. Some of these datasets are huge.

For example, there are more than 80,000 plant specimens, known as vouchers, from the region in the Western Australian Herbarium, some 110,000 bird records from Birds Australia's Bird Atlas and more than 26,000 animal vouchers from the Western Australian Museum. DEC's Threatened Flora Database was also a useful source of information, providing 13,000 records about declared rare flora. Frequently, taxonomy was a major issue—for instance the bird names used by Birds Australia differ from those used at the Western Australian Museum.

Fascinating flora

It is astounding to think that 25 per cent of Australia's flowering plants can be found in the Avon NRM region. The region also has a high number of WA's threatened and priority flora populations and perhaps this is to be expected, given the amount of vegetation that has been cleared during decades of farming in the agricultural region. For example, 34 per cent of WA's 137 critically endangered plant taxa are found in the Avon NRM region.

The process of examining plant specimens at the Western Australian Herbarium showed that there are large areas in the Avon NRM region from which few or no specimens have been gathered. In a region with such high plant species diversity, dozens of rare plants and many endemic ones, this is a cause for concern. Also, there are many taxa that have been recorded infrequently and, due to the imprecise records for the vouchers, it is hard to know exactly where they were collected.

The Avon is also home to one of the world's rarest plants: Bancroft's symonanthus (*Symonanthus bancroftii*). Previously thought extinct, this species was rediscovered in 1998 with the recording of a single plant within the region. This single plant has now been cloned and two new populations established from these clones. No other known populations exist for the species.

Fauna under threat

Across the region there are nearly 1,200 known fauna species, including 165 species of bird, 121 reptiles, 56 mammals, 22 amphibians, 19 fish and more than 800 species of invertebrates. The fauna currently found in the Avon are a subset of what was there historically: the endangered dibbler (*Parantechinus apicalis*) was recorded in the region in 1843 near New Norcia; the western ringtail possum (*Pseudocheirus occidentalis*) was last recorded in the area in the 1970s from Tutanning Nature Reserve; and the endangered western barred bandicoot (*Perameles bougainville bougainville*) also has just one record from the region, in 1906.

These species are now considered locally extinct and this contraction from the region is consistent across the south-west: the dibbler is now only found on off-shore islands and the south coast; there have been no confirmed sightings of the western ringtail possum in the Wheatbelt since the 1970s; and the only natural populations of the western barred bandicoot are on two islands off the mid-west coast.

However, many other threatened fauna can still be found in the region. For example, the red-tailed phascogale (*Phascogale calura*) is still known in

Top left Scarlet lechenaultia (*Lechenaultia laricina*).
Photo – Andrew Brown/DEC

Centre left Botanic Gardens and Parks Authority's Bob Dixon with Bancroft's symonanthus (*Symonanthus bancroftii*).
Photo – Marie Short/DEC

Left DEC conservation officer Rowan Inglis releasing a rock wallaby at Mount Caroline Nature Reserve.
Photo – Nicole Willers/DEC

Right The southern dibbler is now extinct in the Avon NRM region.
Photo – Jiri Lochman

suitable habitat and so are black-flanked rock-wallabies (*Petrogale lateralis lateralis*) and numbats (*Myrmecobius fasciatus*). Declines of fauna, though, are continuing. Of the 165 species of birds in the region many, such as the sedentary woodland birds, are in decline.

The challenge is to identify the taxa in decline, determine ways to halt the decline and ensure that this is incorporated into the ANDA projects. So far, the Avon Baselining project has identified the declining species, their locations, the processes which threaten their survival and what actions are required to ameliorate this decline.

Conservation threats and programs

The conservation of plants and animals in the Avon NRM region is complicated by the patchy structure of its remaining vegetation and the small size of these remnants. Of the 110,000 patches of vegetation in the agricultural area, nearly 70,000 are less than one hectare in size and only about 1,000 are more than 100 hectares. This fragmentation results in the modification of ecological processes and species activities and is a severe threat to biodiversity in the region.

Furthermore, salinity is causing habitat loss, effectively 'clearing' more land of native vegetation. And the situation is probably worse than it currently appears because there is a delay between habitat loss and loss of species. This is called 'extinction debt' and it may be centuries before it is fully realised. Ubiquitous foxes and cats pose another threat, as do *Phytophthora* dieback and climate change, which is expected to substantially reduce the rainfall in the region, having unknown impacts.

Reflecting the substantial biodiversity of the region, there are numerous biodiversity conservation programs in place. Many of the larger nature reserves in the region are part of DEC's *Western Shield* fox baiting and fauna recovery program. Every DEC district in the region has a flora conservation program and staff dedicated to conservation and recovery of threatened flora. DEC's *Land for Wildlife* program works with local landholders to help them manage their bushland to preserve habitat.

The Avon Catchment Council, through ANDA, has provided an opportunity to augment these programs. *Back from the Edge* is an ANDA project aimed at recovering threatened fauna and flora across the region. The Healthy Ecosystems project, which is managed by WWF-Australia, works with landholders to protect priority ecosystems. The Ecoscapes project, managed by Greening Australia, WWF-Australia, the Department of Water and DEC, is working to recover biodiversity at a landscape scale. The Avon Baselining project provides information on the current state of biodiversity in the region, to help each of these projects proceed.

Prioritisation is the key

The first phase of the Baselining project was to collate all the regional biodiversity data into standardised formats. This allowed for the second phase of the project—analysing these data to inform or prioritise the other projects within ANDA. For example, the rare flora monitoring data were analysed, aimed at informing the *Back from the Edge* project about the salinity risk, other risks and the monitoring history of each population of rare flora.

Above Red-tailed phascogale.
Photo – Jiri Lochman

Left Landholders and WWF-Australia officers discuss a voluntary covenant near Trayning in the Wheatbelt.
Photo – Mike Griffiths

Below Colourful snakebush (*Hemiandra rutilans*).
Photo – Andrew Brown/DEC

Baselining also identified the priority ecosystems for the Healthy Ecosystems project.

The third phase of the biodiversity Avon Baselining project was to identify gaps in present knowledge and programs and prioritise them. One of the first gaps identified was the lack of fine-scale vegetation mapping in a format that could be used by ANDA projects. Baselining has now synthesised all existing fine-scale vegetation mapping across the region into a searchable geographic information systems database. This constitutes an area of about 185,000 hectares, or more than eight per cent, of the remnant vegetation in the region's agricultural area.

Another important gap the Avon Baselining project identified was the need to develop a strategic conservation plan for the region. This challenge is now being tackled by Professor Bob Pressey from James Cook University for the Avon's vegetation, ecological communities and species. The plan will create an analysis of return on investment in conserving the rare, priority and of-concern fauna and flora species that have been identified through the analysis stages of the Avon Baselining project. The plan will help determine how best to deal with conserving these valuable assets in a region of such complexity.

Baselining is currently developing a framework for vegetation management and restoration, which defines management objectives.The framework is based on the Avon Baselining project's vegetation mapping component, some work delivered through the Healthy Ecosystems project and a co-managed project between WWF-Australia and the Avon Baselining project. The project, called the 'After the Fence', is being delivered by Murdoch University and CSIRO and asks the fundamental question:"Is fencing remnant vegetation useful?" The project specifically examines what happens when fences are put around patches of York gum, a common Avon community.

Where to now?

The Avon NRM region is an area of high biodiversity conservation significance that is under high threat. In researching biodiversity assets, threats and existing biodiversity-related programs across the region, the Avon Baselining project collated and interpreted data which will enable the all-important prioritisation of conservation actions. The partnering five projects in ANDA are already achieving great results, working at the species, biological community, ecosystem and landscape levels of biodiversity. In addition to the programs which are already under way, it is hoped the knowledge gained will help with prioritising more on-ground work as well as landscape-scale biodiversity planning for the future.

Jeff Richardson is the coordinating ecologist with the Avon Baselining project team and is based DEC's Science Division at Kensington. He can be contacted on (08) 9334 0548 or by email (jeff.richardson@dec.wa.gov.au)

Joanna Moore is a DEC communications officer.

New **marine parks website** a hit with kids

The Department of Environment and Conservation recently developed a new website, **www.marineparks.wa.gov.au,** to inform primary school students about why it is so important to conserve Western Australia's amazing marine environments in marine parks and reserves.

by Carolyn Thomson-Dans, Kate Fitzgerald and Ryan Scott

It is vital that the State's marine parks and reserves are managed to ensure they remain in good condition and one of the most effective ways to do this is through community education and public awareness programs. Young people now access information in more and more sophisticated ways, and any conservation agency that is serious about educating children about our important natural areas needs to have a fun and interactive website. As a result, the Department of Environment and Conservation (DEC) recently developed a new website to educate primary school students about marine parks and the unique plants and animals that they support. The site contains scientifically accurate information and can be found at www.marineparks.wa.gov.au.

Marine park mania

Three friendly animated marine characters feature on the home page of the website: 'Fin' the baby humpback whale, 'Toot' the Western Australian seahorse and a friendly green turtle, yet to be named (kids with any suggestions for names may write to *LANDSCOPE*). The animations were drawn by talented Perth illustrator Darrell White. On another page, kids can 'Meet the Crew' to find out more about these characters and their personalities.

In the Marine Park Mania section of the website, kids can find out what marine parks are and why we need them, what you can and can't do in a marine park and discover the different marine park zones and what they mean. In another area of the site, children can learn all about marine litter and its devastating effect on marine wildlife, and find out what positive action they can personally take to become a Marine Park Protector. This is one of the most popular sections of the website.

Information 'sponges'

Primary school students are often asked to prepare school assignments about marine animals, so in the 'Fun Facts' section they can find information, underwater footage and photographs about marine plants and animals found in Western Australian marine parks. There are 32 topics in 'Fun Facts' ranging from blue whales, coral reefs and mangroves to little penguins, sea stars and great white sharks. This information is presented in a way that also helps children to understand why our State's marine parks are so special and important and how people should care for them.

This will help to educate not just children, but their parents as well, since parents of primary school students usually help them to access and organise information for their homework. As any parent will tell you, primary school aged children are literally 'sponges' who readily absorb and retain information that they gather during their important formative years, so giving them marine conservation messages at this age will

Previous page
Main Animated marine characters featured on the home page of the website.
Illustration – Darrell White
Inset Jellyfish.
Photo – Suzanne Long/DEC

Above Website screen shot.

Left Diver at Marmion Marine Park.
Photo – Ann Storrie

Above Green turtle at Ningaloo Marine Park.
Photo – Tony Howard

Right Clownfish at Rowley Shoals Marine Park.

Below Nudibranch at Jurien Bay Marine Park.
Photos – John Huisman

auger well for the aquatic environment in the future.

The 'Marine Park Secrets' section presents some fascinating facts about Western Australia's marine parks that many people would not know and the 'Galleries' contain stunning photographs of several parks and their wildlife that can be downloaded for free for all non-commercial purposes.

The kids marine parks website is also a platform for linking to information on WA's 12 existing marine parks and reserves and four proposed marine parks and reserves on DEC's main website (www.dec.wa.gov.au). Most people know about Ningaloo Marine Park, but market research undertaken in 2007 showed that very few people could name any of our other, equally special, marine parks. The website will help fill some of these gaps in the public's knowledge.

Big hit

The website became operational in July 2008 and recorded more than 50,000 hits in its first six months. It was promoted later in the year with colourful posters that were distributed to schools throughout WA.

Despite being originally developed for primary school students to use as a resource when researching school assignments, the website is now set to become a resource for school students of all ages. With the Department of Education and Training, DEC's Marine Policy and Planning Branch is also developing a teaching guide on marine parks for Years 8 to 10 Society and Environment students. The resource is being written by Susie Bedford, a highly respected science educator who teaches part-time at Exmouth Senior High School, and should be published in the first half of 2009. The secondary students will be able to access a great deal of the information they need to complete the six-week unit of study at www.marineparks.wa.gov.au.

While the site's popularity is already exceeding expectations, it will continue to be improved and added to over time.

Carolyn Thomson-Dans is a special projects officer with the Department of Environment and Conservation. She can be contacted by email (carolyn.thomson-dans@dec.wa.gov.au).

Kate Fitzgerald was formerly a DEC marine education officer for various marine parks around the State. She can now be found at the Australian Institute of Marine Science working as a research assistant for the Scott Reef Research Project. Kate can be contacted by email (k.fitzgerald@aims.gov.au).

Ryan Scott is a DEC web developer and content coordinator. He can be contacted on (08) 9389 8644 or by email (ryan.scott@dec.wa.gov.au).

Kate and Carolyn were the driving forces behind establishing the new website. Kate designed the site and Kate and Carolyn wrote the content. Ryan built the site and undertook the visual design.

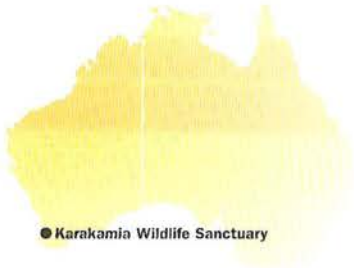
Karakamia Wildlife Sanctuary has been offering refuge for Western Australia's native mammals since 1991.

Bringing back the animals

by Jacqui Richards, Trish Gardner and Martin Copley

Karakamia Wildlife Sanctuary, located in the Perth hills near Chidlow, is one of the Australian Wildlife Conservancy's (AWC's) properties that works to fulfill the not-for-profit organisation's biodiversity conservation mission. It was purchased by Martin Copley in 1991 (see 'Karakamia Sanctuary', *LANDSCOPE*, Summer 1997-98) and was the birthplace and inspiration for AWC's network of 20 sanctuaries now covering more than 2.5 million hectares of Australia. AWC has been able to protect habitat and provide land management to help conserve more than 65 per cent of Australian terrestrial mammal species and 72 per cent of terrestrial bird species, not to mention the reptiles, frogs and untallied invertebrate communities.

The 280-hectare Karakamia Wildlife Sanctuary is situated in the northern jarrah forest in the Darling Range and is surrounded by a vermin-proof fence that excludes foxes and feral cats. The property was purchased to restore some of the former Darling Range fauna that was once widespread and abundant in the region, but had declined or disappeared altogether due primarily to predation by introduced predators.



Reintroductions

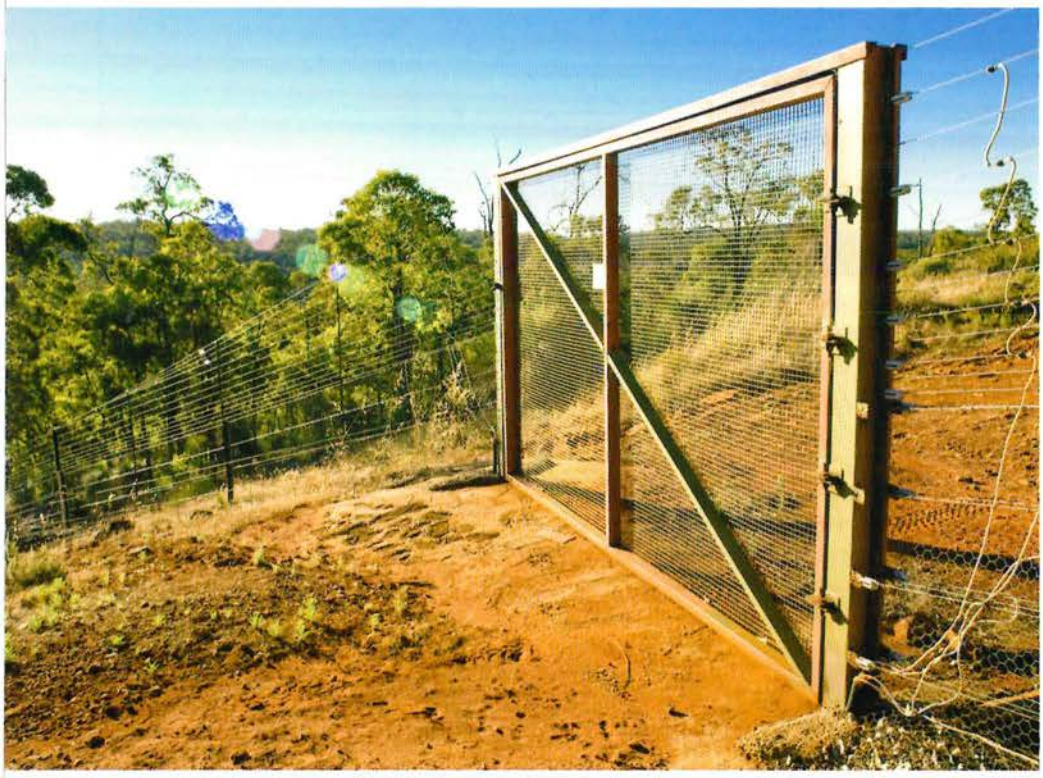
Karakamia is home to a suite of threatened mammal species, which were translocated by AWC and the Department of Environment and Conservation (DEC). A complete lack of medium-sized mammals was addressed with the reintroduction of woylies (*Bettongia penicillata*), quenda or southern brown bandicoots (*Isoodon obesulus*) and numbats (*Myrmecobius fasciatus*) in 1994, western ringtail possums (*Pseudochirus occidentalis*) in 1995, mainland quokkas (*Setonix brachyurus*) in 1996 and tammar wallabies (*Macropus eugenii*) in 1998. Brushtail possums (*Trichosurus vulpecula*) and brush wallabies (*Macropus irma*) were present when the sanctuary was fenced. However, both populations were supplemented with additional animals to bolster the small number of founder animals originally enclosed within the fence.

Since constructing the fence and removing introduced predators, Karakamia has proven itself as a bountiful source population for many threatened mammals. More than 670 animals have been translocated from Karakamia to other reintroduction sites around Australia. The sanctuary offers a safe haven for these threatened mammals that have declined elsewhere on the mainland, where foxes and feral cats remain abundant. Fenced populations also provide a secure breeding nucleus with which to repopulate the landscape if, or when, a global solution to combat the threatening processes causing mammal decline and extinctions has been found.

Woylie wonderland

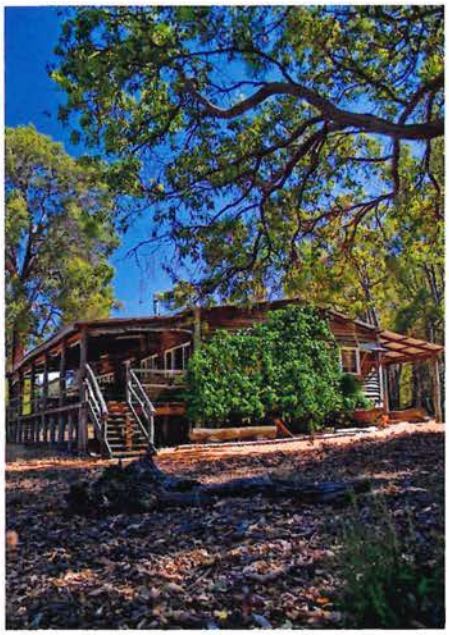
This reintroduction success has been obvious with some species. While the woylie may be experiencing population declines in the south-west of Western Australia, there are no signs of such a decline behind the predator-proof fence at Karakamia. AWC staff estimate there are at least 500 woylies in the 280-hectare sanctuary, a density of two woylies per hectare. This is probably similar to the peak in numbers found in the wild in the 1990s after the instigation of DEC's *Western Shield* fox-baiting program.

Nearly 800 woylies have been born and individually marked at Karakamia, initially with ear tags and, in more recent times, with passive implant transponders (PIT tags), small microchips inserted under the skin at the back of their neck. The high density of woylies combined with recent drier rainfall years led AWC to translocate



Previous page
Main Woylie.
Insets top left Numbat.
Photos –Jiri Lochman
Top right Quenda.
Centre left Tammar wallaby.
Photos – Sallyanne Cousans
Bottom right Brushtail possum.
Photo – Ann Storrie

Left Predator-proof fencing protects the sanctuary.
Photo – Sallyanne Cousans



Above Visitor centre at Karakamia.
Photo – Andy Ballard

Above right Woylies.
Photo – Ann Storrie

Right Brushtail possum.
Photo – Jiri Lochman

animals to alternative sites in an effort to reduce both intra-specific (within species) and inter-specific (between species) competition for food sources.

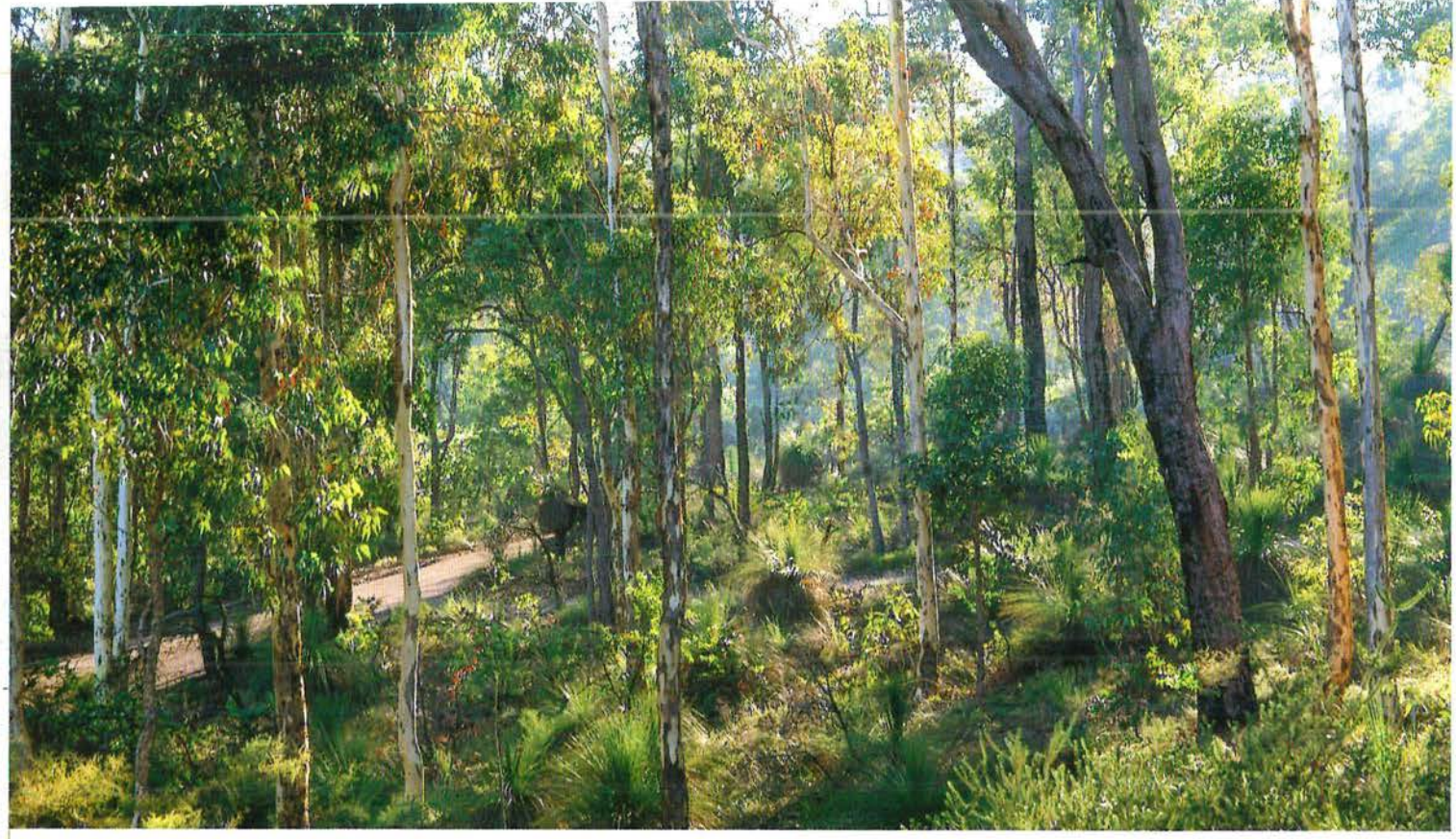
Just five years after their initial release at Karakamia in December 1994, AWC began moving woylies to its Paruna Wildlife Sanctuary, 30 kilometres away in the Avon Valley. More than 300 woylies were moved in five separate translocations between 2000 and 2006. More recently, woylies have been moved to AWC's Scotia Wildlife Sanctuary in New South Wales, into an 8,000-hectare feral-free area enclosed by a fence. Woylies disappeared from New South Wales before the 1920s, and had been declared extinct in that state.

Many woylies were also translocated to conservation estates in the south-west of WA, including Avon Valley and Kalbarri national parks and Tutanning, North Kalgarin, Cervantes and Julimar nature reserves, and to a private sanctuary, Genaren, in New South Wales. Woylies have persisted at many of these reintroduction sites, however, the populations have never mirrored the rapid increase seen within Karakamia. There is little doubt that foxes and feral cats have prevented repopulation of the forested areas of southern WA where it once roamed.

Possums to Lorna Glen

The brushtail possum is another species for which Karakamia has proven a boom town. Any visitor driving through the entrance to the sanctuary in the evening will have to dodge the brushtail possums as they scurry across the tracks. With the absence of foxes and cats it has been very obvious that the brushtail possums spend more time on the ground than they do in the tree tops, making them even more visible than usual.

In 2008, 35 brushtail possums were translocated from Karakamia to Lorna Glen, a pastoral lease managed by DEC about 1,100 kilometres north-east of Perth, to top up the population of animals originally released in 2007. By all accounts the possums have settled in well to their new home, using the hollows in the river red gum woodlands that fringe the creeks and wetlands and provide excellent shelter during the day. Several have even taken up residence at the homestead and are regular visitors to the kitchen and outside dining table. There may be an opportunity to send more animals to the rangelands to further reduce the possum population within Karakamia.



Above Jarrah forest typifies much of the Karakamia Wildlife Sanctuary.
Photo – Richard Woldendorp/AWC

Left A wedge-tailed eagle chick in nest.
Photo – Jiri Lochman

Restoring ecosystem function

One of the original aims in establishing Karakamia Wildlife Sanctuary was not only to recreate the past mammal fauna assemblages of the Darling Scarp, but also to restore function to an ailing ecosystem where natural processes had been disturbed for many years. While obviously not possible to mimic the bushland of 200 or 300 years ago, due to the irreversible environmental changes wrought by European settlement, the vision of reversing some of these changes started with the eradication of introduced species, followed by mammal reintroductions. The hope was that bringing back just a small part of the former ecosystem would ignite a series of processes and linkages to act in a catalytic manner, in turn bringing other processes that had either been disturbed or removed back to the environment.

One of the most remarkable effects has been associated with bringing woylies back to the jarrah forests. The ground litter layer in surrounding long-unburnt areas, such as John Forrest National Park, is often deeper than within Karakamia. Woylies have effectively incorporated much of the leaf litter layer into the soil profile through their daily digging in search of subterranean fungi, which forms a large component of their preferred diet. Their staggering ability to turn over five tonnes of soil a year per woylie improves water penetration and soil nutrient levels—a vital component in improving the typically nutrient-poor lateritic soils of the Darling Range. In turn, this results in lower leaf litter accumulation rates offering a lower fuel load, and thereby decreasing the bushfire risk within the sanctuary. This reduction in fuel load has modified AWC's prescribed burning program, providing an opportunity to conduct fewer, smaller burns to create a fine-scale mosaic of structural diversity and density within the vegetation.

Another interesting outcome has been the replacement of introduced predators by native predators such as the wedge-tailed eagle. A pair of wedge-tailed eagles has nested in or adjacent to Karakamia for many years, constructing grandiose stick nests in

Right Western pygmy possum.
Photo – Jiri Lochman

tall jarrah trees and typically rearing one or two chicks a year. At the end of each breeding season, an assortment of prey remains collect at the base of the nest, providing an insight into the diet of the birds. In WA, wedge-tailed eagles' diets are usually made up of 90 per cent rabbits, with the odd reptile or bird and other mammals such as kangaroos and wallabies.

Not surprisingly, the major component of the diet of the pair at Karakamia was brushtail possums and woylies (57 per cent), Australian ravens and wood ducks, with the odd bobtail skink (*Tiliqua rugosa*) or Gould's monitor (*Varanus gouldii*). There were only a handful of introduced species found among the prey remains. The birds of prey preferred to hunt threatened mammals from within the sanctuary rather than rabbits from surrounding agricultural land and forested reserves, and take birds from open areas in the paddock and near the dam in the southern section of Karakamia. Perhaps a new equilibrium has been attained at Karakamia where the abundant mammal populations can now sustain a level of natural predation.

Other benefits

With the removal of introduced predators, four additional mammal species have made an appearance at Karakamia. The occasional chuditch or western quoll (*Dasyurus geoffroii*) appears in the sanctuary. There is some concern that they will eat the reintroduced threatened mammals. However, like the wedge-tailed eagle, they are simply reclaiming their right as a top predator within the ecosystem.

Another mammal to pop up is the mardo or yellow-footed antechinus (*Antechinus flavipes*). There are not many that can claim to have watched a mardo sunning itself from their office window or heard the pitter patter of paws as they cheekily scamper across the rafters. Western pygmy possums (*Cercartetus concinnus*) and dunnarts (*Sminthopsis griseoventer*) have also appeared in annual trapping surveys. All these animals are likely to have occurred in the Darling Range before the establishment of Karakamia, but the combination of introduced predator control within Karakamia and DEC's *Western Shield* program has undoubtedly provided the opportunity for their numbers to increase.

Birdlife within Karakamia is prolific with more than 100 species recorded, including the beautiful red-tailed black-cockatoo, screeching their distinctive call "karak, karak...", from which the sanctuary derives its name. A large number of water birds are recorded in and around the dams and surrounding riparian habitat, which offer a diversity of vegetation to accommodate a far greater variety of fauna than the surrounding agricultural areas, remnant vegetation and water reserves.

Managing mammal populations

The reality of surrounding an ecosystem with a fence has created some interesting management problems—some predicted, some quite unexpected. The high number of woylies at Karakamia makes it difficult to trap other species, such as quenda, possums or tammar wallabies. Even with intensive trapping programs, nearly all traps are filled with woylies within an hour of dusk. Competition for the universal bait of peanut paste and rolled oats sometimes results in two woylies successfully maneuvering their way into the trap before the door shuts.

One of the key issues at Karakamia, and other fenced areas, is to determine the carrying capacity of target species and manage those populations and their impact on the broader ecosystem and other species. AWC is addressing these issues through ecological monitoring to measure the success of management techniques and by translocating animals to other sites that are free from introduced predators.

For example, the tammar wallaby population has increased significantly

during the past two years, becoming the most frequently seen wallaby in the paddocks at night. In response, AWC is translocating tammar wallabies to its Paruna Wildlife Sanctuary, where a fledgling population has already become well established, providing further insurance for this rare and beautiful wallaby.

Habitat restoration

Considerable effort has been expended on restoring degraded sections of Karakamia with many hours of volunteer assistance. Thickets of golden wreath wattle (*Acacia saligna*), one-sided bottlebrush (*Calothamnus quadrifidus*) and marri (*Corymbia calophylla*) have been planted in paddock areas and are now used by the throngs of tammar wallabies that clump together at the edge of the paddock areas. Where trees have been felled to maintain firebreaks, the logs are moved into the undergrowth to add habitat for invertebrates, reptiles, small mammals and birds. Weed management is an ongoing issue as staff and volunteers target noxious weeds such as cape tulip, arum lillies, lupins and tagasaste from paddock and riparian areas to ensure these species do not infest the bushland.

The area around the dam was successfully rehabilitated using a combination of direct seeding and planting of a range of local reeds and sedges. The resultant vegetation is now so thick that it is almost impenetrable and nine species of frog can now be heard croaking and quacking from the dam and associated creek line. The reintroduced quokkas also favour the habitat, with a pair occasionally sighted on spotlight walks.

Some areas of paddock have been retained within Karakamia as they are preferred foraging grounds for species such as tammar wallabies, brush wallabies and western grey kangaroos. The paddock areas also provide a remarkable viewing point for visitors to the sanctuary. Cryptic animals such as quenda become readily visible by spotlight in the open grassland and even ringtail possums that usually camouflage themselves among the thick foliage can be seen using the large habitat trees that remain in the paddocks.

On the tourist trail

Karakamia presents a rare opportunity for Perth residents and visitors to witness the diversity once present within our jarrah forests. It is one of the few places that people can come to see a suite of threatened mammals in their natural habitat. AWC conducts evening interpretive walks and spotlight tours at Karakamia, fulfilling a role in educating the public about the plight of Australia's threatened mammals, what is being done to reverse the decline of some species, and how AWC has assisted in the process. The regular walks through the sanctuary provide a wealth of opportunistic information to accompany routine monitoring via annual trapping and quarterly spotlighting.

The future

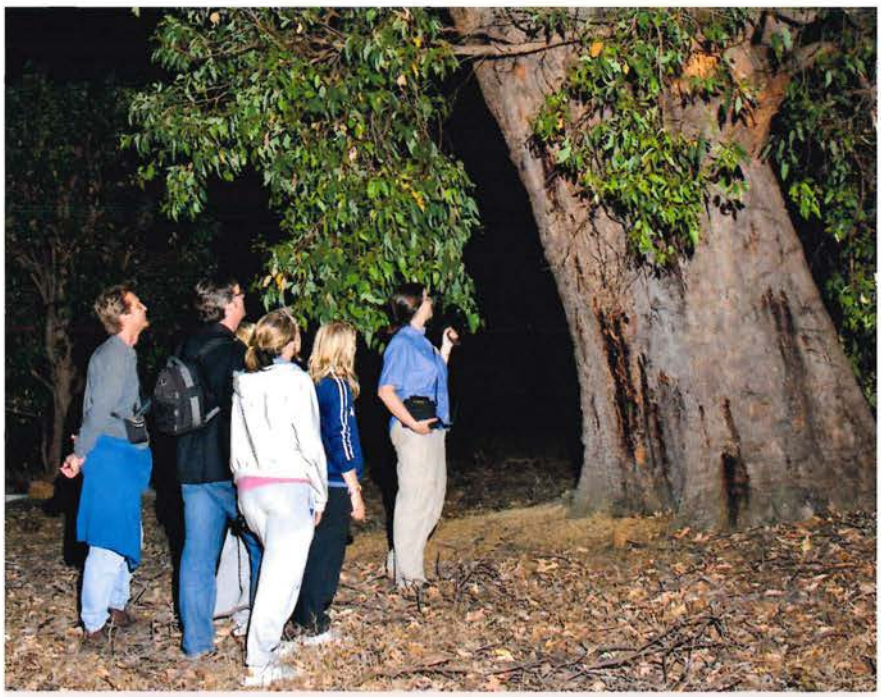
As things stand, the long-term outlook for Australia's medium-sized mammals, along with many other

Above left Signs reminding visitors to take care on sanctuary roads.

Left Revegetation around the dam.
Photos – Sallyanne Cousans

Above Boardwalk over Cookes Brook at Karakamia.

Right Looking for possums during an evening guided walk.
Photos – Sallyanne Cousans



animals, is grim. But in the southern half of Australia, where the fox and cat have wreaked such havoc, Karakamia does provide a glimmer of hope. It shows that, freed from fox and cat predation, successful populations of threatened native mammals can be re-established. AWC manages additional feral-free sanctuaries within Australia, including Faure Island where feral cats have been eradicated (see 'Return to Faure Island', *LANDSCOPE*, Autumn 2007). AWC's overall reintroduction strategy is designed to ensure these places are managed in an integrated manner while continuing to expand a network of feral-free sanctuaries. Meanwhile, the search for a long-term solution for controlling fox and cat predation must continue relentlessly so that AWC and others can help build a future where fences are no longer required.

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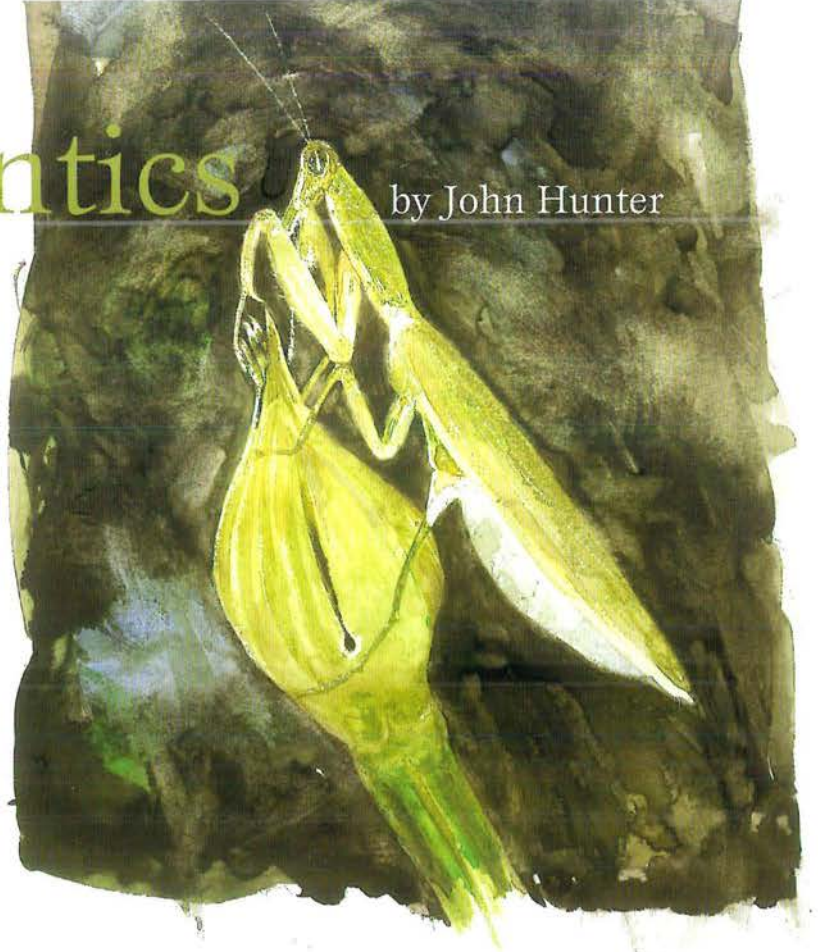
The authors wish to thank the many staff and volunteers who have assisted in creating and managing Karakamia Wildlife Sanctuary as a haven for threatened mammals and a source population for reintroduction sites throughout Australia, particularly Andre Schmitz, Barry Wilson and Jo Williams.

urban antics

by John Hunter



Love is all around...

Summer and early autumn might best be described as a time when spring, for most insects, is really in the air... and on the ground and in the water and the dirt under your feet. It is that time of the year when, from evening onward, being outdoors can be murder or magic.

Around any home barbecue, the near horizontal rays of the sun shaft through the shadows of bush and buildings to expose a seething cauldron of busy bodies and you suddenly realise you are out-numbered, out-flanked and out there with perhaps millions of insects. At times they will bite you, at times they will caress your ear with a cool swish of wings and at other times they will crawl with a nice but nerve-wracking tickle over your bare feet. They are with us, they are on us and, for all we know, they are in us.

Insects are a major group of arthropods, which are those animals having a segmented exoskeleton and jointed appendages. They are the most diverse group of animals on Earth, having more than a million described species and an estimated 30 million undescribed species which altogether represent 90 per cent of the life forms on the planet.

To further excite any human, insects are not to be confused with that group of arthropods with similar appearance, those being wood lice, crabs, lobsters, sand hoppers, spiders, ticks, mites, scorpions, centipedes and millipedes, to name a few.

It might be said that insects have been so successful on the planet for some 300 million years because they possess an uncanny wisdom and do many things that humans do. They raise crops, herd insect 'cattle' that they 'milk' of a sweet liquid and some are like architects and engineers—they construct intricate living quarters with year-round weather control. There are insect carpenters, papermakers, slave raiders and undertakers. It is also well known that ants, bees, wasps and termites live in social organisations more complex than those of human societies.

Some 50 million years before the first vertebrates, the evolution of wings by many insects gave them ascendancy over all other life forms at the time. Most insects advanced even more quickly by achieving complete metamorphosis from egg, through the specialist food gathering activity of larva (grub or caterpillar form) then pupa (dormancy) and then imago or adult form. So efficient is the food-gathering capabilities of the North American polyphemus moth (*Antheraea polyphemus*) caterpillar, it consumes an amount equal to thousands of times its birth weight in days.

In truth, many insects are considered pests by humans but then again we know that they are gatherers of refuse and in doing so, are responsible for much of the planet's good topsoil quality. The most useful of all insects are insectivores, those that feed on other insects. Without them, potential reproduction and survival of all insect offspring could literally bury the Earth in a single season.

Insects have an enormous ability to adapt and resist, so when you next wield that aerosol insect spray, wonder what it's really doing to their genetics. One day they may all gang up on us, or to be more positive, perhaps offer to give us a... claw.

One could go on forever but the more we learn about insects the more they will probably turn out to be the real 'never ending story' of our planet. Who knows?

DID YOU KNOW?

- Caterpillars have several thousand muscles and humans only have about 500.
- Female painted apple moths (*Teia anartoides*) have no wings; their caterpillars disperse by making an open gossamer sail out of silk and sail away on the wind.
- Some wasps can count, they've never been taught, but they know that they must always leave a certain same number of prey for male young and considerably more, but always the same number, for female young to survive.

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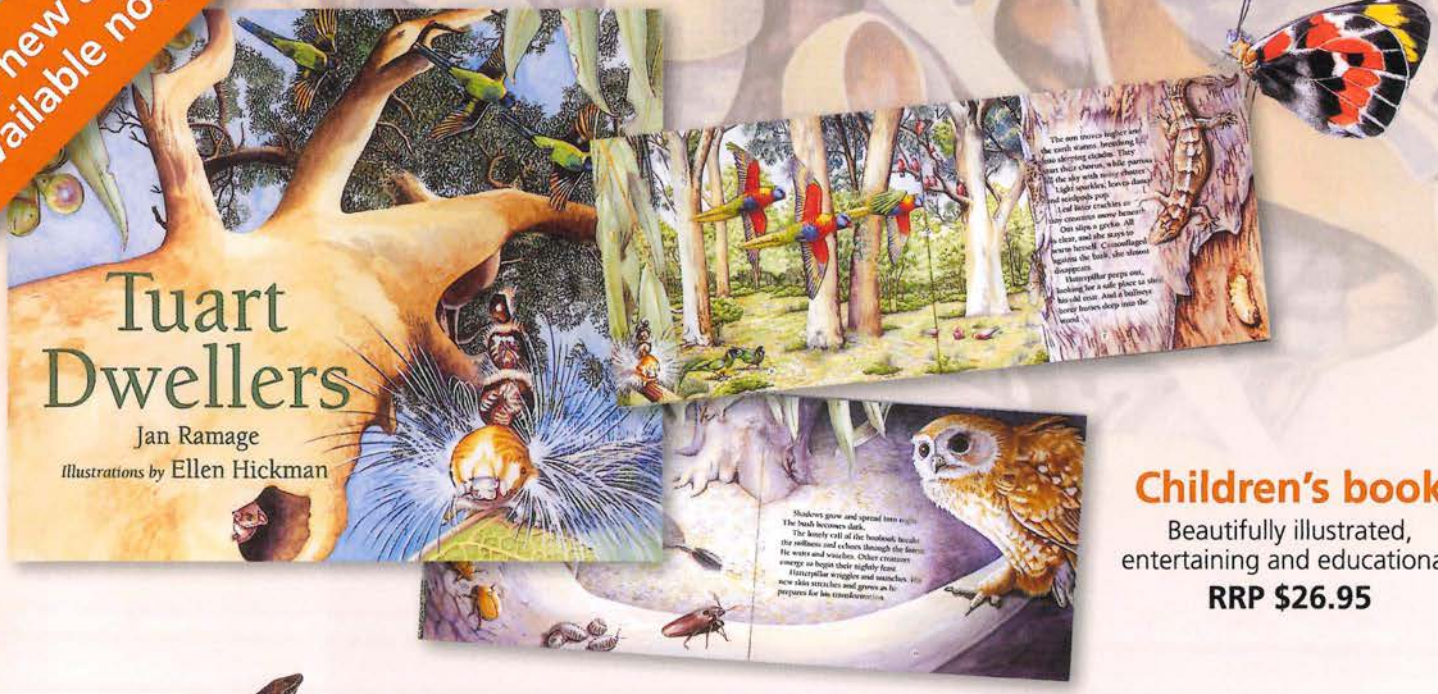

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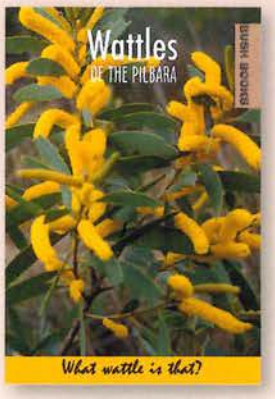

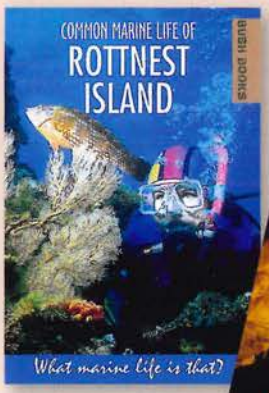

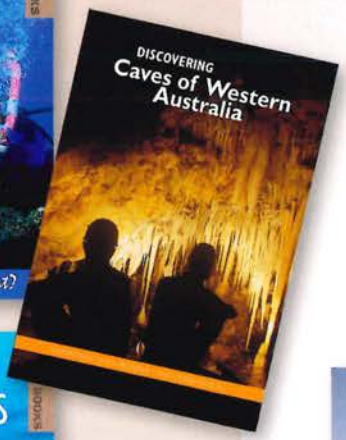

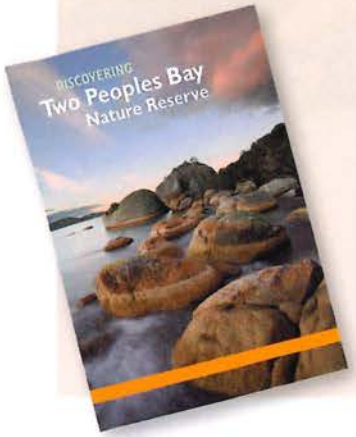

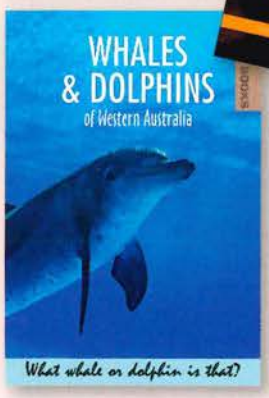

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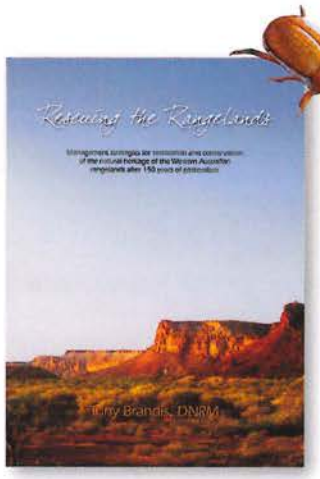

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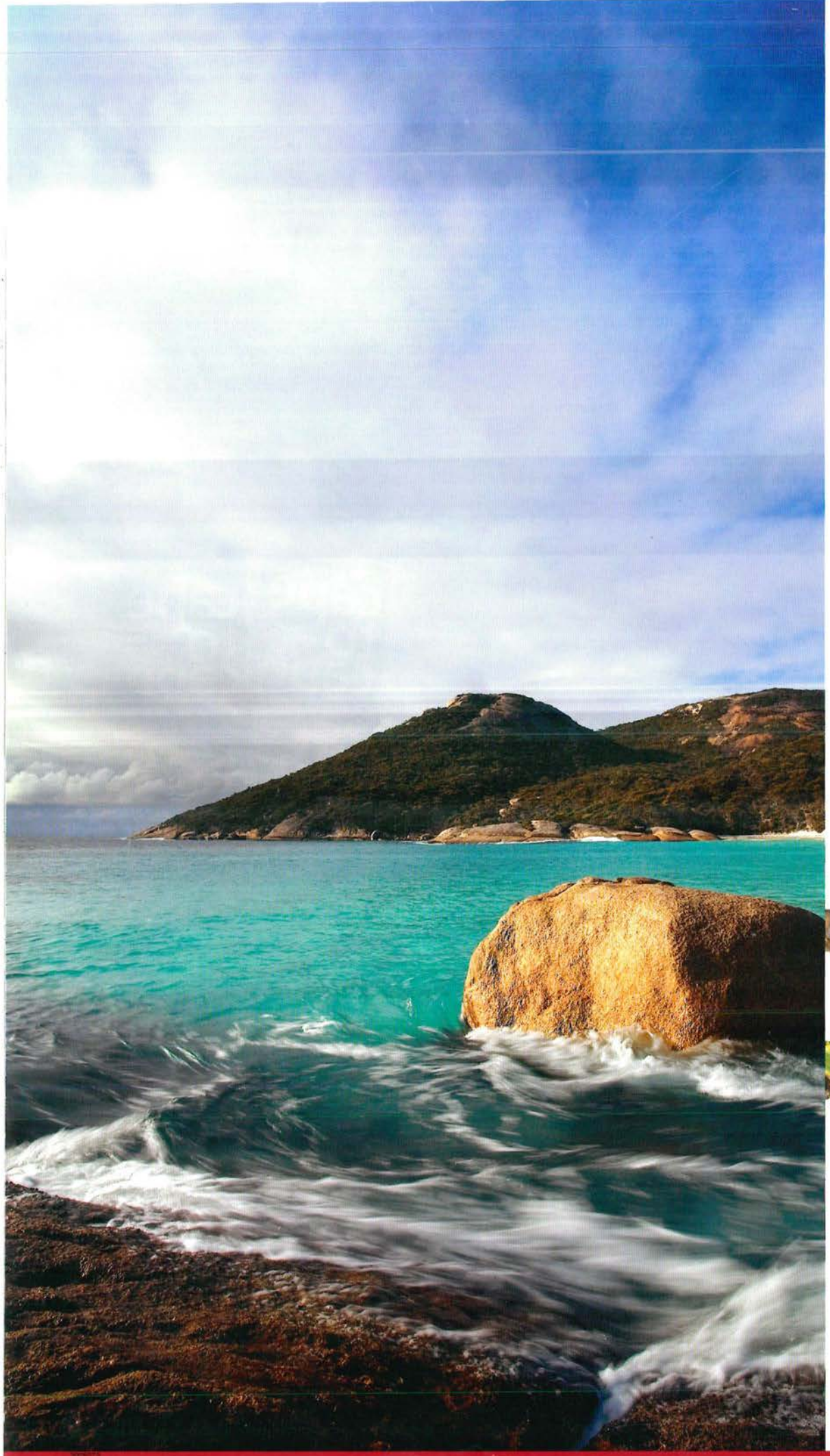
Our environment, our future



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