WA's conservation, parks and wildlife magazine

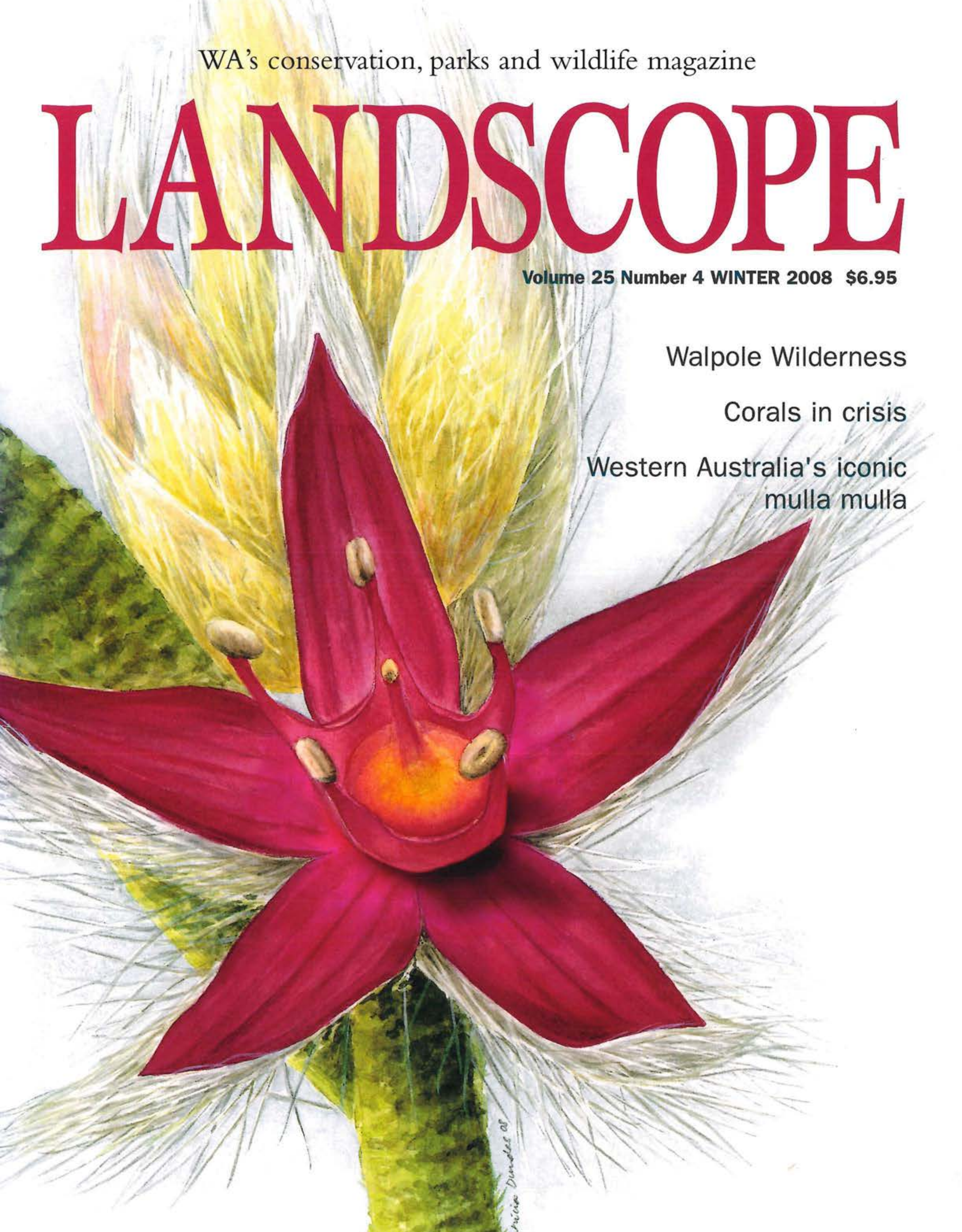
LANDSCOPE

Volume 25 Number 4 WINTER 2008 $6.95

Walpole Wilderness

Corals in crisis

Western Australia's iconic mulla mulla



Fighting dieback at Bell Track **Mysterious decline of the woylie** The black Swan

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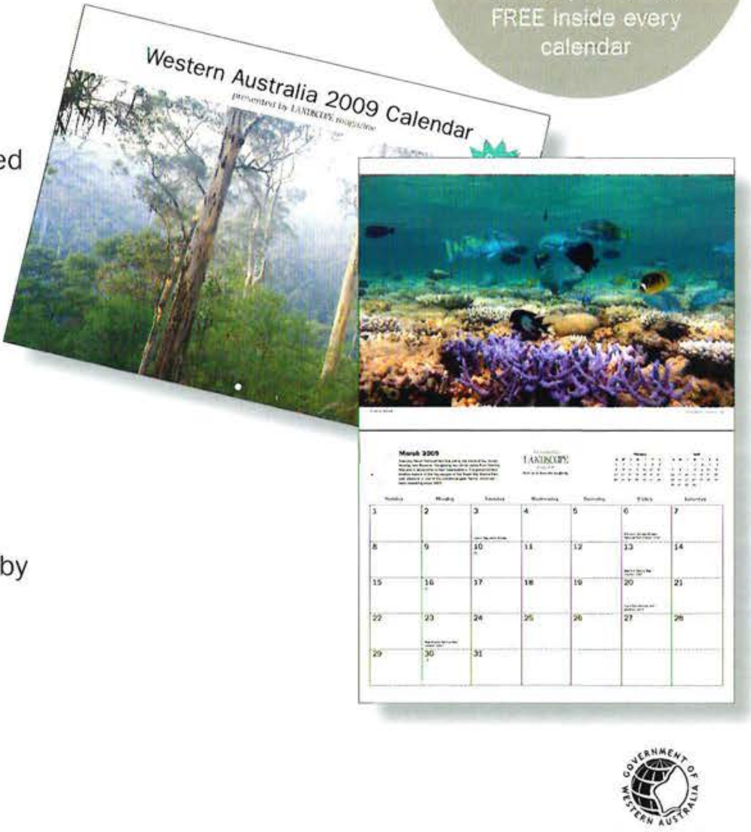
Western Australia 2009 Calendar
presented by LANDSCOPE magazine
March 2009

Each month is accompanied by an individually selected photo, taken by some of Western Australia's top photographers, and includes important dates for the environment and history of conservation in Western Australia. A sturdy envelope is provided for postage and gift presentation.

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Lesley Gibson

Roland Mau

contributors

Lesley Gibson started work with the Department of Environment and Conservation (DEC) in 2004 as a Research Scientist, within the Science Division's Biogeography Program. As a survey zoologist for DEC, she has taken part in a regional biological survey of the Pilbara and is now coordinating a survey of selected Kimberley islands. Previously, she was a Research Fellow with Deakin University, Victoria, for more than two years, developing predictive distribution models of rare and threatened fauna species. Before this, Lesley worked in south-west Queensland for 10 years, where she conducted research on macropods with the Queensland Parks and Wildlife Service, and completed her PhD on the nutritional ecology of the greater bilby through Sydney University.

Roland Mau has been DEC's Ningaloo Marine Park Coordinator for the past seven years. Before taking up the position at Ningaloo, Roland worked in various roles including research, environmental impact assessment, planning and policy, and monitoring in the marine and coastal program for the Queensland Parks and Wildlife Service and the Great Barrier Reef Marine Park Authority. Roland has a keen interest in coastal resource management, especially as it relates to recreational and commercial tourism in tropical marine environments. He has been exposed to a broad range of conservation management issues through his work in the Red Sea in Egypt, the Maldives, the Great Barrier Reef and sub-tropical reefs of northern New South Wales.

Adrian Wayne has been a Research Scientist with DEC since 1997. In 1994, he helped rediscover the Gilbert's potoroo, which was previously thought extinct. Now based in Manjimup, Adrian researches the ecology of forest vertebrate fauna (frogs, reptiles and mammals), focusing on the conservation of threatened species and fauna responses to timber harvesting and prescribed burning. This has included a detailed series of studies on the ecology of the common brushtail possum and the western ringtail possum in the jarrah forest. Since late 2005, Adrian has led the investigation into the woylie decline in the southern forests.

Natalie Jolakoski has been a Graphic Designer with DEC for the past six years. She works on a wide variety of design projects and particularly enjoys designing *LANDSCOPE* articles and books. She is currently working on a book about Kalbarri. Natalie enjoys visiting the places featured in her design work, to gain creative inspiration and a connection with the areas.

Adrian Wayne

also contributing . . .

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Natalie Jolakoski

editor's letter

Welcome to another edition of *LANDSCOPE*. It's an edition that takes us once more from the top of Western Australia right down to the south-west of the State with some fascinating insights along the way.

It takes an extraordinary amount of planning and preparation to enable teams of people to visit some of these regions and carry out the research that is so crucial to the future of our environment. In this edition, 'Treasures of a sunken coastline: a biological survey of the Kimberley islands' (page 38), gives us an insider's view of the planning and preparation involved in a biological survey under way on the islands off the remote Kimberley coastline.

Despite its relative isolation and rugged terrain, parts of the Kimberley have been affected by humans and related impacts such as weeds, feral animals and altered fire regimes since European settlement. While the effects are apparent in some areas, others have been more resilient and are not as affected. Their biodiversity could hold the key to future management strategies in the area and a three-year biological survey being carried out will provide valuable knowledge to help.

Heading south, scientists John Alcock and Winston Bailey describe the amazing burst of life they found in the Kennedy Range National Park during a visit just after rain had drenched the area and interrupted the drought in the Gascoyne region. Their experience and keen interest in insects provides a rare view of the life around them including the well-camouflaged katydids and "multitude of grasshoppers that burst up and away" as they walked through the park. Read their account in 'The hidden katydids of the Kennedy Range' on page 22.

It's not all good news, however, and there are some clear warnings in some of the features in this edition. 'Corals in crisis' (page 16) looks at the coral bleaching that has caused the death of corals and threatens areas of reef around the world. Western Australia's coral reefs are still in a relatively healthy state and the article discusses what can be done to help protect them.

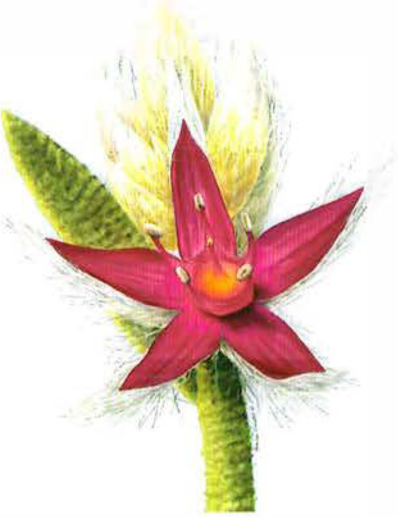
And, something's wrong with our woylies. In 1996 there were great celebrations when the native marsupial was removed from both the State and Federal threatened species categories following the success of recovery programs. Now, something's gone amiss and woylie numbers have dropped to such an extent it is back on the endangered list in WA. 'Down but not out: solving the mystery of the woylie population crash' (page 10) looks at what has been happening.

'The black Swan: investigating the estuary after dark' (page 46) takes on new meaning in this edition through the eyes of night divers exploring the Swan River in Perth who uncover some stunning nocturnal activity. We also find there's good news about what is happening with the western ringtail possum (page 54) and find out more about the new Walpole Wilderness area (page 32).

Browse through the edition and you will find there is plenty to read and some amazing photographs to bring the words to life.

Kaye Verboon

Kaye Verboon
Executive Editor



Cover illustration by Pat Dundas
This striking species of mulla mulla, known only by its scientific name, *Ptilotus arthrolasius*, occurs from the Murchison north to the Kimberley. It is a compact, perennial species which grows from 20 to 75 centimetres high. The flowers are white, pink, red and purple in colour and appear from April to October. It grows in red sand, sandplains and on sand dunes. It is one of many species of mulla mulla, a genus that comes in a huge variety of stunning designs.

Back cover photo by Marie Lochman
Kennedy Range National Park.

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The beautiful and varied designs of mulla mulla are an icon of the arid Pilbara landscapes.

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Prepress and printing Lamb Print, Western Australia.

© ISSN 0815-4465

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

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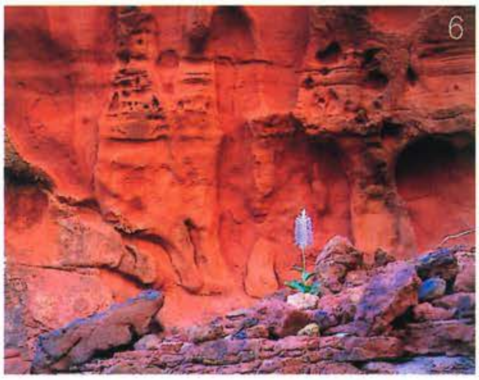
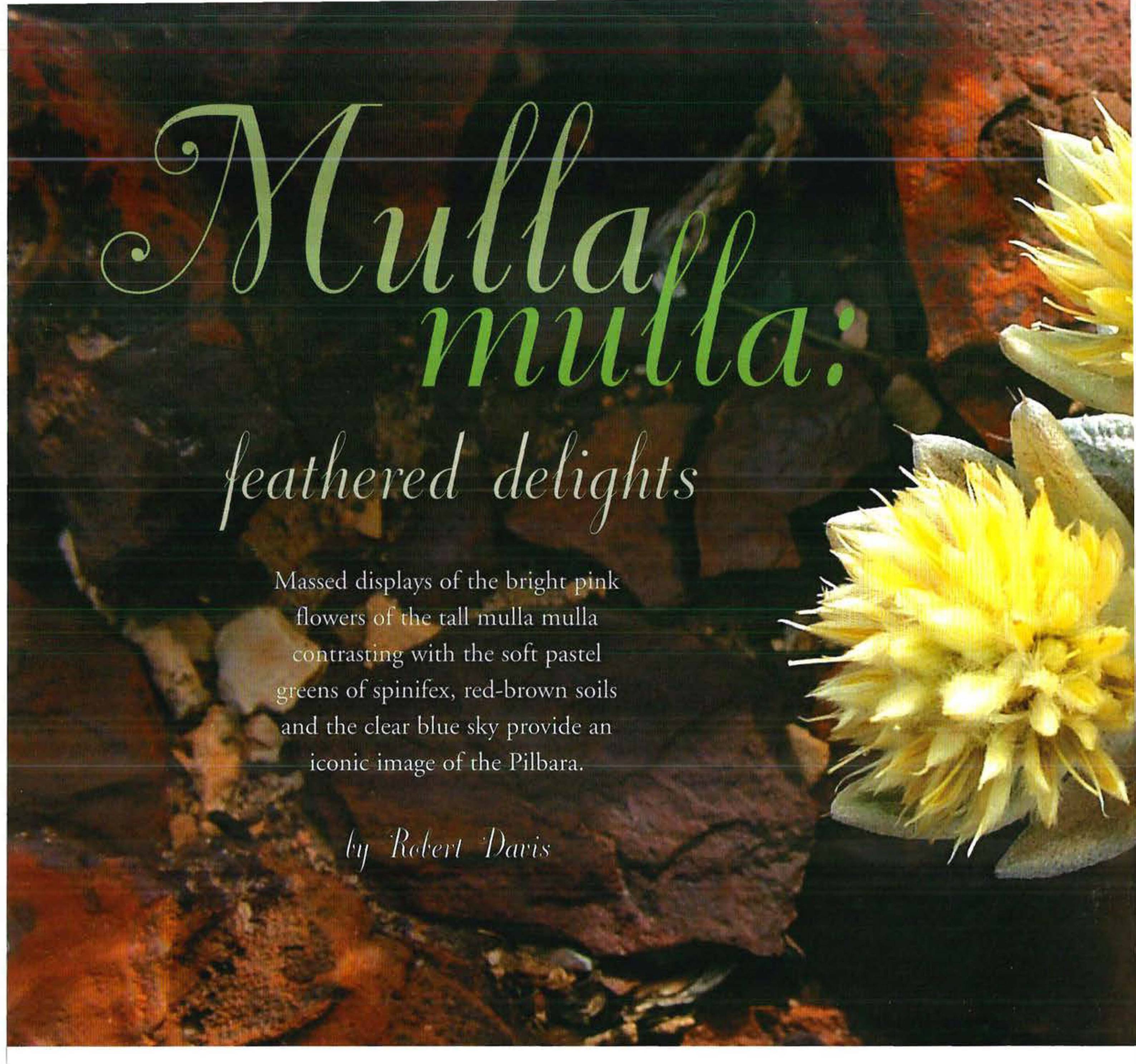




Mulla mulla:

feathered delights

Massed displays of the bright pink flowers of the tall mulla mulla contrasting with the soft pastel greens of spinifex, red-brown soils and the clear blue sky provide an iconic image of the Pilbara.

by Robert Davis

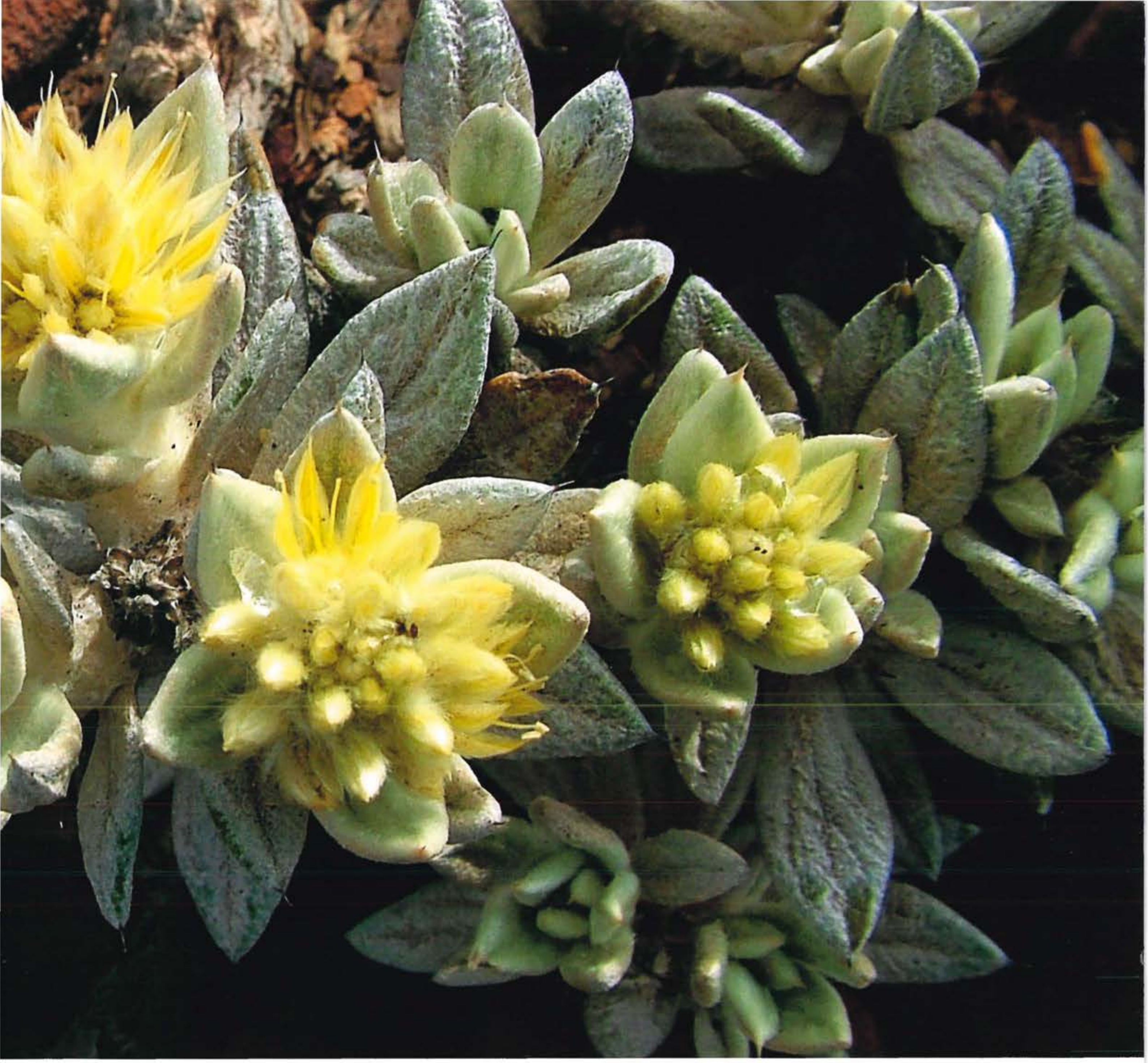
Next to everlastings, the mulla mullas or lambs tails of the genus *Ptilotus* are one of the most readily recognised plants in Western Australia's arid regions. The Pilbara in particular is characterised by swaths of pink, white, green and yellow mulla mulla species covering thousands of hectares. While the genus is most prominent in the Pilbara, other mulla mulla species can be found almost throughout WA, from the heathlands of the south coast to the islands off the Kimberley.

Habit and habitat

The genus *Ptilotus* is large, with more than 100 species. Mulla mullas are almost entirely endemic to Australia, with just one species also occurring on the Indonesian islands of Flores and Timor. The greatest diversity is found in WA where 90 per cent of the species occur. A big proportion of these can be found in the Pilbara and arid zone where they have developed a range of growth forms to cope with the extreme conditions.

About half the species, including the most common and widespread, are annuals or ephemerals and so germinate, grow and flower quickly after desert rains. Others vary from perennial herbs, some with tubers or tuberous rootstocks, to woody shrubs. A good example of an ephemeral is the featherheads (*Ptilotus macrocephalus*). This is a common species found on flood plains and other run-on areas throughout dry regions of WA. The greenish flower heads are among the largest in the genus. In good seasons they cloak the landscape with dense, feathery carpets. Perfect opportunists, they set masses of seeds with a hard outer coat, enabling them to survive extreme conditions in the harsh years before the next rains or floods.

In contrast to the boom and bust cycle of the ephemerals, the cottonheads (*P. obovatus*) are tough, hardy survivors. This small shrub with stiff, tangled branches, grey leaves and pink, cottony flower heads is found throughout Australia from coastal dunes to rocky outcrops. In years



Above Goldfields mulla mulla (*Ptilotus helichrysoides*).
Photo – Robert Davis/DEC

of extreme drought, it can die back almost to ground level then re-sprout when conditions turn favourable.

Several species, such as the soft haired mulla mulla (*P. mollis*), have become scree specialists. These rocky slopes of loose stones on the edges of outcrops and breakaways look like moonscapes and provide some of the harshest environments in Australia. Often one or a few species of mulla mulla are the only plants to be found surviving in these environments. Similar to the cottonheads, the soft haired mulla mulla has the ability to sit dormant through many hard years and is often covered in a dense mat of white hairs for protection against the harsh light. Their soft, grey appearance provides a stark contrast to their rocky habitats.

Other mulla mullas occur in more forgiving environments. Narrowleaf mulla mulla (*P. drummondii*) is one of the most recognisable and is common in the Darling Range and from the south coast to as far north as the Kimberley.

Flowers

The name *Ptilotus* comes from the Greek word *Ptilon*, meaning winged or feathered. The feathery appearance of the flowers is caused by the abundant long, soft, often branched hairs covering and sometimes almost hiding the flower parts. The flowers lack normal petals and sepals, instead having two whorls of stiff, papery flower parts called tepals surrounding the stamens and ovary. Flowers are typically arranged in spike-like inflorescences, ranging in shape from spherical to cylindrical. Their colours are commonly pink, white, green and yellow, while the hairs often add a soft, greyish tone.

With a few exceptions, mulla mulla species fall into two distinct groups. The most readily recognised group has prominent hairs with distinct whorls of side-branches—each hair is like a tiny pine tree. The outer tepals are much

larger than the inner tepals and nearly always have serrated tips. They have a curved style which is fixed off-centre on the ovary and a combination of three fertile stamens and two coloured staminodes.

Flowers in the second group either lack hairs entirely or have unbranched hairs which are segmented in appearance. The style in these species is straight and centrally fixed to the ovary and all five stamens are fertile.

Uncommon and fascinating plants

There are 19 species of mulla mulla classed as a priority species, meaning they are under threat or poorly known, and one species is declared rare. The most threatened species is bunch leaved mulla mulla (*P. fasciculatus*), which is restricted to the margins of salt lakes in the wheatbelt and is susceptible to salinity and rising watertables.

Several species have not been seen for many years and may be extinct. However, this apparent rarity may be explained not by habitat destruction but taxonomic difficulties. Many mulla mullas inhabit remote areas of the State and are opportunists that may only be noticeable in the landscape for short periods of time. This means that they are infrequently collected.

With more botanical exploration and collecting efforts in remote areas, more of these striking and iconic flowers may well be rediscovered.

Top Royal mulla mulla (*Ptilotus rotundifolius*) and tall mulla mulla (*P. exaltatus*) near Tom Price.
Photo – Chris Garnett

Above left Cottonheads (*P. obovatus*).
Photo – Sallyanne Cousans

Above Soft haired mulla mulla (*P. mollis*).
Photo – Michi Maier

Below left Featherheads (*P. macrocephalus*).
Photo – Robert Davis/DEC

Robert Davis has been employed with the Western Australian Herbarium for the past 13 years. He has worked on a range of projects and is currently working as an Identification Botanist. His primary role is general identifications and confirming priority and rare flora. As well as studying the genus *Ptilotus*, Robert is developing electronic keys for *Ptilotus*, *Gomphrena*, *Swainsona* and *Darwinia*.

He can be contacted on (08) 9334 0497 or by email (robert.davis@dec.wa.gov.au).

bookmarks by Samille Mitchell

Shorebirds of Australia

Authors: Andrew Geering, Lindsay Agnew and Sandra Harding
Publisher: CSIRO Publishing
256 pages, paperback, colour photographs
ISBN: 978 0 6430 9226 6
RRP: $49.95

Shorebirds are especially amazing birds—some of them travel more than 10,000 kilometres non-stop to migrate to Australian shores. This book brings together the latest information about the evolution, ecology, behaviour and distribution of shorebirds in Australia. It also provides a wealth of information to help birdwatchers identify different shorebirds, as well as colour photographs of each profiled species.

SHOREBIRDS of AUSTRALIA
Andrew Geering Lindsay Agnew and Sandra Harding

The Hot Topic: how to tackle global warming and still keep the lights on

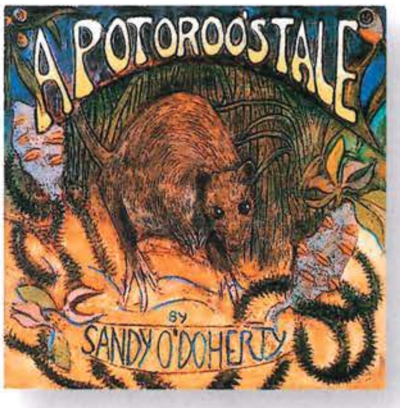
Authors: Gabrielle Walker and Sir David King
Publisher: Allen & Unwin
309 pages, paperback
ISBN: 978 0 7475 9395 9
RRP: $29.95

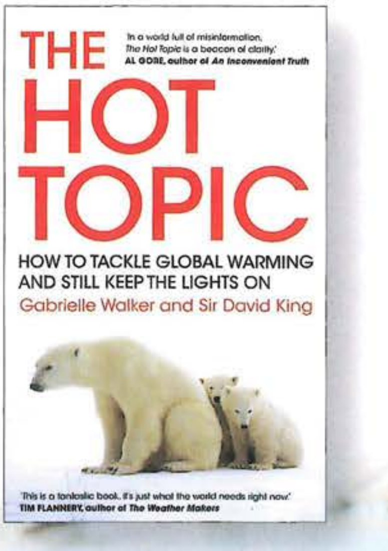
This book cuts to the truth about global warming. It presents solid scientific arguments aimed at debunking theories such as global warming being a natural cycle and talks about the effects global warming is already having on nature's intricate balance. But it's not all doom and gloom either. The book presents practical ways for individuals to make a difference and helps us work out if politicians are on the right track to combat global warming. The book is written in a conversational, easy-to-read style. The author of *An Inconvenient Truth*, Al Gore, rates it as a "beacon of clarity" and author of *The Weather Makers*, Tim Flannery, says: "This is a fantastic book. It's just what the world needs right now".

A Potoroo's Tale

Author: Sandy O'Doherty
Publisher: Sandy O'Doherty
29 pages, full colour illustrations, paperback
ISBN: 978 0 646 48069 5
RRP: $15.00

This children's book tells the tale of Quiz, a Gilbert's potoroo, and the adventures he encounters on his search for truffles. The story should not only delight children, but also help educate them about this highly endangered native mammal, which occurs only at Two Peoples Bay Nature Reserve and on Bald Island near Albany. It also introduces other Australian species such as the tawny frogmouth, quokka and banksia, as well as the introduced fox. Twenty per cent of profits from the sale of the book go to the Gilbert's Potoroo Action Group to support recovery programs for this endearing animal.


A POTOROO'S TALE
BY
SANDY O'DOHERTY


THE HOT TOPIC
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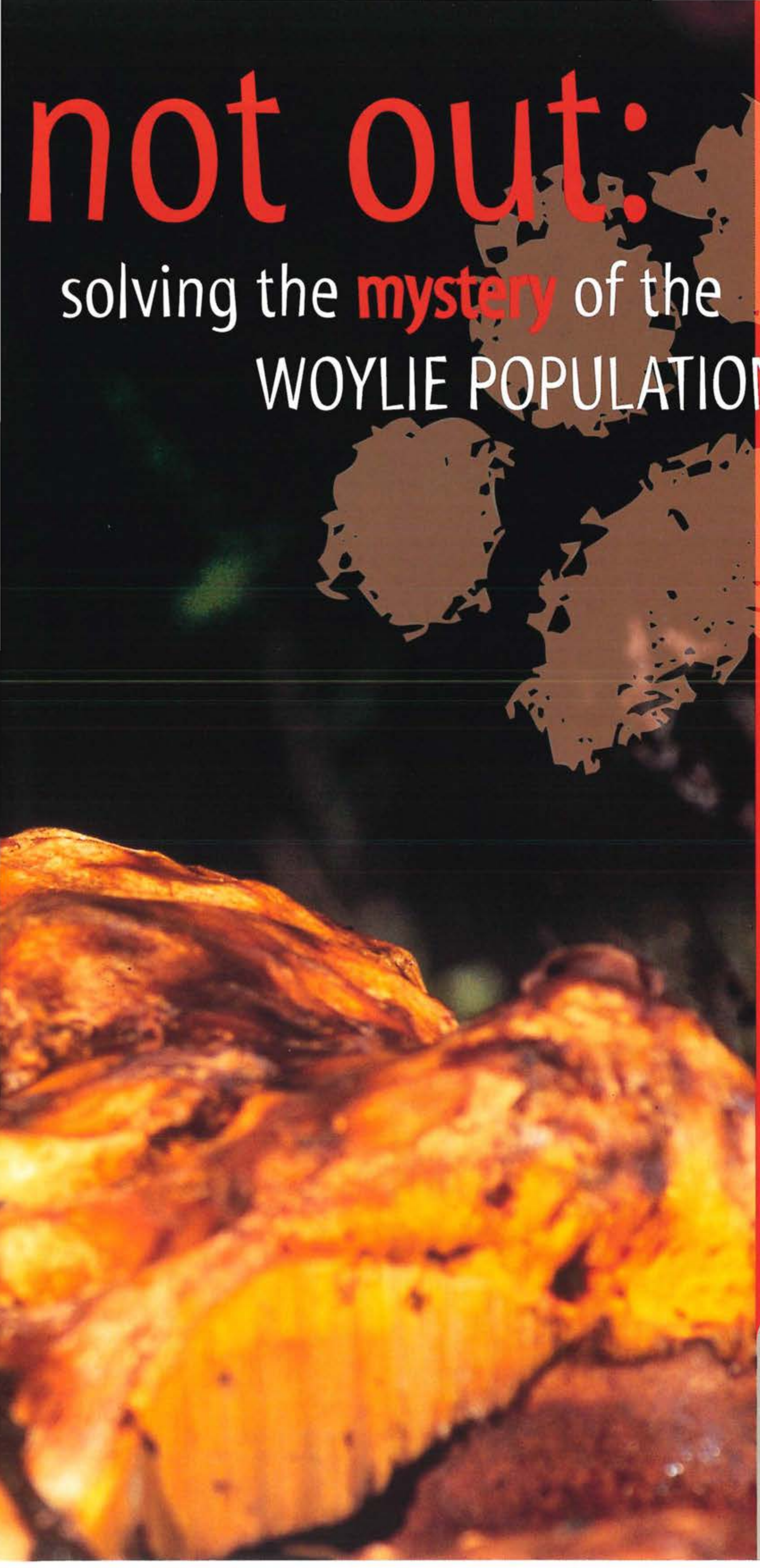
Down but

not out:

solving the mystery of the WOYLIE POPULATION CRASH



After staging an incredible comeback in the 1990s, the woylie population is again plummeting. What has gone wrong for this embattled native marsupial?

by Samille Mitchell
and Adrian Wayne

In 1996 the recovery of the woylie (*Bettongia penicillata*) was hailed a resounding success. Populations of this native marsupial had recovered to the extent it was removed from both State and Commonwealth threatened species categories—the first species in Australia to be delisted. Scientists and managers congratulated each other on the success of recovery programs and conservationists rejoiced—finally a good news story amid a sad chapter for many native animals battling predation by introduced animals and habitat loss. On the back of its success, the woylie achieved iconic status and became the 'pin-up' for conservation efforts around Australia. It also acted as a flagship for the achievements of the Department of Environment and Conservation's (DEC's) *Western Shield* conservation program (see 'Bouncing Back: *Western Shield* update', *LANDSCOPE*, Spring 1998).

But the success story was not to last. In 2001 an alarming chapter was starting to develop. Woylie numbers began plummeting. Consequent research found they had crashed by 93 per cent at Dryandra, 95 per cent in the Upper Warren River Catchment east of Manjimup and 97 per cent at Batalling east of Collie—devastating blows to once vibrant populations (see 'Bountiful Batalling', *LANDSCOPE*, Winter 2004). Woylie numbers had only remained intact in relatively small and isolated populations. Overall, the number of woylies across the country had plunged between 70 and 80 per cent between 2001 and 2006. And where the declines occurred they were rapid—numbers reduced from 25 to 95 per cent each year. Such was the blow to woylie populations that it was re-listed in WA as endangered (more specifically, as Schedule 1 fauna: rare or likely to become extinct) in January this year. Puzzled and alarmed, scientists could only wonder what on earth had gone wrong.

Joining forces

So drastic was the decline that a host of different organisations joined forces to determine a cause for the decline and, hopefully, start preventative action. Together these groups—DEC, Murdoch University, the Australian Wildlife Conservancy (AWC) and Perth Zoo—set to work on the Woylie Conservation Research Project. The project is focused on understanding the declines in the Upper Warren region and has three main components. Firstly, it combined existing datasets into a single database containing 25,479 woylie research and monitoring records spanning 33 years. This helped to characterise the patterns in population change, examine whether demographic changes were associated with woylie declines and thrash out any other circumstantial evidence or clues as to 'who dunnit'.

Previous page
Main Woylie feeding on fungi.
Photo – Jiri Lochman

Above Preparing a sand-pad used to monitor predator and woylie activity by detecting their footprints.
Photo – Marika Maxwell/DEC

Left Releasing a woylie.
Photo – Adrian Wayne/DEC

Right Woylie feeding.
Photo – Ann Storrie

Secondly, the project closely monitored Upper Warren fauna to build on, enhance and coordinate previously independent existing studies to provide information on population changes at the regional scale, while also collecting information on demographics, health, disease, diet and genetics.

And thirdly, the project established a population comparison study designed to work out which factors could be associated with the population crash. Six populations became the core focus of the work, each at different stages of decline. They included the AWC-managed Karakamia Wildlife Sanctuary (see 'Karakamia Sanctuary', *LANDSCOPE*, Summer 1997-1998), which supports the last remaining high-density woylie population in Western Australia, the last three remaining areas in the Upper Warren still supporting healthy woylie populations and two other areas in the Upper Warren that provide examples of populations that have currently or recently declined. The study had five main lines of enquiry—woylie density and demographics, woylie survival and mortality, predators, resources and disease.

Aside from the core group of collaborators, individuals from the South Australian Government, The University of Western Australia, Manjimup Aero Club, Data Analysis Australia and the University of Adelaide have lent a hand. More than 85 people have been involved and contributions by volunteers have also been extremely important—more than 123 individuals have collectively contributed more than 500 days and 4,000 hours of volunteer service so far. But what has their work unearthed?

What's a woylie?

The woylie is a native Australian marsupial that resembles a miniature kangaroo and is about the size of a rabbit. It once occurred across much of southern and central Australia but land clearing and feral predators reduced its range to pockets in the south-west. Successful translocations have enabled woylies to re-establish elsewhere in Australia where feral predators are intensively controlled or absent (such as islands).

The woylie lives in forest and woodland areas with sufficient undergrowth to provide cover and nesting sites, as well as some open areas for feeding. This nocturnal animal is very important to forest and woodland ecosystems. By feeding on above-ground mushrooms but particularly below-ground fungi (i.e. native truffles) as well as seeds, the woylie plays an essential role in spreading these plants and fungi throughout the ecosystems in which they live. While commercially important to industries such as sandalwood harvesting, it is the woylie's ecological role in spreading mycorrihizal fungi that is especially important. Mycorrihizal fungi have important symbiotic relationships with trees and plants (helping them to access much-needed nutrients). By helping spread these fungi, the woylie helps keep the forests and woodlands healthy and productive.

The woylie is also one of Australia's natural 'earth movers'. While digging for its food, each woylie moves about five tonnes of soil a year. This helps in nutrient recycling, reducing fire risk (by burying leaf litter cover as it digs) and creating nutrient-rich seed beds for plants to germinate. It also influences the way water percolates into the soil.

Female woylies usually give birth to their first young when they are 170 to 180 days old and continuously produce subsequent young about every 100 days thereafter for the rest of their life (about four to six years). Like kangaroos, woylies can carry a pouch young ('joey') while having an embryo in suspended animation in the womb, awaiting birth. Joeys live in the pouch for about 100 days before leaving to make room for the next young. Having left the pouch, joeys share their mother's nest and spend several more weeks at their mother's side being weaned, before becoming fully independent and sexually mature. If a female woylie is threatened, she may sometimes eject the young from her pouch, allowing predators to make an easy meal of it, while she makes a quick escape. While this may seem harsh, such behaviour makes good biological sense. The mother already has an embryo 'in waiting' and it is better that she survive to breed another day, rather than die along with her offspring.

What's to blame?

Although it's too early to point the finger at a definite source, early results are providing some clues and paving the way for future works. The study so far has indicated that habitat loss and change is probably not to blame, nor fire or human interference. Climate change and extreme weather events may be associated with woylie declines at Venus Bay Peninsula in South Australia, where populations have also crashed, and cannot yet be ruled out as a factor in WA.

Foxes are unlikely to be the main culprit in the Upper Warren region given that, during the project, foxes only accounted for 15 per cent of the predators or scavengers associated with observed woylie deaths. In addition, none of the mortalities at the Balban study site in the Upper Warren (which underwent a decline during the study of more than 80 per cent in 12 months)

Above Wandoo woodland in Dryandra supports a woylie population.
Photo – Marie Lochman

Right The common native truffle *Hysterangium* sp. forms part of the woylie diet.
Photo – Richard Robinson/DEC

was attributed to foxes. However, a parallel research program lead by DEC Senior Research Scientist Nicky Marlow in Dryandra and Tutanning has shown foxes to be a real problem in these areas.

The research in the Upper Warren has shown that the decline involves increased mortality rates of adult woylies and, although it appears woylies continue to breed despite the decline, it remains unknown at this stage how many young survive through to adulthood.

So what is to blame? Multiple interactive factors are probably responsible. Predators and scavengers, especially cats, have been associated with almost all observed woylie deaths in the Upper Warren. While in stable populations this is likely to be the usual fate of the old, the weak and the unlucky, it seems no woylies are safe in those populations in decline. This may be due to an increase in predators but there is some evidence that disease may be the main culprit. While some of the key evidence remains elusive at this stage (not helped by predators and scavengers eating the woylies and all the evidence of disease along with it), some key suspects have been identified—namely two parasites called *Toxoplasma* and *Trypanosoma*. Together these parasites have proven a particularly devastating mix for other species. The same may be true in this case. Other stresses that help trigger the diseases, or different diseases altogether, may also be involved. While there are some very tantalising clues that have already been unearthed, more is needed to get to the bottom of this mystery.

Understanding disease

Disease is a primary threat associated with at least 11 per cent of declining vertebrate species. The Tasmanian devil is threatened by a facial tumour disease, *Chytridimycosis* attacks many frog species and koalas are often stricken with *Chlamydia*. In addition, western barred bandicoots battle against the *Papilloma* virus and Gilbert's potoroos can become infected with *Treponema* (similar to human syphilis).

Wildlife diseases can also pose significant human health issues, by potentially transferring from animals to humans. Avian influenza, SARS, salmonella and Ross River virus are just some examples of this. Surprisingly little is known about the present disease status of WA's native fauna, including the woylie, let alone what implications there may be for humans.

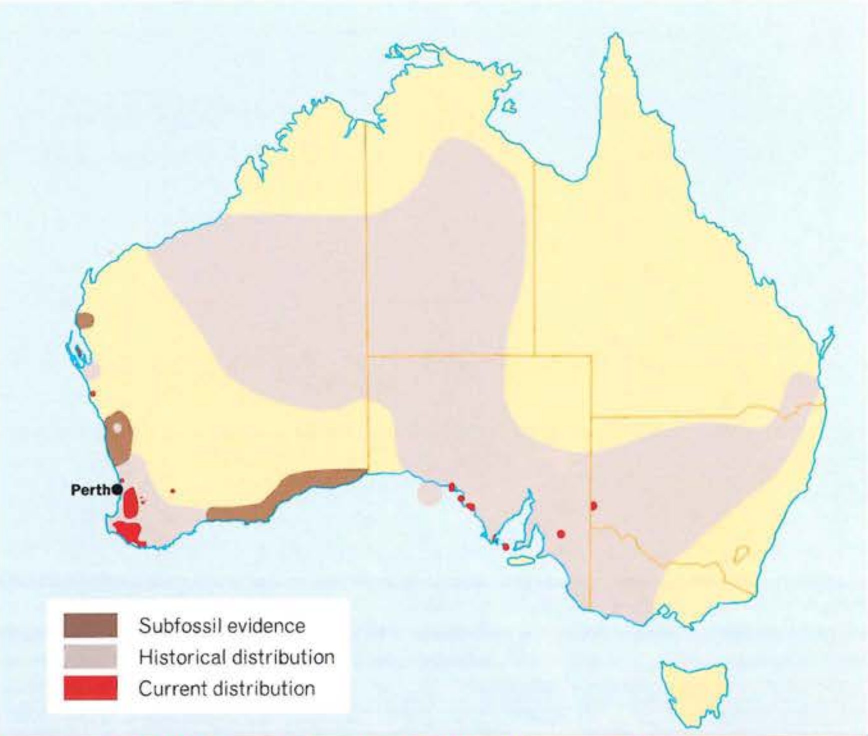
The Woylie Disease Reference Council was established with experts in their field from Murdoch University and Perth Zoo. This highly talented group is charged with the task of trying to understand what diseases woylies may have and, more importantly, what role they may play in the current woylie decline.

Where to from here?

Equipped with such findings, key players met at a major symposium and workshop at Murdoch University in February this year to discuss the problem. Environment Minister David Templeman, WA Chief Scientist Lyn Beazley and DEC Director General Keiran McNamara attended, as well as experts from around Australia and as far away as New Zealand and Canada. As well as sharing their findings, participants considered the priorities and worked out how best to respond to the situation based on the current evidence.

Given the rapid and substantial decline, it is clear that researchers and conservation managers need to build on the achievements of the initial rapid response to give the woylie the best chance of a full recovery. The chances of solving this mystery are immeasurably greater while the declines are occurring and the culprits are still at the 'crime scene'.

Despite the unknowns, people working on the project remain quietly confident about the woylie's future. Armed with this optimism, they are faced with the task of rallying further financial support from government and non-government sectors. With such resources and hard work, scientists remain hopeful the latest chapter in the woylie story will conclude with a happy ending.



Brief history of woylie distribution and abundance

1800s	The woylie is distributed across much of southern and central Australia.
1960s	Only three remnant woylie populations remain—Dryandra, Tutanning and Upper Warren. The rest have succumbed to the effects of land clearing and feral animal predation.
1970s	Isolated increases in woylie populations start in response to fox control and translocations.
1996	The Department of Conservation and Land Management begins its *Western Shield* conservation program, targeting foxes and resulting in more woylie translocations.
1996	Woylie populations have recovered to the extent they are de-listed from State and Commonwealth endangered and threatened species lists.
2001	Woylie populations start to decline at Dryandra.
2002	Populations start to decline in the Upper Warren and Batalling.
2008	The woylie is re-listed as endangered in Western Australian.

Below Woylies.
Photo – Sallyanne Cousans

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Corals in CRISIS

by Roland Mau, Fiona Galloway, Leanne Thompson and Carolyn Thomson-Dans

There is a crisis taking place right now in the world's oceans. Coral bleaching, caused by stressful environmental conditions driven largely by climate change, has already caused widespread death of corals and huge areas of reefs around the world are under threat. Despite being affected by two significant worldwide coral bleaching events—in 1998 and 2002—Western Australian coral reefs are still in a relatively healthy state. But that doesn't mean this will always be the case. What can we do to help safeguard our coral reefs?

A mass coral bleaching event in 1998 affected every geographical coral reef realm in the world and it became the most severe on record at that time. Within Australia, aerial surveys of the Great Barrier Reef Marine Park revealed that 67 per cent of inshore reefs had high or severe levels of bleaching. On the worst affected reefs, 80 per cent of corals died during the following months. Even more severe was the event in 2002, when aerial surveys of 641 reefs recorded bleaching in almost 60 per cent of them. Up to 90 per cent of corals died on the worst affected inshore reefs.

Similar scenarios were occurring in most coral reefs around the world. It is estimated that this event caused the loss of at least 16 per cent of the world's coral reefs—a loss of more than 25,000 square kilometres of reef. Coral reefs in many parts of the Indian Ocean—such as along the eastern coast of Africa—could not recover from coral bleaching and died. The most recent major coral bleaching event occurred in the Caribbean in 2005 (one of the two hottest years since records started in 1880).

The impact of coral bleaching has not been well studied in Western Australia. We do know that during the 1998 mass coral bleaching event, Scott Reef, an offshore Kimberley atoll (see 'Life in isolated oases', *LANDSCOPE*, Winter 2007) was one of the worst affected coral reefs in WA, losing 80 per cent of its coral to depths of 30 metres. Severe bleaching was also recorded in 80 per cent of corals in the Mary Anne Island Group, south of Barrow Island, which is within an area that will be considered for new marine parks and reserves (see 'Pilbara and Eighty Mile Beach: multiple objectives, one marine planning process', *LANDSCOPE*, Autumn 2008). Although there is a knowledge deficit from WA, the extensive research conducted on the Great Barrier Reef and elsewhere has ensured that marine scientists are gaining a thorough understanding of the events that give rise to coral bleaching.

Biology of bleaching

Reef-building corals (hard corals) thrive in the warm waters of tropical and subtropical latitudes, having developed into extensive coral reef ecosystems over thousands to millions of years.

The great majority of hard corals are able to exist in these nutrient-poor waters through maintaining mutually beneficial (symbiotic) relationships with tiny cells of algae known as zooxanthellae. The microscopic zooxanthellae find a safe haven in the living tissue of reef-building corals and contribute to giving the corals their colours. Like other plants, they capture energy from the sun by photosynthesis, producing energy-rich compounds absorbed by the coral host. Corals are highly dependent on this relationship, receiving up to 90 per cent of their energy requirements in this way.

This symbiotic relationship between the coral and the zooxanthellae, however, can run into problems during prolonged, higher-than-normal sea temperatures. Under these conditions, the sun's energy leads to the production of highly corrosive oxygen radicals by the zooxanthellae within a coral polyp. This damages the part of the algae where

Previous page
Main A healthy staghorn coral garden at Ningaloo Marine Park.
Photo – Suzanne Long/DEC
Inset Bleached coral at Rowley Shoals Marine Park.
Photo – John Huisman

Above What WA stands to lose: a diversity of healthy corals in the Montebello Islands Marine Park.
Photo – Suzanne Long/DEC

Left Regular monitoring of WA's marine parks by Department of Environment and Conservation scientists will enable the department to monitor coral bleaching.
Photo – Suzanne Long/DEC

Above The Abrolhos Islands has the world's most southerly coral reef system.
Photo – David Bettini

photosynthesis takes place. As a result, corals expel the algae and the corals look paler as the loss of zooxanthellae renders the tissue largely transparent. The calcium carbonate skeleton is then clearly visible, making the coral appear bright white or 'bleached'.

Although corals are often able to recover from such events quite well, especially if the high temperatures do not go on for extended periods (there is also great variation between different coral species, and even between different colonies of the same species, in their susceptibility to bleaching events), projections of climate change suggest that, by the year 2100, the global average temperature is likely to increase between 1.8 to four per cent from 1980 to 1999 values. This would have catastrophic effects on the world's coral reefs, including those in WA.

Less commonly, coral bleaching can also be caused by anomalously low sea water temperatures. This occurred at Ningaloo Marine Park in July 2006, when most of the back-reef sections were bleached from aerial exposure during low spring tides that coincided with unusually low air temperatures. Fortunately, within a few weeks, almost 100 per cent of affected corals recovered. This was the first major sea temperature-related coral bleaching event recorded at Ningaloo Marine Park, highlighting the importance of careful conservation management to maintain the reef.

A new threat: ocean acidification

A paper published in *Science* magazine in December 2007 argued that unchecked global warming would potentially decimate coral reefs and the 100 million people and one million species depending on them. The study used information built up over the past decade to project how reefs would look if greenhouse gas emissions were, or were not, controlled.

At the same time as the world's oceans are warming, their acid levels are increasing due to higher levels of carbon dioxide in the atmosphere dissolving into the waters. This is potentially disastrous for reef-building corals, as acidification affects their ability to form skeletons. The level of carbon dioxide concentration in the Earth's atmosphere is currently 380 parts per million, the highest in at least one million years, if not 20 million years. According to the paper's authors, if future emissions exceed 500 parts per million the world's reefs will disappear on a large scale. Once this critical threshold is reached, a coral is unable to extract carbonate from the water to form its skeleton. It appears that this acidification is now taking place over decades, rather than centuries as originally predicted.

WA coral reefs

So how will climate change impact on WA corals? Coral reefs in the Ningaloo Marine Park, Rowley Shoals Marine Park, the Dampier Archipelago (likely to be declared a marine park later this year), the Montebello-Barrow Islands marine reserves, the Abrolhos Islands and many other areas are all likely to be affected.

The effect of climate change on Australia's marine areas was a major theme of the Australian Coral Reef Society Conference held in Fremantle in October 2007. According to keynote speaker Professor Charles Sheppard, from the University of Warwick in the UK, coral bleaching in the 1998 and 2002 events has already had a terrible human cost, with uncounted numbers of people from subsistence, fishing-based economies dying and suffering food shortages as a consequence of climate change. Coral reefs in many parts of the Indian Ocean—such as along the eastern coast of Africa—that were subject to major pressures from overfishing and pollution could not recover from coral bleaching and died. Significantly, Professor Sheppard said coral reefs were best able to survive such severe coral bleaching where they were

Left Bleaching can also occur due to factors other than thermal stress. For example, when mass coral spawning occurs in certain weather conditions, the spawn can be pushed into bays and lagoons, deoxygenating the water and killing corals, fish and other animals. *Photos – Claire O'Callaghan/DEC*

not suffering from other pressures. Coral may become stressed from ecosystem pressures due to anchor damage, overfishing, dredging, reduced water quality and associated diseases, thereby reducing its ability to withstand heat stress associated with climate change.

Establishing a comprehensive, adequate and representative network of marine parks is extremely important because, where marine environments are well managed, this contributes to the resilience of marine ecosystems and helps them more easily weather severe environmental stresses such as coral bleaching and other effects of climate change.

What can be done?

Most marine scientists believe the only real solution to coral bleaching is to significantly reduce global carbon emissions that are linked to global warming. It will be important for national and international collaboration to occur and will rely on direct contributions from individuals, industry and governments to reduce carbon emissions and address climate change issues.

Halting climate change will only be accomplished through concerted global action to increase energy efficiency, adopt renewable energy options, reduce greenhouse gas emissions through a range of technological innovations and minimise land clearing.

The WA Government is committed to reducing greenhouse gas emissions. For example, by 2010 the public sector will be buying at least 20 per cent of its energy from renewable sources. The WA Government has almost doubled the length of Perth's rail system—taking about 25,000 cars off our roads every day. It has also established a website (www.actnow.wa.gov.au) to help the public take steps towards a greener future.

Specific actions to protect the marine environment and help make WA's marine ecosystems more resilient to climate change include plans to expand the number of marine parks in WA, with four new reserves expected in 2008. These measures will increase the area protected in marine parks to 14 per cent of our waters.

Marine park management practices, such as the establishment of sanctuary zones and public moorings, all help to increase the resilience of WA's marine parks to bleaching events by reducing or removing additional pressures on coral. Over the past few years the WA Government has significantly increased the amount of funding to manage existing and new marine parks.

It has also committed $21 million over five years from July 2006 to establish the Western Australian Marine Science Institute (WAMSI). WAMSI contributes funding to research by CSIRO, the Australian Institute of Marine Science (AIMS), the Department of Environment and Conservation (DEC) and local universities into WA's marine biodiversity and the impacts of climate change on the State's marine areas.

WAMSI and CSIRO, in collaboration with DEC, are developing a model that will predict the likely effects of different climate change scenarios on Ningaloo Marine Park and which will help manage the impacts of human use of the reef. This model will also apply to the conservation of other coral reefs in WA in relation to climate change.

Marine park management

In late 2007, two DEC marine park management staff attended a workshop at Lady Elliot Island in the Great Barrier Reef Marine Park on managing coral reefs in response to climate change.

Ningaloo Marine Park Coordinator, Roland Mau, and West Kimberley District Marine and Coastal Reserves Officer, Fiona Galloway (who manages the Rowley Shoals Marine Park), attended the workshop with 21 other government and non-government representatives from Indonesia, Malaysia, the Philippines, Thailand, Hawaii, Australia's Great Barrier Reef Marine Park Authority and other Commonwealth marine reserves.

Led by Paul Marshall and Heidi Schuttenberg, trainers from Australia and the USA's National Oceanic and Atmospheric Administration (NOAA) presented an intensive five days of

Background right Healthy corals in the proposed Dampier Archipelago Marine Park.

Below Yellow boxfish in a staghorn coral. Not only corals, but the animals which depend on them, need our help.
Photos – Suzanne Long/DEC

Busting the two top myths about climate change and corals

Myth 1: Corals will simply adapt.

While corals are found in both tropical and temperate latitudes—for example, temperate corals are found at Esperance—their ability to adapt in response to climate change is in doubt. Corals are locally adapted to the water temperature in which they live and their tolerance for conditions can certainly change over time. The problem is the speed at which climate changing is occurring. During the period of warming after the last ice age, the Earth reached a temperature between 5–7°C hotter than today. This change occurred over about 10,000 years but was so dramatic that many species became extinct and most marine life experienced changes in distribution. The rate of change we are currently experiencing is between 50 to 100 times faster and scientists are unsure whether species will be able to adapt in time.

Myth 2: Some corals are more resistant to bleaching the second time around.

When bleached corals reincorporate zooxanthellae into their tissue they may take in more than one type (or clade) of algae, some of which may have increased tolerances to increased water temperatures. Even if corals could take in new types of more resistant algae, there would still be major problems, including the fact that corals themselves only have a specific temperature range at which they can live. The second problem is that there is no scientific proof that this method would happen quickly enough to help corals adapt to increasing water temperatures.

lectures and field exercises to increase capacity for planning, monitoring and responding to climate change and bleaching events in coral reefs.

Topics covered management issues such as developing response frameworks, coral reef resilience, social and economic impacts, interpreting remote sensing data, management interventions, and the development of bleaching response plans.

WA's Ningaloo Marine Park and Scott Reef are already 'virtual' stations for which automated email alerts are issued to Western Australian coral reef managers when NOAA satellite observations indicate that water temperatures are rising beyond critical limits. Roland and Fiona nominated additional locations off the Pilbara and Kimberley coast that will become part of the NOAA's worldwide coral bleaching early warning system (www.coralreefwatch.noaa.gov/satellite). These include the Montebello Islands Marine Park, Rowley Shoals Marine Park and Montgomery Reef, which lies on the Kimberley coast just offshore from the proposed Walcott Inlet National Park.

Since Roland and Fiona's return, a discussion forum has been held through DEC's Marine Science Program to raise the issue of coral bleaching and its implications for Western Australian coral reefs. Further discussions on relevant management actions are planned for 2008.

DEC will continue to monitor the health of coral communities in WA's marine parks and reserves as part of its long-term monitoring programs. The public can help by reporting any observations of coral bleaching to DEC's Marine Science Program or to the department's Exmouth District office.

Sentinels of the sea

Like other important environmental indicators on land, such as frogs, which are the first animals to disappear or show stress when things start to go wrong, coral reefs are the sentinels of the sea. The International and Coral Reef Initiative has declared this year the International Year of the Reef—time for us all to reflect on how our specific actions can have an impact on our oceans.

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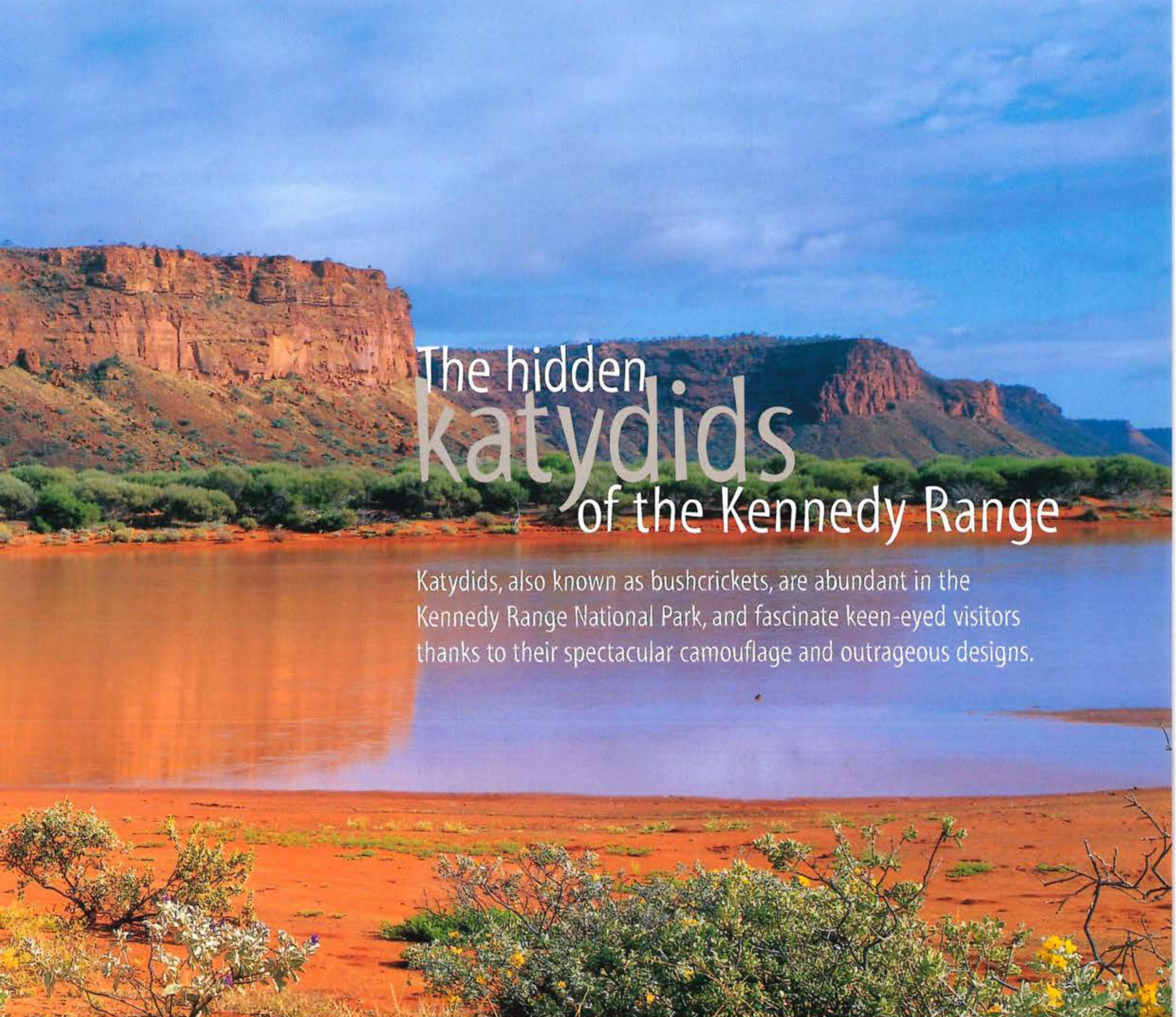
The authors would like to acknowledge Suzanne Long and Chris Simpson from DEC's Marine Science Program and Professor Charles Sheppard from the University of Warwick for input into this article.



The hidden katydids of the Kennedy Range

Katydids, also known as bushcrickets, are abundant in the Kennedy Range National Park, and fascinate keen-eyed visitors thanks to their spectacular camouflage and outrageous designs.

by John Alcock and Winston Bailey

The barren sandstone cliffs that characterise the eastern edge of the Kennedy Range National Park looked down on an unusually cheerful desert scene we observed during a visit last year. Rain had drenched the area at some point earlier in the winter, interrupting the ongoing drought in the Gascoyne region. As a result, we were able to wander among large fields of yellow everlastings while also admiring the flowering flannelbushes, grevilleas, mulla mullas, and many other blooming shrubs scattered through the national park, 150 kilometres east of Carnarvon.

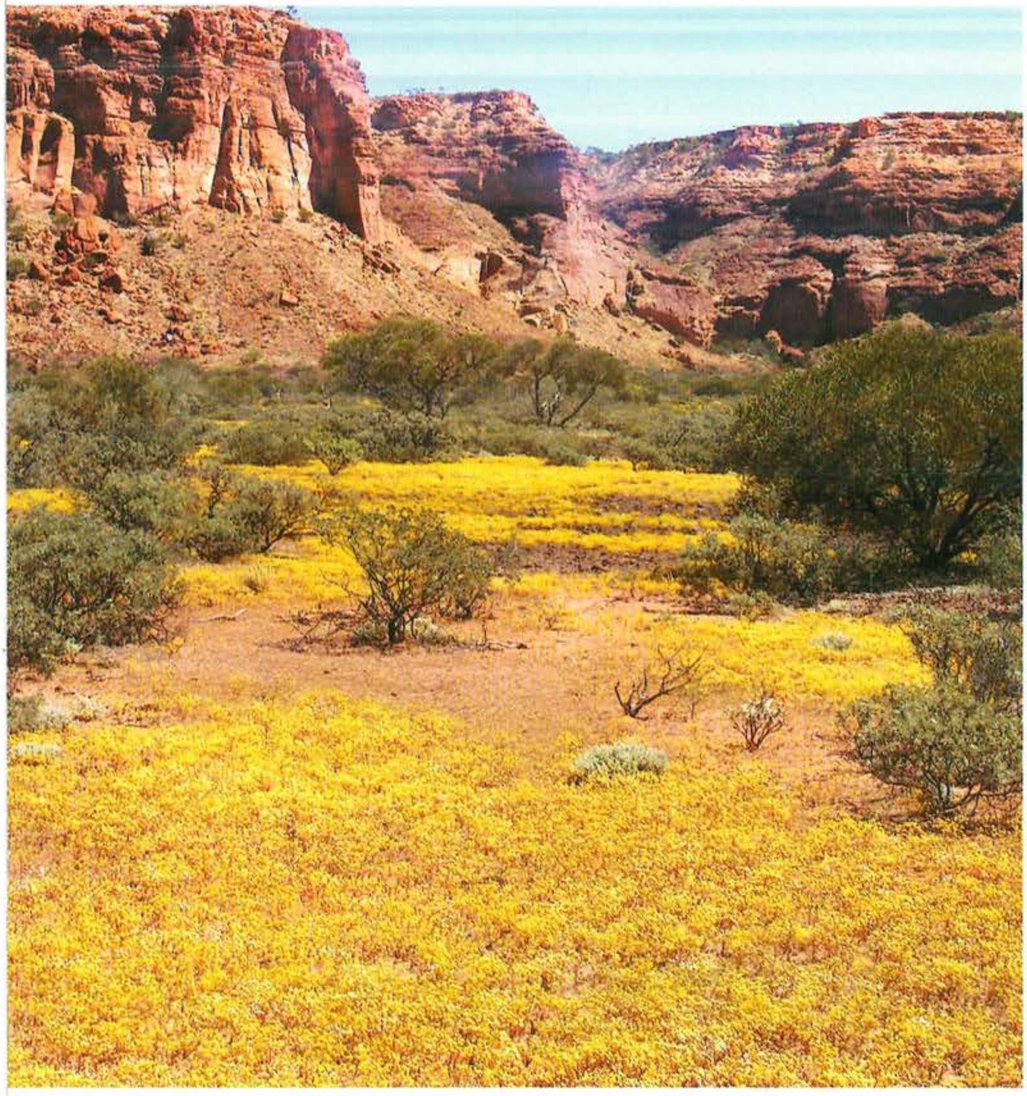
Although we derived aesthetic pleasure from the rain-stimulated burst of plant productivity in the park, other creatures derived more practical benefits from the plant growth that followed the winter rains. Among the beneficiaries were the feral goats that picked their way along ledges in the dramatic red sandstone cliffs. Although the Department of Environment and Conservation (DEC) had successfully removed more than 2,000 goats earlier in the year through its goat eradication program, some of the surviving goats were hungrily working their way through the now-leafy local plants. Happily, native Australian herbivores were also well fed, including the big reddish euros, which leapt from rock to rock on the escarpment.

● Kennedy Range National Park

Grasshopper and katydid metropolis

To the east of the high mesa that dominates the park, a multitude of grasshoppers burst up and away from us whenever we strolled across the *Acacia*-dominated flats. Some species were little more than a centimetre long while others were much bigger, a few even exceeding eight centimetres. Many of the grasshoppers of the Gascoyne and Pilbara live on or among the rocks and pebbles of this dry land and as a consequence they have evolved with a remarkable resemblance to their resting places. Perhaps the most spectacular of these grasshoppers are members of the tribe Catanopini, which include the living stone grasshoppers of the genus *Raniliella* and the toad-hoppers (*Buforania*). The living stone grasshoppers active in August in the Kennedy Range looked astonishingly like the dark chocolate pebbles on which they perched during the day. Other grasshoppers nearby had less remarkable but still serviceable camouflage suits that made them look like a loose collection of pebbles or a lump of reddish sand. Whatever their appearance, all species we encountered were busily engaged in converting plant matter into grasshopper tissues. Such was the skill and hunger of these plant consumers that the total grasshopper biomass surely exceeded that of the plant-eating marsupials of the range by a great margin.

As well as the wonderful array of Kennedy Range grasshoppers (see 'Glorious grasshoppers of the Kennedy Range', *LANDSCOPE*, Winter 2004), the bushland to the east of the mesa was home to a smaller number of katydids of



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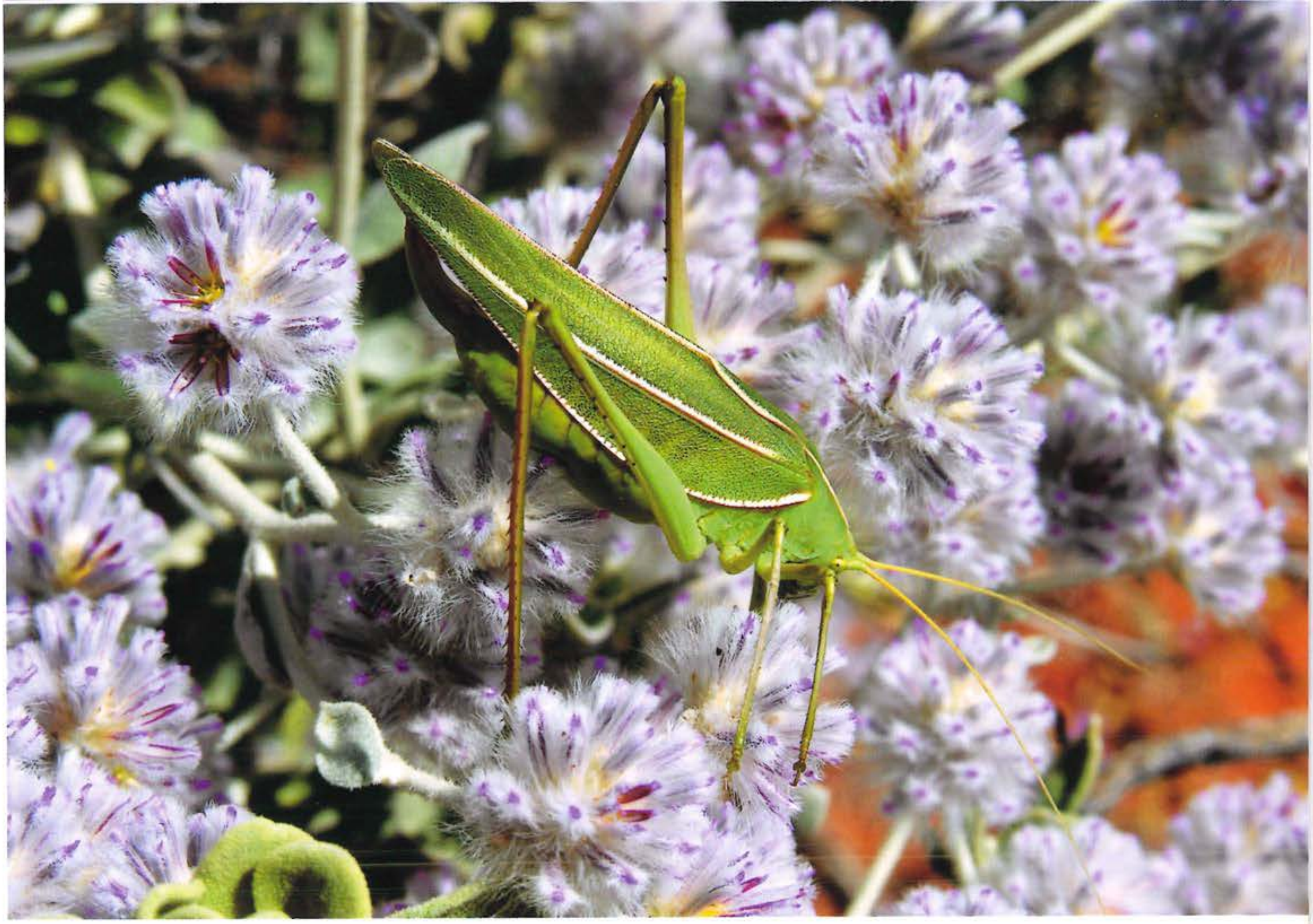
Main Clay pans after rain in Kennedy Range National Park.
Photo – Jiri Lochman
Inset Katydid *Elephantodetta* sp.
Photo – John Alcock

Left Kennedy Range National Park in bloom.
Photo – John Alcock



Above A female katydid *Elephantodetta* sp on mulla mulla flowers.
Photo – John Alcock

the family Tettigoniidae. Katydids (also known as bushcrickets by Europeans and most Australians) and grasshoppers are fairly close relatives, as seen in their placement within the same insect order, the Orthoptera (*ortho* means straight and *ptera* means wings). The insects within this order share leathery flat-sided forewings that cover their pleated hindwings when the animals are at rest. Males of most katydids, grasshoppers and other orthopteran species, such as true crickets, use their wings to attract mates by producing sounds, sometimes by rubbing their legs across their wings, like many grasshoppers, or by rubbing their wings together, as do all crickets and katydids. Another distinguishing feature of the group is that immature orthopterans look like miniature versions of the adults (except that their wings are incomplete) whereas in many other insects, like beetles, flies and wasps, the young stages are grubs that look nothing like the creatures that appear after the metamorphose into adults. Finally, many orthopterans have large hindlegs that their owners use to fling themselves up into the air and away from their enemies, when threatened by a predator.

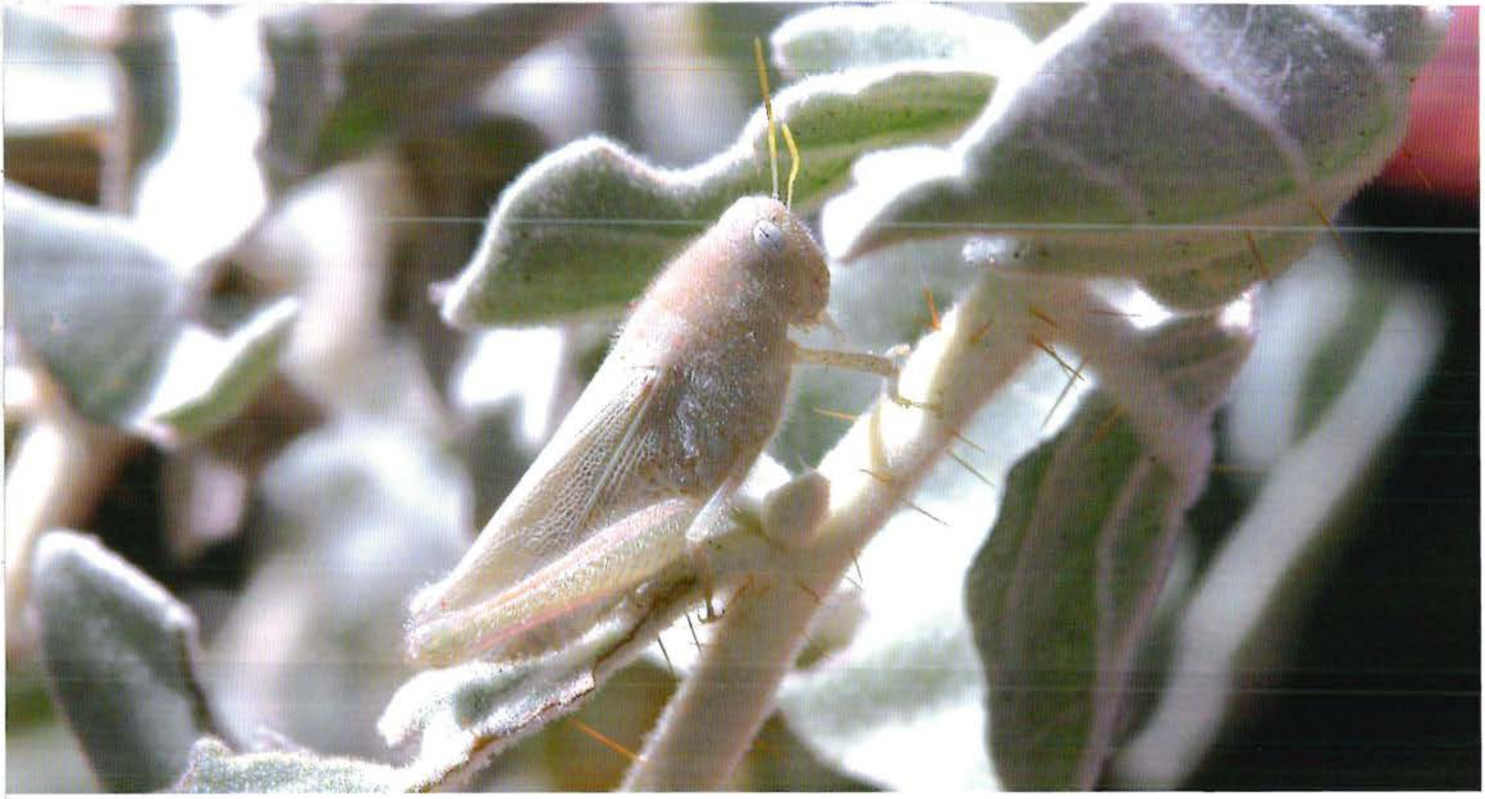
Katydids and grasshoppers —defining the difference

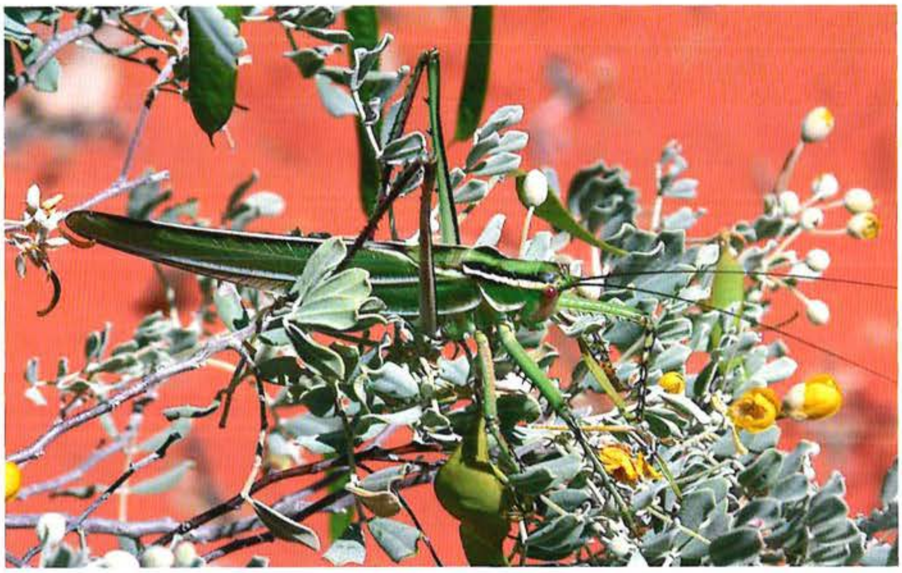
Katydids and grasshoppers share the standard features that distinguish the Orthoptera from other insect orders but the two groups also differ in various ways. For example, grasshoppers are generally active during the day unlike katydids, which come out at night to feed and mate. Because they are more exposed to bird predators, grasshoppers usually have larger and more powerful hindlegs than katydids, the better to jump to safety. Likewise, the diurnal grasshoppers depend on their relatively large eyes whereas the nocturnal katydids tend to rely more on their olfactory and tactile senses, as reflected in their very long and delicate antennae.

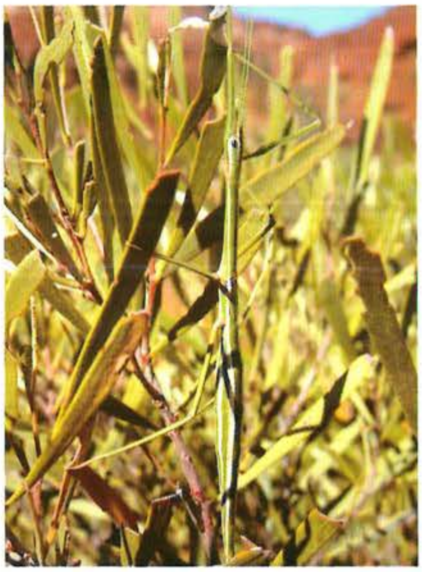
During our daytime walks in Kennedy Range National Park, thousands of grasshoppers used their good vision to spot us before employing their big hindlegs and effective wings (if they were adults) to leap or fly away. Katydids were much less numerous, although we suspect that our record of seeing roughly one katydid for every 1,000 grasshoppers stems in part from the reluctance of the well-camouflaged katydids to move from their daytime retreats in shrubs and trees upon our approach.

Masters of camouflage

Perhaps because katydids were harder to find, we took special pleasure from each one we discovered during our time in the national park. One of the first katydids that we stumbled upon in the Kennedy Range belonged to the genus *Elephantodetta*, an elegant creature some six centimetres long without its antennae, which were longer than its body. The bold white stripes that ran down the camouflaged green of its body may serve to disrupt the overall outline of the katydid's body, drawing a predator's attention instead to two leaf-shaped images on its wings, which partially cover the beautiful purple patches on the sides of the abdomen. The 'leaves' formed by the insect's forewings are not too dissimilar from the actual leaves of some desert wattles, which provide food and shelter for this handsome species. One imagines that a white-







Top Perfect grasshopper camouflage.
Photo – Winston Bailey

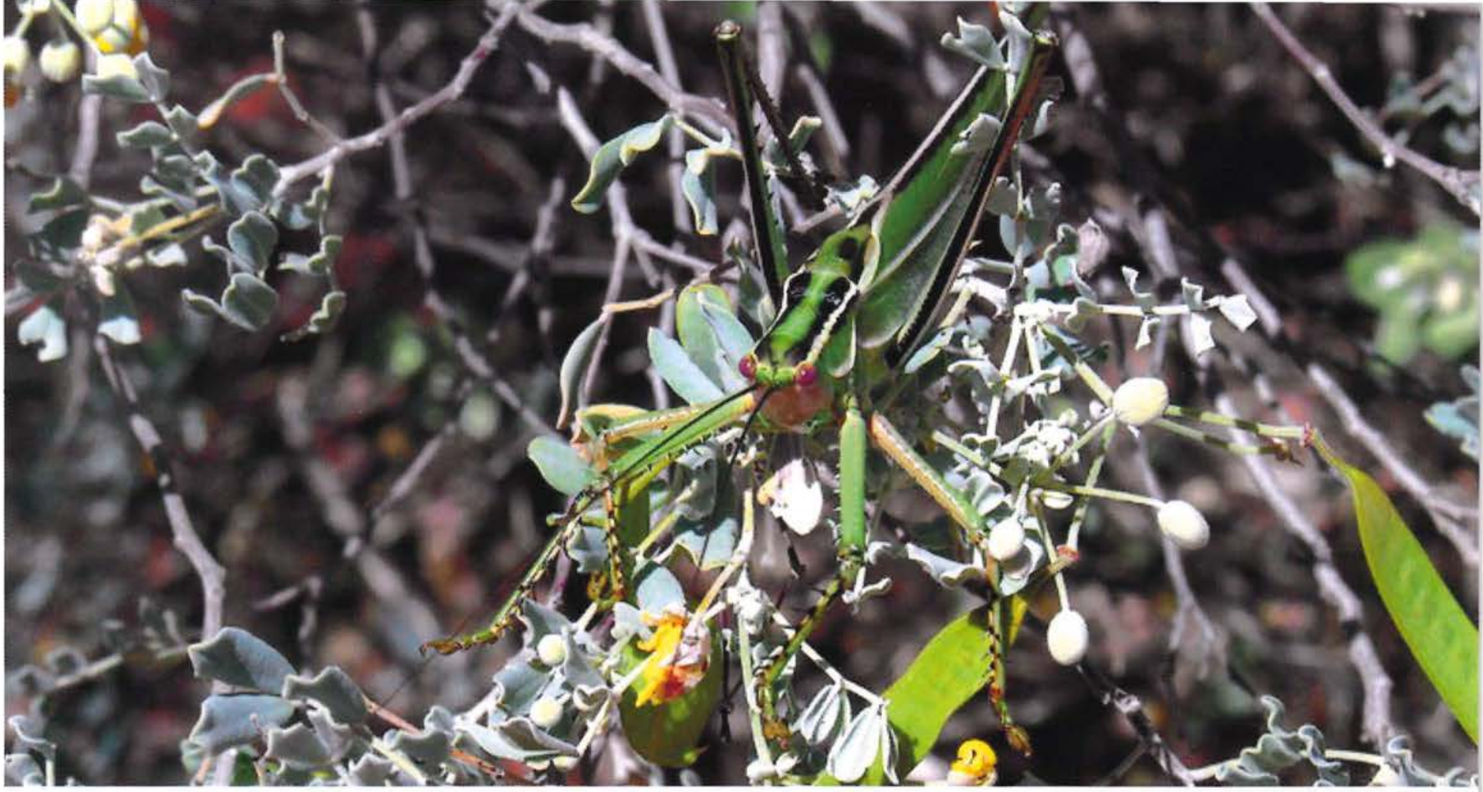
Above left The splendid katydid (*Terpandrus splendidus*).

Above A stick-like katydid *Phasmodes* sp.
Photos – John Alcock

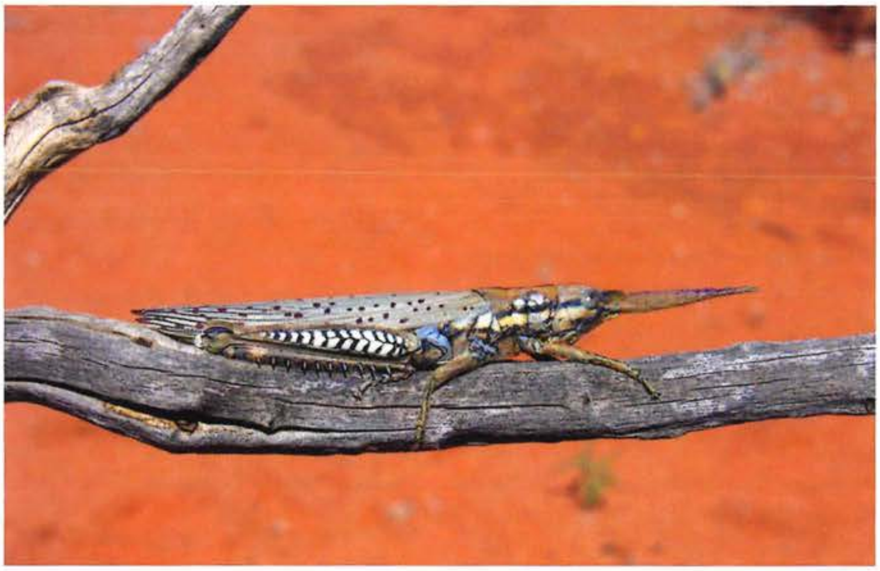
browed babbler could come close to an Elephantodetta and be fooled into ignoring what would be a fine meal, provided that the insect had nerves of steel and could hold absolutely still in the face of danger. Indeed, the only reason that we found our *Elephantodetta* at all was that one of us brushed against a shrub containing the insect, coming so close that the katydid flushed in desperation from its hiding place. The flight of the katydid was much slower than that of the speedy grasshoppers.

Later in the walk, contact with an *Eremophila* shrub enabled us to frighten one of the many katydids in the genus *Caedicia*, most of which have yet to be formally described and named in scientific literature. But the one that we saw was broadly representative of the genus as a whole, with its uniformly leaf-green body, perhaps four centimetres in length. The leaf motif so prevalent among katydids expressed itself most delicately in our *Caedicia* whose forewings looked as if they had been actually constructed from two long, thin *Acacia* leaves. The large mid-vein of each false leaf ran the length of the animal's forewings and was surrounded by a fine network of pseudo-veins that furthered the professional leaf mimicry of this katydid.

For the most part, species such as *Elephantodetta* and *Caedicia* are herbivores, as is the remarkable stick-like member of the genus *Phasmodes*, another katydid that we found serendipitously because it had for some reason taken shelter on the tent occupied by one of our party. When we were packing up to head out from the campground in the national park, this remarkable creature made itself visible to us. We took it to a nearby *Acacia*, released it in the plant, after which the *Phasmodes* quickly oriented itself parallel to the leaves of its new host plant. In this position, the katydid all but disappeared from view, a goal that it promoted by holding its antennae straight out in front of its head, thereby reducing the conspicuousness of that part of its body. The long white stripes that ran the length of its body almost



Above The splendid katydid (*Terpandrus splendidus*).
Photo – Winston Bailey



Right An acridid grasshopper adopting cryptic posture.
Photo – John Alcock

certainly had much the same disruptive function as those of *Elephantodetta*, assuming that these conspicuous stripes draw a predator's attention away from the rest of the body of the katydid by creating the illusion of several thin vertical strips of green. As with many katydids in the region, this species is almost certainly new to science, with the closest described species (*Phasmodes nungeroo*—named after an Aboriginal word meaning whiskers) found far away at Kalbarri National Park.

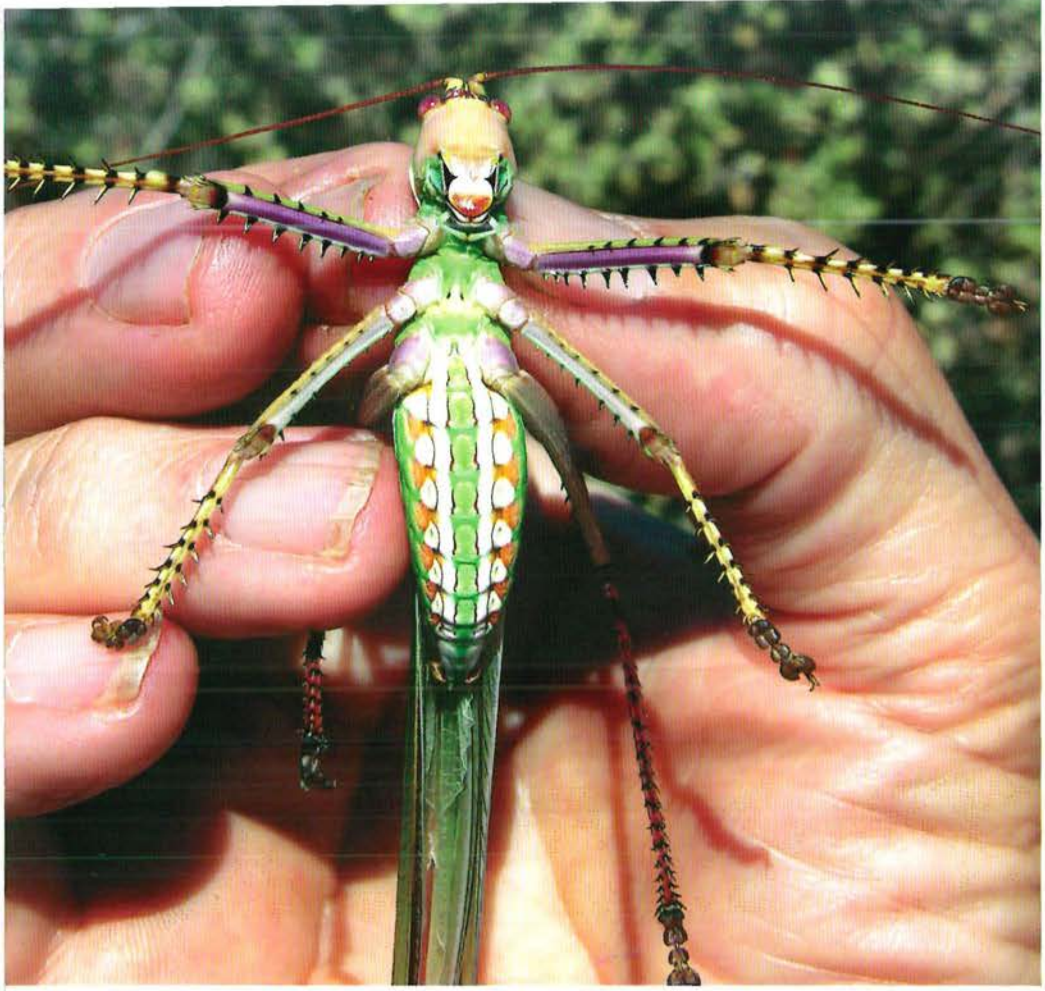
Katydid courtship

At night, males of many katydid species attract searching females by stridulating noisily. In the subfamily *Phaneropterinae*, which includes *Caedicia* and *Elephantodetta*, the male calls and then the female replies with an acoustical signal of her own. The duration of the interval between male call and female reply varies among species, enabling the members of a particular species to communicate with one another. The duetting male knows he has a catch when he calls and then hears the stridulated reply of a female after a precisely timed interval. The male then calls some more, luring the female ever closer until they make contact in the darkness, often on a flowering *Acacia*, which can lead to copulation. After the female has received a packet of sperm from her partner, she is ready to fertilise her eggs and lay them by inserting her eggs into an *Acacia* leaf, known as a phyllode, after using a very clever device at the end of her abdomen to cut open the leaf edge.

Katydid cuisine

Although most katydids are plant consumers, often preferring nitrogen-rich flowers or ripe fruit, not all lead meat-free lives. On our Kennedy Range walks, we found one carnivorous katydid, which rejoices in the name *Terpandrus splendidus*, and what a truly splendid creature it is. This species eschews leafy meals and instead stalks and captures other insects, which it holds tightly with its large and spiny legs while it munches its way through its victims. At night, the loud staccato call of one male splendid katydid may attract other males, which form a loose chorus to compete against one another for the attention of females in their neighbourhood.

Like many other katydids, *Terpandrus* has a dorsal colour pattern that is largely green with some white stripes. You can notice that its disruptive white stripes are enhanced by the lines of black along its back and thorax. These lines surely draw a bird predator's eye to the small regions of high contrast, which presumably helps keep any would-be katydid consumer from



seeing the head of the katydid or the outline of its body. Insect-eating birds that spot an edible insect's head have two advantages: first, they can readily identify a potential prey by its head, and second they then know how to direct an attack to best advantage (a blow to the head is more likely to disable the prey than a strike to the forewing or a leg). But *Terpandrus* does not rely on camouflage alone for its protection as one of us learned when he gingerly picked up the katydid. The unhappy insect promptly bit the finger of its captor and because this katydid's jaws are large (the better for disabling and consuming small insect prey), the bite drew blood. In addition, this species has strongly spiny forelegs, which it can use for slashing at its own enemies as well as for holding onto its prey. Other Australian species, like the crested katydid (*Alectoria superba*) are also spiny, which may protect them against birds during the day and bats at night when the katydids call for their mates.

Above The underside of katydid *Terpandrus splendius.*

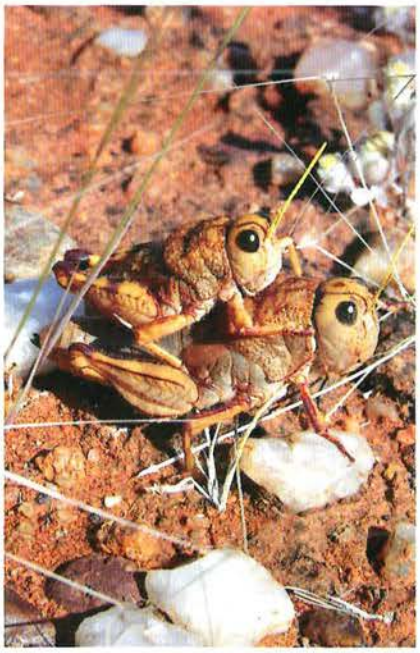
Top right A pair of toad grasshoppers (*Buforania*) mating with the smaller male on top.
Photos – John Alcock

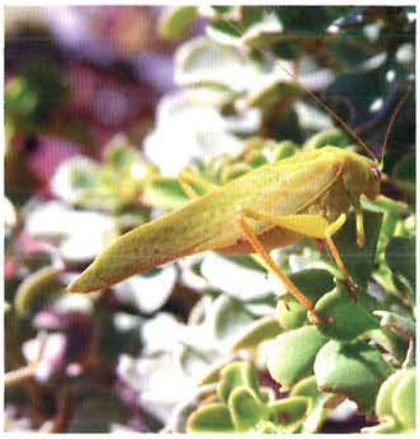
Centre right One of the many species of duetting *Caedicia.*
Photo – Winston Bailey

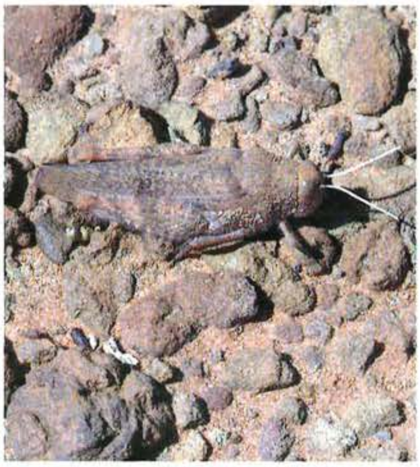
Bottom right A living stone grasshopper (*Raniliella*).
Photo – John Alcock

Wild designs

By carefully holding the splendid katydid between thumb and forefinger we were in position to see the strikingly ornate green, orange and white colour pattern on the underside of its abdomen as well as the delicate patches of purple on the upper part of its forelegs. We were stymied when we tried to think of functions for these body colours but were delighted by this creature, just one of a diversity of katydids in the Kennedy Range, a diversity rich in questions for anyone interested in the natural history of Western Australia. We strongly recommend that bush walkers take advantage of those uncommon occasions when an inadvertently disturbed katydid flutters out of its hiding place. The colour pattern of the insect alone will be worth the price of admission to many Australian parks and reserves, home to so many species of these beautifully camouflaged insects.







John Alcock and Winston Bailey are both retired academics with an interest in insects. John is professor emeritus at Arizona State University in the United States who fell in love with the biology of Western Australia during a period of study leave in the 1980s.

Winston is professor emeritus at The University of Western Australia where he studied the physiology of hearing and behaviour of katydids.

Last stand at **Bell Track**

Originally considered worthless by early explorers, Fitzgerald River National Park is today world-renowned for its amazing biological diversity. The importance of conserving this unique area is reflected in a major $1.4 million investment to contain dieback.

by Katie Schoch

● Fitzgerald River National Park

Situated between Bremer Bay and Hopetoun on the south coast of Western Australia, the 330,000-hectare Fitzgerald River National Park is home to 1,800-plus plant species (nearly 20 per cent of the plant species found in WA) and at least 19 native mammals. Such is its importance that the park has been declared a World Biosphere Reserve—one of 529 places in the world to receive this internationally recognised conservation listing from UNESCO.

Unfortunately, the park is also home to a 185-hectare infestation of *Phytophthora cinnamomi*, an introduced water mould that attacks plants and causes root rot and is the cause of the deadly plant disease, *Phytophthora* dieback. Now known as the Bell Track infestation, the pathogen was introduced in the 1970s by earth-moving equipment constructing an unauthorised track through the park.

Tackling dieback

Faced with the challenge of containing the Bell Track infestation, and with no known cure for the disease, the Department of Environment and Conservation (DEC)—with additional support and funding through South Coast Natural Resource Management—is undertaking a $1.4 million dieback containment project. The project is funded by DEC's biodiversity conservation initiative *Saving our Species* and aims to prevent the infestation spreading beyond the micro-catchment boundary.

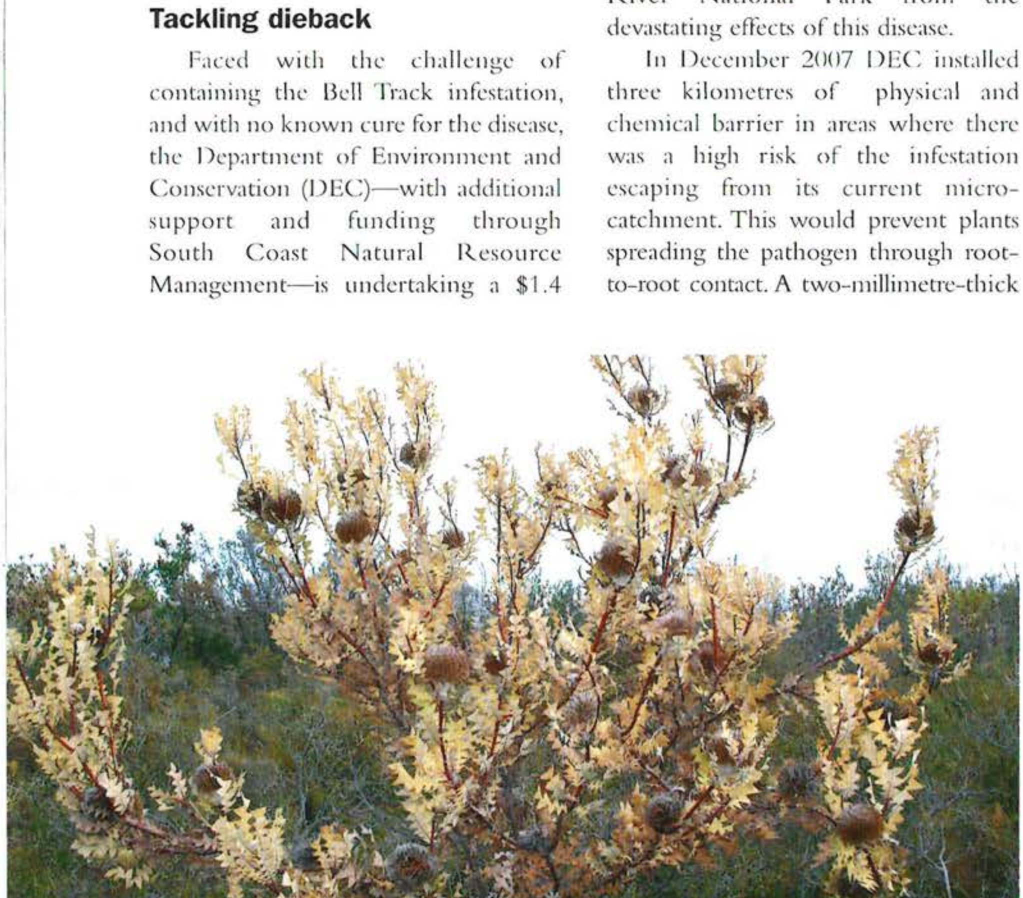
While containing the infestation and treating affected areas is not a new issue, the strategies being implemented under the Bell Track *Saving our Species* project are innovative, multi-faceted and experimental, reflecting the importance of protecting Fitzgerald River National Park from the devastating effects of this disease.

In December 2007 DEC installed three kilometres of physical and chemical barrier in areas where there was a high risk of the infestation escaping from its current micro-catchment. This would prevent plants spreading the pathogen through root-to-root contact. A two-millimetre-thick plastic membrane was trenched one metre into the ground. A chemical dispersion system was then placed at the bottom of the trench to deliver a root-inhibiting and fungicide chemical to discourage deeper roots growing under the membrane.

The membrane was the latest stage in the project, which also involved the construction of a 12-kilometre fence to prevent kangaroos spreading infested soil—a major cause of the spread. The 1.8-metre-high fence, which took nearly four weeks to complete, now surrounds the entire Bell Track infestation.

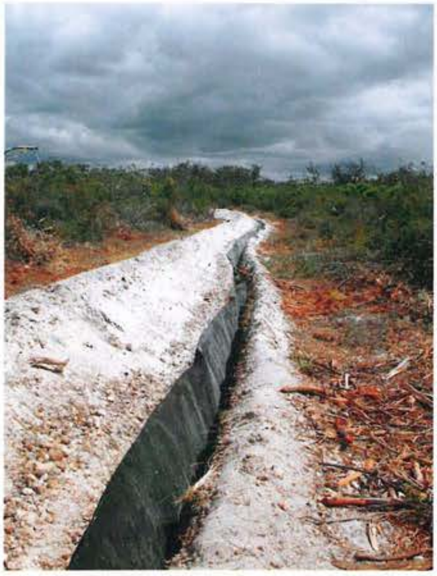
Phosphite, which is known to inhibit the growth of the pathogen in plants, has also been aerially applied to the infestation on a periodic basis. In conjunction with aerial application, high-intensity phosphite has been applied by hand to areas recognised as high-risk sites within Bell Track.

Strict measures have been taken throughout each stage of the project to ensure that the work does not contribute to spreading the infestation. Hygiene management has included the wash down and inspection of all vehicles and machines, restricted access along the fence alignment and preventing the movement of vehicles and equipment at the site on wet soil days. Intensive soil sampling was also undertaken before any on-ground works started to ensure areas were free of the pathogen. Samples were subject to innovative DNA extraction and analysis by the Centre for Phytophthora Science Management at Murdoch University and further analysis by DEC's Science Division's Vegetation Health Service.



Previous page
Main DEC staff monitoring typical Bell Track vegetation for signs of infestation.
Insets Baxter's banksia (*Banksia baxteri),* scarlet banksia (*B.coccinea*).

Left *Phytophthora cinnamomi* can devastate banksia.
Photos – Maria Lee



Future tactics

A hydrological investigation and feasibility study is currently under way and will provide DEC with options to manage surface water flow within the micro-catchment. Several other strategies will begin this year, including the design and construction of engineering works to manage surface water run-off. High-water intake native plant species that are tolerant to *Phytophthora cinnamomi* will also be planted in areas where the pathogen has reduced the quantity of original vegetation. These plants will help to use up the rainfall and surface water on site, reducing the risk of water spreading the pathogen to other areas.

Throughout the project, DEC research scientists have studied the management responses being trialled, and monitored their effectiveness. This has included a detailed study that has described the behaviour of the pathogen on the site. The information gathered through this research has ensured that project management decisions are based on sound scientific principles.

Importantly, techniques used in the *Saving our Species* Bell Track project have the potential to be applied worldwide to help fight the devastating effects of *Phytophthora cinnamomi*.

Recently a new infestation of *Phytophthora cinnamomi* was confirmed in the national park on the Susetta River. It is believed this infestation may have been introduced through *Phytophthora cinnamomi*-infested gravel on a road outside the park. It is hoped that the lessons learnt from the operation at Bell Track will help in the management of the Susetta River infestation and also in preventing new infestations elsewhere.

Top left A plastic membrane to prevent the root-to-root spread of *Phytophthora cinnamomi*.
Photo – Maria Lee

Top right Western pygmy possums inhabit Fitzgerald River National Park.
Photo – Stuart Miller

Above left Bell Track.

Above centre Nari Williams from Murdoch University extracts and analyses *Phytophthora cinnamomi* DNA from soil samples.

Above right Prickly dryandra (*Dryandra falcata*).
Photos – Maria Lee

Katie Schoch was the *Saving our Species* Communications Project Officer at the Department of Environment and Conservation when she contributed this article.

Valuable contributions to the article were made by DEC staff Malcom Grant, Maria Lee and Chris Dunne.

Walpole
Wilderness

A vast area of land in the south-west was unofficially declared the Walpole Wilderness in 2001. This resulted in the establishment of several new national parks, branding and further protection for the area. Now the area is subject to a management plan which, when released, will pave the way for a formal declaration of this spectacular and nature-rich place.

by Samille Mitchell

The Walpole Wilderness embraces more than 363,000 hectares of Western Australia's south-west with a beautiful tapestry of rushing river ways, gnarled trees, rising mists and wild coast. Rare and threatened plants and animals, many found nowhere else in the world, inhabit the rolling landscapes and the rivers, inlets, wetlands and the ocean are home to a riot of species, including humpback and southern right whales, which annually patrol the coast.

Here towering stands of tingle trees provide a window into the forest's ancient past—the trees and their surrounding environment are reminiscent of the grand rainforests that once characterised the now-dry Australian continent. Indeed, walk among the towering trees, listen to the screech of birds, smell the damp earth at your feet and it's easy to imagine you are walking through an ancient land. Such are the natural values of this landscape that the Department of Environment and Conservation (DEC) has written and is now planning the launch of a management plan for the area—a move that will guide the protection of this natural environment now and into the future.

Previous page
Main Snake Gully on the Great Forest Tree Drive, Shannon National Park—part of the Walpole Wilderness.
Photo – Jiri Lochman

Above Valley of the Giants Tree Top Walk.
Photo – Trevor Burslem

Right View of the coast west of Peaceful Bay, Walpole-Nornalup National Park.
Photo – Marie Lochman

What is the Walpole Wilderness?

The Walpole Wilderness covers the vast area of forests and other landscapes between Walpole, Denmark and Rocky Gully, taking in nature reserves, forest conservation areas and seven national parks—Mount Frankland, Mount Frankland North, Mount Frankland South, Mount Roe, Mount Lindesay, Shannon and Walpole-Nornalup. It is also home to the soon-to-be-declared Walpole and Nornalup Inlets Marine Park. Within this region, two areas will be gazetted as 'core wilderness'. In these areas, access is only by foot or canoe, and there are no marked trails. In contrast, three sites have been set aside for higher level visitation and collectively named the 'Walpole Wilderness Discovery Centre'.

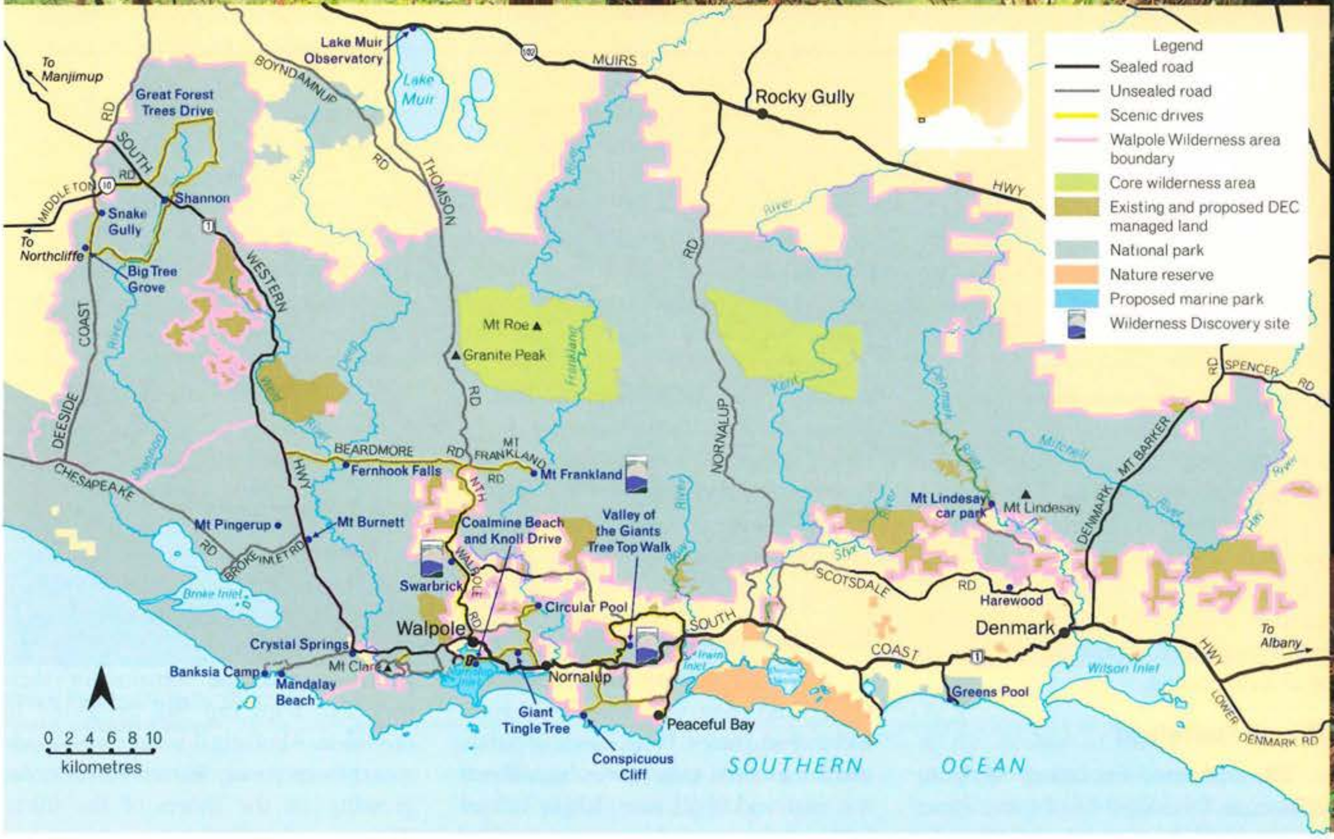
These sites—the Valley of the Giants, Mount Frankland and Swarbrick—feature attractions designed to enhance human interaction with the natural environment. They provide visitors with the opportunity to find inspiration and enjoyment from nature while also gaining an understanding of natural and cultural stories of the area.

The Valley of the Giants

The Valley of the Giants is perhaps the best known of the three sites that make up the Walpole Wilderness Discovery Centre. It is home to the Tree Top Walk, which features a stunning walkway positioned 40 metres above the ground amid the dizzying heights of the tingle forest canopy. A boardwalk meandering across the forest floor called the Ancient Empire also features here, enabling visitors to explore the forest floor without damaging the environment they've come to admire.

More recently, an interactive discovery centre and outdoor classroom have also been developed at the Valley of the Giants to further inspire and educate visitors about the wilderness. The centre includes an interpretive display with an extensive mural depicting the Walpole Wilderness from the hinterland to the inlet. Inclined panels tell the stories of wilderness people and wildlife over time. A 'naturalist's diary' showcases invertebrates that once lived here, including the 'giant' tingle spider, centipede, 'roly poly' millipede, bull ants, elephant weevil, frogs, spring beetle and an ancient slug-like creature known as a 'big foot'. Descendents of these creatures survive today, but are much smaller than their super-sized ancestors.

Visitors can also view a large map of the Walpole Wilderness with press button lights to locate sites of significance and site-related pictures. Globes of the Earth reveal the evolution of the landscape and wildlife by showing the effects of continental drift and climate change—hints to


Lake Muir Observatory
To Manjimup
BOYNDAMNUP
Lake Muir
MUIRS
102
Rocky Gully
Great Forest Trees Drive
RD
SOUTH
RD
MIDDLETON
10
Shannon
Snake Gully
To Northcliffe
1
WESTERN
Big Tree Grove
RD
THOMSON
RD
HWY
River
River
Mt Roe ▲
▲ Granite Peak
Frankland
RD
COAST
DEESIDE
River
Deep
Weld
River
Shannon
BEARDMORE
RD
MT FRANKLAND
RD
NTH
Fernhook Falls
Mt Frankland
NORNALUP
Kent
Denmark
River
Mitchell
MT BARKER
SPENCER
RD
RD
CHESAPEAKE
HWY
Mt Pingerup
Mt Burnett
Coalmine Beach and Knoll Drive
Valley of the Giants Tree Top Walk
River
Bow
Mt Lindesay car park
▲ Mt Lindesay
DENMARK
River
Hay
River
RD
BROKE INLET RD
Broke Inlet
Swarbrick
WALPOLE
RD
Circular Pool
Styx
River
SCOTSDALE
RD
Harewood
Walpole
SOUTH
Denmark
To Albany
Crystal Springs
Mt Clare
Banksia Camp
Mandalay Beach
Nornalup
Irwin Inlet
COAST
1
HWY
Wilson Inlet
Greens Pool
Giant Tingle Tree
Peaceful Bay
LOWER DENMARK RD
Conspicuous Cliff
SOUTHERN OCEAN
0 2 4 6 8 10
kilometres
Legend
Sealed road
Unsealed road
Scenic drives
Walpole Wilderness area boundary
Core wilderness area
Existing and proposed DEC managed land
National park
Nature reserve
Proposed marine park
Wilderness Discovery site

Background above Ancient Empire.
Photo – DEC

Right View from Mount Frankland.
Photo – Michael Pelusey

the origins of the species which live in the Walpole Wilderness today. In addition, a 3-D viewer provides a remarkable perspective of wildflowers and common invertebrates in the area.

While the area is well set up to cater to visitors today, it was not always the case. Years ago, visitors would drive their cars into a well-known, hollowed-out tingle tree at a picnic spot to take photos. The site became so popular that by 1989 the number of visitors had reached 100,000 a year. Sadly, the tree's age, combined with visitor impacts over the decades, contributed to its eventual demise.

The death of this famous tingle made it clear that the remaining trees in the Valley of the Giants needed protection. As such, the then Department of Conservation and Land Management (CALM) envisaged the Ancient Empire boardwalk and the Tree Top Walk.

Swarbrick

The Walpole Wilderness Discovery Centre site at Swarbrick, about 10 minutes drive north from Walpole, features forest art exhibits which celebrate the changing perceptions of forest and wilderness over time. It was chosen as a site for its towering stands of karri trees and because of its role in the fierce, anti old-growth forest logging debate which gripped Western Australia in the 1990s and early 2000s. On the strength of the debate, the then opposition Labor leader, Dr Geoff Gallop, visited Swarbrick during logging operations and proposed the creation of the Walpole Wilderness. The issue was a turning point in the 2001 election, which was won by the Labor party.

In developing the Walpole Wilderness Discovery Centre at Swarbrick, planners envisioned an area that fired passion about wilderness through art. As such, 16 artists submitted concepts which combined their artistic interpretation of the area's history with their perception of wilderness. From there, three artists were asked to further develop their concepts and two artists, Lorenna Grant and Alan Clarke, were commissioned to develop artworks. The result is a selection of art exhibits along a 500-metre return walk through the old-growth karri forest. The walk also takes you past a 'wilderness wall of perception'. The 25-metre long and three-metre high stainless steel wall of perception features more than 30 forest-related quotations from the past 100 years, with dates of political events relevant to logging and the wilderness.

The artwork ranges from a sculpture depicting Aboriginal message sticks to a giant suspended ring called the Torus through which the artists prompt the visitor to explore the interconnectedness of all living things.

Mount Frankland

The Mount Frankland Walpole Wilderness Discovery Centre site, about 30 minutes drive north of Walpole, marks the boundary between vast tracts of pristine bush in the wilderness to the north and the human-occupied areas to the south. The site will feature interpretive information panels which provide insights into the wilderness area through the eyes of a tower man—the person responsible for manning the fire lookout on top of Mount Frankland to scan for fires. During summer, the summit of Mount Frankland continues to be used as a fire lookout tower.

A wheelchair-accessible boardwalk will be built during 2008-2009 to provide sweeping views over the wilderness. Those seeking to better explore the wilderness here can set out on one of two walk trails. One circles the base of Mount Frankland while the other climbs to the summit. While the summit walk is strenuous, the views on a clear day sweep from the Porongurup and Stirling ranges in the east, south to the Southern Ocean.

Natural wonders

The Walpole Wilderness is treasured for its wild coast, untouched wilderness and majestic forest. Here, stands of jarrah, marri and karri trees tower high above the earth and tingle trees delight visitors with their gnarled appearance. The red, yellow and Rates tingles are relicts from ancient times. Some 65 million years ago, when Australia was part of the supercontinent Gondwanaland, the climate was warm and continuously wet. However, the gradual drying of Australia marked the end for many flora species. But in the Walpole-Nornalup area, which has the wettest and least seasonal climate in the south-west, the ancestors of today's tingle trees survived.

The survival of these trees also enabled the survival of invertebrate species which hark back to primitive times. They include the tingle spider (*Moggridgea tingle*) and other spider species (*Baalebulb* and *Dandarnus*), primitive snails, and the ancient *Peripatus*, which is a living link between worms and arthropods. Related species survive in the rainforests of Tasmania, eastern Australia, New Zealand, Chile and Madagascar—far flung places that were once united as Gondwana.

The human past

This area of rich natural value was important to Aboriginal people who lived in the region nomadically. One of these groups was known as Murrum, and the remains of their rock fish traps can still be found in the inlets. Aboriginal people also made spears from young Warren River cedar growing on the shores of the inlets. These people called the area Nornalup, meaning 'place of the black snake'.

It wasn't until the 1600s that Europeans first sighted the area. The *Gulden Zeepaard* (Golden Seahorse), a Dutch East India Ship, sailed along the south coast in 1627 and then, in 1831, Captain Thomas Bannister and his party came across the Nornalup Inlet when they strayed off route while travelling

Below Wilderness wall of perception.
Photo – Michael Pelusey

Above Fernhook Falls, Walpole.
Photo – David Bettini

overland from the Swan River Colony to Albany.

William Nairne Clark and his party visited 10 years later, rowing into Nornalup and describing the areas around the Deep and Frankland rivers:

> "The sail up was truly delightful. The river actually appeared to be embosomed amongst lofty wooded hills, with tall eucalypt trees close to the water's edge, and crowning the summits of these high hills thus casting a deep gloom over the water and making the scenery the most romantic I ever witnessed in the other quarters of the globe".

European settlement started in the mid 1850s when settlers from further inland began to drive cattle down to coastal areas in the present Walpole-Nornalup National Park for summer grazing. Stock camps were established along the coast. You can still see part of one camp at Crystal Springs. Permanent settlement began in 1910 when Frenchman Pierre Bellanger and his family took up land beside the Frankland River.

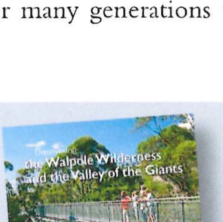
The same year Premier James Mitchell visited the Frankland River and, impressed by its beauty, he created the Walpole-Nornalup National Park. Such a move proved highly important in preserving the region's natural values as, by the 1920s, land was being extensively cleared for agriculture under the Group Settlement Scheme. These schemes, promoted by Premier Mitchell, were intended to create a flourishing agricultural community that would create livelihoods for unemployed men and their families. They provided enough population growth for the development of the town of Walpole, which began as a tent, tin and bush pole shanty town in 1930. At first called Nornalup, the name was changed to Walpole in 1934.

In 1951 logging began in earnest—an important industry that continued until 1995, providing employment for many residents. But the anti-logging movement of the 1990s contributed to the decline of the timber industry in Walpole and a consequent fall in employment. On top of this, increasing numbers of visitors led CALM to seek more innovative ways of enabling visitors to experience the natural environment in the area without damaging it. A result of these combined factors was the development of the Valley of the Giants Tree Top Walk, which opened in 1996. This facility stamped Walpole firmly on the State's tourism map and helped turn around the fortunes of the coastal township, where tourism is now a major industry.

By 2004, the creation of the new national parks and reserves in the Walpole Wilderness further added to the protection of this magnificent area. Now, with a management plan being prepared, the Walpole Wilderness will be preserved for many generations to come.

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

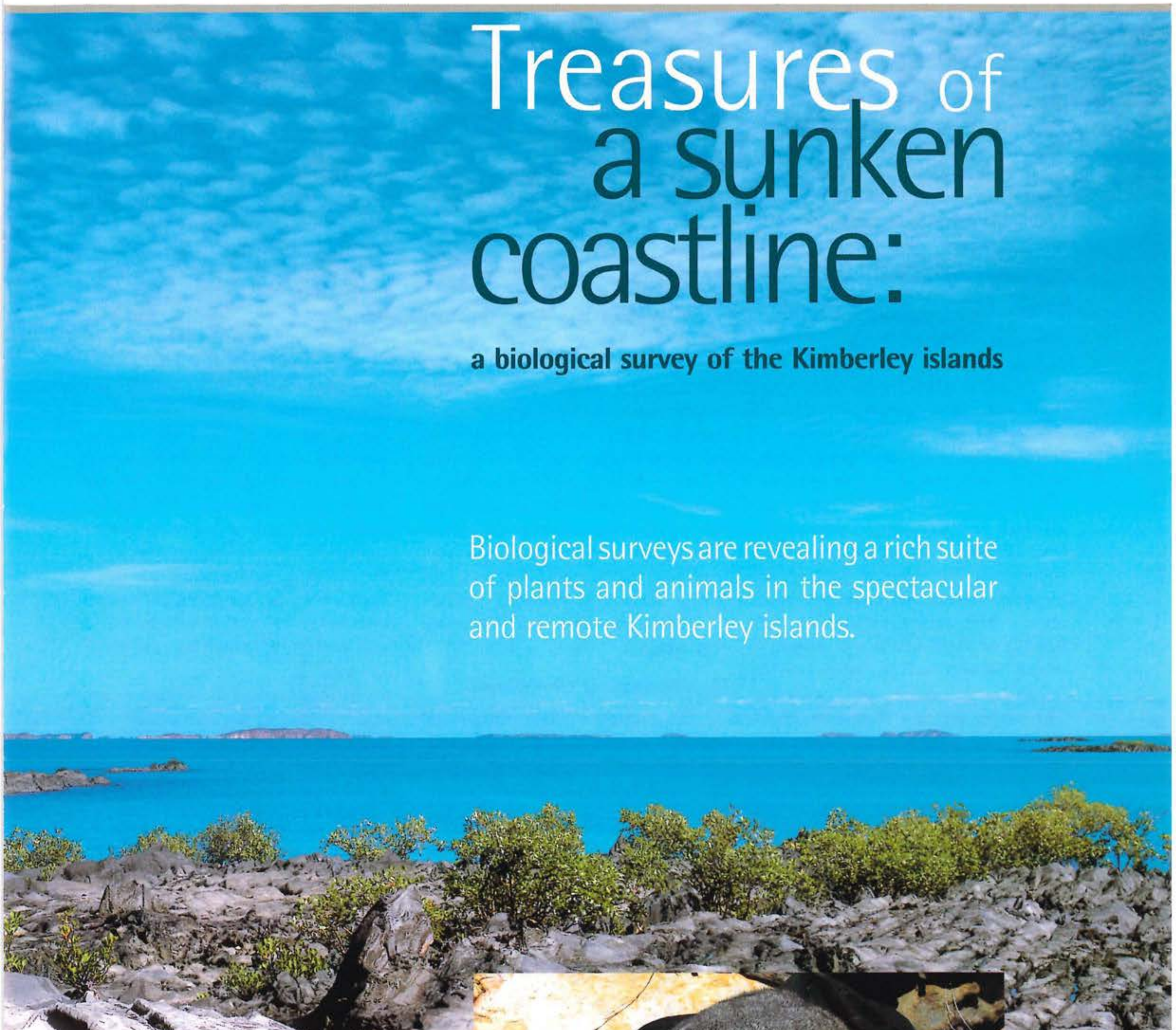
The information in this article is based on the pocket-sized field guide *Discovering the Walpole Wilderness and the Valley of the Giants* which was written and researched by DEC district and regional staff. The book is available for $6.50 from bookshops and tourist outlets, by phoning WA Naturally Publications on (08) 9334 0437, or by ordering online at www.naturebase.net.



Treasures of a sunken coastline:

a biological survey of the Kimberley islands

Biological surveys are revealing a rich suite of plants and animals in the spectacular and remote Kimberley islands.



by Lesley Gibson, Norm McKenzie, Tony Start, David Pearson and Russell Palmer

The ancient rocky ranges, plains and spectacular coastline of Western Australia's Kimberley region form a rich tapestry of landscapes inhabited by tropical plants and animals. However, the area's relative isolation and rugged terrain, particularly in the north-west, has restricted comprehensive assessments of its flora and fauna. Biological surveys in such environments are expensive and, consequently, knowledge of the region's biodiversity is limited.

The only previous systematic biological survey of the area focused on rainforest patches across the region and revealed a rich diversity of plant and animal species. The survey was led by the then Department of Conservation and Land Management, now the Department of Environment and Conservation (DEC), and also involved a Wunambal elder, the late Geoffrey Mangglamarra, who contributed his extensive knowledge of plants, animals and country to the project. This survey highlighted the fragility of the Kimberley to human-related impacts such as the pervasive influence of cattle and wildfire. The south and east Kimberley have experienced pronounced changes to the landscape since European arrival. A wave of extinctions among medium-sized or 'critical weight range' mammals occurred during this time.

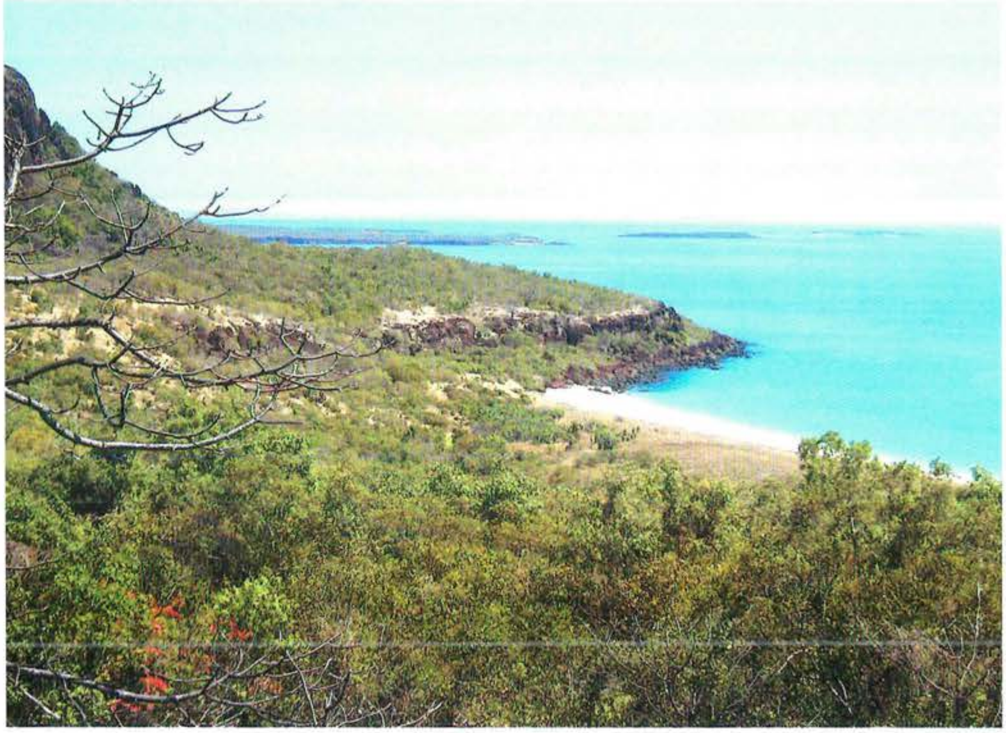
Weeds, introduced stock such as cattle, donkeys and pigs, and changed fire regimes, now characterised by extensive and intense fires (see 'Fire in the Kimberley', *LANDSCOPE*, Autumn 2008), have contributed to loss of biodiversity in the Kimberley. Repeated burning and erosion due to over-grazing simplifies the vegetation and weeds choke natural vegetation. The imminent invasion of the cane toad from the Northern Territory into WA is likely to add further pressure to already modified and vulnerable ecosystems.

Significance of the islands

The impacts of these threatening processes have not been equally felt across the Kimberley. The high rainfall, near-coastal region of the north-west has been more resilient, and the Kimberley region's many islands in particular have been sheltered from many mainland disturbances. Created by the drowning of an ancient coastline, these islands collectively support representative examples of much of the adjacent mainland's geology and vegetation communities. As such, they are likely to be important refuges for fauna, including species that may be susceptible to cane toad impacts. Some islands may also act as future safe-havens for translocated species that are threatened on the mainland.

The islands are not only important for their biodiversity values, but also for their cultural values. Many Aboriginal elders lived on country into their teenage years before meeting Europeans and are familiar with the plants and animals of the islands. Aboriginal people maintain strong connections to the region and all of the islands are under native title claim. Each tribal language group has its own knowledge system that includes names and ecological knowledge for plants and animals.

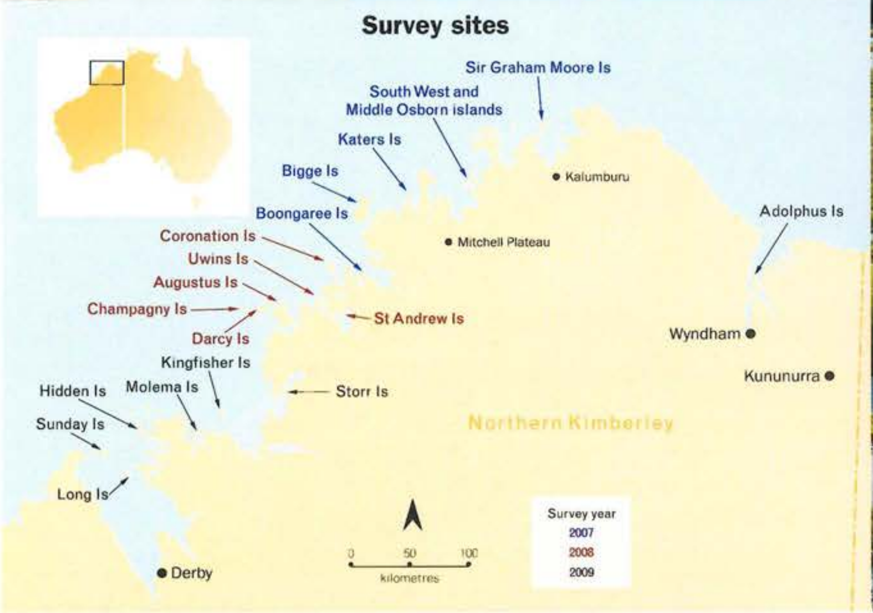
In recent years, the coastal region of the Kimberley has increasingly been exposed to disturbances associated with casual visitors, tourism, fishing, aquaculture, mining, and oil and gas exploration. While these industries offer potential economic benefits for local Aboriginal communities, they also place increasing pressure on Aboriginal people to manage their country. As



Previous page
Main Weathered siltstone on an island in the Buccaneer Archipelago, which will be surveyed in 2009.
Photo – David Bettini
Inset Scaly-tailed possum.
Photo – Andrew Burbidge

Above Feral donkeys have had a great effect on parts of the Kimberley but many of the islands have been sheltered by these and other influences.
Photo – Dennis Sarson/Lochman Transparencies

Left Middle Osborn Island.
Photo – Lesley Gibson


Survey sites
Sir Graham Moore Is
South West and Middle Osborn islands
Katers Is
Bigge Is
Kalumburu
Boongaree Is
Adolphus Is
Coronation Is
Mitchell Plateau
Uwins Is
Augustus Is
Champagny Is
St Andrew Is
Darcy Is
Wyndham
Kingfisher Is
Kununurra
Hidden Is
Molema Is
Storr Is
Sunday Is
Northern Kimberley
Long Is
Derby
Survey year
2007
2008
2009
0
50
100
kilometres

Background right West coast on Bigge Island. *Photo – David Pearson/DEC*

Below right DEC Research Scientist David Pearson with an olive python. *Photo – Patricia Handasyde*

such, traditional owners are keen to work with DEC to gain access to new research that can help in future management of the islands.

Currently, many of the islands are unallocated Crown land and have been effectively unmanaged. However, as native title holders return to country and take on management responsibilities, there are opportunities to develop management strategies incorporating conservation and sustainable development. This will help to ensure that the biodiversity and cultural values of the Kimberley islands are protected. A good knowledge base of what is already there in terms of flora and fauna will underpin these management decisions.

Survey preparation

In December 2006, DEC, in collaboration with the Kimberley Land Council, Western Australian Museum and Australian Museum, started preparations for a biological survey of these remarkable islands. The project was jointly funded by the Western Australian and Australian governments, with three dry season (winter) and wet season (summer) surveys planned over three years. There are hundreds of islands along the Kimberley coast, with 155 of them bigger than 100 hectares, 22 more than 1,000 hectares and nine exceeding 2,500 hectares (two of which are nearly 20,000 hectares). While most of the islands are big enough to support a diversity of plants and animals, only a small subset could be sampled within the project's time frame. Nineteen of the biggest islands were chosen, especially those with a variety of geological surfaces and those at varying distances from the coast (and therefore variable distances from land-based threats). The information gained from studying the islands will help predict where plants and animals may occur on other islands and test assumptions that the islands provide microcosms of the adjacent mainland.

While there is information on plants and animals for some islands, most previous studies have been opportunistic or focused on particular types of species. This survey aims to expand knowledge of six ecologically and biogeographically different components of biodiversity across the variety of islands present.

What will be surveyed?

Logistically, it is impossible to sample every component of biodiversity on the islands. This survey focuses on mammals, birds, reptiles, frogs, land snails and plants. These groups are most at risk from threatening processes affecting the mainland, including the arrival of cane toads. Mammals such as possums, bandicoots, quolls, small wallabies and rodents have

Left Camp site on Middle Osborn Island.
Photo – Lesley Gibson/DEC

Below left Monjon rock-wallaby on Bigge Island.
Photo – David Pearson/DEC

disappeared throughout much of the Kimberley, with remaining populations concentrated in the north-west of the region. Two mammal species endemic to the Kimberley—the tiny monjon rock-wallaby (*Petrogale burbidgei*) and scaly-tailed possum (*Wyulda squamicaudata*)—are restricted to the north-west as is the golden-backed tree rat (*Mesembriomys macrurus*), which was once more widely distributed in northern Australia.

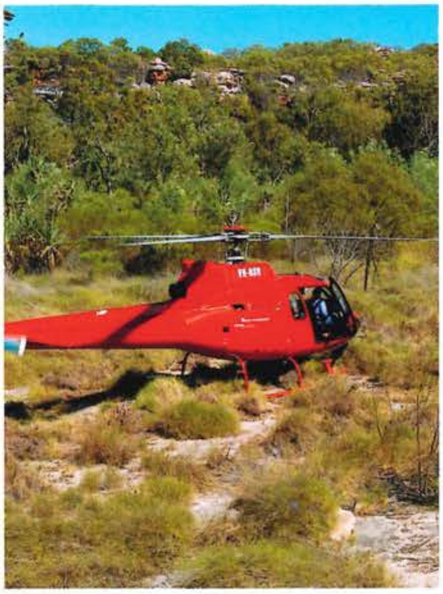
Cane toads pose an additional threat to some of these mammals, as evidenced by the decline in northern quoll populations in the Northern Territory. Similarly, the survey focuses on frogs, goannas, snakes, large skinks and dragons because it is thought that they may be particularly vulnerable to toads. For instance, monitoring in the Top End has shown that populations of the monitor lizard (*Varanus panoptes*) have collapsed following the arrival of cane toads. Since islands potentially provide refuges for such species, the importance of locating any island populations is clear.

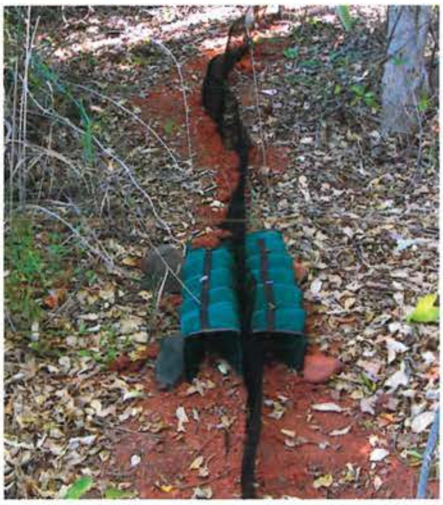
While on the islands, opportunistic records of birds are collected to improve overall knowledge of their distributions. Some carnivorous and omnivorous birds such as raptors are potentially threatened by toads, while some granivorous birds, such as the Gouldian finch, are declining across northern Australia due to altered fire regimes. The surveys will also involve the study of land snails, which are endemic in areas of the Kimberley mainland due to their limited mobility. Land snails on the islands are likely to show similar species diversity and indeed some species may only occur on a single island or rock outcrop. Consequently, populations of land snails are particularly susceptible to the impacts of fire and other factors that affect their sheltered habitat. And it's not just the snails at risk—they are likely to be indicators for other animals of limited mobility. Distributional information for these species will help assess the impacts of proposed mining or other industrial developments.

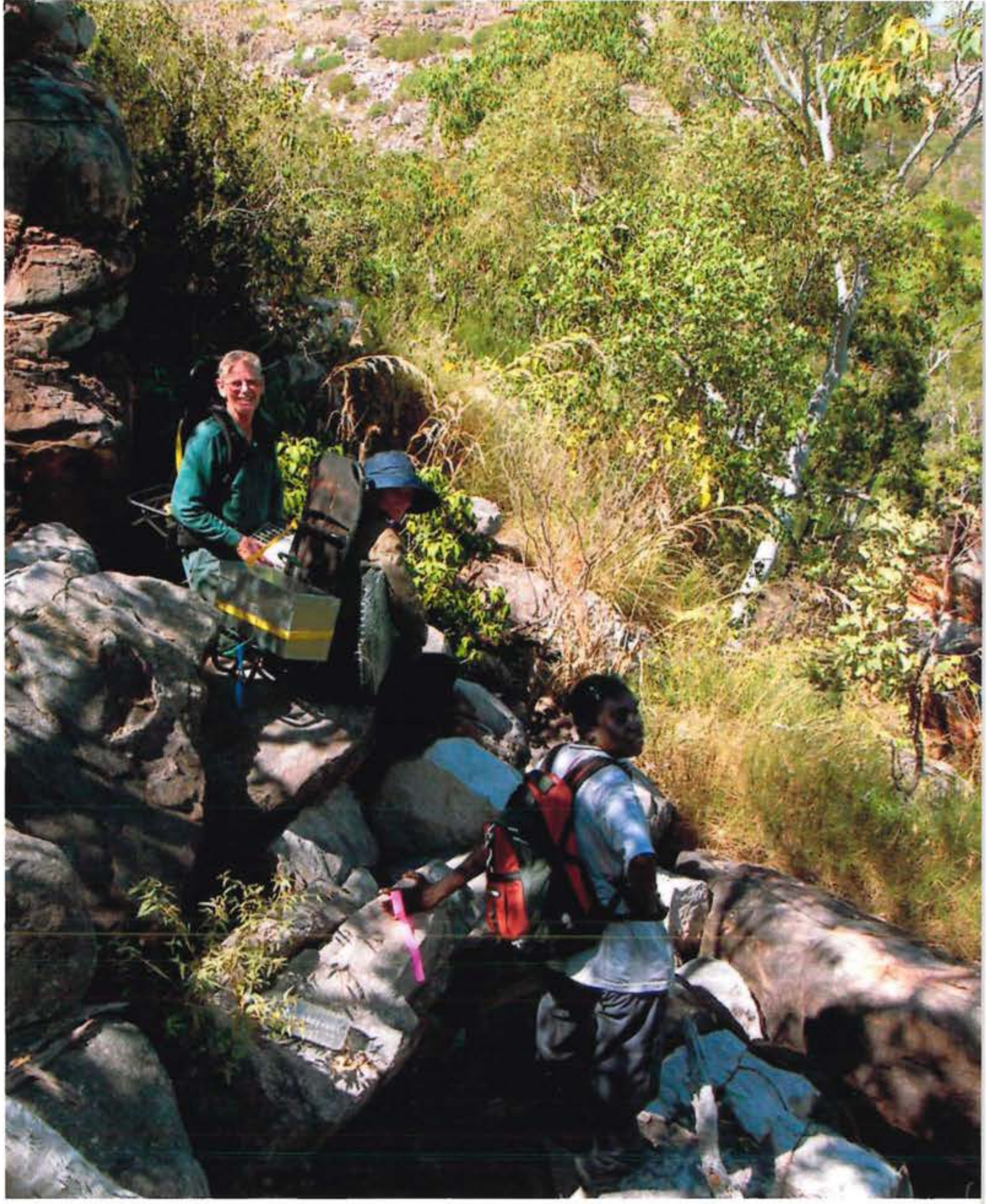
Frequent burning and erosion threaten many plant species and communities in the Kimberley. Identification of plant species also helps to characterise the habitats of the survey sites and allows for comparison with habitats on the mainland and other islands. Site-based vegetation descriptions also form benchmarks for monitoring island environments and understanding future change.

Survey set up

Given the isolation, rugged topography and limited access, field trips to the north-west Kimberley are logistically demanding and each trip requires careful planning. Wet and dry season surveys need different strategies, largely dictated by the weather. Helicopters are the preferred means of transport as they are the most efficient way of transporting teams to, and between, islands in this environment. Dry season surveys involve three teams, each comprising two vertebrate zoologists, a land snail specialist, a botanist and at least one local Aboriginal traditional owner. Each team shifts to a new survey site every six days. On the bigger islands two sites are surveyed,







Top Moving camp on Bigge Island.

Right Laying traps on Bigge Island.
Photos – David Pearson/DEC

Above Material is set up on the island to encourage animals into traps.
Photo – Russell Palmer/DEC

and each team surveys three sites in one dry season field trip.

The helicopter schedule is coordinated from a base camp on the mainland. Here, the base camp team also manages communications, food and water supplies, and deals with any emergencies. Due to limited space on the helicopter, camping and personal items are kept to a minimum, with water and survey equipment making up the bulk of transported gear. It usually requires at least three trips in a helicopter to place a team on an island.

Preliminary selection of island sites is made using local knowledge, inspection of satellite imagery and a reconnaissance flight. The aim is to place each team within walking distance of as many habitat types as possible. A number of alternative sites are presented to the traditional owners for their consideration so teams avoid culturally sensitive sites.

Once on the ground, the team works together to set trap lines. One line of alternating box (Elliott) and cage traps are set to capture ground mammals in each habitat type. Two lines of four funnel traps (a modified fish trap) with low fly-wire fences to direct animals into the funnels are also set up on each mammal trap line. Funnel traps are effective at catching reptiles, particularly snakes. Setting traps can be hard work and time consuming as lines can extend across boulder slopes and up rock faces. Spotlighting at night is also used to detect mammals and nocturnal reptiles such as geckos, and ultrasonic equipment is used to record the echolocation calls of bats for later identification. Aside from the vertebrate trap lines, at least one plant quadrat of 50 by 50 metres is also established in each habitat type, within which all species are recorded. Land snails, which aestivate during the dry season, are actively searched for by raking, lifting rocks, digging and examining tree crevices, mainly in densely vegetated areas such as rainforest patches. Some reptiles are also captured this way.

All sites are re-sampled in the wet season, but the focus is primarily on frogs, land snails and plants. As frogs and land snails are more active in the wet, there is a good chance of finding additional species to those recorded in the dry season. Extra plant species are also likely to be discovered as many annuals only live during the wet season and many others only flower at this

Left Sylvia Djanghara pressing plants.
Photo – Tricia Handasyde

Below left Northern grass frog (*Litoria bicolor*).
Photo – Russell Palmer

Below Pale field rat (*Rattus tunneyi*)
Photo – Andrew Burbidge

time. Again, islands are accessed by helicopter, but the team is based on the mainland and each site is visited for one day or night so that teams return to a base camp each day.

Indigenous participation

The Balanggarra, Uunguu, Dambimangari, Mayala and Bardi-Jawi native title claims cover all the islands earmarked for survey, stretching from Adolphus Island in the east to Sunday Island in the west. Accordingly, close liaison with the relevant traditional owners who speak for these islands is imperative. Not only is it important for survey scientists to be aware of culturally sensitive areas that should be avoided, but a survey such as this provides training opportunities for traditional owners who are interested in learning about survey techniques and the flora and fauna of their country. Through collaboration with the Kimberley Land Council, the island survey employs traditional owners who help the survey team in all their activities, particularly by providing important guidance about appropriate places to situate camp sites and trap lines.

Results so far

In the dry season of 2007, Boongaree, Bigge, Katers, South West Osborn, Middle Osborn and Sir Graham Moore islands were surveyed. These islands were again sampled in February 2008 at the height of the wet. Based on preliminary data, 36 reptile, 19 frog and 18 mammal species have been recorded from the surveyed islands. New vertebrates were detected from all six islands, and several were recorded for the first time on islands off the Kimberley coast. Approximately 40 species of land snails were collected, with at least 11 undescribed species and one new genus found.

Species identifications are yet to be finalised for most groups but, in terms of mammals, the highest species richness was recorded from Bigge Island, the largest island of the six sampled. Among the species on Bigge were the mammals: monjon rock-wallaby, northern quoll (*Dasyurus hallucatus*) and scaly-tailed possum. The Kimberley rock rat (*Zyzomys woodwardi*) was the most commonly caught species, occurring on all but one island. The pale field rat (*Rattus tunneyi*) was abundant on Boongaree, while the mosaic-tailed rat (*Melomys burtoni*) was common on Sir Graham Moore. A small carnivorous marsupial, the red-cheeked dunnart (*Sminthopsis virginiae*), was recorded for the first time on the Kimberley islands. The herpetofauna—reptiles and frogs—highlight was the addition of 23 species to the survey list for Sir Graham Moore Island, four of which were new to the islands.

Where to next?

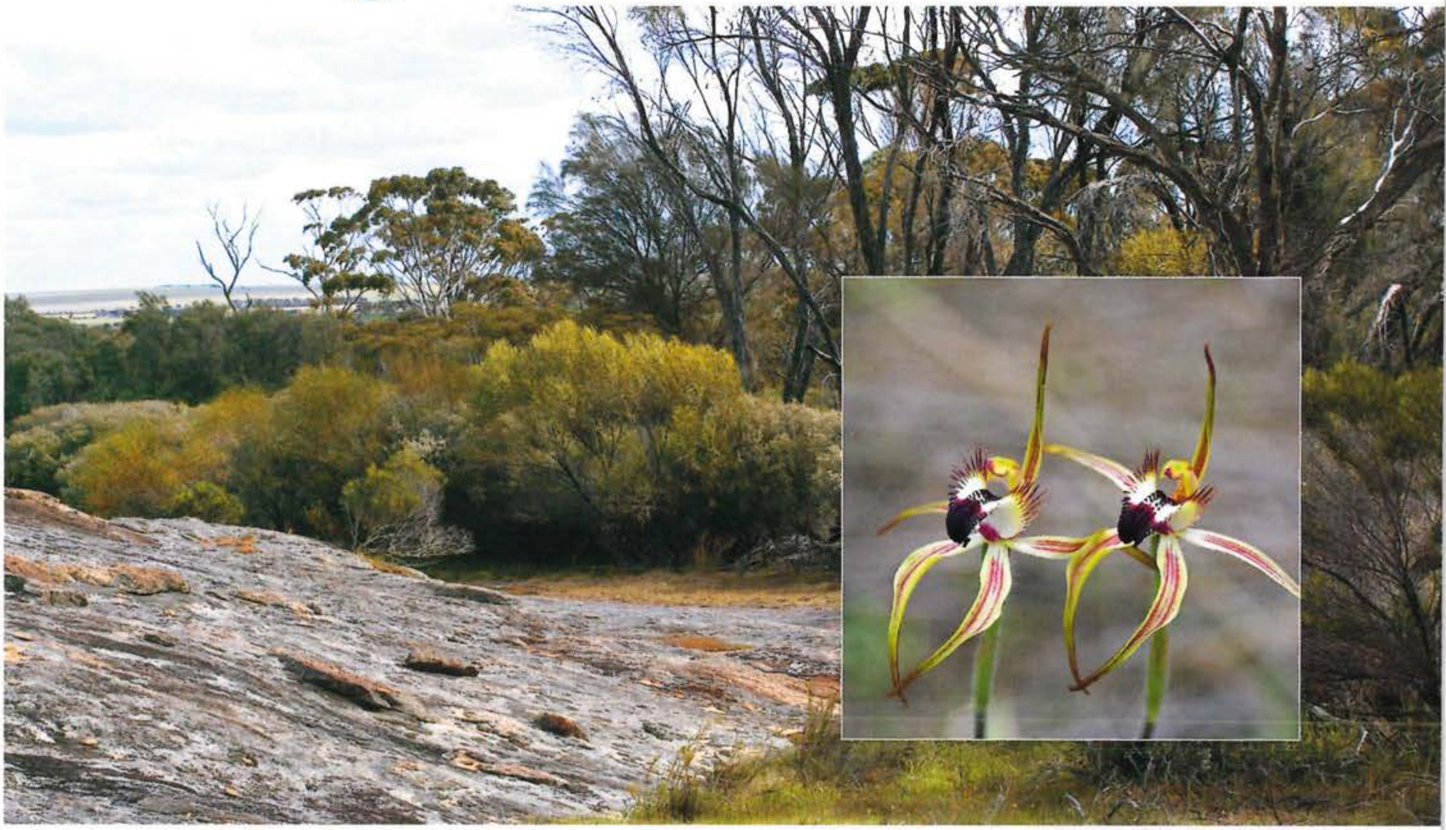
Working southwards, the teams are now focusing on islands in the Bonaparte Archipelago and will target the Buccaneer Archipelago in May and June 2009. Adolphus Island in Cambridge Gulf will be surveyed in 2008, and wet season surveys of these islands will be conducted in 2008-2009. This exciting project will provide the first detailed and comprehensive fauna and flora information for many islands along the Kimberley coastline. The information collected will guide future land managers, both Aboriginal and non-Aboriginal, to make sound management decisions for many decades to come.

Lesley Gibson, Norm McKenzie, David Pearson and Russell Palmer are all research scientists based at the Department of Environment and Conservation's (DEC's) Wildlife Research Centre in Woodvale. Tony Start was also based at the centre and has recently retired. Lesley Gibson is coordinating the Kimberley island survey and can be contacted on (08) 9405 5152 or by email (lesley.gibson@dec.wa.gov.au).

The surveys have involved many people. The authors wish to thank colleagues from DEC, the Western Australian Museum and Biota Environmental Sciences who took part in the fieldwork. They also thank the participating Balanggarra and Uunguu traditional owners. DEC staff based at Mitchell River National Park were most accommodating.

endangered

by Andrew Brown



Granite spider orchid

In late 1801 the naturalist aboard the *Investigator*, Robert Brown, first set foot on Australian soil at King George Sound (now Albany). The same year he described the terrestrial orchid genus *Caladenia*, which now comprises about 340 species, most of which are found in southern Australia and 140 of which are endemic to the south-west of Western Australia.

Commonly known as spider orchids, *Caladenias* are small, herbaceous perennials that emerge from an underground potato-like tuber in late April, grow through the autumn–spring period and flower in the winter, spring and early summer. All species have a single hairy leaf and flowers with a prominent, highly modified petal (lip) containing rows of glands (calli), these leading to the scientific name *Caladenia* which in Greek means 'beautiful glands'.

Nineteen species of *Caladenia* are now considered rare with one of the rarest being the granite spider orchid (*Caladenia graniticola*). This orchid is a small plant to 30 centimetres high with one to two attractive red, white, yellow and green spider-like flowers to five centimetres across. These appear between late September and October and are distinguished from the closely related Hoffman's spider orchid (*C. hoffmanii*) by their generally larger size and later flowering period.

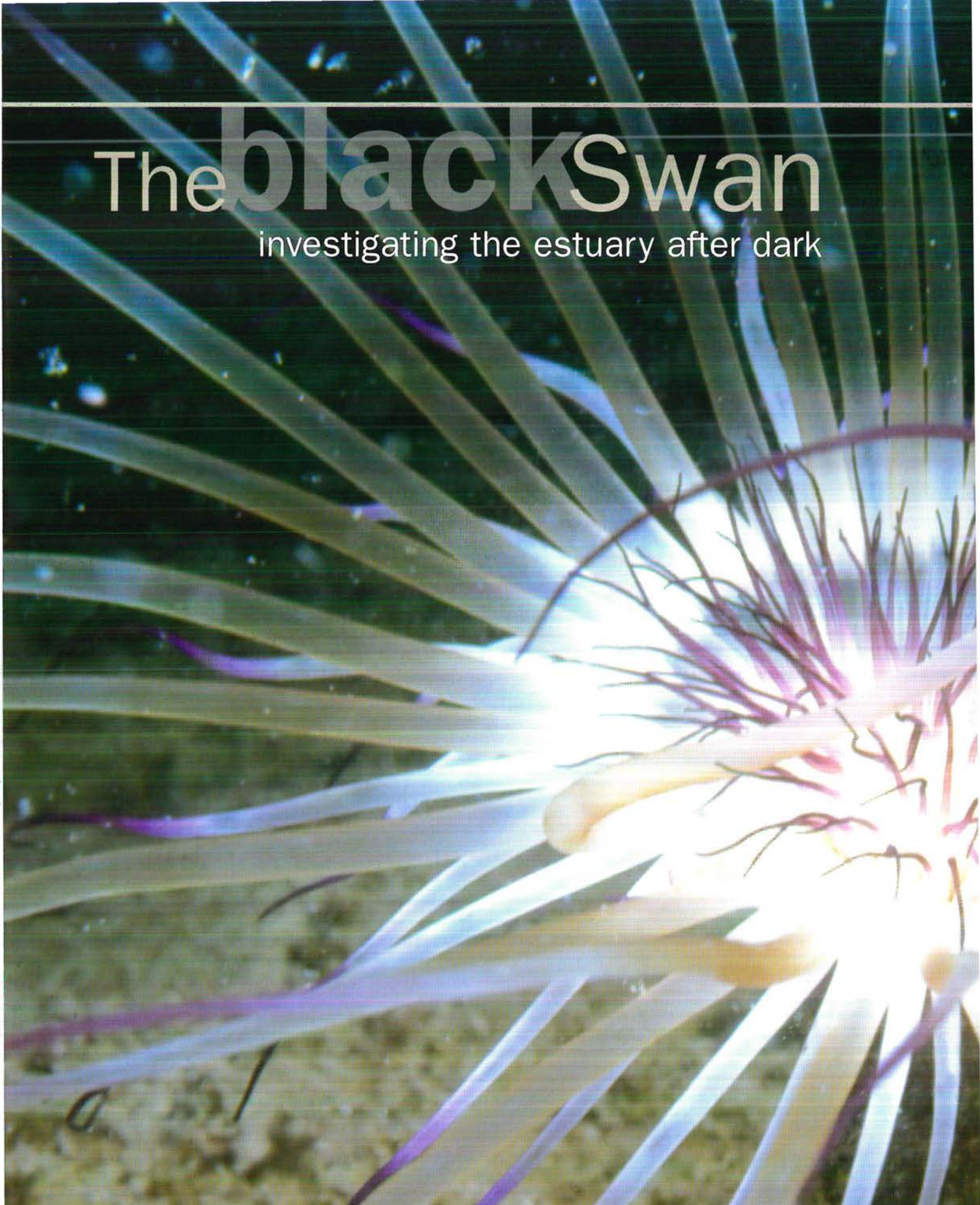
Granite spider orchid was first collected west of Karlgarin in the wheatbelt, in the 1970s, and has since been found in a handful of locations between there and Newdegate, growing beneath tall shrubs and sheoaks on granite outcrops. Due to restricted habitat and threats associated with low population sizes, introduced weeds and a drying of habitat following poor winter rainfall, the species is currently declared as rare flora under the Western Australian *Wildlife Conservation Act 1950* and ranked as critically endangered. The species is listed as endangered under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

Granite spider orchid is currently undergoing a four-year intensive research program funded through Lotterywest in collaboration with the West Australian Native Orchid Study and Conservation Group, the Botanic Gardens and Parks Authority, The University of Western Australia and the Department of Environment and Conservation. Research includes measuring mortality, seed set and recruitment, determining critical factors limiting population size, undertaking actions to promote population growth and assessing the habitat required to maintain viable populations of pollinators. It also includes the use of orchid seed baiting techniques to identify soils that contain fungi needed to promote germination, and isolate fungi that aids propagation.

Photos by Andrew Brown

The black Swan

investigating the estuary after dark

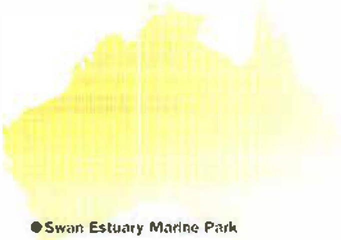


Come sundown, when many creatures are winding down after the bustle of the day, the cloak of darkness prompts others to get moving. They belong to the night shift, the nocturnal animals that take advantage of the gloom to forage in relative safety. We look at some of those found on Perth's doorstep after dark, in the waters of the Swan estuary.

by John Huisman and Luke Twomey

The Swan estuary is truly the lifeblood of Perth. Although we might not readily acknowledge it, the estuary plays a major role in the lives of most Perth residents. This beautiful waterway provides us with a foreground to vistas of the city and a backdrop to our drives along the freeway. And we use it. We swim in it, fish from it, sail on it, have picnics on its shores and spend many hours just sitting and looking at it. The estuary enhances our lives in many ways and the fact that it is in a reasonably healthy condition is something we should all be grateful for, but not take for granted (see 'Ecosystem health of the lower Swan estuary' on page 50).

While it's a major part of our lives, for the most part we don't look below the surface. The Swan's beauty is more than skin deep and the only way to view some of its unique attractions is by diving. Western Australia has some of the most spectacular diving locations in the world, from the rugged, high-energy coasts of the south, to the limestone reefs of Rottnest Island Marine Reserve and the spectacular corals of Ningaloo Marine Park. Perhaps understandably, given the extent of such marine riches, investigating the Swan is rather low on most divers' list. But, given the right circumstances, the estuary can be very rewarding. The best way to view its beauty is at night. It's dark and most often cold, and given a choice most people would prefer to be curled up with a good book. But it's an entry into an alien world that exists right on our doorstep.



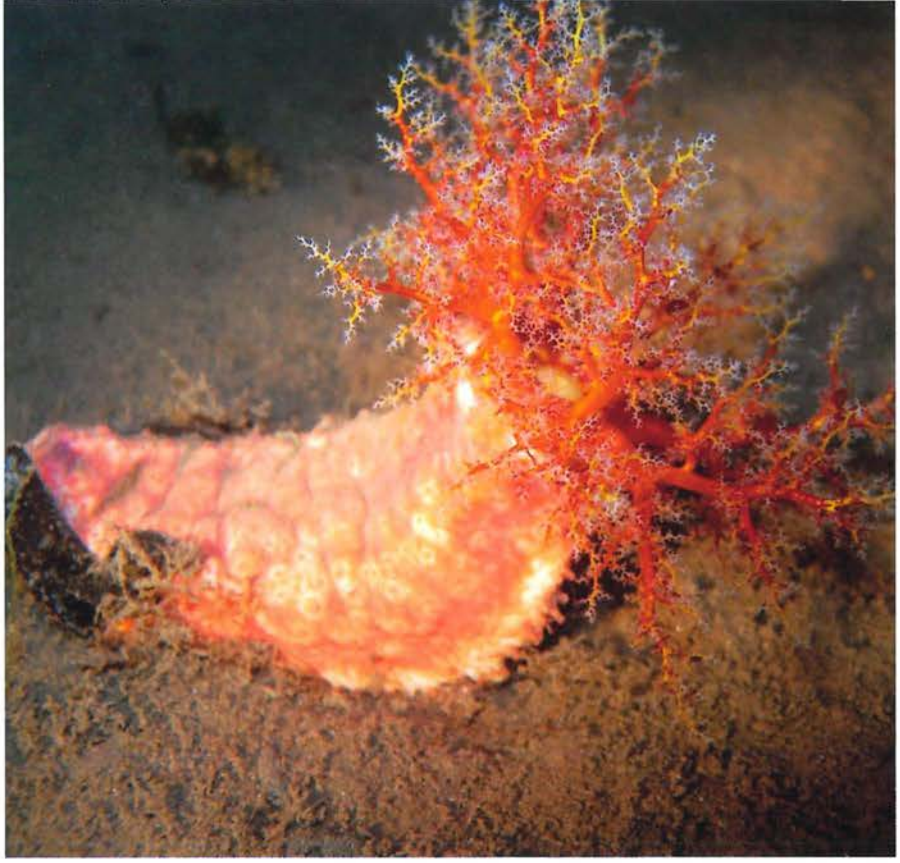
Night stalking

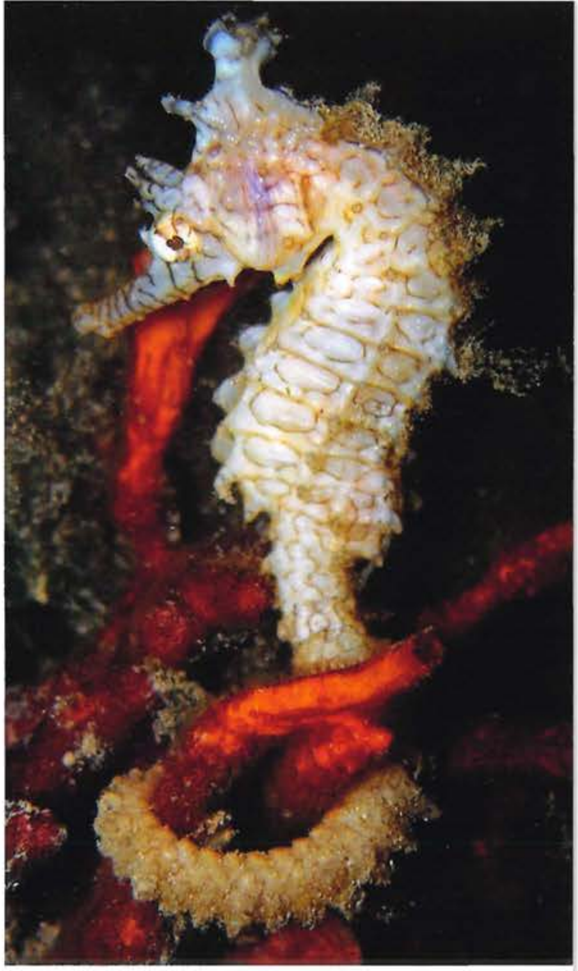
Night diving is an activity that requires specialist training, more so than for daytime scuba diving. Although not inherently more dangerous, it's easy to become disoriented without the sun's rays to guide you, and an underwater torch is essential. Several things happen on a night dive. The beam of the torchlight narrows your focus, so you are not distracted by what is going on around you and can concentrate. It's surprising what leaps out—the busy reef suddenly yields a beautiful seahorse, or a crab scurries along the soft estuary floor. And prawns. Yes, it must be stated that many night divers have a singular objective, to collect a feed of delicious western king prawns (*Penaeus latisulcatus*). When disturbed, the prawns do their best to nestle into the soft sediments of the estuary floor. But this is often to little avail as their eyes shine like beacons under the torchlight and the diver has little trouble locating them.

Western Australian seahorses (*Hippocampus subelongatus*), which as their name indicates are found only in WA, are common in the estuary's lower reaches and are easily observed at close view. They tend to congregate

Previous page
Main The purple-tipped tube anemone (*Pachycerianthus* sp.), one of the estuary's more spectacular inhabitants.
Photo – John and Val Butler/Lochman Transparencies
Inset Lesueur's sand dollar (*Peronella lesueuri*) feeds along the estuary floor.
Photo – John Huisman

Below Swan River near Coombe Reserve.
Photo – Rob Olver





Above A warty sea cucumber (*Cercodemas anceps*) catches drifting food particles.

Above right A female Western Australian seahorse (*Hippocampus subelongatus*).

Right A western king prawn (*Penaeus latisulcatus*) hides in the soft sediment. *Photos – John Huisman*

around solid structures, as they require something to attach to. Although they are timid, as long as you observe them without touching, most seahorses will stay put, providing excellent views of their incredibly detailed patterns. The colours of Western Australian seahorses vary from white to brown, orange, yellow or pink, but they always have a distinguishing series of brown lines on their snout. Seahorses have an unusual method of brooding their young. The female lays her eggs in a pouch on the male's belly, which the male then fertilises and incubates until they hatch as miniature seahorses. Males tend to be darker in colour and have the obvious pouch, whereas females are often pale.

One very surprising change when darkness falls is the appearance of large numbers of blue manna crabs (*Portunus pelagicus*). At sunset the crabs emerge to feed, either scavenging detritus or eating small crustaceans and other invertebrates. Only the male is the vibrant blue colour; the female is a drab brown. Large numbers of crabs are fished from the Swan estuary each year. From a recent survey it was estimated that the total annual recreational catch of blue manna crabs from the Swan-Canning Estuary Basin was 20,875 crabs or 7.3 tonnes.

Spineless wonders

The purple-tipped tube anemone (*Pachycerianthus* sp.) is truly spectacular. Its mixture of vivid purple and white tentacles waves in the water, trapping all manner of small food. These anemones stand proud in the muddy sediments of the deeper parts of the estuary, their tentacles spreading to about 30 centimetres. While the tentacles of this anemone do not sting, be very wary of a second, less common species, the armed anemone (*Dofleina armata*), which can cause a very painful sting.

An animal with similar feeding habits is the warty sea cucumber (*Cercodemas anceps*). If you watch closely, you can see this animal use its arms to catch small morsels of food that drift by in the water, then insert its arms into the central mouth to suck off the food. The warty sea cucumber, however, is not related to anemones. It is actually a holothurian, a close relative of the sea cucumbers that are collected as 'trepang' in many tropical areas. These are a culinary delicacy in parts of Asia.

Like the sea cucumbers, Lesueur's sand dollar (*Peronella lesueuri*) is related to sea stars and sea urchins. Looking very much like flattened urchins, sand dollars move about on very short spines, typically buried under a layer of sand or pieces of broken shell. They are very slow moving and feed on organic particles in the soft sediments. If you gently brush away the sand, the attractive star pattern on the sand dollar will be revealed. Closely related is a pale orange sea star (*Stellaster* sp.), which also emerges to feed. Sea stars use small tubular feet on their underside to move about. One such sea star was photographed feeding on the remains of a blue manna crab. Nothing is wasted.

Cuttlefish (*Sepia* sp.) are related to squid and octopuses, both of which also inhabit the Swan estuary. They are able

Ecosystem health of the lower Swan estuary

The lower Swan estuary is a highly modified system that has been significantly changed since European settlement. Perhaps the largest single impact was the development of Fremantle Harbour in 1896, as the river mouth was widened and deepened to allow access to shipping. These alterations greatly affected the estuary and transformed it from an environment with moderately salty water to a system dominated by salty marine waters.

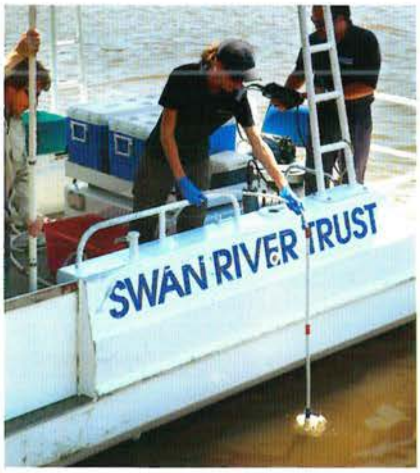
A more incremental impact has been the population growth of Perth, which has now exceeded 1.5 million. The vast majority of Perth's residents live within the Swan catchment and their activities have directly impacted on the river system, including increased nutrient and sediment loading and contamination by chemical pollutants such as petrochemicals, pesticides and heavy metals.

The Swan River Trust, established in 1989, protects and enhances the ecological health and long-term community benefit of the Swan and Canning rivers and associated land. A major focus of the trust is to reduce algal blooms associated with excessive loads of nutrients (eutrophication) and promote healthy functioning of the ecosystem. The trust is working with the community, stakeholders and other government departments to reduce environmental degradation and improve the management of the river system.

Since 1994, water quality in the Swan River system has been monitored weekly. In general, the water quality is good with no indications of decline in the past 20 years. Hearteningly, the levels of nitrogen and phosphorus, major components of the fertilisers that many Perth residents apply liberally to their gardens but which also fuel algal blooms when they enter the river system, have continued to decrease in the lower estuary during the past decade.

The lower Swan estuary supports a highly productive food chain involving communities of plankton, invertebrates and fish that are the most diverse of the system. These animals are largely marine and include recreationally fished species such as black bream, Australian herring, tailor and whiting.

However, there are several problems associated with the river. In some locations, heavy metals have been detected at concentrations above levels regarded as acceptable by Australian guidelines. This is largely due to industrial practices, disused landfill facilities and boat maintenance facilities. In some of these areas there has been a direct influence on organisms, such as black mussels, that are susceptible to this kind of contamination. According to the Department of Health, people should never eat wild mussels from the Swan and Canning rivers, as numerous human health risks associated with eating them have been identified.



Above Water sampling, a key part of the monitoring of the estuary's health.
Photo – Swan River Trust

Background left The armed anemone (*Dofleina armata*) is spectacular to look at but can deliver a painful sting.
Photo – John Huisman

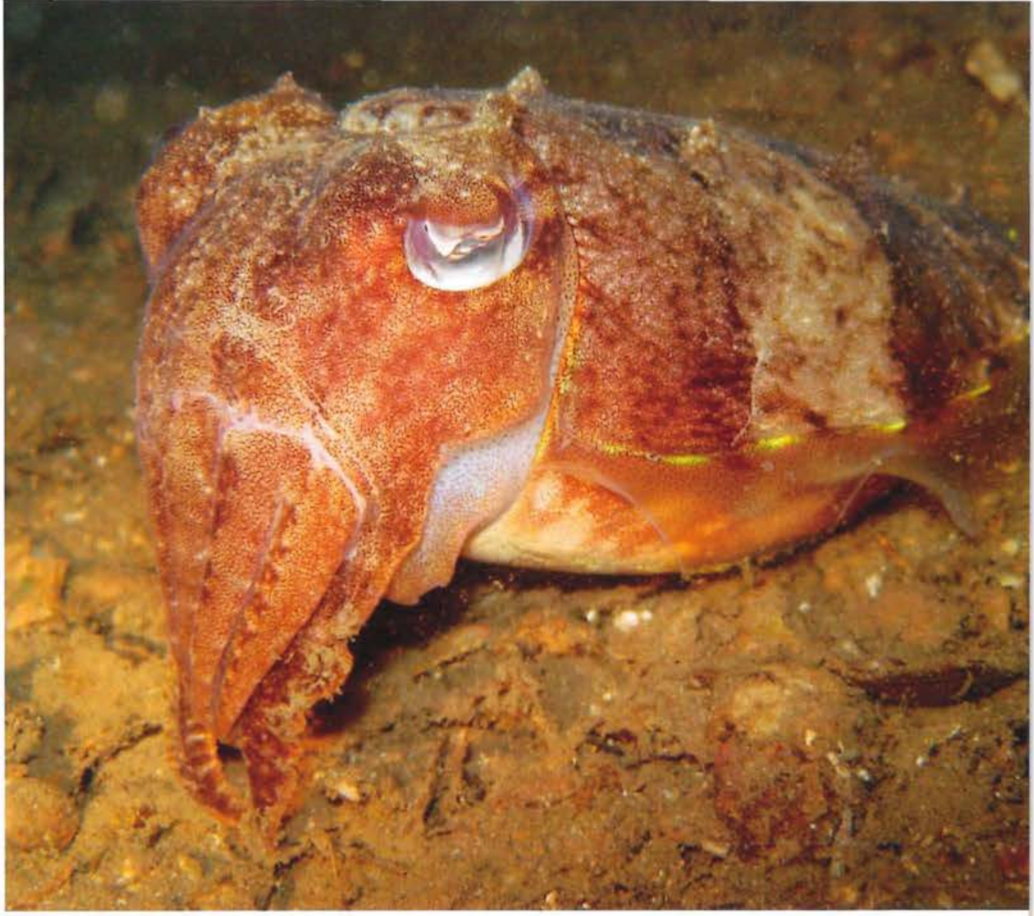
to rapidly change colour to match their surroundings. This instant camouflage gives them a distinct advantage when avoiding predators, or conversely when hunting prey. Cuttlefish move by gently undulating the fins along their sides, but if they need to move in a hurry they can propel themselves by expelling water at a rapid rate.

Fishy practices

The bottom-dwelling smalltooth flounder (*Pseudorhombus jenynsii*) is almost perfectly camouflaged against the mottled estuary floor. It is an ambush predator, waiting patiently until a suitable prey comes along, which it will then pounce on. Flounder are able to change their colour and even their pattern to match their surroundings, making them very difficult to spot. The flounder's body is unusually modified to suit its lifestyle, with both eyes having migrated to the upper side of the body. This allows the fish to lie flat on the estuary floor, almost perfectly camouflaged. Almost as well camouflaged is the finger dragonet (*Dactylopus dactylopus*), which props itself on the detached 'finger' at the start of its ventral fin and appears to 'walk' along the bottom.

Nestled among the seaweed on the estuary floor you often see wavy grubfish (*Parapercis haackei*). These fish are part of the sandperch family and can be recognised by their white-to-brown body, which has a stripe along the upper side. Wavy grubfish are found only in Australia, from eastern South Australia to the central coast of WA. They are usually active during the day, feeding on small invertebrates and fish. Come nightfall, the fish change to their nocturnal colours. Adopting a blotchy, disruptive colour pattern makes them harder to see, and therefore less vulnerable to predators.

Common blowfish (*Torquigener pleurogramma*) are regarded as a bit of a curse by estuary fishers, as they often take the bait intended for more desirable species. A recent survey found blowfish were the most commonly caught fish in the Swan estuary. Many of these were left to die—a cruel and pointless exercise as there is no way that numbers could possibly be reduced by this practice. These fish are poisonous, so leaving them lying on the shore also places curious children and pets at risk. Blowfish fill an important role in the estuary, as they are helpful scavengers, cleaning up anything edible. Being toxic, they have little to fear from predators. They feed on a wide variety of prey. The small fish take mainly polychaete worms and small crustaceans, whereas larger adults feed mostly on bivalve molluscs. Blowfish tend to congregate in the shallows and sometimes reach densities of five fish per square metre and even more at night. They are an extremely common sight during night dives, particularly near the shoreline.



Right A cuttlefish (*Sepia* sp.) displays one of its many colour patterns.

Below right A smalltooth flounder (*Pseudorhombus jenynsii*) almost perfectly camouflaged on the estuary floor.
Photos – John Huisman

The toxin in blowfish, known as tetrodotoxin, is one of the most potent recognised, more than 10,000 times more toxic than cyanide. The same toxin is found in the blue-ringed octopus (another estuary occupant) but is not, in fact, produced by either the blowfish or the octopus, but by bacteria within them. Fish reared in the laboratory are not toxic until they eat something containing the bacteria, which they then accommodate. A single mutation has given the fish and octopus (among others) immunity to the toxin, which they are then free to use for their own protection. In its refined state, a lethal dose of tetrodotoxin is less than a milligram and could be delivered on the head of a pin. Death is by respiratory arrest and there is no known antidote. Blowfish are related to the species used in the Japanese delicacy known as 'fugu'. To prepare fugu, specially trained chefs remove the poisonous parts of the fish (mostly the organs, the ovaries and liver) before serving. Deaths from correctly prepared fish are rare, but many people die from eating inadequately prepared fugu, mostly fishermen without the specialist training. Eating fugu is not something that most Western Australians would consider, but in 2007 a Chinese doctor on board an iron-ore ship in Dampier caught and ate an unidentified species of blowfish. The doctor suffered paralysis and his breathing became laboured. Despite receiving CPR and being evacuated to hospital, he died the next morning. The toxin is so potent that one of the people administering CPR also fell ill after coming into contact with the doctor's vomit, despite not having eaten any fish.

Colourful anemones, innocuous seahorses and voracious and potentially lethal blowfish are just some of the Swan estuary's inhabitants. All of these and more can be seen only a short distance from Perth city. All you need to do is look.

John Huisman is a research scientist, presently holding a joint position with the Western Australian Herbarium and Murdoch University. He is an international expert on seaweeds but also dives for pleasure and is an underwater photographer of note. He can be contacted by email (john.huisman@dec.wa.gov.au).

Luke Twomey is the Principal Scientist at the Swan River Trust and an adjunct senior lecturer at Murdoch University. Luke has worked extensively on the problems associated with algal blooms and water quality in local and international estuaries. He can be contacted by email (luke.twomey@dec.wa.gov.au).

Discovering
the Swan River
and the Swan Estuary
Marine Park

For more information, see DEC's pocket-sized field guide, *Discovering the Swan River and the Swan Estuary Marine Park*. It is available for $6.50 from bookshops and tourist outlets, by phoning WA Naturally Publications on (08) 9334 0437 or by ordering online at www.naturebase.net.

The authors would like to thank Sue Morrison (Western Australian Museum), Glenn Moore and Fiona Valesini (Murdoch University) for their helpful advice.

feature park by Samille Mitchell

Above Mount Lesueur in Lesueur National Park.

Opposite page
Top right Signage on the Lesueur Trail.
Photo – Sallyanne Cousans
Far right Queen of Sheba orchid (*Thelymitra variegata*).
Right White-breasted robin.
Photos – Babs and Bert Wells/DEC

Lesueur National Park

The stunning floral diversity of Lesueur National Park is now more accessible thanks to a redevelopment project resulting in new walking trails and interpretive information sites.

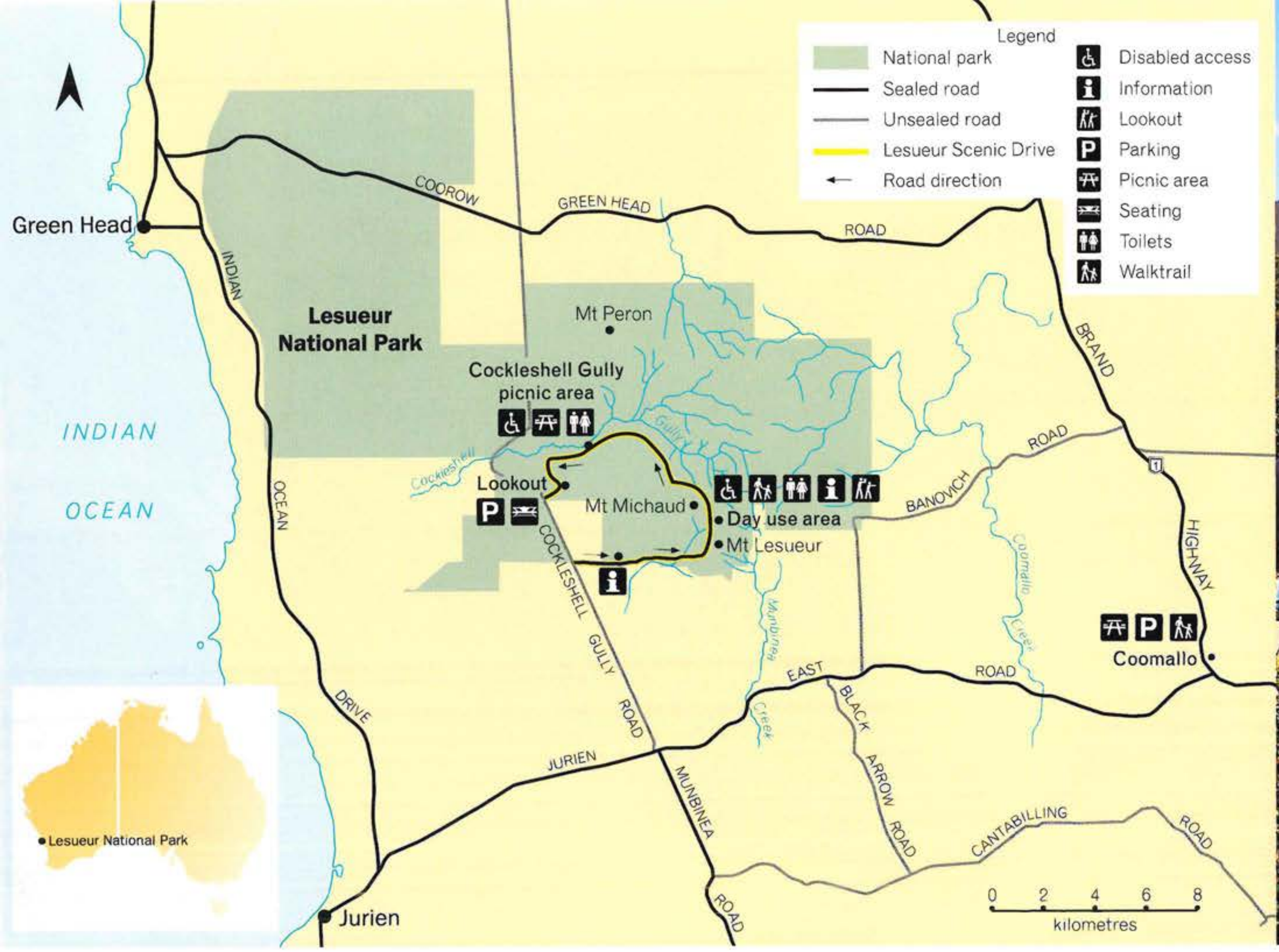
Lesueur National Park is renowned as one of the most important flora conservation reserves in Western Australia. Its 27,987 hectares harbour more than 900 known species of flora as well as an ever-changing landscape of salt lakes, remnant coastal dunes, laterite ridges and attractive hills and gullies. Such is the level of biodiversity in the park and its surrounds that it has been declared one of Australia's 15 national biodiversity hotspots. These hotspots recognise areas of high biological diversity that are under threat.

Natural riches

Examine the flora of Lesueur National Park and you'll find a kaleidoscope of different species types. This is particularly obvious in spring when the greens and browns of the bush erupt into lashings of brilliant colour. Scarlet red kangaroo paws brighten the undergrowth while smoke bush transforms whole landscapes into tones of beautiful, dusky grey. *Verticordias*, *Hakeas*, *Grevilleas*, *Leschenaultias* and more all explode into a blaze of different colours, providing a viewing spectacle for those who take the time to get up close and examine this nature-rich landscape.

Many of these flora species grow nowhere else in the world. In fact there are more than 250 endemic plant species in the area, many of which are restricted to the heaths and scrub heaths.

These species-rich and endemic flora communities also offer a stronghold for fauna. The park is home to at least 52 species of reptiles, 122 species of native birds and 15 native mammal species. Sandplain birds are particularly prolific, with honey eaters, thornbills and several different wren species commonly seen flitting delicately through the bush. You may also be lucky enough to spot the threatened Carnaby's cockatoo squawking raucously from the branches or perhaps a western rosella or pink and grey galah.


Legend
National park
Sealed road
Unsealed road
Lesueur Scenic Drive
Road direction
Disabled access
Information
Lookout
Parking
Picnic area
Seating
Toilets
Walktrail
Green Head
Lesueur National Park
INDIAN OCEAN
INDIAN OCEAN DRIVE
COOROW GREEN HEAD ROAD
Mt Peron
Cockleshell Gully picnic area
Cockleshell
Gully
Lookout
Mt Michaud
Day use area
Mt Lesueur
COCKLESHELL GULLY ROAD
BANOVICH ROAD
BRAND HIGHWAY
1
Coomallo Creek
Munbinea Creek
Coomallo
EAST ROAD
BLACK ARROW ROAD
JURIEN
MUNBINEA ROAD
CANTABILLING ROAD
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kilometres

History

The Lesueur area was traditionally the home of the Yued—Aboriginal people who are thought to have lived here from tens of thousands of years ago. The Yued refer to Mount Lesueur as "Koomba Chiler" and say it served as a landmark to guide people here to trade such items as shields, flint spearheads, stones, shells, animal skins and even women's hair.

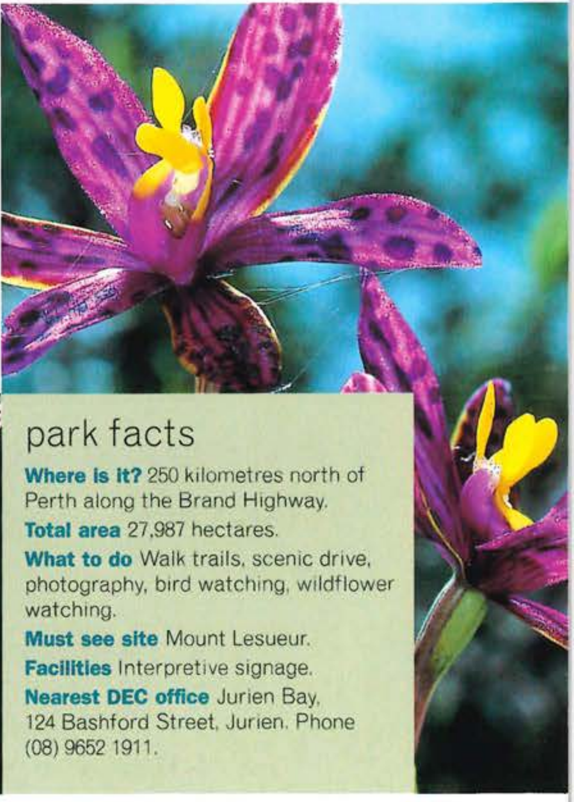
It wasn't until 1801 that Europeans officially recorded the area, when the French ship *Naturaliste* sailed past Jurien Bay. The trip resulted in the naming of Mount Lesueur after Charles-Alexandre Lesueur, a topographical painter and natural history artist on board the *Naturaliste*.

Exploring the park

The best way to explore Lesueur National Park is to drive the 18-kilometre sealed Lesueur Scenic Drive on the eastern side of Cockleshell Gully Road. This one-way-loop drive guides you past steep, red laterite hills and flat top mesas blanketed in rich green kwongan heath with strips of white-trunked wandoo. You can stop at 'wildflower discovery nodes' along the way—stopping points where you can get out to marvel at the plant growth.

The more energetic can set out on walking trails. The easiest option is the 400-metre return Botanical Path, which is wheelchair accessible. It features interpretive signs that help you identify local plants and fill you in on their biology and traditional uses. This trail leads you to Iain Wilson Lookout, where the four-kilometre return Lesueur Trail travels to the top of the 313 metre-high Mount Lesueur. This trail passes a range of floral communities and offers sweeping views from the peak.

An easier option is the Gairdner Ridge 2.5-kilometre loop trail which starts at the Drummond car park day-use area and travels through low heath, by kwongan heath and low woodlands of wandoo to the sandstone outcrops of Gairdner Ridge.



park facts

Where is it? 250 kilometres north of Perth along the Brand Highway.

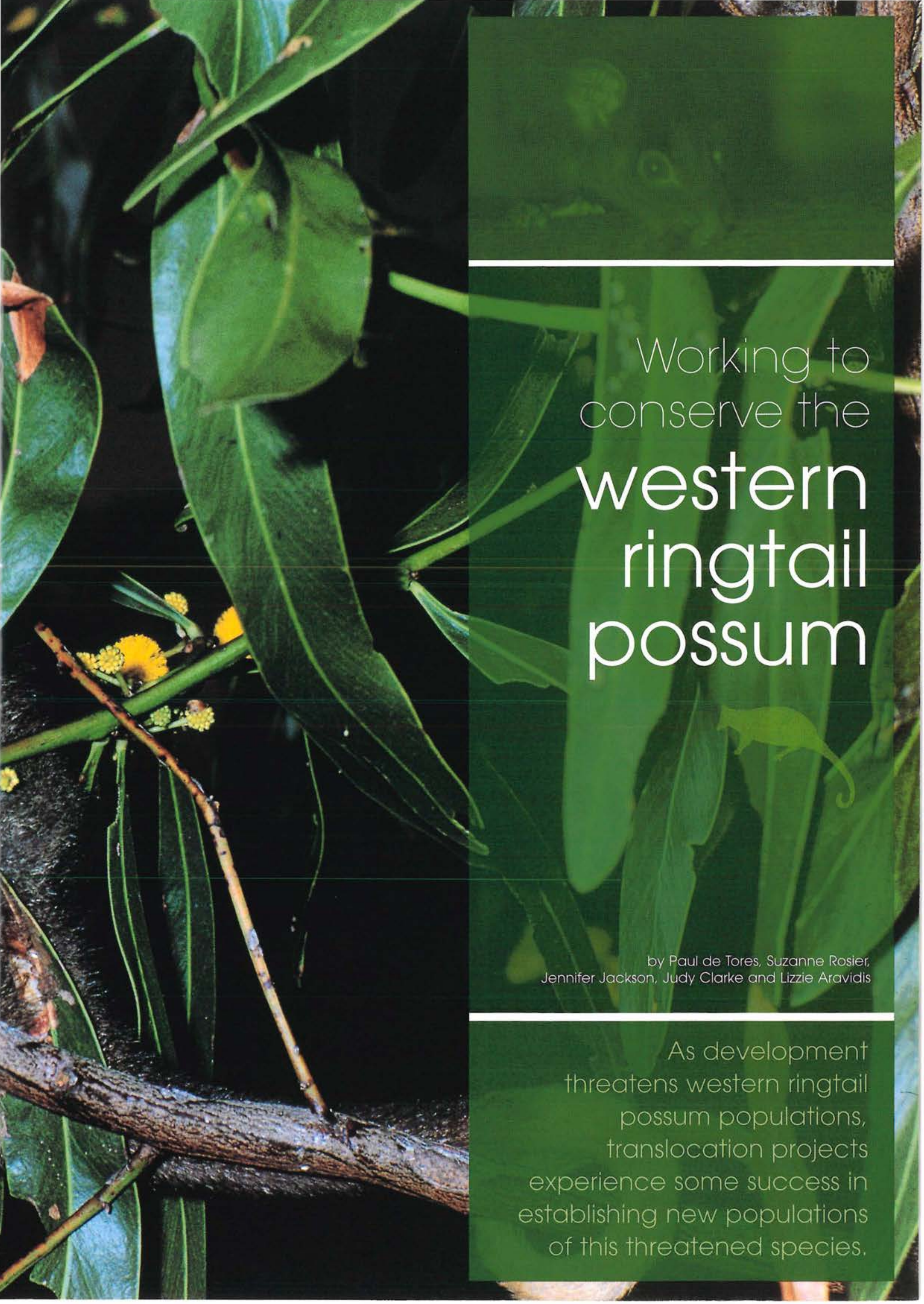
Total area 27,987 hectares.

What to do Walk trails, scenic drive, photography, bird watching, wildflower watching.

Must see site Mount Lesueur.

Facilities Interpretive signage.

Nearest DEC office Jurien Bay, 124 Bashford Street, Jurien. Phone (08) 9652 1911.



Working to conserve the western ringtail possum

by Paul de Tores, Suzanne Rosier, Jennifer Jackson, Judy Clarke and Lizzie Aravidis

As development threatens western ringtail possum populations, translocation projects experience some success in establishing new populations of this threatened species.

The western ringtail possum (*Pseudocheirus occidentalis*) is a small to medium-size arboreal marsupial. The species was, until relatively recently, considered the same species as the common ringtail possum (*P. peregrinus*) from Queensland, New South Wales, South Australia and Tasmania. But in no way is the western ringtail possum 'common'.

In terms of its evolutionary strategies, the western ringtail possum is best described as naïve. It shows minimal predator avoidance and research by Phil Clark from Murdoch University and Felicity Bradshaw, a practising veterinarian in Busselton, has shown the western ringtail possum has very limited capacity to mount an immune response to infection. These two characteristics immediately disadvantage the species, especially in an environment where introduced predators such as foxes and cats are recognised threats and where there is increasing risk of disease due to human disturbance to natural ecosystems and invasion by a suite of exotic species and pathogens. In addition, research by scientist Christine Cooper and honours student Hau Kung Yin from Curtin University confirmed what most wildlife carers and ecologists suspected—the western ringtail possum is not well adapted to cope with high temperatures. The pattern of evaporative water loss for the western ringtail possum is consistent with that for most other marsupials, but only up to an ambient temperature of 25°C. At ambient temperatures higher than this, evaporative water loss increases significantly. At ambient temperatures of 35°C, western ringtail possums easily overheat. Conversely, the western ringtail possum was shown to be well adapted to cooler conditions.

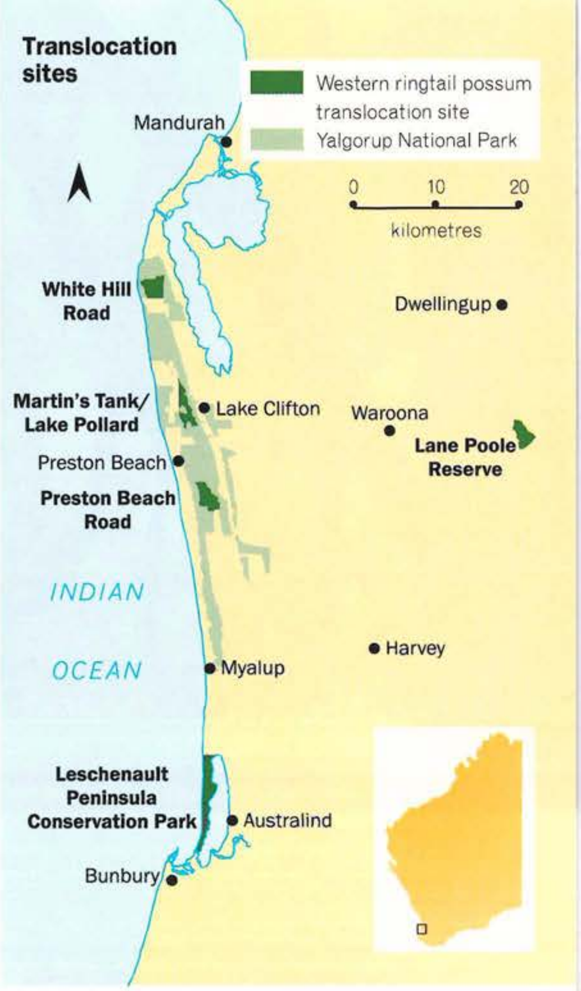
The conservation implications of these three things—predator naïvety, limited ability to mount an immune response and poor adaptation to extremes in heat—are immense. The last of these is of particular concern given the predictions associated with climate change. However, the immediate major threat to the conservation status of the western ringtail possum is habitat loss from land clearing. Land clearing not only results in the immediate loss of habitat but has flow-on effects to surrounding environments including increased numbers of exotic predators such as foxes, cats and pet dogs, and a reduction in the amount of vegetative cover in patches of retained vegetation. The loss of vegetative cover results in increased water loss, making survival even more tenuous for a species which shows an increase in evaporative water loss at only moderately high ambient temperatures.

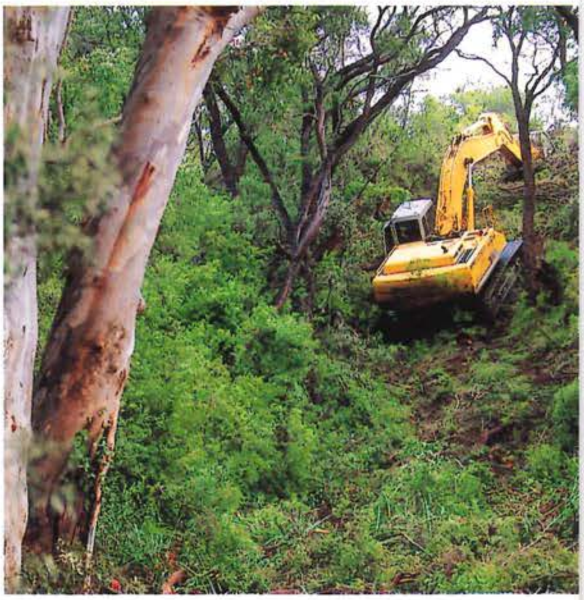
Therefore, it is not surprising to find the distribution of the western ringtail possum has contracted in the time since European settlement. In the 1950s the distribution extended to the southern

Previous page
Main Western ringtail possum.
Photo – Babs and Bert Wells/DEC
Inset Peg, a translocated western ringtail possum.
Photo – Judy Clarke

Below Western ringtail possum.
Photo – Marie Lochman

Above The common ringtail possum is not found in Western Australia.
Photo – Jiri Lochman





Right Bushland being bulldozed for roads and housing development in the south-west.
Photo – Brett Dennis/Lochman Transparencies

and eastern outskirts of Perth and as recently as the 1970s populations were known from near Pingelly. The western ringtail possum is now restricted to the wetter, south-west corner of Western Australia. Unfortunately for the western ringtail possum, this south-west corner is also experiencing an explosion in urban development.

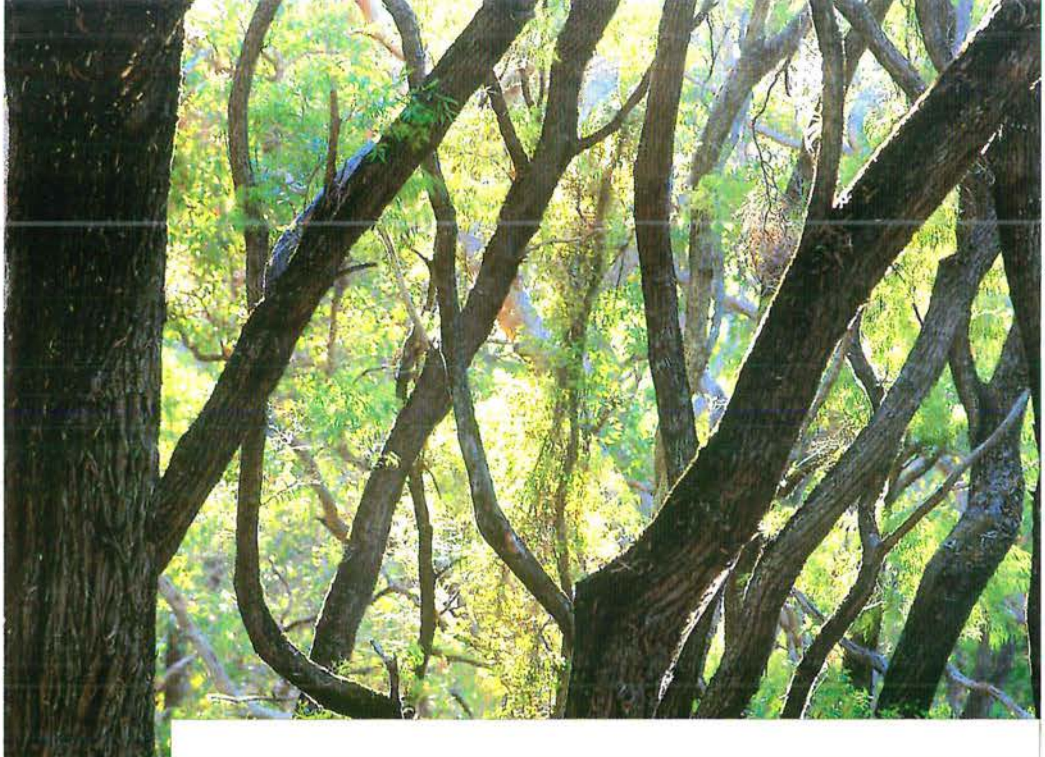
Balancing nature and development

Improvements in infrastructure, new housing and new facilities such as aquatic centres, aged-care facilities, coastal resort complexes and housing estates by the sea, usually come at an environmental cost. The difficult decisions to ensure the environment remains capable of supporting as much of the natural biodiversity as possible, while still providing for the demands of an ever-increasing urban society, remain with planners and legislators. However, planners and legislators cannot make the relevant decisions without basic ecological information—or at least they can't make good decisions without this information.

Establishing the balance between development and retaining biodiversity values is not simple. In the case of the western ringtail possum, State and Commonwealth legislation offers considerable protection. The Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires any developer to refer proposals to the Commonwealth where the proposal is "likely to have a significant impact on a matter of national environmental significance". The EPBC Act recognises seven matters of national environmental significance. One of these is "threatened species and ecological communities". The western ringtail possum is listed in Western Australia, nationally and internationally, as a threatened species and clearly meets the criterion. However, it is less clear what constitutes a "significant impact".

To answer this satisfactorily requires an understanding of which populations of the western ringtail possum are critical for the long-term conservation of the species. This requires knowledge of the population size, population structure, breeding capability, dispersal patterns and an understanding of the genetic structure of these populations. This information is not available at the detail required for local, state and national decision makers. In recognition of this, the Commonwealth Government has supported a pilot study to assess the conservation significance of a suite of western ringtail possum populations in the Busselton area. The Department of Environment and Conservation (DEC) is conducting the research, in collaboration with ecologists and geneticists from Murdoch University. Completion of this study will provide only part of the information required, but will be a major step in achieving better understanding of areas and populations of conservation significance for the western ringtail possum.

In the interim, development applications need to be assessed and decisions made. To date, development applications have been assessed with the best information available. If DEC and the Department of the Environment, Water, Heritage and the Arts approve



Left Peppermint trees provide important western ringtail possum habitat.
Photo – Dennis Sarson/Lochman Transparencies

A tail of two possums

The western ringtail possum has acquired its common name from its ability to use its tail as an additional limb. The tail is truly prehensile. This characteristic makes it immediately distinguishable from the brushtail possum (*Trichosurus vulpecula*) with which it often cohabitates. The tail of the ringtail is approximately equal to its head–body length, whereas the brushtail possums' tail is considerably shorter than the head–body length.

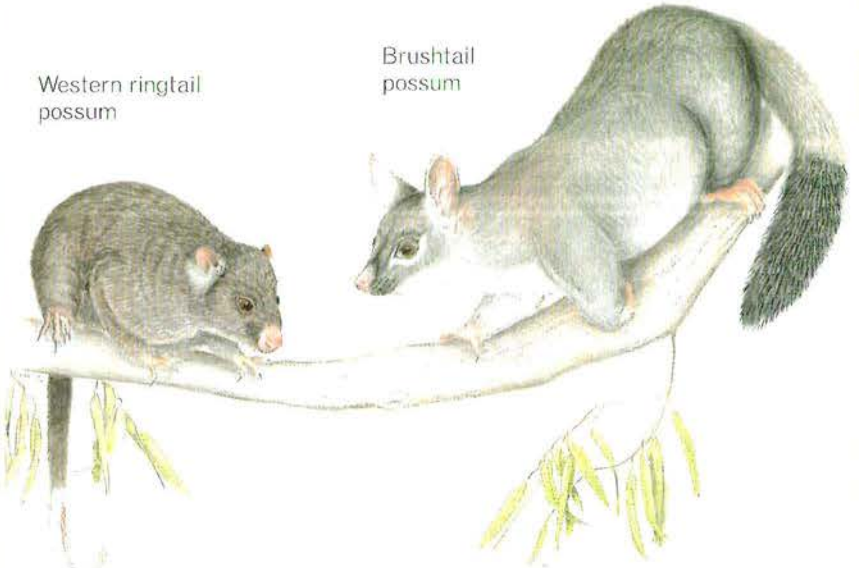


Illustration – Nadine Guthrie/DEC

translocation as an appropriate response, developers must pay the cost of capture and removal of animals from the development sites and must also contribute to the costs for monitoring at the translocation release sites.

Does translocation work?

Translocation is not always the preferred option as a wildlife management tool. In the case of the western ringtail possum in south-west of Western Australia it is preferable to maintain healthy populations in their existing habitat. Where this is not achievable, translocation has become a tool to mitigate the effect from development. Although not a perfect solution, translocation does provide some respite to a situation which would otherwise most likely result in the loss of local populations. For western ringtail possums, translocation has resulted in establishing new populations within secure conservation estate.

The translocation project for the western ringtail possum began in 1991. The translocated animals had been held by wildlife carers and were deemed sufficiently rehabilitated to be released into the wild. Most of these possums had been found injured, orphaned or simply suffering from heat stress and then passed on to carers.

The initial release site was Leschenault Peninsula Conservation Park, immediately north of Bunbury. These releases were to peppermint (*Agonis flexuosa*) dominated habitat within the park, where a fox baiting program had been implemented and been maintained. By 1995, the western ringtail possum population had increased and additional sites were identified for release of possums rehabilitated by wildlife carers and those displaced by approved developments. By 1998 the Leschenault population had appeared to meet all the criteria for translocation success.

Additional sites were established in Yalgorup National Park and Lane Poole Reserve. Most of the released possums came from development sites, where the possums were caught immediately before clearing. Monitoring from these sites indicates all have met with some translocation success.

Positive conservation benefits from the translocation research include the establishment of what appear to be viable populations at two sites within Yalgorup National Park–Preston Beach Road and White Hill Road. Monitoring has confirmed the populations have survived and there has been continued recruitment of young. Spotlight monitoring in 2006 resulted in 24 western ringtail possum sightings. At least 21 of the animals sighted were offspring from the original translocated possums. This is clear evidence of successful breeding at both sites. More recent data suggests a similar pattern has occurred at Martin's Tank and Lake

Pollard—the third translocation release site within Yalgorup National Park.

Monitoring has been less intense at Lane Poole Reserve, but the trends in the data are similar to those from Yalgorup National Park. Ringtails released at Lane Poole have survived to produce young, have established regular use of tree hollows and constructed nests. The data from Lane Poole Reserve and Yalgorup National Park were the first to reveal western ringtail possums regularly use grass trees as rest sites during the day.

Offspring from the Lane Poole population have been observed, but none of these has been radio-collared. However, one of the possums translocated to Lane Poole Reserve has resulted in a longevity record for the western ringtail possum (see 'Possum antics' on page 60).

Monitoring through the use of radio-telemetry requires capture and recapture of individual possums. Western ringtail possums are not easily caught using conventional trapping methods. The most effective technique is capture through the use of a tranquiliser dart gun. Possums are darted at close range, the tranquiliser takes up to two minutes to take effect and the possum is caught in a blanket as it falls from the tree.

Reports of western ringtail possums have now become a regular occurrence from numerous locations north and south of the translocation release points within Yalgorup National Park. These reports are further indications of translocation success. Through the use of DNA analysis we are now able to determine if these new sightings have originated from dispersal of individuals from the translocation release sites.

Why the translocation concern?

Follow-up surveys at Leschenault in 2002 showed the population had declined. Several hypotheses have been proposed to explain this, including disease, changes to the fox baiting regime and prey switching (rabbit numbers have been reduced and the major predators may have switched from preying on rabbits to other predation-sensitive species such as the western ringtail possum). The phenomenon of mesopredator release has also been suggested as a cause for the decline. Mesopredator release is where a reduction in the dominant predator (foxes) allows other, subordinate predators such as cats, pythons and chuditch, to increase in number and add predation pressure on other species (see 'Will curiosity kill the cat?', *LANDSCOPE*, Autumn 2007).

Monitoring at Leschenault from 2004 to 2006 indicated predation by cats and pythons was potentially limiting translocation success at Leschenault and there was evidence to support the disease hypothesis (toxoplasmosis had previously been detected in offspring

Below Leschenault Peninsula Conservation Park.
Photo – Andrew Davoll/Lochman Transparencies

Background left Yalgorup National Park.
Photo – Gordon Roberts/DEC

Left The male offspring of the translocated possum 'Peg', from Yalgorup National Park.
Photo – Helen McCutcheon/DEC

Possum antics

At least two of the translocated western ringtail possums have set benchmarks.

Possum one: A rehabilitated possum called 'Philadelphia', held in care for about three weeks, was known to be at least 18 months old when released in 1998 at Lane Poole Reserve. Philadelphia was fitted with a radio collar which stopped functioning shortly after release. Philadelphia reappeared in January 2006 in the Dwellingup town site, in the grounds of 'Dwellingup Adventures'. Researchers believe she stowed away in a kayak or vehicle and was transported to Dwellingup from Lane Poole. She was showing the signs of age and was partially blind. She spent her final days at the Fauna Rehabilitation Foundation in Malaga where she lived to a record age of nine years. Western ringtail possums were previously only known to reach six to seven years.

Possum two: The possum known as 'Peg' met the criteria for both categories of translocated possums: those held by wildlife carers until considered rehabilitated and suitable for release and those which have been caught for translocation and relocated directly from development sites where the habitat is to be cleared.

Peg was caught at a development site in Busselton and, at the time of capture, had an injury to her hip area. Peg was taken to the Fauna Rehabilitation Foundation in Malaga where she was given immediate veterinary attention. An X-ray revealed Peg had a dislocated hip. After seven months of rehabilitation, Peg was considered ready for release into the wild.

Peg was fitted with a radio-collar, released at the Martin's Tank–Lake Pollard release site in Yalgorup National Park and monitored regularly. There are more than 30 location records for Peg collected in the period from July 2006 to March 2007. Peg's day-time rest sites included nests, hollows, grass trees and forks in *Melaleuca* trees. She raised at least one (male) offspring to weaning age before her collar prematurely ceased transmitting.

from the population at Yalgorup). In 2005 the then Department of Conservation and Land Management (now DEC), in collaboration with Murdoch University and the University of Sydney, successfully sought Australian Research Council funding. This program, together with funds from developers responsible for habitat clearing, is enabling two PhD students to examine the prevalence of disease in naturally occurring and translocated populations. The students, both qualified veterinarians, are also examining survivorship, habitat use and the predators responsible for any predation events. A third PhD student is examining the role of pythons from a mesopredator release perspective, specifically the importance of python predation to western ringtail possum translocation success.

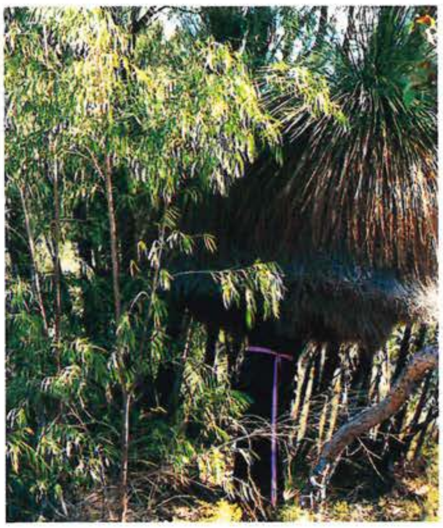
Predation by cats and pythons at Leschenault has now been clearly quantified and there is very strong evidence for the mesopredator release hypothesis. This is also supported by results from western ringtail possum releases at the Australian Wildlife Conservancy's Karakamia Sanctuary in Chidlow, which is protected by a predator-proof fence and is free of foxes and cats. Translocated western ringtail possums have continued to increase in number within the privately owned sanctuary.

Pythons and western ringtail possums occur together naturally over much of the possums' range. Consistent with ecological theory and the principle of mesopredator release, DEC researchers have hypothesised translocated ringtail populations at Leschenault will be able to withstand some level of predation by pythons and, if cat density is reduced, the ringtail populations will become self sustaining.

Leschenault Peninsula Conservation Park has now been identified as a priority site for cat control. Before this can occur, the recently developed cat-control bait, Eradicat, will be tested to ensure native fauna from the south-west are not at risk from the effects of the bait. This testing will be carried out in 2008 using non-toxic baits at Leschenault. If there is no risk to the native species, toxic (1080) Eradicat baits will be deployed at Leschenault Peninsula Conservation Park later in 2008. DEC researchers and the Invasive Animals Cooperative Research Centre are also undertaking concurrent trials in the northern jarrah forest and anticipate broad-scale cat baiting research to start in the jarrah forest in 2009.

Future translocations

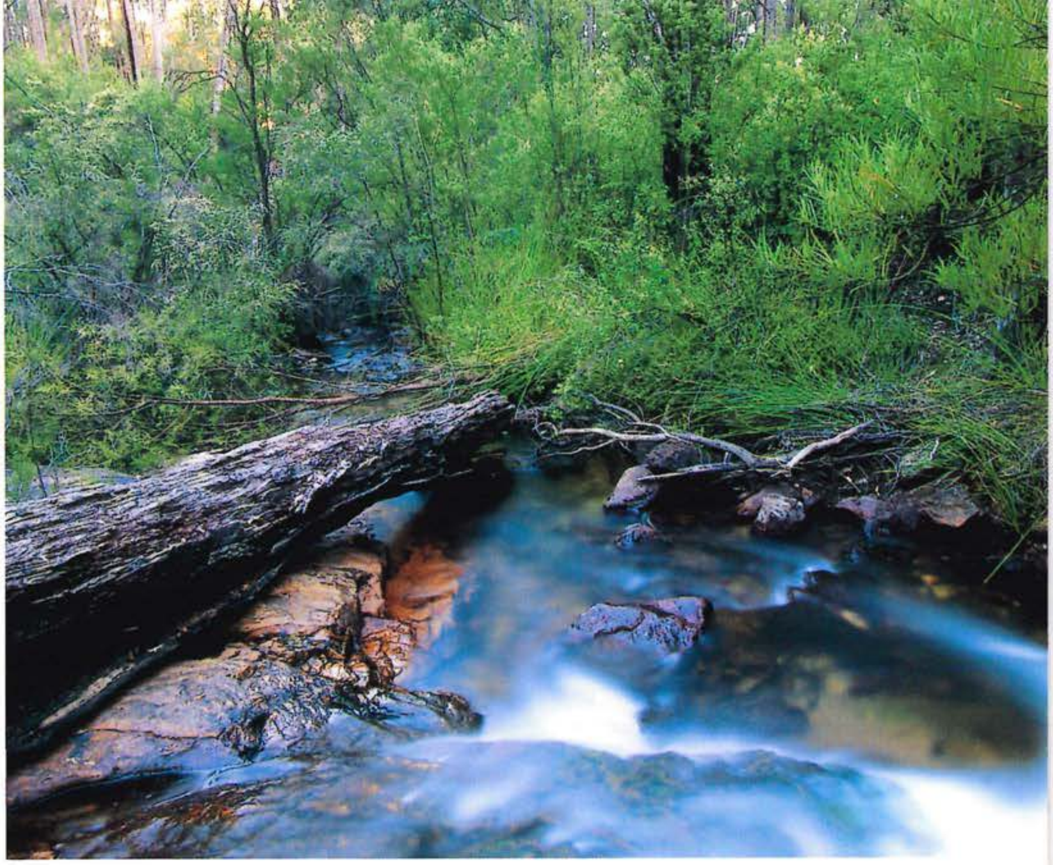
Translocation has been increasingly used as a mitigation measure for many threatened species. It may provide hope for populations otherwise doomed by habitat loss through clearing. If it can be shown to be successful over the longer term, it may well be an



Above A typical grass tree (*Xanthorrhoea preissii*) used as a day-time refuge by translocated western ringtail possums at Yalgorup National Park.
Photo – Paul de Tores/DEC

Above right Lane Poole Reserve.
Photo – Brett Dennis/Lochman Transparencies

Right Carpet python—a natural predator of western ringtail possums.
Photo – Marie Lochman



important component in the mix of management and planning options for improved conservation of the western ringtail possum.

The selection of translocation release sites now needs to take into account the consequences of global warming. We are unlikely to see the western ringtail possum translocated to sites in the wheatbelt where the species once occurred. Future translocations to sites within the temperate higher rainfall zones such as Lane Poole Reserve and Yalgorup National Park can provide an extension to the existing range of the western ringtail possum, thus contributing to the conservation of the species.

There are no quick fix solutions. Western ringtail possums are threatened by habitat loss, predation, fire, diseases and climate change. The use of translocation should not be regarded as a panacea for resolution of conflict between development and conservation, particularly where the habitats at risk are those of high conservation value for a threatened species.

Paul de Tores is a Research Scientist with the Department of Environment and Conservation (DEC), and is based at DEC's Dwellingup Research Centre. Paul can be contacted on (08) 9538 0025 or by email (paul.detores@dec.wa.gov.au).

Suzanne Rosier is a DEC volunteer who has been actively involved in the western ringtail possum translocation research since 1991.

Jennifer Jackson is a Technical Officer, based at DEC's Wildlife Research Centre in Woodvale. Jennifer was involved in the translocation research from 2004 to 2006.

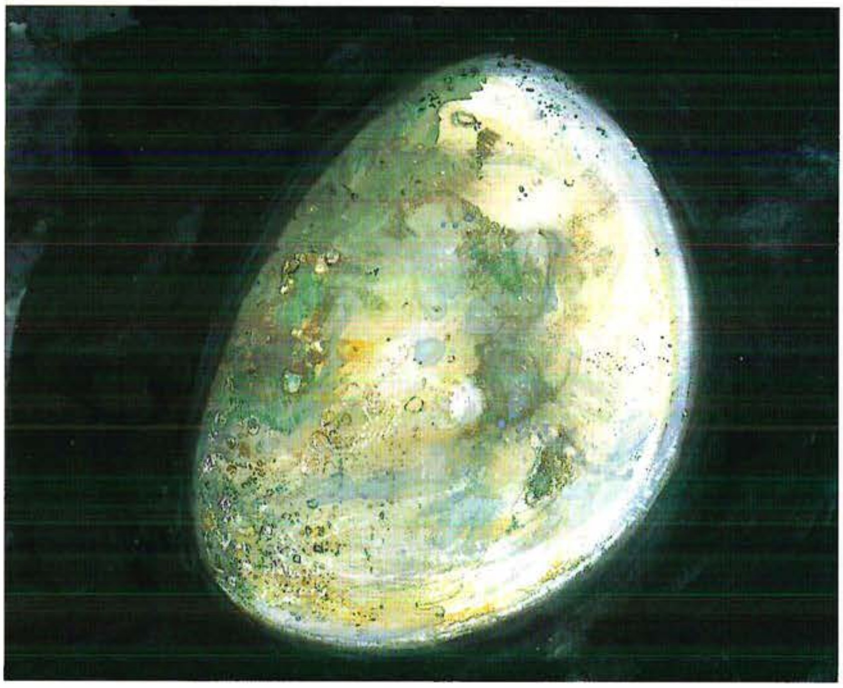
Judy Clarke is a veterinarian, now undertaking a PhD examining the outcomes from translocation of the western ringtail possum. Judy started her research in 2006.

Lizzie Aravidis is the President of the Fauna Rehabilitation Foundation (FRF), at Malaga. FRF volunteers have been involved in ensuring orphaned and injured western ringtail possums are appropriately rehabilitated and released into the wild.

urban antics

by John Hunter

Fly me to the moon



The moon may not be your average choice as one of the major things to observe in your backyard, but it is definitely the biggest and most re-occurring.

Found in all backyards from Tuart Hill to Timbuktu and from Wembley Downs to Wyoming, the Earth's moon has a major effect on many of the planet's animal and plant species.

A big statement, but I'm sure even the smallest troglodyte is affected at times by Earth–moon gravity and tide, while surface dwellers may become psychologically involved with a full moon or an eclipse. One thing is for sure, since humans first looked to the heavens and muttered "What is that?", the moon has been the catalyst for songs, poems, prose, courtship and war.

The moon is the closest astronomical object to Earth. With the Earth it forms almost a double planet as no planet that we know of has a satellite which is as large in comparison to the size of its planet.

Four times smaller in diameter than the Earth, our moon was probably formed shortly after the rest of our solar system about four and a half billion years ago. The big question is how it formed.

Was it the 'escape' theory where the Earth and moon were one single body and that the sun's gravity caused a bulge on one side of a fast-spinning Earth where the bulge broke away to become the moon? Or was it that the moon and Earth were formed at the same time and in the same region and made from huge whirlpools of gas and dust that were left over when the sun was formed? Or was it the capture theory where the moon was once a planet that was caught in the Earth's gravity to become a natural satellite?

Two scientists, Hartman and Davis, suggest the leading modern hypothesis is the 'collision theory', which proposes that a large body from space smashed into the Earth and knocked a mass of solid material from Earth's mantle. This material orbited the Earth and eventually united into a single mass to form the moon.

The collision theory is probably more acceptable in that the Earth has a large iron core but the moon does not. This is because Earth's iron had already drained into the core by the time the giant impact happened. Therefore, the debris blown out of both Earth and the impactor came from their iron-depleted, rocky mantles. The iron core of the impactor melted on impact and merged with the iron core of Earth. To further back this theory, the moon has exactly the same oxygen isotope composition as Earth, whereas Mars' rocks and meteorites from other parts of the solar system have different compositions.

Compared with the Earth, the moon has changed little over billions of years. There is no air, wind or water. During the day the sky is black and the stars are visible. At night the desolate rocky surface is extremely cold and the temperature is lower than any place on Earth. During the day, the temperature of the rocks is slightly higher than that of boiling water.

However, the moon is a beauty to behold at any of its stages of light and shade. Earth dwellers admire its eerie presence and respect its lofty place from our cosy spaceship.

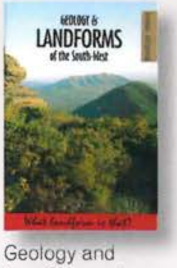
Let's hope the human race for dominance and economic growth on our planet doesn't eventually turn our beautiful landscape into another moon.

DID YOU KNOW?

- The diameter of the moon is about 3,475 kilometres—about the distance across Australia from Perth to just beyond Sydney.
- In its elliptical-shaped orbit around Earth, the moon travels at about 3,700 kilometres per hour in its 2.3-million-kilometre journey and passes as close as 356,399 kilometres to us.
- The moon is occasionally referred to by its Latin name *lunar* and an adjectival prefix *seleno* from the Greek deity Selene.

Bush Books...

Explore Western Australia's plants, animals and special features with this series of interesting and informative pocket-sized guides. Packed with information set out with scientific accuracy and full-colour photographs, these books are a fantastic reference and the perfect companion for any trip or outing.


GEOLOGY & LANDFORMS
of the South-West
What landform is that?

Geology and Landforms of the South-West

WATERBIRDS
What bird is that?

Waterbirds of the South-West Wetlands

BUSH TUCKER
What plant is that?

Bush Tucker Plants of the South-West

BEACHCOMBING
Perth and South-West beaches
What plant or animal is that?

Beachcombing Perth and South-West beaches

MARINE PLANTS
What plant is that?

Marine Plants of the Perth Region

ORCHIDS
of the South-West
What orchid is that?

Orchids of the South-West

COMMON TREES
What tree is that?

Common Trees of the South-West Forests

COMMON WILDFLOWERS
What flower is that?

Common Wildflowers of the South-West Forests

WILDFLOWERS
of the South Coast
What flower is that?

Wildflowers of the South Coast

WILDFLOWERS
of the Stirling Range
What flower is that?

Wildflowers of the Stirling Range

FUNGI
What mushroom is that?

Fungi of the South-West Forests

MAMMALS
of the South-West
What animal is that?

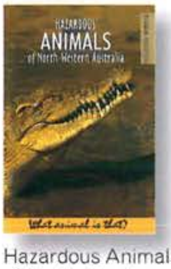
Mammals of the South-West

COMMON BIRDS
What bird is that?

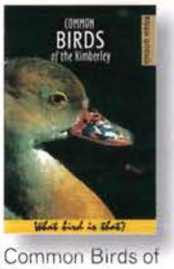
Common Birds of the South-West Forests

MAMMALS
What animal is that?

Mammals of North-Western Australia


HAZARDOUS ANIMALS
of North-Western Australia
What animal is that?

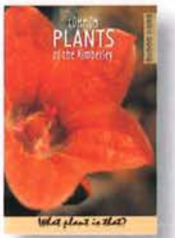
Hazardous Animals of North-Western Australia


COMMON BIRDS
of the Kimberley
What bird is that?

Common Birds of the Kimberley

GEOLOGY & LANDFORMS
of the Kimberley

Geology and Landforms of the Kimberley


COMMON PLANTS
of the Kimberley
What plant is that?

Common Plants of the Kimberley

COMMON PLANTS
of the Pilbara
What plant is that?

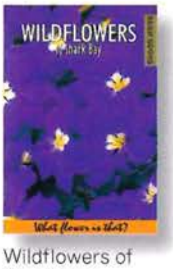
Common Plants of the Pilbara

GEOLOGY & LANDFORMS
of the Pilbara
What landform is that?

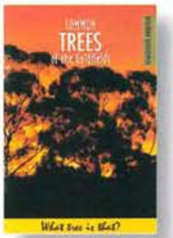
Geology and Landforms of the Pilbara

ANIMALS
of Shark Bay
What animal is that?

Animals of Shark Bay


WILDFLOWERS
of Shark Bay
What flower is that?

Wildflowers of Shark Bay


COMMON TREES
of the Goldfields
What tree is that?

Common Trees of the Goldfields

COMMON WILDFLOWERS
of the Mid-West
What flower is that?

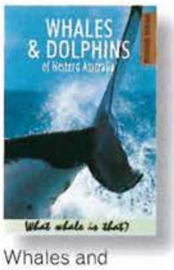
Common Wildflowers of the Mid-West

THREATENED WILDFLOWERS
What plant is that?

Threatened Wildflowers of the Mid-West

WILDFLOWERS
of Dryandra Woodland
What flower is that?

Wildflowers of Dryandra Woodland


WHALES & DOLPHINS
of Western Australia
What whale is that?

Whales and Dolphins of Western Australia

THREATENED & RARE BIRDS
of Western Australia
What bird is that?

Threatened and Rare Birds of Western Australia

AUSTRALIAN BIRDS OF PREY
What bird is that?

Australian Birds of Prey

COMMON BIRDS
in the Backyard
What bird is that?

Common Birds in the Backyard

BUGS
in the Backyard
What bug is that?

Bugs in the Backyard

FROGS
What frog is that?

Frogs of Western Australia

SNAKES
of Western Australia
What snake is that?

Snakes of Western Australia

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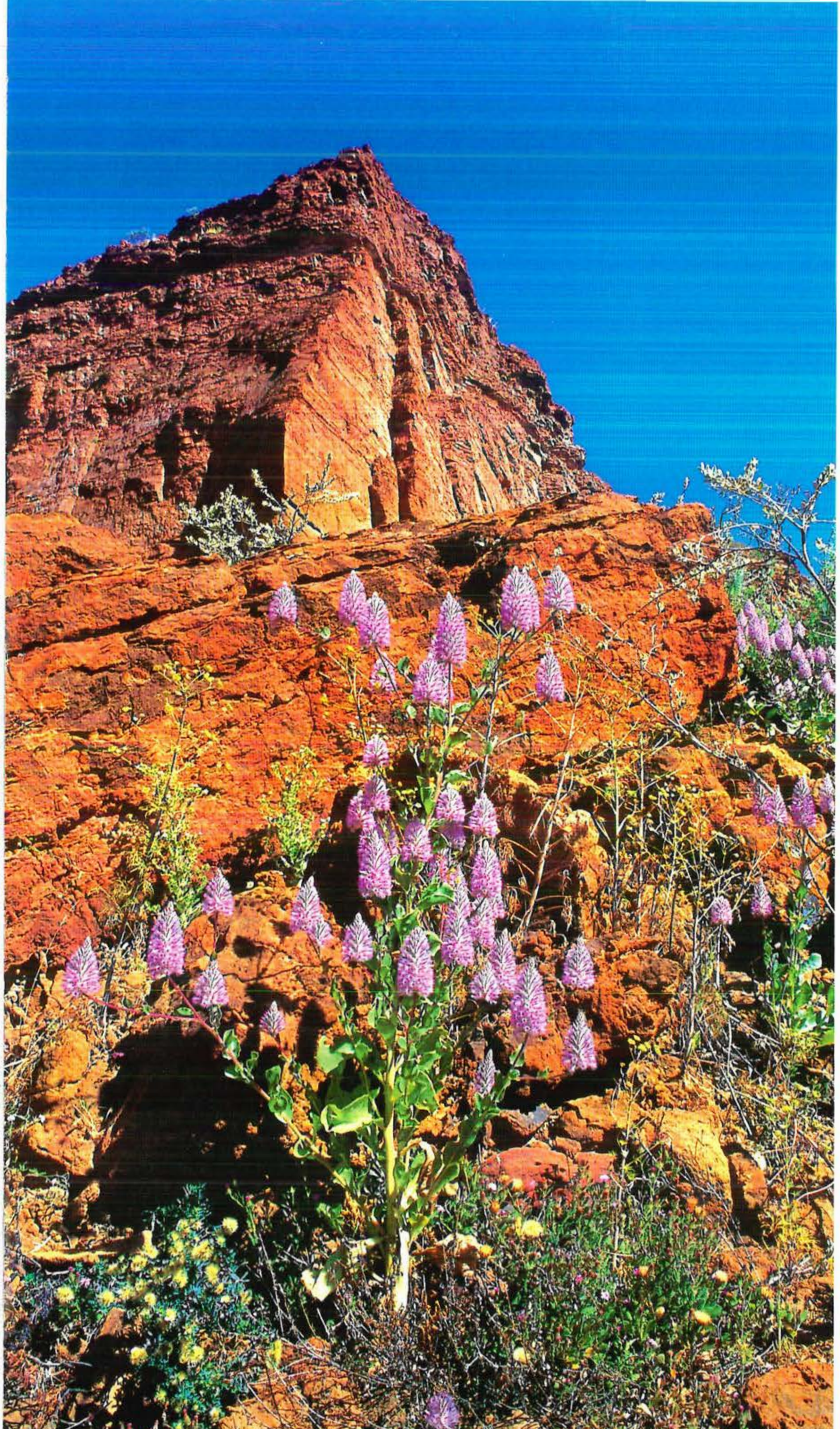

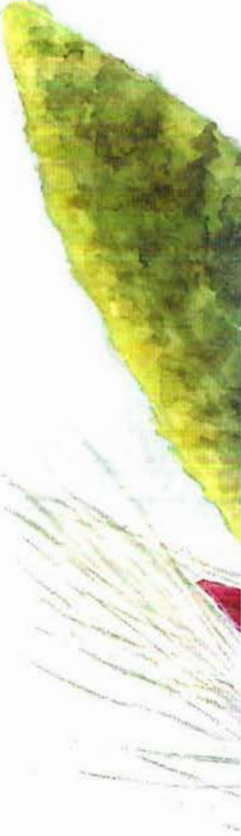

ISSN 0815-4465

Print Post Approved pp665002/00004

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