WA's conservation, parks and wildlife magazine

LANDSCOPE

Volume 23 Number 2 SUMMER 2007–08 $6.95

Flatback turtles

Learning about country

Capes coast beneath the surface

Discovering flora's hidden diversity **Dirk Hartog Island** Marmion Marine Park

Making a world of difference since 1992
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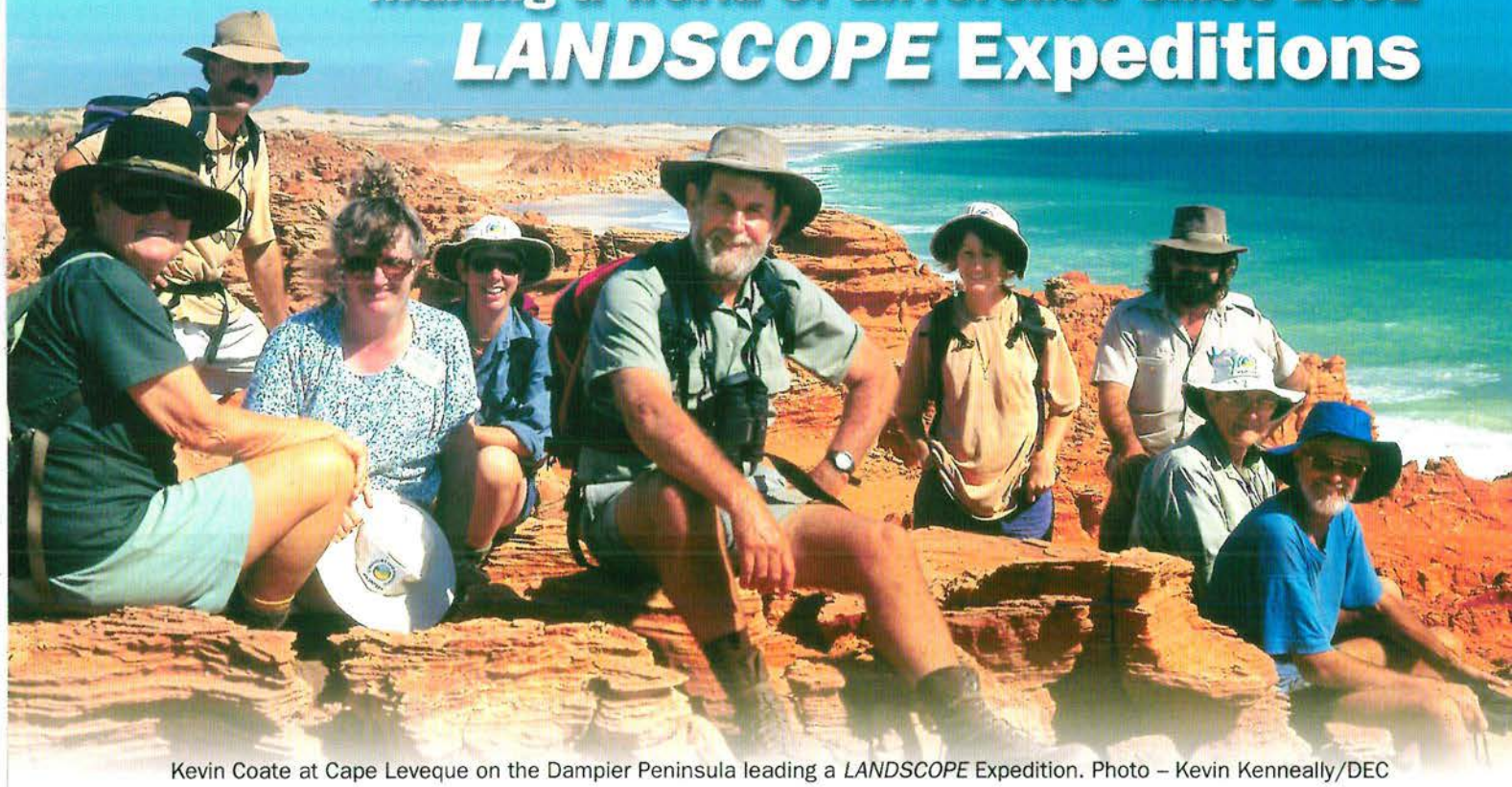

Kevin Coate at Cape Leveque on the Dampier Peninsula leading a *LANDSCOPE* Expedition. Photo – Kevin Kenneally/DEC

Birds of the Tanami Desert - Ornithological Investigations at Paruku (Lake Gregory)

Paruku (Lake Gregory) 29 June–7 July 2008
Paruku (Lake Gregory), in the Tanami Desert, is home to 73 species of waterbird and is an important stopover for 16 migrant shorebirds. Join Kevin Coate, one of Western Australia's foremost naturalists, in this expedition to observe migrating waterbirds and to determine major waterbird breeding activity areas. Tag-alongs are welcome.

Desert Tracks - Animals and plants of the Canning Stock Route

Canning Stock Route 10–22 August 2008
Experience the true Australian outback while conducting important research into desert ecology and biodiversity. For scientists, the Canning Stock Route represents a long biodiversity transect through several different biogeographical regions. Discover local fauna and flora, map fire scars and search for evidence of introduced predators while experiencing the magnificent Australian desert. This expedition will investigate the area of the Canning Stock Route from wells 23 to 35. Tag-alongs are welcome.

A Brush With Nature - The Art of the Flower Hunters

Thundelarra 8–17 September 2008
Discover the art of botanical painting with botanical artist Katrina Syme at Thundelarra, a former pastoral lease being managed for its conservation values. You will also assist Department of Environment and Conservation (DEC) scientists establish flora monitoring quadrats and compile a field herbarium for the area. This is a rare opportunity to combine scientific research and botanical observations with the tradition of botanical illustration in an area world famous for its wildflowers.

In the Tracks of Len Beadell - The plants and animals of the Neale Junction Nature Reserve

Great Victoria Desert 28 September–11 October 2008
Len Beadell explored and opened up more than 2.5 million square kilometres of rugged Australian outback. This project seeks to improve our understanding of the geographic distributions of the biota that inhabits the Great Victoria Desert. We will be surveying the plants and animals in the Neale Junction Nature Reserve, which lies where two of Len Beadell's tracks meet. Tag-alongs are welcome.

Researching the Recherché - Wildlife of Southern Ocean Islands

Middle Island, Recherché Archipelago 20–27 October 2008
From Esperance to Israelite Bay on the south coast of Western Australia there are more than 100 islands and 1500 islets that make up the Recherché Archipelago. The largest of these is Middle Island, where this expedition will be based. This expedition will conduct searches for rare flora and observe and record small mammals, reptiles, seabirds, seals and sea lions. Join DEC scientists on a journey to undertake research into the wildlife of these remote and relatively untouched islands.

Sanctuaries of the Sea - Wildlife of the Montebello Islands

Montebello Islands 5–12 October 2009
The Montebello Islands are home to many native animals severely affected by introduced predators, which arrived at the turn of the century. DEC has removed these threats to allow the recovery of native species. Join scientists in searching for boodies, mala, golden bandicoots, Shark Bay mice and discover the history of this magnificent marine sanctuary.

Send for your copy of the *LANDSCOPE* Expeditions 2008 brochure:

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The University of Western Australia
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or visit DEC's website at
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THE UNIVERSITY OF WESTERN AUSTRALIA


Terry Houston


Margaret Byrne

contributors

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Margaret Byrne has been a Research Scientist in the Department of Environment and Conservation (DEC) for 11 years. She came to DEC from CSIRO and established the molecular genetics laboratory at DEC's State Operations Headquarters at Kensington. She conducts genetic research to assist with the conservation of Western Australia's diverse flora and works on rare and common species as well as landscape genetic processes.

Jeff Short is Director of Wildlife Research and Management, a consultancy working with community groups in rural and regional areas of WA to deliver biodiversity solutions. He is a former principal research scientist with CSIRO Sustainable Ecosystems in Perth. He has worked on the conservation and management of threatened mammals in western and eastern Australia and in Africa. Jeff has provided support over many years to the Useless Loop community at Shark Bay to re-establish threatened mammals on Heirisson Prong—a project that won the 2001 Gold Banksia Award and Banksia Environment Award for Community Group Achievement. His research interests include historical ecology, mammalian ecology, the role of threatening processes in species decline, and conservation through reintroduction.

Alex Bowlay is DEC's District Wildlife Officer in the East Kimberley District. Alex has worked in the district as a National Park Ranger since 1998 and, after working as a Senior Ranger near Dwellingup, returned to the East Kimberley in 2006. Alex has an active interest in the wildlife and landscapes of the Kimberley.

editor's letter

One of the best parts of working with the team bringing *LANDSCOPE* together is seeing the range of stories being developed for publication throughout the year.

Each of the four editions sees a fascinating collection of information with stunning images that give an extra meaning to the scientific and field work being done across Western Australia. Some intriguing science, fascinating research and extraordinary dedication underlie the stories—and many also hint at a taste of adventure behind the scenes as scientists, researchers and others travel to amazing locations and set about their work.

Just getting to those locations is often part of the challenge of the job. In this edition, there is an account of the work being done at Cape Domett, right at the top of WA, to get a better understanding of flatback turtles. 'Uncovering turtle antics' includes an outline of the effort involved in reaching the beach which is accessible only by boat and is in an area with a tidal range of more than seven metres during spring tides.

'Learning about country' takes us to the Central Ranges, and almost the centre of Australia. Here, a collaborative effort between Commonwealth and State government agencies and the Ngaanyatjarra people is improving knowledge of the distribution of plants and animals—including some that have never been identified before.

It is an area where little has changed visually in the 150 years since Europeans first arrived. However, exotic plants and animals Europeans brought to Australia have spread right across the landscape and it is imperative for us understand more about the flora and fauna of the region to help manage future impacts.

The great results coming from improving our understanding of what is happening around us is a common theme in many *LANDSCOPE* articles. It is also highlighted in 'Snail threat to Ningaloo Marine Park?' which looks at the scientific attention that has followed the outbreak of the marine snail drupella in the late 1980s. The outbreak devastated sections of the reef by killing its coral and sparked fears for the future of Ningaloo Reef. The cause of the outbreak remains a mystery, despite a range of theories, but the current work monitoring and gathering information in the hope of understanding more about the small coral predator will be invaluable if there is a future outbreak.

And, what drives a scientist to take on a long-term study to find out more about the life history of a tiny insect? 'Unearthing the secrets of sandgropers' shows just how casual interest and curiosity can lead to an extraordinary commitment.

Other articles in this edition take us to some stunning areas of WA, including the proposed Capes marine park in the south-west—one of the most popular playgrounds for Western Australians and tourists alike.

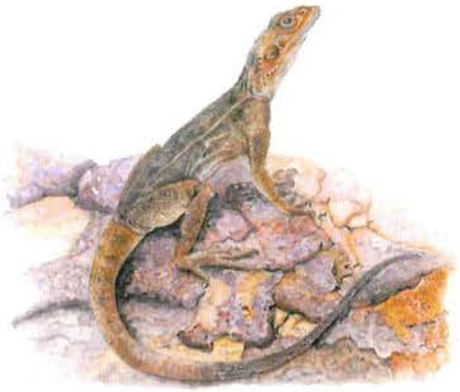
We also look at the progress of changes on Dirk Hartog Island where the process has started to preserve the island as a national park. Besides its historical significance, the island has immense biodiversity conservation values and, as a national park, will be a haven for threatened species.

Kaye Verboon
Executive Editor

also contributing . . .

David Pearson, Jo Miller, Mark and Maimee Butler, Karl Brennan, Wendy Thompson, Mark Westera, Brenda Smith, Marie Milagro, Stephen Crane, Shannon Armstrong, Jill Pryde, Verna Costello, John Hunter, Carolyn Thomson-Dans, Samille Mitchell and Andrea Whiting.


Jeff Short



Cover illustration by Philippa Nikulinsky
The rusty dragon (*Ctenophorus rufescens*) occurs only in the arid inland, around the junction of the Western Australian, Northern Territory and South Australian borders. It lives in rocky hills and ranges and shelters at night and during winter under rock slabs and in crevices. During warmer weather, it forages on open rock surfaces for invertebrates. Its long rear legs and a long tail enable it to run quickly to shelter when threatened by predators. The sexes have different colouration. The adult male is dull reddish brown with brown blotches on its back and develops a dark-grey patch on its chest during the breeding season. Females and immature rusty dragons are paler.

Back cover photo by Karl Brennan
Kutjurntarri, Central Ranges.

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Snail threat to Ningaloo Marine Park?

During the late 1980s an outbreak of the marine snail drupella sparked fears for the future of Ningaloo Reef. The snail devastated large sections of the reef by killing its coral. By the mid-1990s the outbreak had subsided and concerns eased—but what is the status of drupella in Ningaloo Marine Park today?

by Samille Mitchell and Shannon Armstrong

In the early 1980s locals first raised alarm bells about the state of coral communities in the northern section of Ningaloo Marine Park. Great tracts of the reef were dying, suddenly turning stark white (see 'Fatal attraction', *LANDSCOPE*, Winter 1989). A 100-kilometre stretch of reef was said to have lost an incredible 90 per cent of its coral. The culprit? An inconspicuous looking marine snail known as drupella (*Drupella cornus*).

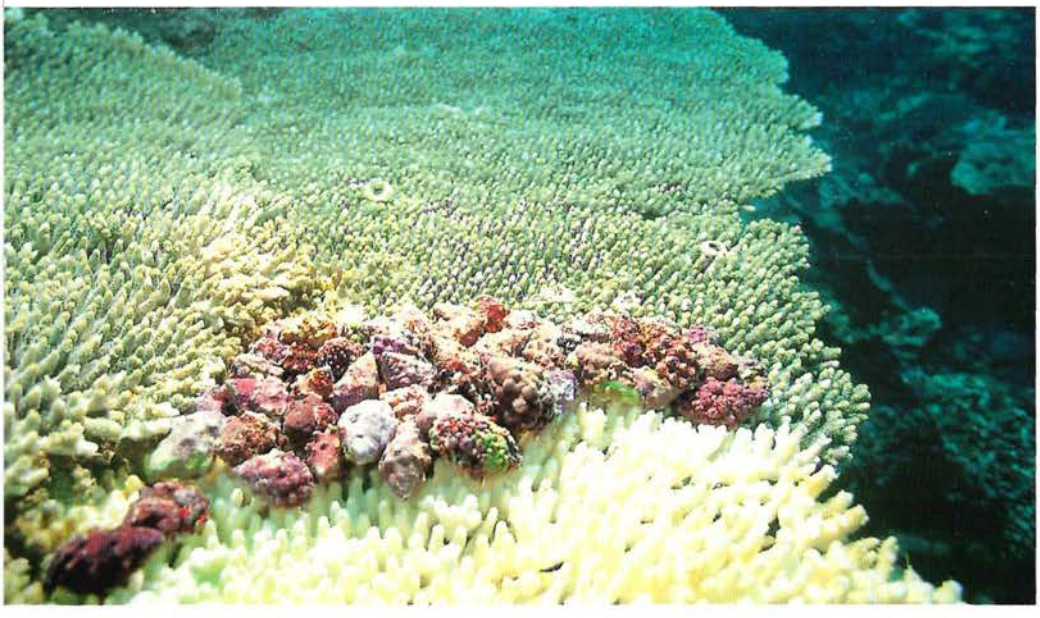
For reasons still open to debate, drupella populations had increased dramatically. In army-like fronts, lines of the snail moved across Ningaloo's dazzling corals, using their modified mouths to suck out polyps from their coral homes.

Monitoring drupella numbers and effects

Scientific attention ensued. In the late 1980s the Department of Conservation and Land Management (CALM), now known as the Department of Environment and Conservation (DEC), conducted a major survey of Ningaloo Reef and found coral cover in the back-reef zone where the snail was most prominent had been reduced by more than 75 per cent in two-thirds of the reef.

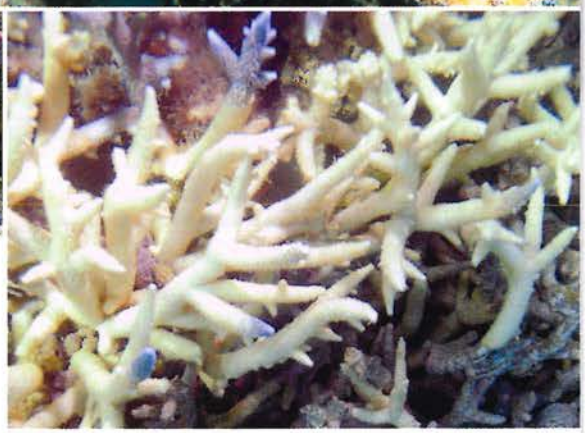
CALM conducted another survey in 1991, which involved monitoring 13 locations in the Ningaloo Marine Park. By this time drupella numbers had decreased, but remained a worry. A follow-up survey in 1994, however, found populations had dropped considerably. The problem had subsided as fast as it began.

These surveys involved many volunteers and CALM staff and were expensive and time-consuming



Above Reef colony partly destroyed by drupella.
Photo – Gerhard Saueracker/Lochman Transparencies

Left Drupella feed on coral leaving a bleached skeleton.
Photo – Eva Boogaard/Lochman Transparencies



Top right Drupella snails feed on staghorn coral.
Photo – Gerhard Saueracker/Lochman Transparencies

Right Denuded coral skeletons.
Photo – Shannon Armstrong/DEC

to organise and run. A new, more cost-effective method was needed to continue monitoring this voracious coral predator while maintaining the integrity of the historical data.

In 2005, Honours student Shannon Armstrong developed a new cost-effective drupella monitoring protocol and resurveyed the original 13 drupella monitoring sites in Ningaloo Marine Park. This provided an update on the status of drupella abundance and the health of coral communities in the park.

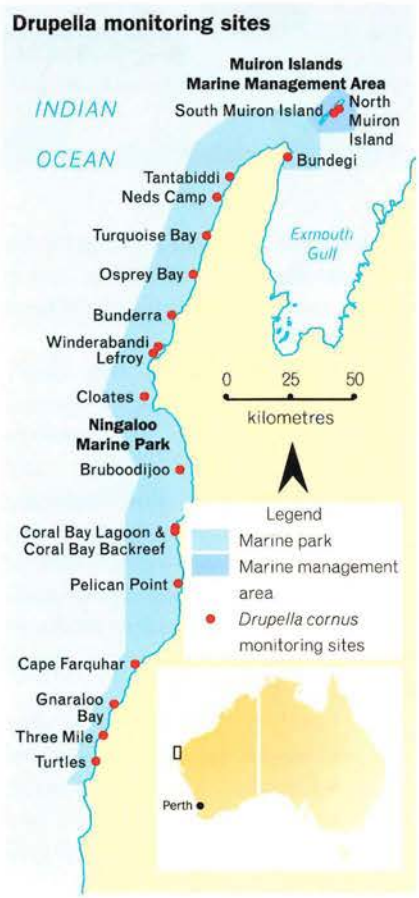
After joining DEC's newly formed Marine Science Program in 2006, Shannon established another six 'new' drupella monitoring sites to cover the area resulting from the 2004 southern extension to the Ningaloo Marine Park and gazettal of the Muiron Islands Marine Management Area. Shannon's 2005 and 2006 surveys found drupella numbers continued to remain in check since the population explosion of the late 1980s and early 1990s.

While the positive results of the 2005 and 2006 surveys are good news, there is no room for complacency. A strategy in the revised Ningaloo Marine Park Management Plan 2005–2015 states that drupella abundance and the health of the coral communities will be surveyed at least every three years. The next major survey is planned for 2008.

What caused the outbreak?

The most puzzling facet of the Ningaloo drupella outbreak was its cause. Outbreaks in other areas across the world, like Japan and the Philippines, have been attributed to reef siltation due to heavy rainfall, dredging or coastal development. Consequent increases in nutrients in the water may have stimulated phytoplankton growth, providing drupella larvae with increased food supply. This in turn may have increased the survival chances of drupella larvae and thus resulted in larger numbers of drupella recruits. Within two to four years the drupella recruits could have grown to reproductive size and the effect of their predation would emerge.

But with its low rainfall and lack of development, it is doubtful such factors



Above left Ningaloo Reef.
Photo – David Bettini

Above Monitoring reef health.
Photo – Suzanne Long/DEC

Left Measuring drupella.
Photo – Shannon Armstrong/DEC

prompted the outbreak at Ningaloo. So what was the cause? While no-one is entirely sure, several theories have been put forward.

One theory points the finger at overfishing of drupella's natural predators—thought to include emperors, baldchin groper and octopuses. However, this reasoning has not been proven. Another lays the blame on damage from divers or boats, with the suggestion that drupella is attracted to the mucous produced by broken corals. Again, no strong evidence backs this theory.

Yet another explanation is that such outbreaks are part of natural cycles, when the right mix of water temperature, settlement surfaces and currents occasionally produce optimal conditions for drupella to thrive.

Managing a future outbreak

While drupella numbers currently remain in check, any future outbreaks would again place the reef in jeopardy. But is there a need to intervene? And, if so, how could numbers be curtailed? There is no clear cut answer. If the outbreak was indeed a natural process, should nature be left to run its course? Studies have already shown that picking the snail by hand is fruitless. It would take sustained and intensive effort to make even the tiniest dent in outbreak populations.

So, for now, managing drupella is a matter of monitoring its population and gathering information in the hope of understanding more about this small coral predator. Armed with more information, DEC may be in a better position to manage any future outbreak, should one occur.

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

Shannon Armstrong is a Research Scientist with the Marine Science Program in DEC's Science Division. She leads the Ningaloo Marine Park drupella long-term monitoring program and can be contacted on (08) 9219 9794 or by email (shannon.armstrong@dec.wa.gov.au). Anyone who thinks they have seen unusually large numbers of drupella in WA should contact Shannon.

The establishment of the Marine Science Program in May 2006 represents a significant increase in DEC's capacity to provide a strong scientific foundation for the management of WA's world-class system of marine parks and reserves and for the conservation of the State's unique marine biodiversity.

bookmarks by Verna Costello

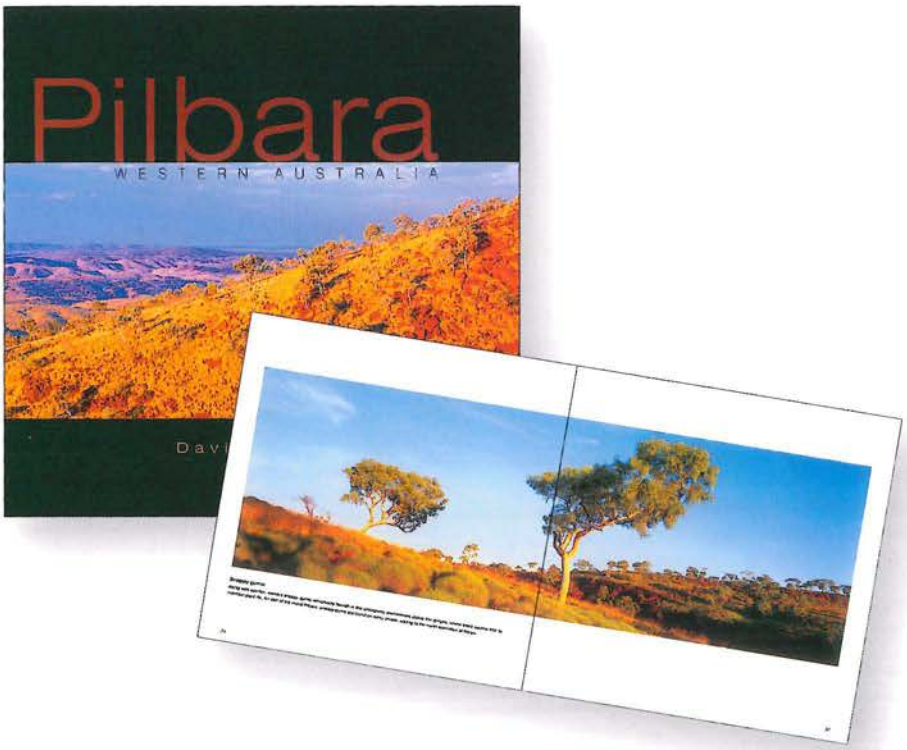
Pilbara Western Australia

Photos: David Bettini
Text: David Bettini and Janet Wainwright
Publisher: David Bettini
160 pages, hard cover, full colour
ISBN: 978-0-9579197-2-3
RRP: $50.00

This author is no mere 'happy snapper'. His stunning photographs of the ancient Pilbara landscape reveal an eye for the artistic while also showcasing his consummate skill with the camera.

David Bettini has not only captured the Pilbara's breathtaking landscapes and the grandeur of its tall mountains, he has also snared its uniquely striking colours.

Pilbara Western Australia is available from all major bookshops in the Perth metropolitan area and tourist bureaus and newsagents in the Pilbara.



Western Weeds – A guide to the weeds of Western Australia

Authors: BMJ Hussey, GJ Keighery, J Dodd, SG Lloyd and RD Cousens
Publisher: The Plant Protection Society of Western Australia (Inc.)
271 pages, soft cover, full colour
ISBN: 978-0-9581111-2-6
RRP: $35.00

More than 10,000 named species of flowering plants grow wild in Western Australia, of which 90 per are native to WA, with the other 10 per cent having been brought into the State.

Western Weeds describes about 1050 weeds, with 625 illustrated in colour to help the reader identify the many agricultural, environmental and garden weeds throughout the State.

This book is a comprehensive reference book for gardeners, environmentalists, farmers, horticulturists and students.

It is available from the Department of Agriculture and Food and all major bookshops.

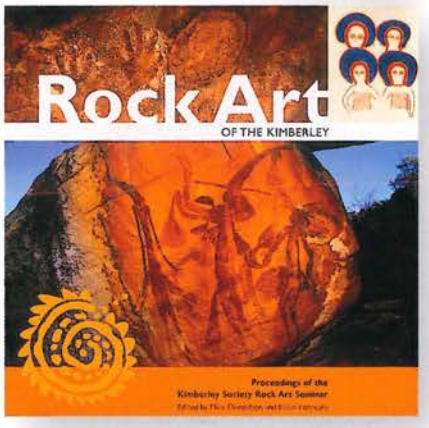
Rock Art of the Kimberley

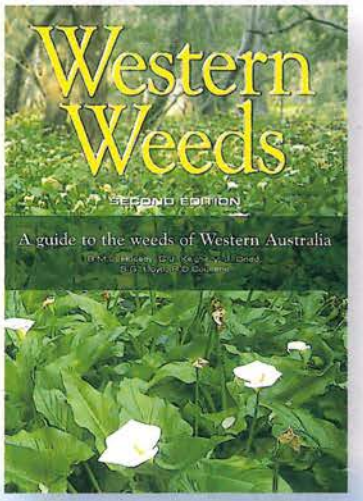
Editors: Mike Donaldson and Kevin Kenneally
Publisher: Kimberley Society
158 pages, soft cover, full colour
ISBN: 978-0-9587130-1-6
RRP: $49.95 ($33.00 for Kimberley Society members)

This book has been compiled from the proceedings of the Kimberley Society Rock Art Seminar held in September 2005 at The University of Western Australia.

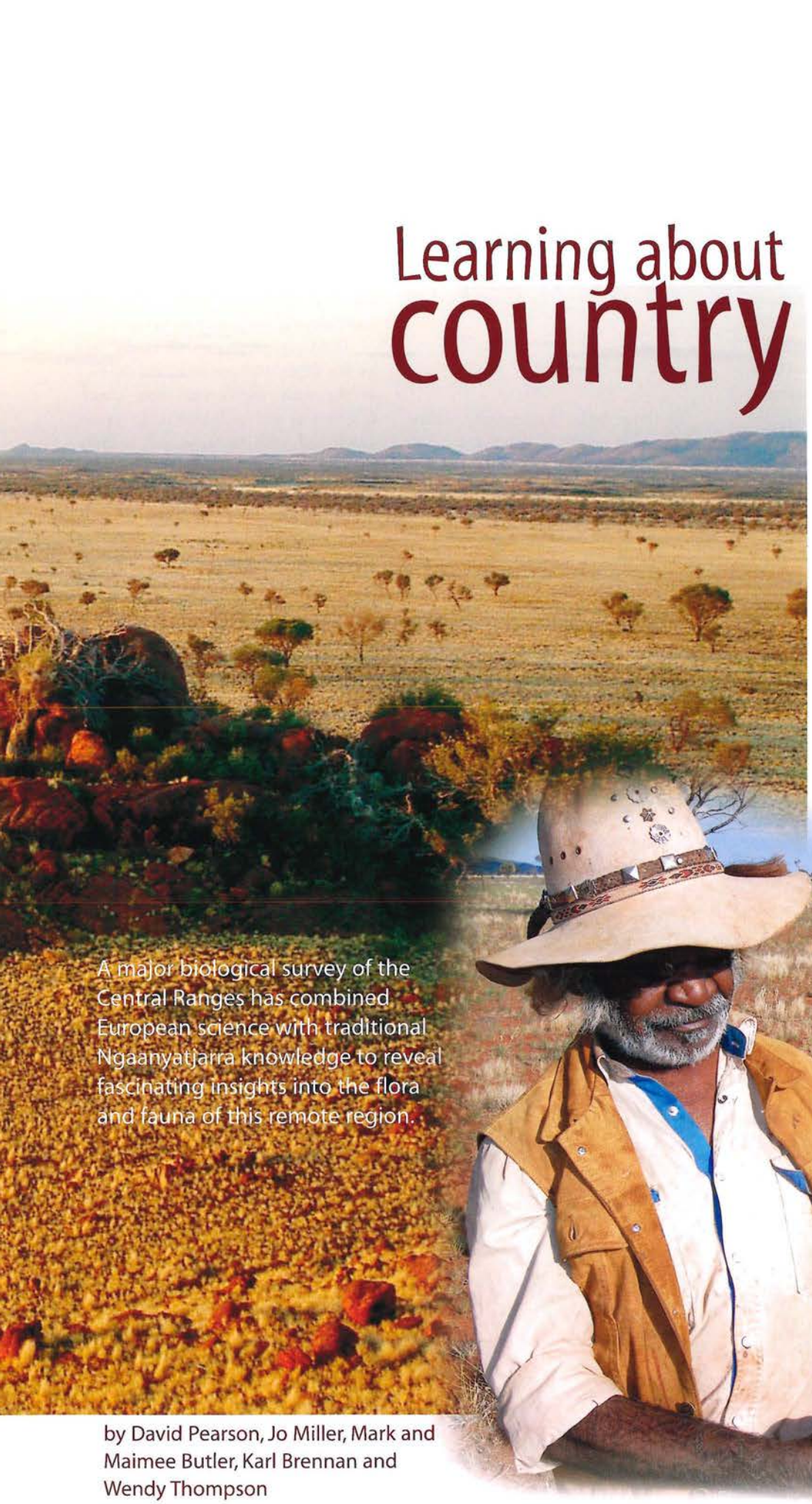
The lavishly illustrated book includes seminar papers and more than 100 photographs displayed at the seminar. Also included are the ancient *Gwion Gwion* or Bradshaw paintings and works of art from the Wanjina Galleries that represent a wealth of stories from the Aboriginal Dreamtime.

Rock Art of the Kimberley is available from major bookshops, the Department of Environment and Conservation and from the Kimberley Society.





Learning about country



A major biological survey of the Central Ranges has combined European science with traditional Ngaanyatjarra knowledge to reveal fascinating insights into the flora and fauna of this remote region.

by David Pearson, Jo Miller, Mark and Maimee Butler, Karl Brennan and Wendy Thompson

If you sweep your eyes across a map of Western Australia starting at Exmouth and heading east, you traverse a vast area of desert, firstly the Little Sandy and then the Gibson. Near the Northern Territory border a jumble of ranges appears, prefaced with very English names like Warburton, Jamieson, Rawlinson and Walter James. These ranges were named by early explorers such as Ernest Giles as they staggered westward, ever searching for water.

Still today many people see Australia's western deserts as a great remote wilderness, a place to discover and explore.

However, if you spend any time here with the Ngaanyatjarra people who have lived here across the millennia, there is no mistaking that you are in a place that is extremely well known. The 250,000 square kilometres of Ngaanyatjarra land is a rich social and cultural domain, filled with signs of birth, life, death, stories, people and spirit beings. Traditional culture and law is followed in a practice that has been unbroken by European influence. English is spoken, but for many people it is a second or third language.

To live here successfully takes considerable skill, knowledge and understanding. The Aboriginal people who live on Ngaanyatjarra land have an intimate relationship with their country, its features, flora, fauna and seasons, and a strong cultural tradition centred on ecological skills used to manage and renew the land and its resources.

Change

In the 150 years since Europeans first infiltrated the Central Ranges, little has changed visually—there are now a few roads and small Aboriginal communities but no mining or pastoral operations. However, exotic plants and animals brought to Australia by Europeans have spread right across the landscape. Weeds arrived on camels, domestic stock and during the construction of roads and towns. For instance, buffel grass (*Cenchrus ciliaris*) originally introduced as fodder for stock is now a major environmental weed, choking creek-side native grasslands and carrying frequent hot fires.

Feral cats were present in the area by the 1890s. Rabbits swarmed through in the early 1900s and were closely followed by the fox. These three species, combined with drought and wildfire, had tremendous impacts on the mammal fauna of the region, resulting in the extinction of many species.

The impact of these past pressures and possible future land-use changes in the Central Ranges has made it important to understand more about the flora and fauna of the region. Such an understanding would enable existing disturbances and any further developments to be managed to reduce their environmental impacts.

Project genesis

The idea of conducting a wildlife survey incorporating European science and traditional Ngaanyatjarra knowledge had been proposed in the late 1980s. In 2005, the Commonwealth Department of the Environment and Water Resources provided funds for the Western Australian Museum and South Australian Museum to jointly conduct a survey to 'fill in the gaps' in museum collections and improve knowledge about the flora and fauna of the Central Ranges. Western Australia's Department of Environment and Conservation (DEC) staff were to provide scientific expertise and liaison with Ngaanyatjarra people.

DEC and the Ngaanyatjarra people already had a history of collaborative work on the management of the Gibson

Previous page
Main View across open mulga woodland from Amy Giles Rocks in the Central Ranges.
Photo – Helen Vonow
Inset Winston Mitchell with a pygmy mulga monitor or pinakunytjinytji (*Varanus gilleni*).
Photo – David Pearson

Left Ngaanyatjarra ladies returning to camp.
Photo – Wendy Thompson

Top Collecting insects at Bell Rock Range.
Photo – Wendy Thompson

Above from left Wolf spider (*Hoggicosa* sp.), butterfly bush (*Petalostylis cassiodes*) and a western blue-tongue lizard or nyarlamira (*Tiliqua occipitalis*).
Photos from left – Karl Brennan, Vanessa Clarke and Karl Brennan

Desert Nature Reserve and efforts to save rock-wallabies (see 'Last Bastion', *LANDSCOPE,* Autumn 2004). This relationship and history of cooperation were major factors in the Ngaanyatjarra people's support for the project.

Building a project

The Central Ranges region was claimed under native title and handed back to its Aboriginal custodians in June 2005. While they now have legal ownership, Ngaanyatjarra people never felt as if their responsibilities and associations to the country had been severed. The region is also part of the Ngaanyatjarra Indigenous Protected Area, proclaimed in August 2002, which included one of only two of Australia's 80 biogeographic areas without land managed for conservation.

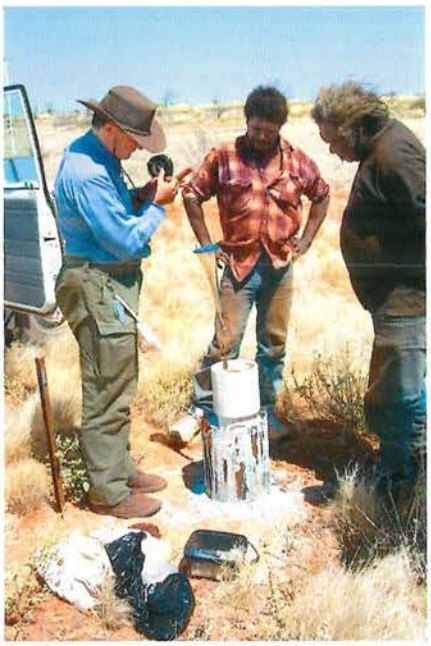
Ngaanyatjarra people follow strict codes of conduct on country and take their responsibility for the safety and welfare of visitors or strangers to their country very seriously. While scientists might be eager to wander unrestricted in search of new and rare species, such behaviour could have dire consequences. Places in the landscape contain dangerous spirits, while other areas are sacred sites that should be visited only by initiated men, or by women. Such places are numerous and are certainly not signposted! So when outsiders travel in such areas they should do so with the people who know and speak for those areas.

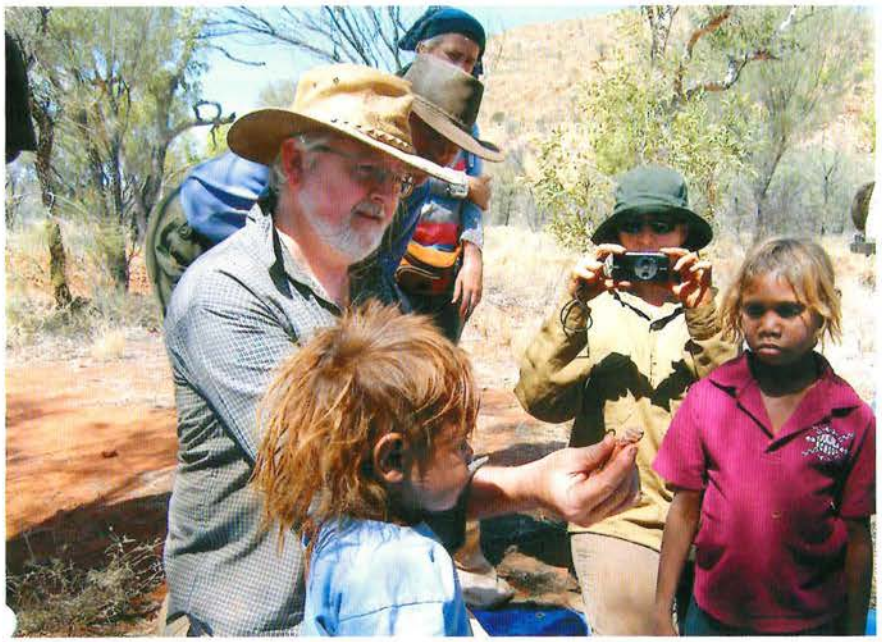
But this posed some questions. How could scientists collect the data they were interested in? How could Ngaanyatjarra people ensure the scientists did not stray into places they shouldn't and how could the survey benefit local people?

The answers came from extensive liaison between the scientists and the Ngaanyatjarra people. The Ngaanyatjarra people expressed a vital interest in preserving the flora and fauna on their country, hunting, collecting plants for food, medicine and artefacts, burning and performing ceremonies for ongoing productivity. Senior people expressed their desire to pass on knowledge about wildlife to their children and to see land management employment opportunities for current and future generations. Such desires paved the way for the survey to proceed.

Desert logistics

The scientists and Ngaanyatjarra people were keen to involve as many people as possible in the survey. This included elders who knew where and





how to catch certain species and who could guide scientists safely through the landscape. Other community members and school-aged children were encouraged to come to learn more about their country from elders and the scientists.

A Memorandum of Understanding spelt out the responsibilities of the scientists and Aboriginal people involved in the survey, the costs, employment opportunities and how data would be stored and reported. The composition of the survey team was selected to ensure a range of expertise, without overwhelming local people with too many scientists. It included arachnologists, entomologists, botanists, herpetologists and mammalogists from DEC, the Western Australian and South Australian museums and the South Australian Department for Environment and Heritage. Sampling was to focus on vascular plants, non-vascular plants (such as lichens), small mammals, reptiles, frogs and invertebrates, especially spiders, pseudo-scorpions, beetles, sucking bugs and stygofauna (invertebrate fauna living in underground water bodies).

Diverse techniques

In October 2006, the scientists from Perth and Adelaide set out in four-wheel drive vehicles with trailers laden with a mass of camping equipment and sampling gear for the first sampling sites near the Walter James Range. Over the next three weeks they used a variety of techniques for sampling. The botanists (Helen Vonow, Vanessa Clarke and Wendy Thompson) set up quadrats to record the plant species occurring in

Top left Botanists Wendy Thompson and Vanessa Clarke explain how they collect plants.

Centre left Karl Brennan collecting insects attracted to a mercury vapour light.
Photos – David Pearson

Centre right 'Fishing' for stygofauna.
Photo – Karl Brennan

Left Mark Hutchinson conducts his daily 'show and tell' for local schoolchildren.
Photo – David Pearson

Right Installing pitfall traps and drift lines.
Photo – Karl Brennan

dunefield, sandplain and rocky outcrops. With the Ngaanyatjarra women, they collected opportunistically while visiting distant gorges and creeklines. The women demonstrated the use of local plants for food or medicine and dug up tubers that could be used to assist their identification. Wendy Thompson from DEC's Goldfields Region was on the lookout for cryptogams (mosses, liverworts and lichens), as they are important elements in ecosystem function and are rarely sampled during biological surveys.

Mammals were captured in Elliott traps (small collapsible metal traps) and pitfall traps (20-litre plastic buckets buried into sand linked by flywire fences which direct the fauna towards the buckets), while reptiles and even some frogs were captured in pitfalls, in funnel traps and by hand. The Ngaanyatjarra women proved to be particularly adept at locating and digging up goannas, while the Ngaanyatjarra men followed tracks of pythons and other fauna seen when driving, catching many species by hand.

In addition to vertebrates, an inventory of arthropods (insects, arachnids and centipedes) was carried out as these animals make an incredible contribution to Australia's biodiversity (there are an estimated 253,000 species of terrestrial arthropods in Australia). Scooping dip nets into rocky gorge pools caught an array of aquatic beetles. At night, torchlight illuminated the numerous eyes of wolf spiders hunting for prey, while hand-held ultraviolet lights located scorpions, betrayed by their fluorescence, which were of particular interest to arachnologist Julianne Warnock from the Western Australian Museum.

Hanging a mercury vapour lamp next to a calico sheet at camp attracted a bewildering array of beetles, cicadas, lacewings, leaf hoppers, mantids, midges, moths, plant hoppers, stink bugs and stoneflies. Each morning a myriad of ants, beetles, centipedes and spiders greeted those inspecting the pitfall traps.

The most intriguing survey technique of all became known as 'fishing for nirri-nirri' (the Ngaanyatjarra word for beetles). It was employed by entomologist Chris Watts to sample stygofauna and aroused great interest (and considerable mirth) among local people as he lowered a fine mesh net down bore holes with a short rod and fishing reel. No survey of stygofauna in Central Ranges aquifers had been conducted previously. These aquifers occur in friable limestones (calcretes) deposited by groundwater flowing through ancient valleys. Such aquifers occur widely across much of arid Australia and contain a significant component of Australia's biodiversity (see 'Beasts of the Underworld' *LANDSCOPE*, Autumn 2006).

The Ngaanyatjarra people's local knowledge of their homeland was critical in locating bores, many of which were long abandoned, not marked on maps and hidden by vegetation. Despite the best efforts by seasoned scientists and Aboriginal elders, the first to catch a nirri-nirri was local boy, Rasjad Butler. A quick check by Chris Watts that evening under the microscope back at camp revealed it to be a species new to science and most likely endemic to the Central Ranges.

Explaining European scientific techniques

Biological surveys are reliant on the collection of specimens so that species identifications can be checked back in the laboratory against descriptions in books and reference collections. Since the Central Ranges region has had so little collecting, it was highly probable that we would collect new species.

The need to take specimens, particularly of vertebrates, to assist with identification and for lodging in museums for future reference, is often difficult for a scientist to explain to the public. The idea that scientists working for a conservation agency like DEC would kill fauna seems an anathema. However, the correct identification of species captured in a biological survey is essential to understand the biodiversity of a region, and in turn leads to the discovery of new species.

Genetic techniques using small samples of tissue have led to the identification of new species that looked similar to others (so-called 'cryptic species'). Specimens sent to museums are valuable to understand many other aspects of an animal's biology, including its diet (by looking at

the stomach contents), its reproduction (by examining ovaries and testes), its anatomy and even the sorts of parasites that colonise it. Identification books on most species are written using museum specimens so they have immense value to European science.

Explaining the need to take specimens to Aboriginal people was sometimes difficult, particularly when the species concerned might be a fat goanna ideal for eating! Ngaanyatjarra people often have different views to scientists about what constitutes a species and the link between themselves, the living animal, and the 'tjukurrpa', or creation period. Added to that, is the incredible notion that the animal will be stored in an alcohol-filled bottle in the basement of a distant building for perhaps many hundreds of years!

So many ranges, so little time

The first segment of the survey concentrated on quartzite ranges close to the Northern Territory–WA border, especially the Rawlinson and Walter James ranges. People from the nearby communities of Warakurna and Tjukurla camped with the scientists and made daily forays to check traplines.

Each morning, herpetologist and Curator of Reptiles at the South Australian Museum, Mark Hutchinson would conduct a 'show and tell' to display the animals captured overnight. Groups of schoolchildren travelled from the communities to see the animals being caught as well as listen to elders talk about Ngaanyatjarra knowledge of these species. In addition, the school group from Tjukurla worked with the elders and the scientists to clear vegetation that had grown up and almost obscured a thorny devil (nyigari) 'tjukurrpa site'.

The second part of the survey focused on rugged ranges of black dolerite that occur further south alongside the South Australian–WA border and close to the communities of Wingellina and Blackstone. The team camped alongside the Morgan Range in a mulga patch with close access to the dolerite, a sand-dune and isolated granite outcrops.

Amazing new finds

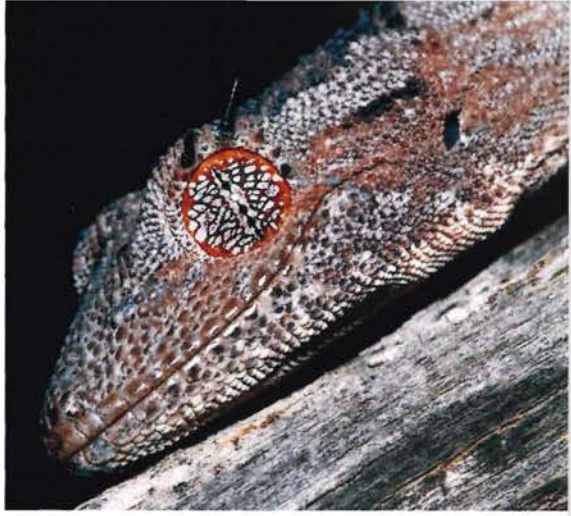
The survey greatly improved our knowledge of the distribution of many plants and animals. About 720 plant specimens were collected with 37 species found to be new records for the region or range extensions, some more than 400 kilometres from their previously known habitats. One species new to WA was discovered and it is likely that, over time when specialists examine the material, new species will be recognised and described.

The most exciting find for the vertebrate zoologists proved to be a new species of snake, although it was not noticed until some weeks after the expedition. When first collected by Mark Hutchinson, the thin active brown snake was thought to be a western brown snake (*Pseudonaja nuchalis*). However, while inspecting the specimen, Brad Maryan of the Western Australian Museum noticed something unusual. He checked the scales of the head and scale counts on the body and alerted the other herpetologists.

Genetic work by Steve Donnellan from the South Australian Museum confirmed that it was a new species of taipan, since named *Oxyuranus*

Above left Mintbush (*Prostanthera centralis*).
Photo – Vanessa Clarke

Left Perentie or ngirntaka (*Varanus giganteus*) in the Blackstone Range.
Photo – David Pearson



Right Newly discovered taipan (*Oxyuranus temporalis*).
Photo – David Pearson

Far right Northern spiny tailed gecko or pirurrpa (*Strophurus ciliaris*).
Photo – Paul Doughty

Below right Base camp in the Walter James Range.
Photo – Karl Brennan

temporalis. Its nearest relative, the fierce snake or inland taipan (*O. microlepidotus*) occurs many hundreds of kilometres away in western New South Wales, South Australia and Queensland. Perhaps this new species of taipan was isolated from its relatives by increasing aridity in central Australia.

Fishing expeditions in bore holes led to the discovery of a new species of aquatic beetle and many other interesting stygofauna including copepods (prawn-like crustaceans). More than 100 species of spiders were collected with most species unnamed and awaiting description by museum taxonomists. Of those spiders recognisable as described species, some have been collected only rarely. For instance the prodidomid spider (*Cryptoerithus nyetaut*) was known from only three specimens and was unknown from WA. Despite these initial exciting finds, it will be some years before the full significance of the entire catch of arthropods is understood. However, it is already obvious that there are many new species and some of these may be endemic to the Central Ranges.

In addition, several geckoes known from surrounding regions were found to have distributions that extended into the Central Ranges. A range of mammals was captured; of particular interest to Ngaanyatjarra people was the fat-tailed antechinus (*Pseudantechinus macdonnellensis*). This solidly built marsupial (up to 35 grams) lives in rocky areas and most people had not seen this species before and were intrigued by its amazing foot pads for travel on rocky surfaces.

Outcomes

The survey created an opportunity for both Ngaanyatjarra people and the survey team to experience a different perspective and approach to being on country. It was fascinating to see two groups of people, both skilled and highly knowledgeable in their own fields, operate side by side in vastly different ways. Despite the differences, trust and relationships grew through mutual respect and goodwill towards resolving logistical issues.

The survey collected the first systematic biological data for the region and will assist the Ngaanyatjarra Council and DEC in their land management operations. Both DEC and the Western Australian Museum derived valuable information on the distribution and abundance of many species including several rare and threatened species. The discovery of a new species of snake was obviously an exciting aspect of the survey.

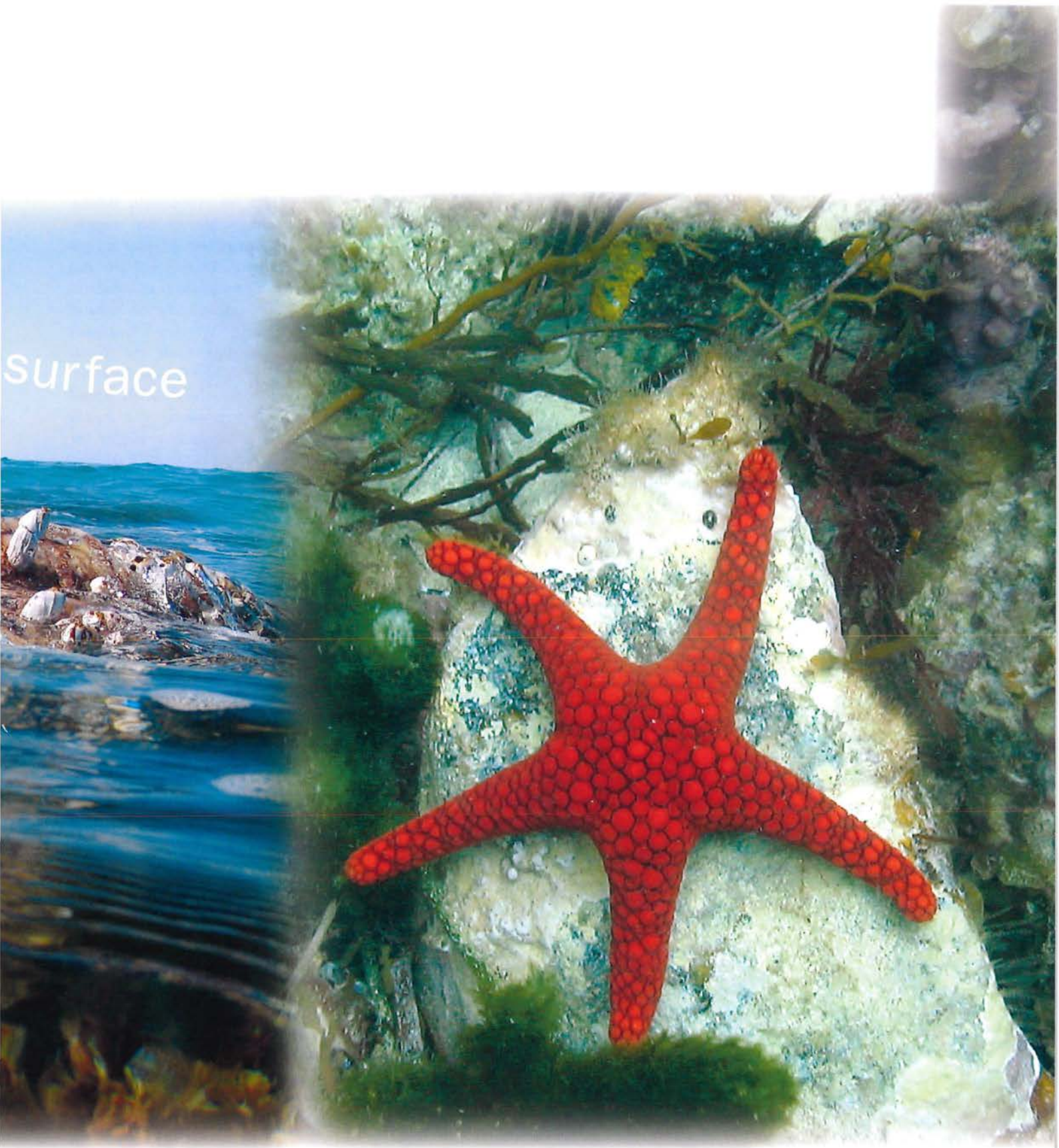
For the traditional owners, the project created relevant employment as liaison officers, collaborators and guides to the survey team; opportunities for kids and younger people to participate and learn from both their own elders and the scientists; and an opportunity to visit country in a well-resourced way with safe, reliable vehicles that is often not otherwise possible.

Such was its success that the research team hopes for future opportunities to jointly survey other areas in this biologically and culturally rich region.

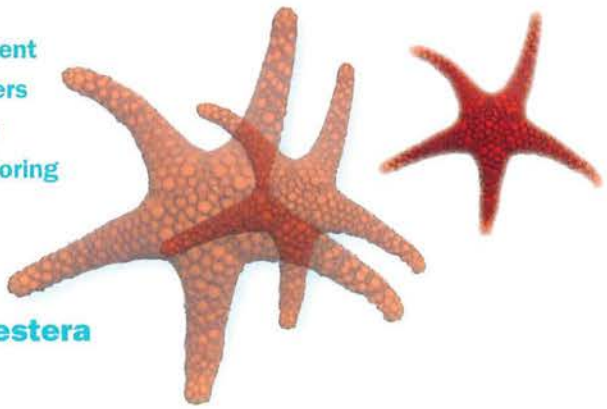
David Pearson is a Principal Research Scientist with DEC and has research interests in threatened reptiles and biological surveys. Jo Miller works for the Ngaanyatjarra Land Management Unit based in Warburton. Mark and Maimee Butler are Ngaanyatjarra Elders who have lived in the Central Ranges region all their lives. Karl Brennan is the DEC Regional Ecologist for the Goldfields. His research interests are biological surveys, particularly those involving terrestrial invertebrates. Wendy Thompson is a Flora Conservation Officer based at DEC's Goldfields Region office in Kalgoorlie.

The authors wish to acknowledge the many Ngaanyatjarra people who assisted during the survey as well as the vital input of staff from the South Australian Museum and Western Australian Museum. Jan Turner, Di Newham and Alex Knight provided valuable advice. Thanks to colleagues in the team who made the survey such an interesting experience.

For more information please contact David Pearson on (08) 9405 5100 or by email (david.pearson@dec.wa.gov.au).



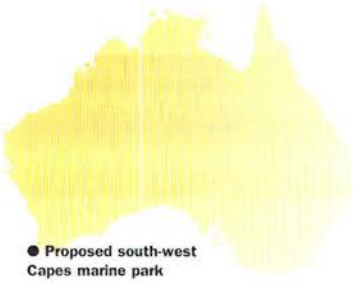
A major benchmark study of the marine environment in the south-west 'Capes' region will give managers of a proposed marine park, encompassing waters from Busselton to Augusta, a head start in monitoring and managing this special and much-loved area.



by Carolyn Thomson-Dans and Mark Westera

The proposed 'Capes' marine park features several seascapes, each with its own special character. It is home to the wide, north-facing Geographe Bay, the exposed waters between Cape Naturaliste and Cape Leeuwin, the south-facing, crescent-shaped Flinders Bay and the wide lower basin of the Blackwood Estuary at Hardy Inlet. Every year, hundreds of thousands of locals and visitors enjoy or make use of the Capes' stunning marine environment.

The sheltered waters of Geographe Bay are popular with fishers, swimmers, snorkellers, scuba divers, windsurfers, sailors and water skiers. Busselton Jetty is the longest wooden jetty in the southern hemisphere, stretching almost two kilometres into Geographe Bay. Built over a 95-year period from 1865, it is used by fishers and divers alike. An underwater observatory at Busselton Jetty enables non-diving sightseers to view the spectacular marine life beneath the jetty. The reefs of the Capes coast provide spectacular snorkelling and diving opportunities. The HMAS *Swan* wreck provides an excellent dive site in Geographe Bay for those suitably qualified.



● Proposed south-west Capes marine park

The large swells and excellent surf breaks along the Leeuwin–Naturaliste coast, such as those at Yallingup and Margaret River, provide some of the world's best surfing and excellent venues for national and international surf competitions.

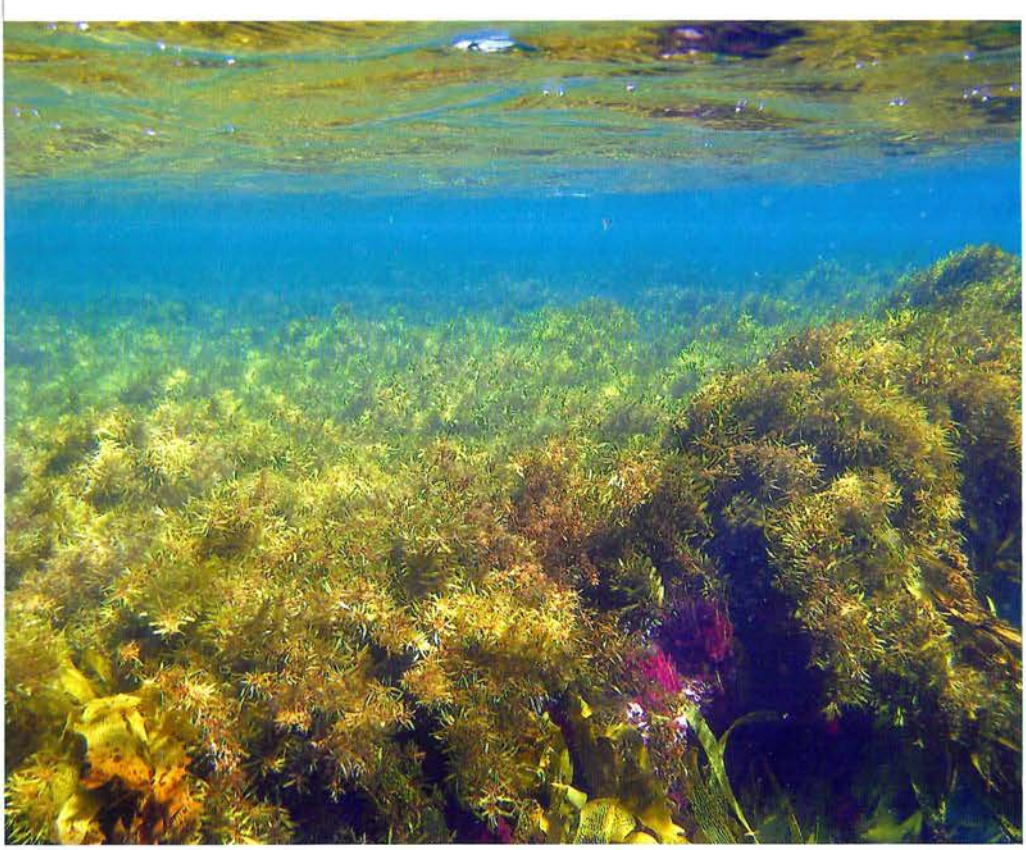
The beaches, rocky headlands and offshore waters provide a range of opportunities for recreational fishing. Dhufish, salmon, blue groper, snapper, tailor and skippy are popular targets for recreational fishers. Fishers also target western rock lobster and abalone. During autumn, schools of salmon migrate along Western Australia's southern coastline from the Great Australian Bight towards Cape Leeuwin. During this run, salmon often school inshore, moving along the beach and making them prime targets for recreational fishers. Hardy Inlet is also a favourite spot for recreational fishing.

Pressure on this unique area is set to increase dramatically, with a predicted doubling in the numbers of tourists and a 60 per cent increase in residential population by 2030.

Marine wildlife

The proposed Capes marine park's special character is derived from the fact that it lies at the southern end of the overlap between northern tropical species and the temperate plants and animals of the south.

At least 247 fish species have been recorded in the Bunbury–Geographe Bay area. The coastline between Busselton and Dunsborough provides important spawning and nursery habitat for at least 13 recreationally and commercially important fish, including Western Australian salmon (*Arripis trutta*), herring (*Arripis georgianus*) and King George whiting (*Sillaginodes punctatus*). The Hardy Inlet is used by both marine and estuarine fish, and is a nursery area for some species. The leafy seadragon (*Phycodurus eques*)—a protected species—lives in shallow reef and seagrass areas of southern WA, including Geographe Bay.



Previous page
Main Barnacle-covered reef.
Insets Sea star.

Above Western Australian nudibranch.

Left Seagrasses.
Photos – Mark Westera

Right A sea squirt.
Photo – Mark Westera

Areas with caves and overhangs support brightly coloured sea squirts, sponges, bryozoans or lace animals, and soft corals. Sea stars, sea urchins, crustaceans and shellfish are also found in this habitat. Many large fish, such as dhufish, western blue groper and harlequin fish, are associated with limestone and granite reef habitats.

The largest shoreline reef platforms are at Yallingup, Cowaramup, Gnarabup, and around Hamelin Island and the islands off Cosy Corner. They are home to a diverse range of invertebrates—such as turban shells, dogwhelks, abalone, sea urchins, anemones, sea stars, sponges, molluscs and crustaceans—and predators such as shorebirds and fish.

In winter and spring, watching humpback and southern right whales is very popular, particularly from Cape Leeuwin, Cape Naturaliste, Gracetown, Cowaramup and the Sugarloaf car park. Whale-watching charters operate from Flinders Bay and Geographe Bay. The peak southern migration of humpback whales in the area occurs during mid-October, and the peak northern migration occurs at the end of June. Blue whales—the largest living animals on Earth—frequent Geographe Bay and Flinders Bay, particularly during November. Geographe Bay is believed to be an important feeding area.

New Zealand fur seals only reappeared near Augusta during the past 20 years or so, after having been decimated by sealers last century. Numbers of fur seals—which haul out on Flinders, St Alouarn and Seal islands—are increasing, and breeding has been recorded on St Alouarn. A new colony recently began to inhabit a rocky island near Cape Naturaliste during the winter months.

The biodiversity and beauty of the proposed Capes marine park is clearly worthy of protection and dedicated management. But if the area is to be well managed, scientists first need to determine exactly which marine plants and animals live in the proposed park now, what their natural levels of abundance and diversity were before human-induced changes over the past few decades, and what levels of change are occurring as a result of human impact such as nutrient-rich run-off from terrestrial development. This is where a major University of Western Australia (UWA) benchmark study, led by marine scientist Mark Westera, comes in. This research project is an initiative of the South West Catchments Council, funded by the Natural Heritage Trust, a joint program of the Australian and Western Australian governments.

Oral history

One important component of the study has been to conduct an oral history of the Capes region to document perceptions of how the marine environment might have changed in the past few decades. Interviews with many locals have unearthed a fascinating array of people and stories about fishing, crabbing, diving, boating, whale watching, water quality and other facets of the Capes marine and coastal environment.

The interviews indicated there had been substantial changes in the abundance and distribution of heavily targeted fish species. One fisherman has memories in relation to Flinders Bay in the 1940s:

> "I can remember in the old days people came in with their catch and they'd string them all up and they'd all stand in front of their catch and have their photos taken—huge catches of lots of dhufish, snapper and groper".

Several interviewees described an increase in sightings of whales in recent years, suggesting they are present in increasing numbers along the coast. Interviewees identified humpback, sperm, blue and killer whales as present in the region, with a 15-to-18-metre blue whale being reported in Flinders Bay.

Interviewees also described relevant changes to marine and estuarine environments in the region, including some specific observations of the impacts of land-source pollution and dams, and the declining health of a reef. Pollution from increasing tourism in the region was observed, but not linked with specific impacts, while changes in prevalence of some species were explained with reference to changes in ocean currents. On the positive side, most people believed there was now increased appreciation among fishers of all types and ages of the need for sustainable fishing practices, though views on the best way to manage fish resources differed. The oral history will be published in the near future and should make for fascinating reading.

Sanctuary zones

Marine parks in WA differ from our national parks in that people can still fish for native species (according to Fisheries Department regulations) in the majority of waters within most marine parks. Some areas, however, are set aside as sanctuary zones—look but don't take areas managed solely for nature conservation and low-impact recreation and tourism. Although these are generally relatively small in area, they sometimes result in criticism from some recreational fishers and from some conservation groups who say they aren't big enough. The indicative management plan for the proposed Capes marine park has proposed establishing 16 sanctuary zones which cover about 11 per cent of the park.

Top left Lush areas of kelp and other seaweeds in Hamelin Bay.

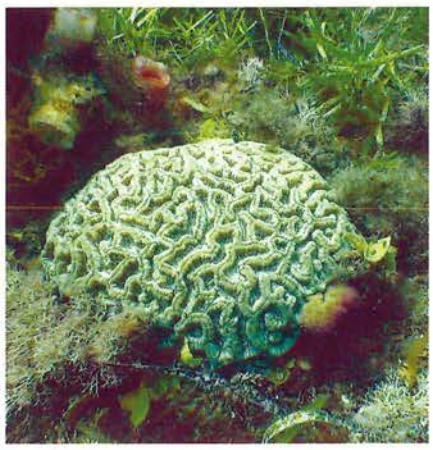
Centre left Marine scientists sample sponges.

Left A researcher records marine life with an underwater video.
Photos – Mark Westera and Euan Harvey

Right Eagle ray at Hamelin Bay.
Photo – Ann Storrie

Below right A cuttlefish hidden in the kelp.

Below far right Corals grow in the proposed south-west Capes marine park but do not form reefs.
Photos – Mark Westera



Mark Westera, Euan Harvey and Gary Kendrick are undertaking research that provides a benchmark of what is there now, which, over time, should be able to detect changes that occur as a result of sanctuary zones being established in the proposed marine park. He has established 22 study sites from Geographe Bay to Flinders Bay. These have been paired so that the sites inside the proposed sanctuary zones have been matched to comparable sites outside sanctuary zones.

Fish are being investigated using baited remote underwater video, a technique developed by researchers at UWA. Video cameras baited with pilchards are lowered to the seafloor to record the size and numbers of fish during set time intervals. Fish communities can be compared by repeating these video drops at different locations and different times. The researchers also take hand-held videos of fish and other marine animals as they swim along set transect lines.

By the time the park is declared, the study will have collected two years of data on the size and abundance of various fish, seaweed and invertebrate species in the Capes region including proposed sanctuary zones. The three-year study will hopefully be funded to continue into the future, enabling assessment of the potential impacts on the marine environment and the effects of sanctuary zones on biodiversity of marine animals and plants of the Capes region. The benchmark provided will include information on seaweeds, invertebrates and numbers and sizes of fish species which are commonly targeted by fishers—such as dhufish, western blue groper, breaksea cod and queen snapper—before and after the sanctuary zones are established.

Sanctuary zones will also allow researchers to compare populations of fish, seaweeds and invertebrates in these relatively undisturbed areas with those in areas that are potentially impacted by people.

Other marine life

Marine scientist Peter Barnes, an expert on invertebrates, particularly sponges, has so far documented 80 species of sponges, sea stars, urchins and other invertebrates in the proposed park. Of these, half are sponges and some are thought to be completely new to science.

The influence of the Leeuwin Current is very evident, particularly in Geographe Bay, where small patches of cabbage corals (*Turbinaria reniformis* and *T. mesenterina*) are quite common, despite being so far south.

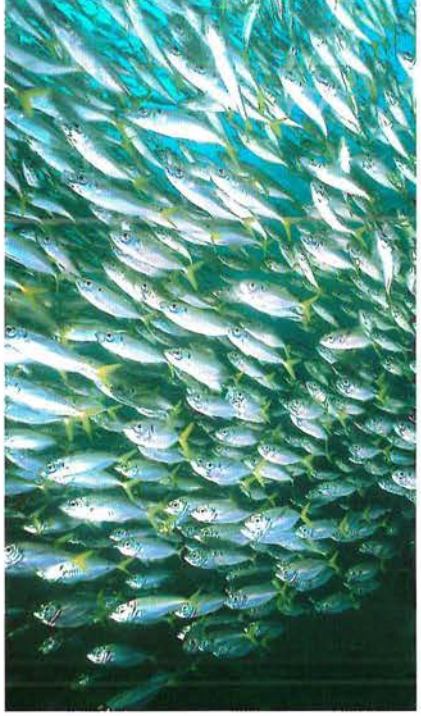
Even the fish species have provided a few surprises, with a tropical fish species, gold-spotted sweetlip, being found to be quite common as far south as Injidup. The subtropical peacock wrasse and baldchin groper are also surprisingly evident in the proposed marine park.

At least 251 species of seaweeds have so far been identified by seaweed experts Julia Phillips and Gary Kendrick during the study. Thirteen of these species are believed to be 'range extensions' from further north and 14 species have only previously been found in more southerly locations.

Climate change may eventually lead to tropical species becoming even more evident further south, so the benchmark data that this study will provide is likely to become important in monitoring such changes.

Drain on seagrasses

A serious potential threat to marine life in Geographe Bay, in the northern part of the proposed marine park, are the nutrients from fertilisers and livestock droppings carried by run-off into waterways, such as rivers and



Above left Keen-eyed divers can sometimes spot leafy seadragons in Leeuwin-Naturaliste waters.

Above Yellowtail scad.
Photos – Ann Storrie

Below Seagrass meadow.
Photo – Mark Westera

drains, which empty into Geographe Bay and via groundwater into the surrounding marine environment.

In overabundance, nutrients such as nitrates and phosphates are detrimental to most plants and animals. Seaweeds respond rapidly to increased nutrient levels whereas seagrasses prefer low nutrient levels. Elevated nutrient levels increase the growth of small seaweed species that attach themselves to the stems and leaves of seagrasses, causing shading which inhibits photosynthesis. If this shading is prolonged it can eventually kill the seagrass.

Geographe Bay is dominated by three seagrass species: southern strapweed (*Posidonia australis*), sinuous strapweed (*P. sinuosa*) and southern wireweed (*Amphibolis antarctica*), which is most common in central parts of the bay. Between 1954 and 1976, seagrass cover declined at some locations in Geographe Bay, but is in overall good health.

The seagrass meadows of Geographe Bay form an important habitat for numerous fish and invertebrate species, utilise nutrients from terrestrial run-off and help stabilise sand throughout the bay, thus reducing erosion of the shoreline. A major study of the ecology of the bay's seagrasses has begun to help ensure they remain in good condition.

The study aims to set a benchmark of seagrass health and water quality for Geographe Bay so that any impacts of human population growth on seagrasses can be protected and minimised. Researchers will measure the number of seagrass shoots per area and assess the biomass or weight of seagrass per area of seabed, as well as algal communities growing on seagrass leaves.

Some of the techniques used to collect this information are quite innovative and sophisticated. For instance, artificial seagrass leaves made of strips of plastic are placed in seagrass beds. These are later removed and the attached algae are weighed and measured to assess their effect on live seagrasses. Seagrass tissue is also analysed to measure the levels of nitrogen and phosphorus in leaves. Scientists can even determine if they are terrestrially or naturally derived.

Given that one of the goals of marine park management is to increase understanding of fish diversity and to ensure that there is no loss of fish species over the long term, the research now under way is a gift to the future managers of the Capes marine park. No other marine park in WA has had the benefit of such 'before and after' research—targeted specifically at finding out the information that managers need to know—being done before the establishment of the marine park and so comprehensively. It should help to ensure that this marine environment, which holds such an important place in the hearts of Western Australians, will be well managed into the future.

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Mark Westera is a marine ecologist at The University of Western Australia, School of Plant Biology. He can be contacted by email (markw@cyllene.uwa.edu.au).

Important contributors to the study include participants in the oral survey, DEC, local councils, GeoCatch, Department of Water, Department of Fisheries staff in Busselton, Department of Agriculture and Food staff in Bunbury, the Busselton Underwater Observatory, CSIRO Marine Research, the Cape to Cape Catchment Group, South West Aboriginal Land and Sea Council, WWF, Cape Dive and the Dive Shed.

Discovering our flora's hidden diversity

The survival of Western Australia's spectacular, yet threatened flora, relies on scientific intervention. Research into plant genetics is uncovering some interesting finds and helping scientists conserve for the future.

by Margaret Byrne

The diversity of Western Australia's wildflowers has been recognised internationally as one of the great wonders of the natural world, a biodiversity 'hotspot' renowned for its diverse, yet threatened, flora. The measure of diversity used to come to this conclusion was based on the appearance of the plants (their morphology). But these plants also have a high degree of hidden diversity in their genetic makeup, which is not seen because it doesn't cause any specific change to how the plants appear. This unseen genetic variation is just as diverse and complex as the morphological diversity we can see. Although the genetic diversity of plants cannot be seen by the human eye, it can be made visible with new genetic techniques.

Why genetics is important to conservation

Genetic diversity is fundamental to the functioning of all plants, animals and ecosystems. It is the means by which species evolve and adapt to new environments and is important in adaptation to climate change. Effective conservation management means conserving both the morphological diversity we can see and the genetic diversity underneath it.

Conservation genetic analyses have not only confirmed the high diversity of our plants but have also revealed some interesting surprises that directly influence conservation management. Knowledge of genetic relationships between species, known as phylogeny, means that our conservation management activity is based on the evolutionary history of our flora—a flora that has persisted for very long periods of time in this ancient landscape.

In WA there are many species that are quite restricted and occur in localised areas that may be large distances apart. These plants may show few morphological differences but that does not necessarily mean that they have no genetic differences. For example, most populations of the round leaf honeysuckle (*Lambertia orbifolia*) occur near Augusta but there are also small populations approximately 200 kilometres away near Narrikup, north of Albany. There are no obvious morphological differences between the plants from the two areas but genetic analysis has shown that the isolated populations near Narrikup are quite distinct from the populations near Augusta. This means that they have been separated for long periods of time and have not been isolated by recent events such as agricultural clearing. The long period of separation for these populations means that they have accumulated lots of differences and have changed over time into different genetic forms that are known as evolutionary lineages. This pattern of restricted distribution is quite common for plant species in WA and is a result of the biogeographical history of the region. As such, the Narrikup populations have now been recognised as distinct and have been described as different subspecies. This means that the Narrikup subspecies has a higher conservation status than previously allocated, and has been targeted for conservation activity through translocation to a secure, disease-free site (see 'Critical Action', *LANDSCOPE*, Spring 2006). This translocated population is now flowering and new seedlings have become established thus reducing the chance that the subspecies may go extinct.

Previous page
Masses of wattle and black-eyed Susan on a Perth hillside.
Photo – Bill Belson/Lochman Transparencies

Above left Round-leafed honeysuckle (*Lambertia orbifolia*).
Photo – Andrew Davoll/Lochman Transparencies

Left WA is renowned for its floral diversity.
Photo – Rob Olver

Above Karri (*Eucalyptus diversicolour*) with flowering understorey.
Photo – Len Stewart/Lochman Transparencies

Right Stirling Range National Park located in WA's biodiversity hotspot.
Photo – Rob Olver

Defining a species

The flora in south-west WA contains many species complexes with lots of morphological variation. Narrow leaved mallee (*Eucalyptus angustissima*) is one such species complex where species and subspecies have been defined but there are still some uncertainties about the relationships and whether the species are valid. The complex has a restricted distribution in flat low-lying areas north of Esperance, and contains three species—*E foliosa, E. misella* and *E. angustissima*—with two subspecies in *E. angustissima*. If there are few genetic differences between the species they should not be recognised as separate species and would have a low priority for conservation. A phylogenetic study of the narrow leaved mallee complex showed that the species were all genetically distinct and thus the species are valid. In addition, the two subspecies of *E. angusissima* showed large genetic differences and should therefore be recognised as separate species instead of subspecies. This means that the conservation listing of the rare species in this complex should be retained, although further field survey is required to confirm their geographic distribution and abundance, and hence their conservation status.

Sometimes the large amount of morphological variation in our widespread species means that closely related species are not recognised as clearly different. The rare splendid wattle (*Acacia splendens*) was recently recognised as a distinct species separate from the very widespread manna wattle (*A. microbotrya*), based on a genetic study of the group. Splendid wattle is restricted to a ridge outside Dandaragan on the western edge of the range of the manna wattle. It has been listed as a threatened species that is critically endangered. However, there was some uncertainty about its taxonomic status in relation to the common manna wattle. Genetic analysis showed that splendid wattle is distinct from manna wattle and confirmed that it should be recognised as separate species. The identity and conservation status of rare species may be masked by unresolved variation present in species complexes such as manna wattle, and phylogenetic studies provide assistance in resolving these ambiguities so that the conservation status of species is appropriately recognised.

An ancient flora

The ancient landscape of WA means the flora is a combination of ancient relictual species that have persisted for a long time, along with newly derived species that have recently diverged

from their common ancestors. But morphological similarity between species is not always a reliable way of knowing which species are closely related. In the same way that family trees can show the pattern of relationships through many generations in human families, genetic trees can show whether plant species are closely or distantly related. Several studies using genetic trees have identified species that are quite genetically different from what has been presumed to be their closest relatives based on similarities in appearance. For example, dragnet wattle (*A. verricula*) and Chiddarcooping wattle (*A. lobulata*) were thought to be related since they both have a network pattern in the veins on the 'leaves' (technically known as phyllodes in wattles). But a genetic study has shown that they are very distinct and have probably been separated for more than three million years.

In another example, Oldfield's wattle (*A. oldfieldii*), which was thought to be closely related to jam (*A. acuminata*), is quite distinct and has also probably been isolated from jam for nearly three million years. Chiddarcooping wattle and Oldfield's wattle have very restricted distributions and are most likely ancient relictual species that have persisted in suitable habitat (such as near granite rocks or mild coastal areas) through the dramatic climatic changes that have occurred during the Pleistocene era over the past two million years. In contrast, other restricted species are not ancient. For example, Wundowlin wattle (*A. sciophanes*) is a rare species that shares a similar wispy growth habit with Yilgarn broken wattle (*A. anfractuosa*). These species have few genetic differences and can be considered sister species that have arisen through recent separation. In this case similarity in physical characters does indicate a close relationship between the species.

Top left Coastal heath in the south-west's Ravensthorpe Range.

Centre left Coastal dune with wattle, Shark Bay rose and poverty bush in flower.

Left Carpet of everlastings in the Midwest Region.
Photos – Jiri Lochman

Right Karri dampiera (*Dampiera hederacea*) and holly flame pea (*Chorizema ilicifolia*).
Photo – Jiri Lochman

Right box insets (left) DEC staff at work in the DNA laboratory; (right) liquid handling robot.
Photos – Shelly McAuthur

Below Raspberry jam (*Acacia acuminata*).
Photo – Marie Lochman

Reading DNA

Analysing a plant's genetic diversity involves examination of its DNA. One method of doing this is through a process known as 'Polymerase Chain Reaction' (PCR). This method uses just a small amount of DNA and is therefore useful on small herbarium specimens or on plants that only have a few small leaves. So how does it work?

PCR produces many copies of a piece of DNA. DNA is made of two strands which are held together by bonds. However, these bonds can be broken and the strands multiplied by a series of heating and cooling cycles. A single piece of DNA would not be visible, but after 30 or 40 heating cycles the many copies of the piece of DNA are clearly seen when run on a gel and stained —a process which reveals a plant's DNA and therefore highlights differences between plant species.

Defining flora conservation priorities

In a region like WA there are a large number of species identified as rare and threatened. Unfortunately, conservationists don't have enough resources to do all the things they would like, and some assessment of priority has to be made. Most often priorities are assigned based on the degree of threat the species is under. But some would argue that ancient species have greater priority for conservation than more recently derived species. This is because ancient species carry a greater level of different genetic history than more recent species. Therefore, if we conserve the ancient species we will be conserving more genetic variation than if we conserve recently derived species. Hence genetic studies can identify the relationships between species and this can be taken into account when making decisions about priorities for conservation efforts. For example, the ancient species Chiddarcooping wattle would have a higher priority for conservation than the more recently derived species Wundowlin wattle which has a widespread common relative.

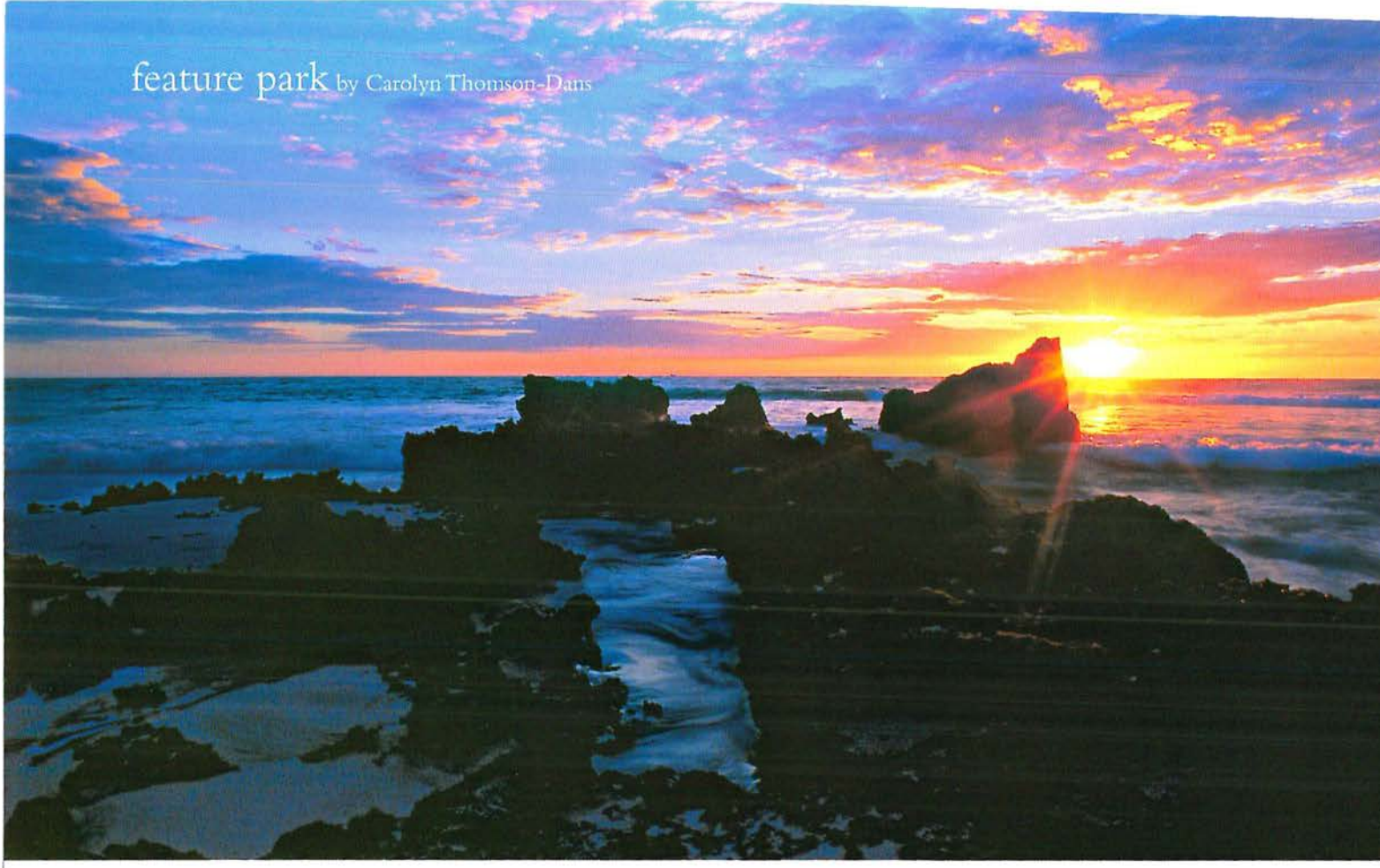
Knowledge of genetic relationships between species also allows appropriate comparisons between rare species and their common relatives, rather than between rare species and other unrelated species that have no common history. This means that scientists are more likely to identify the particular aspects of a species biology that is contributing to its rarity. They can then target conservation action much more precisely and achieve better results.

Technology

In this modern age we rely more and more on technological innovations. These technological innovations are also relevant to conservation biology. The Department of Environment and Conservation (DEC) established a DNA laboratory 11 years ago so the genetic diversity of flora could be determined with modern molecular techniques (see 'More than meets the eye', *LANDSCOPE*, Spring 1997). Through the *Saving our Species* program, the department is continuing to implement such vision (see 'Saving our Species, Saving our State', *LANDSCOPE*, Winter 2007). It recently purchased an advanced liquid handling robotic system to improve the speed and accuracy with which scientists can use DNA techniques to assess phylogenetic relationships in our plants. This robotic system processes 96 samples at a time to extract DNA, determine DNA concentration and set up analysis reactions, all with high accuracy.

This means that the conservation management of our rich and diverse flora will continue to be based on the best scientific knowledge we can get. The flora we have is rich and diverse but faces many threats, and there is much that we still have to learn about the diversity hidden in its genetic makeup so that we can conserve and manage the rich inheritance of a long period of evolutionary history.

Dr Margaret Byrne is a DEC Principal Research Scientist. She specialises in genetics for conservation and uses of native flora. She can be contacted on (08) 9334 0503 or by email (margaret.byrne@dec.wa.gov.au).



Marmion Marine Park

Marmion Marine Park has great natural beauty and is one of Perth's most important areas for aquatic recreation.

Above Trigg Island in Marmion Marine Park.

Opposite page
Top right Gorgonian coral.
Right Diver with a western red scorpioncod.
Photos – Ann Storrie

The clear shallow lagoons, reefs and small islands of Marmion Marine Park provide habitats for seabirds, marine mammals and other remarkably diverse marine life. The reefs are a diver's paradise, forming ledges, caves and swimthroughs. They are inhabited by a wonderful array of fish and invertebrate species. Marmion was the State's first marine park, declared on 13 March 1987.

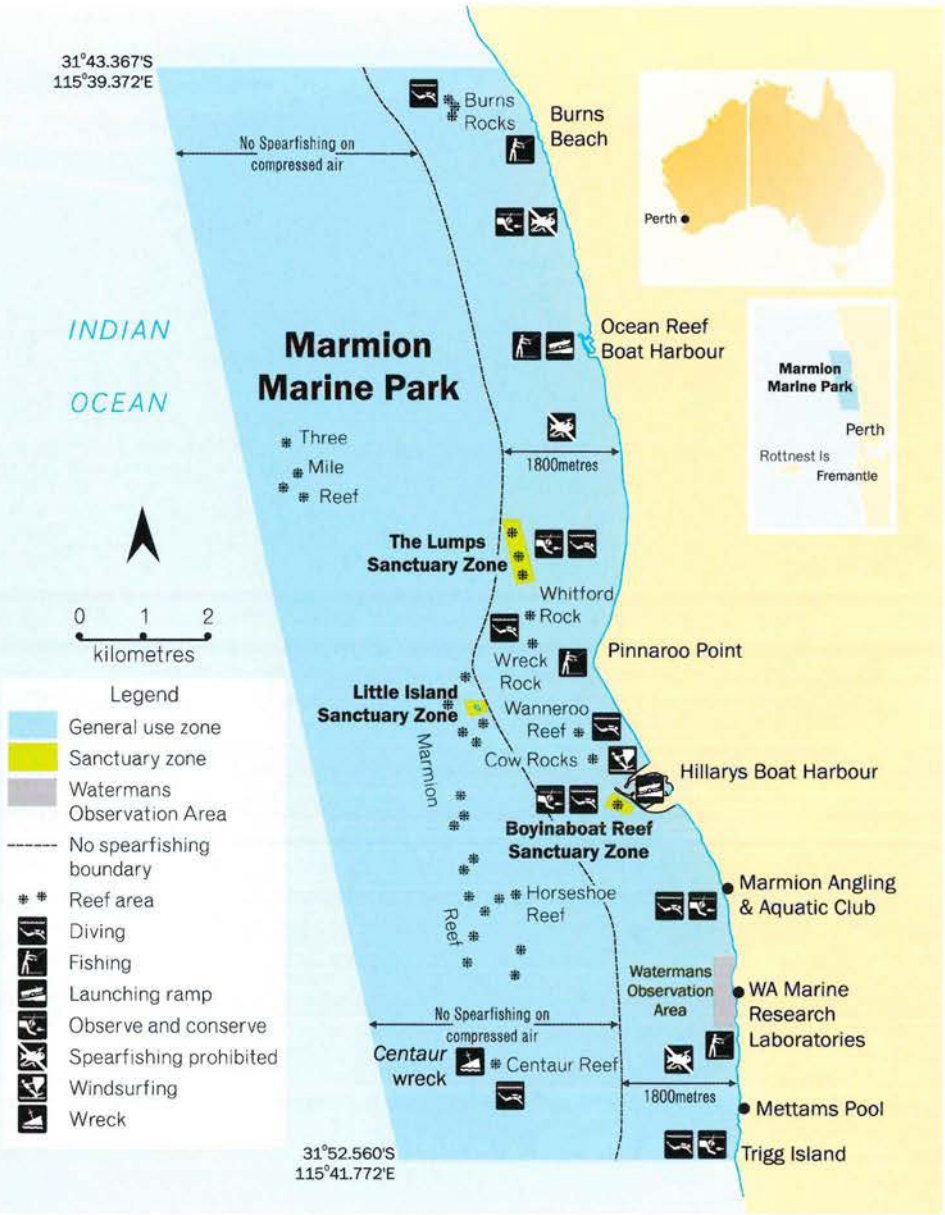
Superb dive sites

One of the park's jewels is undoubtedly Boyinaboat Reef, which lies in a sanctuary (no-take) zone in about six metres of water at the southern end of a chain of inshore reefs. It is just 75 metres from the sea wall of Hillarys Boat Harbour and its accessibility and beauty have made it one of the most popular dive sites in Perth. Caverns in the reef provide homes for many fish, including western blue devils, old wives, banded sweep, crested morwong, horseshoe leatherjackets, dusky morwong, truncate coralfish, bullseyes, wrasse and red-striped cardinalfish. The reef top often comes alive with the frantic feeding of large schools of buffalo bream. Blue and orange nudibranchs are common and add to the colour.

Offshore from Little Island, sponges, gorgonians, hydroids, sea urchins and sea squirts crowd beneath ledges and into caves, and sea lions laze on the island's beach. The seagrass meadows that grow in sandy areas around the island support a huge range of animals such as baler shells.

If you are looking for a safe place close to Perth to introduce your children to snorkelling, look no further than Mettams Pool. This sheltered pool is a good family spot in which you can see a range of marine plant and animal species close to shore. It is less than two metres deep inside this naturally formed lagoon. There is also access for people with disabilities.

You will need a boat and scuba gear to explore North Lump, an entirely submerged reef that offers a rewarding dive within a small area. It has interesting arches, caves and tunnels



park facts

Where is it? Marmion Marine Park lies offshore from Perth's northern suburbs, between Trigg Island and Burns Beach.

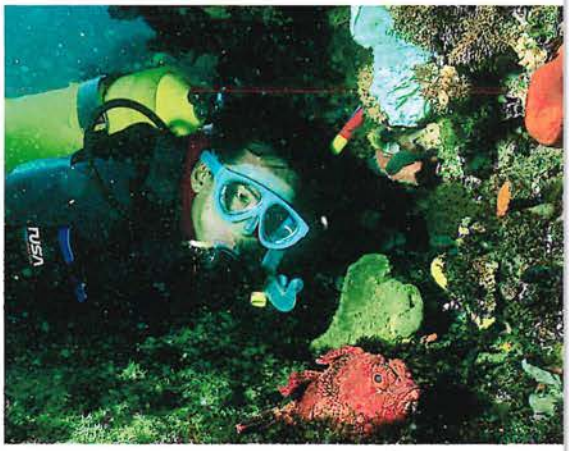
Total area 9500 hectares.

What to do Diving, snorkelling, boating, whale watching (in season), surfing, fishing (outside sanctuary zones), windsurfing and swimming. Spearfishing is prohibited within 1800 metres of the shore and for divers using underwater breathing equipment.

Must see sites Stunning Boyinaboat Reef, in about six metres of water and just 75 metres from the sea wall of Hillarys Boat Harbour.

Naming The suburb of Marmion, after which the park takes its name, was named after early settler Patrick Marmion (1815–1856) of the schooner *Pelsart*, who operated a whaling station in the area in 1849. A plaque was placed in Padbury Circle, Sorrento, to commemorate this in 1970.

Relevant DEC office Swan Coastal District Marine Group, Unit 1A, 8 Calabrese Avenue, Pearsall WA. Phone (08) 9206 4795.



and excellent invertebrate life. North Lump is protected by a sanctuary zone so no fishing is permitted in the area. Wreck Rock, Cow Rocks, Wanneroo Reef and many other submerged reefs within the marine park also entice divers. A historic shipwreck lies in the waters of Marmion, testimony to days when sailing vessels provided an important lifeline. The *Centaur* was wrecked on the southernmost section of Marmion Reef in 1874, while en route to Fremantle.

Diving charters operate for most of the year and diving instruction is available. See the Department of Environment and Conservation's (DEC's) book *Dive and Snorkel Sites in Western Australia* (available from DEC and most dive shops around Perth) for mud maps and more information on these and other suggested dive sites.

Marine mammals and seabirds

Various marine mammal species are common in the park. The bottlenose dolphin can often be seen in all areas and Australian sea lions use Little Island as a resting place. While sea lions may look friendly, they are wild animals and should be viewed from a distance. Swimming with Australian sea lions is prohibited.

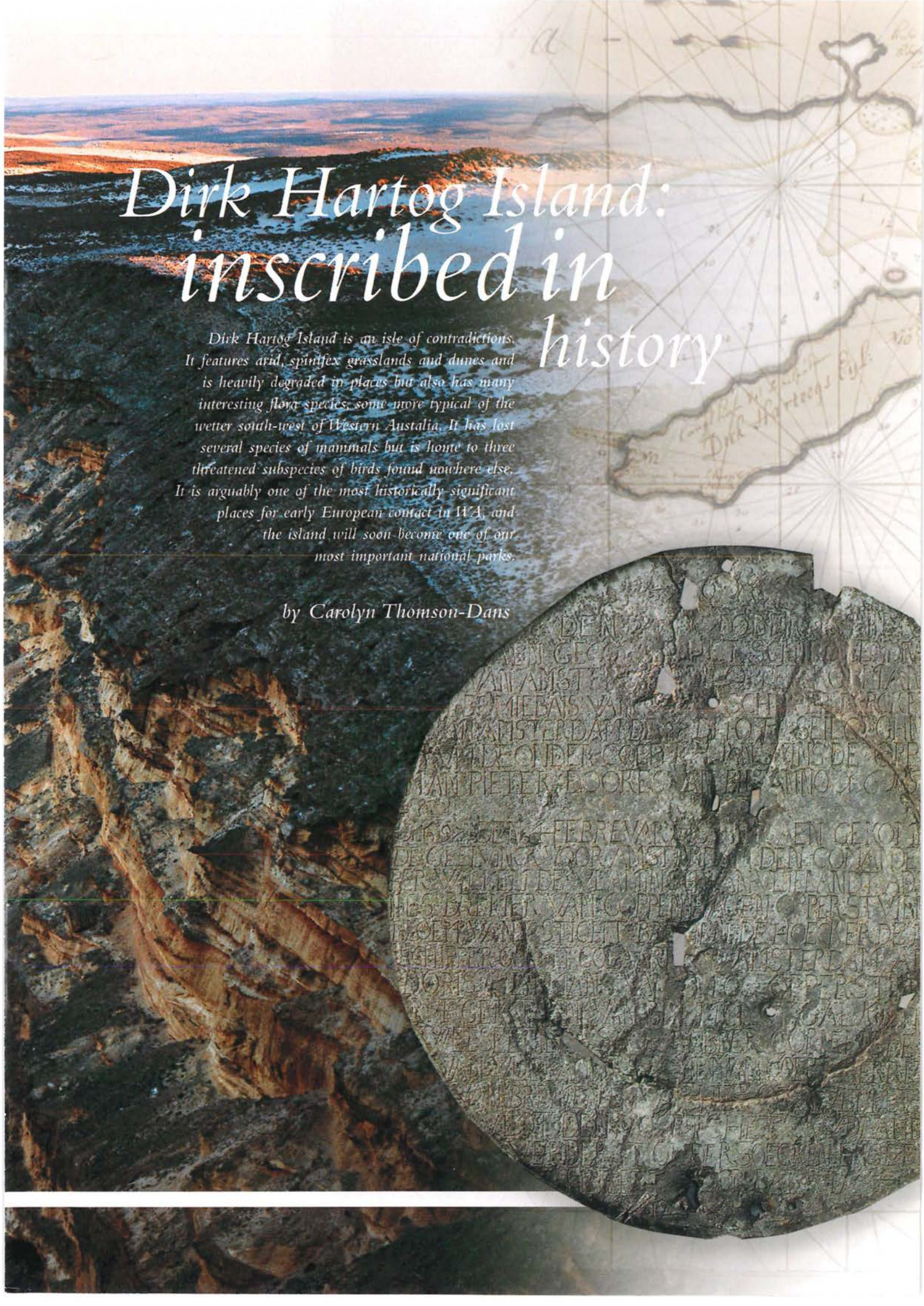
Humpback whales swim past Perth during their migration, from September to November, between breeding areas in the north and feeding areas in Antarctic waters and are frequently seen in Marmion Marine Park waters during these times. In winter and early spring, southern right whales sometimes migrate north to the park and may be accompanied by calves. They will approach the shore and create a sensation for shore-based onlookers. Whale-watching charters leave from Hillarys marina at the peak of the humpback migration.

Seabirds abound through the park, but the best areas to view them are at Little Island, Burns Rocks, the Trigg Island area and Hillarys Boat Harbour. The beaches are also frequented by birds, including crested and Caspian terns and, of course, the ubiquitous silver gull. Little pied cormorants are often seen in the water or perched, holding their wings out to dry.

Dirk Hartog Island: inscribed in history

Dirk Hartog Island is an isle of contradictions. It features arid, spinifex grasslands and dunes and is heavily degraded in places but also has many interesting flora species, some more typical of the wetter south-west of Western Australia. It has lost several species of mammals but is home to three threatened subspecies of birds found nowhere else. It is arguably one of the most historically significant places for early European contact in WA, and the island will soon become one of our most important national parks.

by Carolyn Thomson-Dans



Previous page
Main The spectacular western coast of Dirk Hartog Island.
Photo – David Bettini
Insets from left Silver coin left by Saint Aloüarn; pewter plate erected on Dirk Hartog Island by Vlamingh; part of a map produced as a result of Vlamingh's 1697 expedition.

Left Silver coin in lead seal and a bottle thought to have contained a French claim over Australia.
Photos – Patrick Baker/Western Australian Maritime Museum

Below left Replica posts in the same position as those which held historic pewter plates.
Photo – Carolyn Thomson-Dans/DEC

Dirk Hartog Island, covering 62,000 hectares, is Western Australia's largest island. It is 76 kilometres long and between three and 11 kilometres wide and boasts about 200 kilometres of coastline. On its western edge, the island plunges dramatically into the ocean and receives a constant battering from the waves and swell. This gives rise to some of the most dramatic scenery anywhere along the State's coast. The island forms the westernmost point of Australia.

Dirk Hartog Island is thought to have become isolated from the mainland in relatively recent times. Shell middens and stone artefacts dated at between 6000 and 3500 years show that Aboriginal people lived on the island at times of lower sea levels.

Tale of three plates

The earliest record of Europeans having landed on Australian soil was inscribed on a pewter plate nailed to a post on Dirk Hartog Island. Translated from Dutch, it reads:

> "1616. On the 25th October the ship *Eendracht* of Amsterdam arrived here. Upper merchant Gilles Miebais of Luick (Liege); skipper Direk Hatichs (Dirk Hartog) of Amsterdam. On the 27th ditto we sail for Bantum. Under merchant Jan Stins; upper steersman Pieter Doores of Bil (Brielle). In the year 1616."

History records that the plate was removed by Dutch mariner Willem de Vlamingh in 1697, who left a plate of his own, inscribed with both Dirk Hartog's original words and a record of his own visit. The original Dirk Hartog plate is now on display in the Rijksmuseum in Amsterdam. It is the oldest European artefact that relates to Australia's history.

Louis Saint Aloüarn in the *Gros Ventre* became the first French navigator to sight the Australian continent. He landed at Turtle Bay on Dirk Hartog Island on 30 March 1772 and took possession of the country in the name of the French King Louis XV. To support his claim, he buried a bottle containing a parchment of annexation and two coins, each enclosed in a lead seal. Saint Aloüarn died before his return to France. Two coins and one bottle were rediscovered on the island in 1998, although, as could be expected after such a long time, there was no trace of the parchment.

Frenchman Nicolas Baudin, who arrived in the area on the *Géographe* on 23 June 1801, was unimpressed with his first views of Dirk Hartog Island:

> "During the entire afternoon we coasted, a league off, along the western shores of Dirk Hartog's Island. For its entire length, it looked arid, disagreeable and dreary. It was, in fact, worse than the part of the Terres de la Concorde that we had seen the day before. The sea broke heavily all along the coast, and we often saw it rise to the height of the cliffs, which are straight and sheer like a wall and with not one noticeable slope."

As such a scenario was a mariner's nightmare, Baudin did not endeavour to land on the island.

The following month, crew from

Top left Pied cormorants at Quoin Bluff South.

Above left The pastoral history of Dirk Hartog Island stretches back to 1868. *Photos – Carolyn Thomson-Dans/DEC*

the French vessel *Naturaliste* arrived in Shark Bay (having become separated from the *Géographe* in a storm some months before) and found Vlamingh's plate, which had fallen from its post. Captain Jacques Felix Emmanuel Hamelin insisted on nailing the plate to a new post and leaving it in situ, regarding it as 'a sacrilege' to do otherwise. He also left an inscribed plate of his own.

It seems that Hamelin's deputy Louis de Freycinet disagreed with the decision to leave this iconic piece of history on the island. Freycinet returned to Shark Bay on the *Uranie* in 1818 and took Vlamingh's plate with him back to France. There it languished, lost and forgotten, for more than a century until it came to light in 1940, on a bottom shelf in the French Academy in Paris mixed up with some odds and ends. It was repatriated to WA on 28 May 1947, a gift from the French government, and the original can now be seen in the Western Australian Maritime Museum in Fremantle. A replica can be viewed at the Shark Bay World Heritage Discovery Centre on the foreshore in Denham.

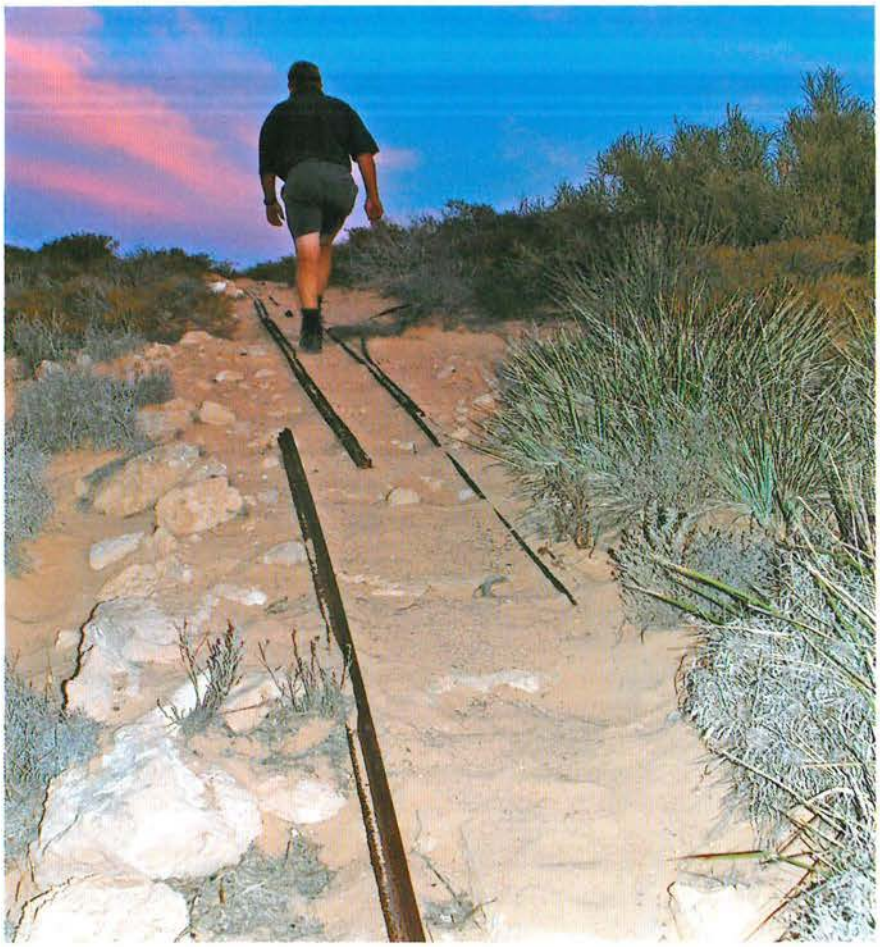
The whereabouts of Hamelin's plate are not known, although it is thought to have been erected somewhere on the north-eastern coast of the island.

Other early history

In the nineteenth century Dirk Hartog Island became used as a base for whaling, guano collecting, pastoralism and pearling. The French whaler *Perseverant* was wrecked at Levillain Shoals at the northern end of the island in 1841.

Strangely enough, bird droppings led to the establishment of an army garrison on Dirk Hartog Island in 1851. At first the garrison was established at a site later named Quoin Bluff, with the officer residing in a wooden structure and 12 soldiers camping in tents. Accumulated guano on many of the smaller islands in the bay, which were used as seabird roosts, was an extremely valuable fertiliser at the time, and the Colonial government at Swan River established the army outpost to collect a royalty of two pounds per ton. On arriving, they found numerous vessels anchored in the bay—all collecting guano. But within months the supplies had run out and the islands scraped clean, so the regiment was called back to Fremantle. The ruins of their stone storehouse and stone jetty foundations can still be seen on the island today.

When Captain Henry Mangles Denham anchored in the bay adjacent to Quoin Bluff in 1858, while conducting a major survey of the area on behalf of the British navy, he was puzzled to discover an iron tank, bottles, pipes and other remnants of the garrison. Denham released rabbits and pigeons on the island, presumably to provide a future food source. Fortunately, a major ecological disaster was averted as the rabbits did not survive. Introduced



pigeons are found on the island today.

Aubrey Brown and the von Bibra family were among the earliest pastoralists in Shark Bay. Frank von Bibra was granted a lease to run sheep on Dirk Hartog Island in 1868. With no water on the island, one of the von Bibras' first tasks would have been to sink wells. They subsequently built a homestead, a shearing shed and shearing quarters. Aubrey Brown settled at the southern end of the island. As it took time to build up the flocks, supplementary income from collecting guano, pearls and sandalwood was important to the Browns and von Bibras in the early years.

The Cape Inscription lighthouse and keepers' quarters were built between 1908 and 1910. The lighthouse still operates, but is now automated. The keepers' quarters were unused for many years and fell into disrepair, but are now being renovated by the Shire of Shark Bay.

After a series of lessees, the island was finally leased by Sir Thomas Wardle (better known as 'Tom the Cheap', as his chain of supermarkets was called) in 1968.

Wildflowers and wildlife

Dirk Hartog Island has tremendous biodiversity conservation values, with 84 species of birds and 48 species of reptiles recorded there. With more than 250 native plant species, it has one of the most diverse island floras in the south-west.

The island is a special and important place for birds. The isolation of Dirk Hartog Island from the mainland has given rise to several subspecies that are

Top left This knob-tailed gecko is a common Dirk Hartog Island inhabitant. *Photo – Carolyn Thomson-Dans/DEC*

Above left Freycinet had removed Vlamingh's plate by the time Phillip Parker King visited Cape Inscription in 1822, so King nailed his name on one of the posts. *Photo – Patrick Baker/WA Maritime Museum*

Left A tramline was built at Turtle Bay early last century to service the lighthouse. *Photo – Carolyn Thomson-Dans/DEC*

Right Dirk Hartog Island in spring.
Photo – Eva Boogaard/Lochman Transparencies

found nowhere else. Three of these birds are listed as threatened, primarily because of their small population size and vulnerability to habitat modification by introduced stock and the threat of fire. They include the Dirk Hartog Island black-and-white fairy-wren (*Malurus leucopterus leucopterus*), the Dirk Hartog Island southern emu-wren (*Stipiturus malachurus hartogi*) and the Dirk Hartog Island rufous fieldwren (*Calamanthus campestris hartogi*). Although there are differences between the plumages of these species and their counterparts on the mainland, recent genetic studies have indicated that at least one of these species—the Dirk Hartog Island black-and-white fairy-wren—may not be sufficiently different to the mainland birds to be regarded as a separate subspecies. This bird looks similar to the white-winged fairy-wren of the mainland, but is black and white rather than blue and white. Dirk Hartog Island also has the largest breeding colony of pied cormorants in WA, with up to 2500 breeding pairs at Quoin Bluff South.

The island is home to a threatened reptile, the western spiny-tailed skink (*Egernia stokesii badia*), and supports a lizard, the Shark Bay ctenotus (*Ctenotus youngsoni*) that, although not threatened, is confined to Dirk Hartog Island and nearby Edel Land.

Dirk Hartog Island supports the largest loggerhead turtle breeding colony in Australia, with possibly as many as 1000 turtles nesting at the island's north-eastern corner each year. The rookery is also globally significant, as these numbers place it in the top five most important sites in the world. The loggerhead turtle is considered to be the most threatened turtle that nests in the Australian region.

Navigator William Dampier was the first person to collect Australian plants and his first specimens came from Dirk Hartog Island. He described the island's vegetation, as seen during his visit in 1699, in his book entitled *A Voyage to New Holland*:

> "The Grass grows in great Tufts, as big as a Bushel, here and there a tuft: Being intermix'd with much Heath, much of the kind we have growing on our Commons in England. Of Trees or Shrubs here are divers Sorts; but none above 10 Foot high: There [sic] Bodies about 3 Foot about, and 5 or 6 Foot high before you come to the Branches, which are bushy and compos'd of small Twigs there spreading abroad, tho' thick set, and full of Leaves; which were mostly long and narrow. The Colour of the Leaves was on one Side whitish, and on the other green; and the Bark of the Trees was generally of the same Colour with the Leaves, of a pale green. Some of these Trees were sweet-scented, and reddish within the Bark, like the Sassafras..."

Today, Dirk Hartog Island contains quite a large number of species growing at the ends of their ranges. As well as being the type locality for a large number of Western Australian plants, Dirk Hartog Island has a mixture of south-west and arid-zone species. There are many colourful wildflowers growing on the island, including Fraser's lantern bush (*Abutilon fraseri*), running postman (*Templetonia retusa*) and native rosemary (*Olearia axillaris*).

Towards a national park

In 1993, Geoff and Keiran Wardle (son and grandson of Sir Thomas) assumed management of the Dirk Hartog Island pastoral lease and began to develop it as a tourist attraction. Their tourism operations are generally open to the public between March and

Above Large mobile dunes at Dirk Hartog Island are visible from the mainland.
Photo – Carolyn Thomson-Dans/DEC

Left The Tamala rose (*Diplolaena grandiflora*) was collected by William Dampier from Dirk Hartog Island in 1699.
Photo – Jiri Lochman

Below Detail of Vlamingh's plate.
Photo – Patrick Baker/WA Maritime Museum

October. Accommodation is provided in the station homestead and there are also six designated camping areas. Visitors can bring their four-wheel drives to the island by barge from Steep Point (by prior arrangement). The island is particularly popular with fishing enthusiasts but also provides superb diving and snorkelling opportunities. It is an interesting place to explore on foot and a variety of marine animals such as whales, sharks, manta rays and turtles can be seen from higher vantage points.

The State Government has started a process to preserve Dirk Hartog Island as a national park which will require the surrender of the pastoral lease on the island. The Wardle family will retain some small parcels of land so they can continue to provide limited, low-key, nature-based tourism facilities in designated areas. Following the removal of the sheep, feral goats and feral cats from the island, a huge project to restore the natural values of the island will start. Baseline monitoring of small mammals and reptiles is being done on an annual basis to establish exactly which species live there. Further scientific studies—such as a comprehensive botanical survey—are also planned.

Because Dirk Hartog Island has immense historical significance, is located within a scientifically important World Heritage Area and is an island on which feral animals can therefore be controlled, the Department of Environment and Conservation's (DEC's) vision is to turn it into a showcase national park.

Many of the 15 native mammal species originally found on the island are now locally extinct, most likely because of feral cat predation, but several of these species will be reintroduced after DEC undertakes a restoration program of the island's vegetation and controls feral cats. These mammals—most of them listed as threatened—include the chuditch, dibbler, western barred bandicoot, woylie and boodie.

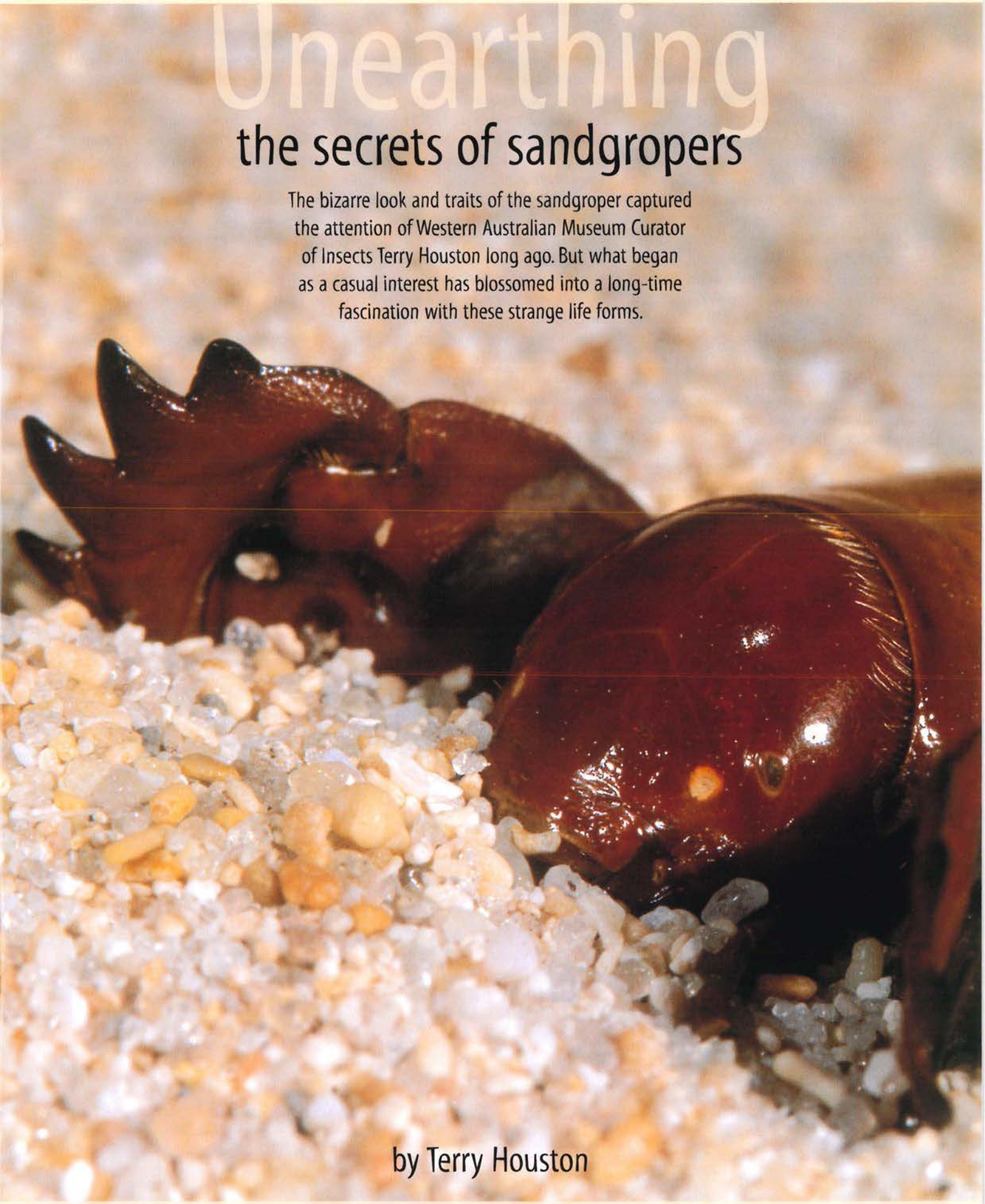
Eventually, the proposed Dirk Hartog Island national park will become a secure haven for threatened species and will enhance the values that make Shark Bay worthy of World Heritage listing.

Carolyn Thomson-Dans is Senior Communications Officer (Marine) for DEC and a long-time contributor to *LANDSCOPE*. She can be contacted on (08) 9336 0121 or by email (carolyn.thomson-dans@dec.wa.gov.au).

Valuable contributions to the article were made by DEC staff David Charles, Brett Fitzgerald, David Rose, Cheryl Cowell and Linda Reinhold as well as retired DEC scientist Andrew Burbidge, and Mike McCarthy and Patrick Baker of the WA Maritime Musuem.

Unearthing
the secrets of sandgropers

The bizarre look and traits of the sandgroper captured the attention of Western Australian Museum Curator of Insects Terry Houston long ago. But what began as a casual interest has blossomed into a long-time fascination with these strange life forms.



by Terry Houston

'Enigmatic', 'bizarre' and 'elusive' are commonly used terms for a small group of soil-dwelling creatures known as sandgropers. Some Western Australians (also known colloquially as 'sandgropers') still doubt that such creatures exist and suspect that they are as mythical as the bunyip.

For years, I lamented the dearth of information on the life histories and habits of these fascinating insects, particularly when faced with public inquiries such as "I've just dug up this weird creature that looks like a beetle at the front end and a witchetty grub at the rear, and it appears to have a pair of big ears. Do you know what it would be?" I could inform the inquirer that the creature was a sandgroper and the 'ears' were the highly modified first pair of legs but I was stumped when it came to the inevitable next question: "What do they do?" Sandgropers first came to the attention of science in 1832 with the description of the first species (actually from Melville Island in the Northern Territory) but the succeeding 170 years saw only a few scattered anecdotal observations on their habits appear in scientific literature.

During fieldwork on the sandplains north of Perth, I frequently saw signs of sandgroper activity in the form of long, raised lines snaking across bare ground, often for tens of metres, where the insects had burrowed just beneath the sand surface. I used to think, "surely some entomologist's curiosity will be sufficiently piqued one day that he or she will get busy with a spade and reveal to us all what sandgropers are up to down there". In the end, it was my curiosity that was sufficiently piqued.

Sandgroper hunt

City folk may doubt the existence of sandgropers but not so the cereal farmers of WA's mid and northern Wheatbelt. In that region, farmers consider the insects to be serious pests to their crops and some regard them as virtual underground locusts. The allusion to locusts is fitting in one sense—sandgropers, which can reach lengths of 35 to 88 millimetres depending on their species, are descendants of grasshoppers and share many anatomical features with them. Before the 1930s, though, they had been regarded as degenerate mole crickets.

When I set out in 2002 to try to learn something of sandgroper biology, my first challenge was to find specimens. The insects are rarely seen and difficult to find in natural environments but I hoped that their habit of burrowing near the surface would reveal them. During the cooler, wetter months from May to September fresh surface trails appear a day or two after heavy rain when the soil surface is damp. By setting out intercept traps, I hoped to secure fresh specimens for dissection. But my pitfall and gutter traps never yielded a single sandgroper. Were these insects too smart to be caught this way?

Then came a stroke of luck. Driving along a farm road late one afternoon

Previous page
Koch's sandgroper (*Cylindraustralia kochii*).
Photo – Jiri Lochman

Below An adult female Koch's sandgroper. This species occurs from Perth to North-West Cape.
Photo – Terry Houston

Right Sandgropers' mid and hind legs recess into the sides of the abdomen when burrowing.
Photo – Jiri Lochman

Centre right An adult male Tindale's sandgroper (*Cylindraustralia tindalei*) exposed in its near-surface gallery by scraping away the surface sand.

Below right Agricultural land can support large populations of sandgropers.
Photos – Terry Houston

following earlier showers, I came across several fresh trails extending partway across the bare, sandy surface. The compacted surface was slowing the insects' progress and, by simply scraping away the surface sand with a trowel, I found an open gallery beneath each trail within which was an adult male. This led to a simple but productive technique—driving back and forth over the same stretch of road after rain and looking for fresh trails. The only hitch was that all the specimens I obtained in this way (about 30) were males.

By keeping some of these specimens alive in soil in glass containers, I was able to observe how they burrowed. Unlike other burrowing insects that throw out soil to create a tunnel, sandgropers simply part and compress the soil with breast-stroke-like movements of their fore legs. They shuffle forwards on their tiny mid and hind legs and leave an open gallery behind themselves as they progress. If at any time they encounter an obstacle or perceive a threat, they back up along their galleries before striking off in a different direction. Compression burrowing takes some real 'grunt', especially in the more compact and less yielding sub-soil. Hold a sandgroper in your fingers and you soon become aware of the power of the fore legs. That power is generated by muscles packing the enlarged first section of the body, the prothorax.

To build a picture of sandgroper biology, I needed to obtain both sexes and desired good samples of the population year round. Thankfully, this was made possible by a number of interested farmers who invited me to their properties with the promise of all the sandgropers I could want.

Sandgropers at a glance

Sandgropers are classified along with grasshoppers and crickets in the order Orthoptera. Long regarded as degenerate mole crickets, sandgropers are now known to be more closely related to the diurnal grasshoppers and are placed in their own family, the Cylindrachetidae. They are highly adapted for burrowing, being wingless in all stages, having reduced legs and only vestigial eyes. They grow gradually (without metamorphosis), the immature stages (nymphs) resembling adults in form. Contrary to popular belief, sandgropers are not exclusively Western Australian. Fourteen Australian species have so far been formally recognised in two genera, *Cylindracheta* with one species and *Cylindraustralia* with 13. These species are distributed across the Australian continent except for the south-eastern corner and Tasmania. A third genus with one species is known from South America. One species of *Cylindraustralia* has been described from New Guinea but the record needs verification.

On one farm near Dandaragan, for example, I was able to find specimens easily at any time simply by digging a hole sufficiently large and deep in a pasture paddock. Virtually all native vegetation had long since been cleared from this farm, so it was clear that the sandgropers had adapted to the agricultural environment. Excavating to a depth of two metres, I obtained approximately 100 sandgropers per square metre of surface. This was indeed a population of locust proportions.

Sandgroper cuisine

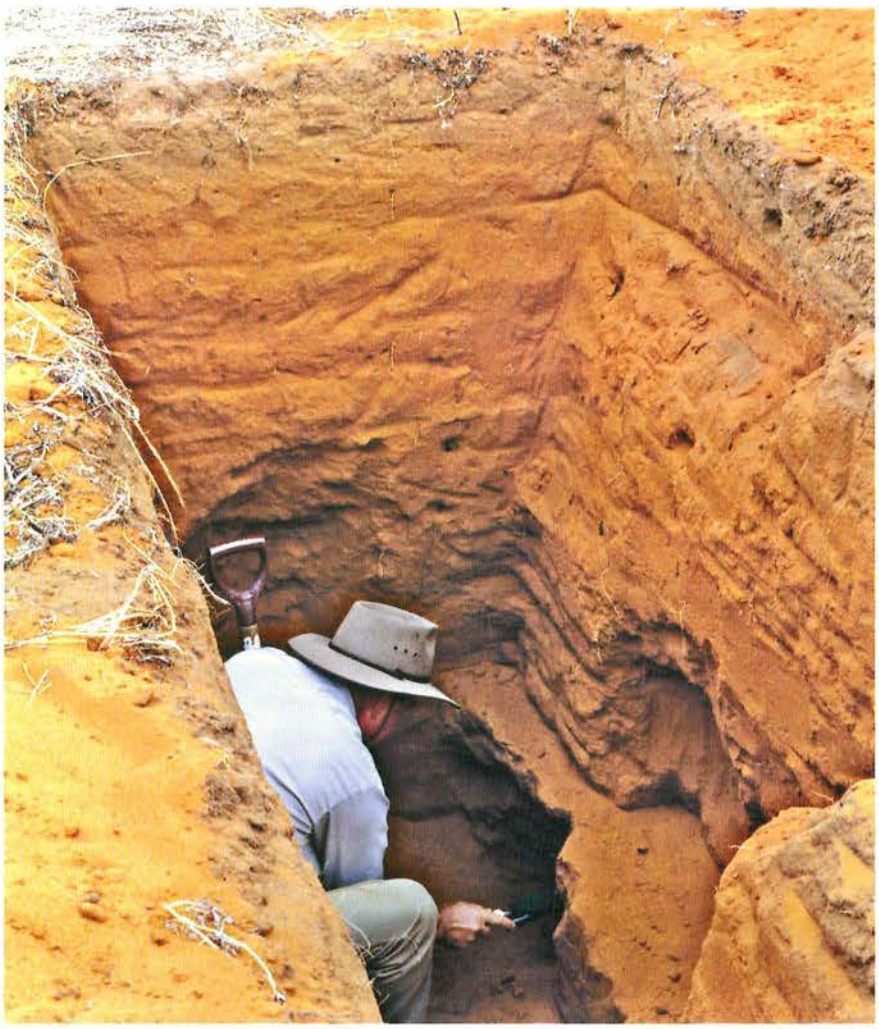
What did all these sandgropers eat? The answer came from dissecting 162 specimens and examining their gut contents under a microscope. This revealed a varied diet. Plant material predominated in gut contents and comprised root, leaf, flower and seed tissue. How did the insects obtain above-ground parts of plants? Very likely by browsing on surface litter and nibbling at prostrate plants. Among the various sorts of seeds consumed, those of the weed 'double-gee' appeared to be especially favoured (surprising in view of the tough, spiny fruits that enclose them). Fungi formed another component of the diet. But sandgropers are certainly not vegans—they proved to have quite a taste for flesh with insects of many kinds and even the occasional spider and mite turning up in gut samples.

Tindale's sandgroper (*Cylindraustralia tindalei*) seems to have a fondness for termite workers and some individuals had stuffed themselves on these soil-dwellers. One of the most surprising prey items was a native bee (obtained when the sandgroper burrowed through an aggregation of ground nests). Cannibalism was rife in dense populations of Koch's sandgroper (*C. kochii*) with larger specimens preying on smaller ones. So, to some degree, the dense populations would be self-limiting.

Sandgropers have fat bodies that surround their gut and other organs. Doubtless, this serves as a food reserve, sustaining the insects during times of food scarcity.

Reproductive traits

The eggs of sandgropers and the method of depositing them proved to be quite intriguing. Unlike grasshoppers, which lay their eggs in batches (or 'pods'), sandgropers invest a good deal of effort in each egg, laying them individually, each in its own chamber at depths of 40 to 190 centimetres. Koch's sandgroper, which attains a body length of six centimetres or so, produces eggs some 7.5 millimetres in length and

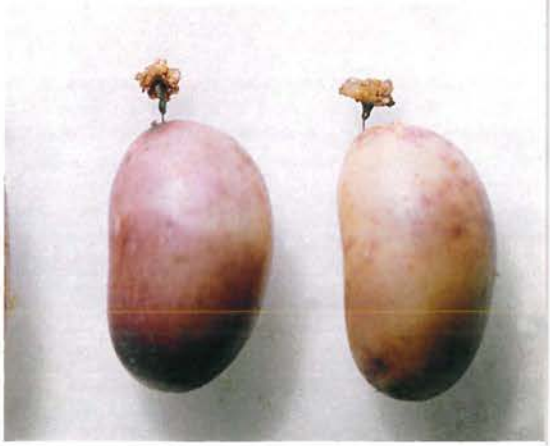


Left Terry Houston at work near Dandaragan. Digging by hand proved to be the best way of obtaining specimens which were found from near the surface to depths of almost two metres.
Photo – Terry Houston

Right A freshly laid egg suspended in its chamber. A drop of water clings to the egg and mould grows on the cell floor.

Below right Red eggs like this one were found occasionally (many others were white marbled with pink).

Below far right Eggs found in summer had opaque shells. The eggs have pedicels and attachment discs with adhering sand grains.
Photos – Terry Houston



suspends them on short, flexible stalks (pedicels) from the ceiling of the egg chamber. The process involved has not been observed but must involve some clever manoeuvres.

Presumably the female begins by excavating a blind horizontal gallery, the end of which will become the egg chamber. By some means unknown, she must then reverse her direction so that she has her abdomen in the blind end of the gallery, and to deposit an egg on the ceiling would seem to necessitate her lying on her back. Oviposition complete, she must then withdraw, reverse direction again, and proceed to back-fill the access burrow with earth, leaving the egg in a 20-millimetre-long air space. As females were found to carry only a few ripe eggs at a time, their rate of reproduction appears to be rather low. What has not been established, however, is how long females go on laying.

The life cycle of the sandgroper is now better known and indications are that its duration is impressively long, perhaps several years. The egg hatches to a non-feeding 'larva' that moults within hours to the first nymphal stage, a miniature of the adult. After feeding on its eggshell, the little nymph burrows out of its brood cell and begins a life of independence. As the nymph feeds and grows, it moults five times before reaching adulthood.

In four samples of the population taken at different times of the year, eggs, nymphs of various sizes and adults were present, but small nymphs predominated. At first this was suggestive of year-round breeding but later, when it became apparent that eggs are laid only during the winter rainfall months and remain dormant until hatching en masse in mid-summer, it became clear that this idea had to be wrong. The new recruits to the population in summer could be expected to feed, grow and soon moult to second stage nymphs. However, the abundance of first stage nymphs at all times of the year leads to only one conclusion—they must live for at least 12 months, overlapping with the next generation. If each of the five nymphal stages develops this slowly, the life cycle would extend over at least five years. Further work is required to see if this is true.

Underground homes

Why have the sandgropers evolved their subterranean lifestyle? Possibly one of the greatest benefits of living under the soil is the avoidance of vertebrate and invertebrate predators and parasitic (more correctly parasitoid) insects. Certainly, my study revealed no evidence of sandgropers having any kind of insect parasitoid at any stage of their life cycle, a most uncommon situation. The insects do produce a pungent and possibly defensive odour from glands on the abdomen, yet they are clearly very palatable to ravens and the occasional hawk that swoop in behind farm ploughs to gorge themselves on the hapless specimens turned out onto the surface. Another benefit may be the avoidance of desiccation through the summer months when the insects are able to retreat to the cool, moist depths of the soil.

While much is still to be learnt about these bizarre creatures, at least now we have some information to provide when people ask "what are sandgropers" and "what exactly do they do?"

Terry Houston is Curator of Insects at the Western Australian Museum. He is especially interested in Western Australian insects including sandgropers, mole crickets, spoon-winged lacewings and truffle beetles. He can be contacted by email (Terry.Houston@museum.wa.gov.au).

Names have changed from the 'Hills Forest Discovery Centre' to the 'Perth Hills National Parks Centre' and 'Go Bush' to '*Nearer to Nature*' but the message of the initiative remains the same: 'Encourage members of the public to explore, learn about and enjoy Perth's unique ecosystems in a fun and interactive way'. With about 55,000 visitors to the centre last year, it seems this message is being heard loud and clear!

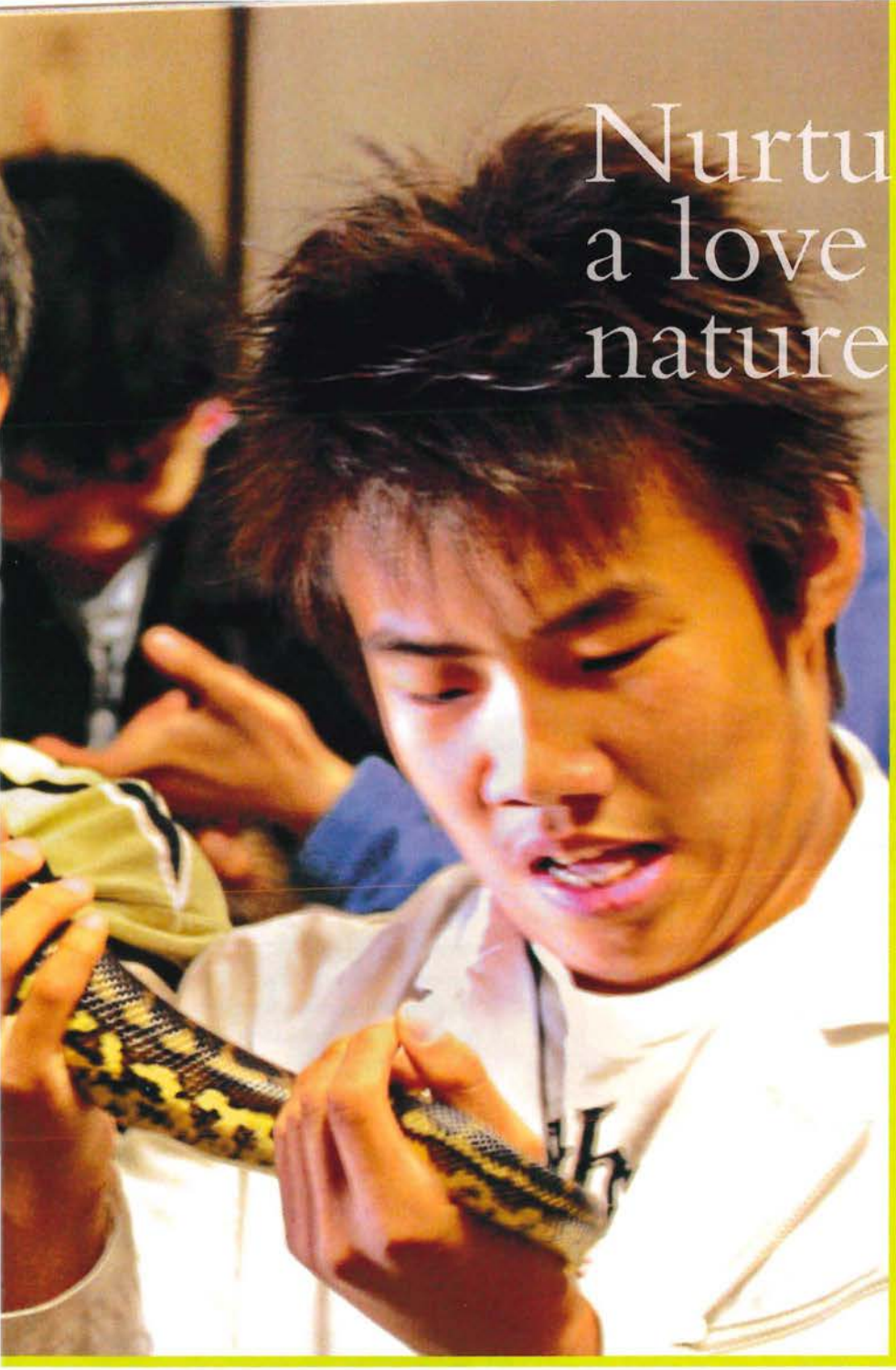
The Department of Environment and Conservation's (DEC's) Perth Hills National Parks Centre is nestled in the forest near Mundaring Weir, 40 minutes drive from Perth. It has three main functions: to develop and provide environmental interpretation *Nearer to Nature* activity programs; to provide schools with nature-based *EcoEducation* programs; and to operate a seven-day-a-week visitor centre providing information about recreation and nature-based tourism opportunities in the Perth hills.

Over the years, visitor numbers to the centre have grown. In its first year, 1992, the centre received 300 visits, by 1997 visitor numbers had grown to more than 16,500 people and in 2006 visitation had grown to 55,000. These numbers included a range of people who visited the centre to take part in programs, find information and use recreational facilities around the centre.

Visitor information

With the number of national parks within the Perth hills growing from five to 10 in the past seven years under the State Government's *Protecting our old-growth forests* policy, it became important to provide a seven-day-a-week recreational information service. As a result, the Perth Hills National Parks Centre's visitor information building was opened in April 2007.

The centre is the hub of the national parks in the area and showcases the



Nurturing a love of nature

The Perth Hills National Parks Centre, located 40 minutes drive from Perth, has become a popular site for visitors of all ages to retreat into the bush and enjoy a range of facilities and nature-based experiences. As we look back on its progress during 15 years of operation, exciting opportunities also present for the future.

by Brenda Smith, Marie Milagro and Stephen Crane

Above *Nearer to Nature* enables you to get up close to nature.
Photo – Blanca Garcia

Perth hills using a variety of interpretive displays. International visitors and locals alike often return time after time to experience the forest ecosystem which surrounds the centre. Opportunities to hike or ride the numerous walk and mountain bike trails are abundant and staff at the centre are equipped to provide information on the many recreational opportunities in the area.

Nature-based activities

Fifteen years after its inception, the *Nearer to Nature* program continues to deliver innovative, nature-based activities which encourage the community to enjoy and appreciate Western Australia's natural heritage. Initially, activities were based solely at the Perth Hills National Parks Centre but, due to its success, in 2001 the program was expanded to offer experiences to a wider audience at other locations around Perth. It was then that the name changed from 'Go Bush' to *Nearer to Nature*. The change reflected the aim to connect people to a variety of natural ecosystems and not just the jarrah and marri forests. *Nearer to Nature* activities are designed to excite and intrigue people about nature by presenting often complicated concepts in a vibrant and simple manner. The program's hands-on experiences increase understanding of nature which in turn increases community commitment to the long-term conservation of urban nature.

Now held in national parks, regional parks and marine parks, the program is able to focus on the fascinating variety of ecosystems across Perth. It has spread from the forests of the Perth hills to WA's beautiful coastline, which offers a plethora of possibilities for marine-based activities. Previously only snorkellers or scuba divers could

Above Students take part in *EcoEducation's* Forest Detective Trail.
Photo – DEC

Above right People of all ages enjoy *Nearer to Nature* programs.
Photo – Brenda Smith/DEC

Below right Learning about nature on the coast.
Photo – DEC

view WA's underwater world without going to an aquarium but now *Nearer to Nature* provides opportunities to touch and feel varieties of algae, sea stars, seagrasses and other marine life, thereby increasing appreciation of this remarkable marine environment. The riverine environment is not forgotten, with activities along the Swan and Canning rivers held during the year.

Education programs

DEC's *EcoEducation* program for schools delivers environmental education programs to teachers and students at locations throughout WA. The programs take students from the classroom, place them in a natural setting and teach them in a fun and informative way about natural ecosystems and the environment. Importantly, EcoEducation strikes the balance between strong curriculum links, adherence to guidelines set out by the Department of Education and Training and ensuring the students enjoy hands-on, relevant activities. It also offers professional development opportunities for teachers.

As the needs of schools and environmental issues are constantly changing, so are the programs. After starting with a just few programs, *EcoEducation* now offers 14 environmental programs and five Aboriginal cultural programs. The programs provide for students who range from Pre-Primary through to Year 12. University groups also have the chance to join in with the option of professional learning activities.

The future

Fostering an ongoing appreciation and understanding of the balance that is required to conserve our natural places is vital, and this means the Perth Hills National Parks Centre has an important role to play in the future.

From incorporating interpretive material on climate change into nature-based activities, to responding to Perth's ever-changing demographics by ensuring the centre and its programs are accessible, the team at the Perth Hills National Parks Centre is constantly evolving its programs to suit future needs. The centre offers a wheelchair-accessible campsite within 40 minutes drive of Perth. The team also has visions of connecting the campsite with internet access to enable students to communicate great camping experiences to students at other sites around the world. Could it soon be possible for a group to camp in the hills, look through small cameras in burrows to see native fauna and communicate with students at campsites in New Zealand, or for a family to show their relatives in England the possum sitting next to their tent, live? Stay tuned.

Brenda Smith is the Marketing and Promotions Officer for DEC's *Nearer to Nature* program. Marie Milagro is the Manager of the Perth Hills National Parks Centre in Mundaring. Stephen Crane is Team Leader for *EcoEducation*.

For more information about the Perth Hills National Parks Centre or *Nearer to Nature*, please call (08) 9295 2244, for information about *EcoEducation* please call (08) 9295 6149 or visit www.naturebase.net.

endangered

by Jill Pryde

Rottnest Island pine community

Callitris preissii and *Melaleuca lanceolata* forest and woodland is a threatened ecological community restricted to the Quindalup coastal dunes on white calcareous sands and sometimes brown sands near Perth.

The community's dominant plant species include the Rottnest Island pine (*Callitris preissii*), the Rottnest teatree (*Melaleuca lanceolata*) and occasionally tuart (*Eucalyptus gomphocephala*). Although these species are found scattered in Western Australia's south-west they only co-occur as a community with a group of mainly coastal-related shrubs, including basket bush (*Spyridium globulosum*), the spiky prickle lily (*Acanthocarpus preissii*), berry saltbush (*Rhagodia baccata*) and a suite of annual herbs including the pretty blue lace flower (*Trachymene coerulea*) in locations around Perth.

While the community was identified as rare in 1994, it historically occurred in a continuous belt along the coast. The remaining occurrences extend from Trigg in the north to Woodman Point in the south with a few remaining disturbed stands along the Swan River around Peppermint Grove. It also occurs on Garden and Rottnest islands. Quokkas often take refuge under the dense canopies of Rottnest Island pine and Rottnest teatree on Rottnest Island while tammar wallabies inhabit the State's best example of this plant community on Garden Island. Since European settlement the community is thought to have been reduced by 70 to 90 per cent due to clearing and probably by too frequent fire. Only about 500 hectares remain, of which about 20 hectares occur in conservation reserves.

The *Callitris* plant community is a very simple one and typically contains a very narrow range of flora species in the understorey. As a consequence, it is highly prone to weed invasion and is easily degraded by threats such as too frequent fire and recreational overuse. Most occurrences have suffered some level of weed invasion. The Rottnest Island pine that generally typifies the community can live up to 100 years but generally dies of old age from about 80 years. It is killed by fire, but regenerates well from seed if the fire occurs after it has reached maturity. Historically, *Callitris* forests were cut for timber and firewood.

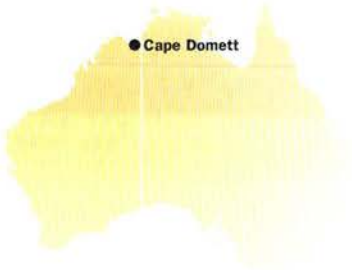
The Department of Environment and Conservation is conducting several studies and working to conserve this important plant community on Garden Island and other coastal sites with help from other groups and Department of Defence personnel, who manage some of the sites.

Photos by Sallyanne Cousans

UNCOVERING TURTLE ANTICS

Research on the Cape Domett flatback turtle population in the Kimberley has revealed fascinating new insights into this threatened species.

by Alex Bowlay and Andrea Whiting



Marine turtles evolved about 65 million years ago from their ancient land-dwelling ancestors and spread throughout the world. Since then, they have survived several ice ages, fluctuating sea levels and changes in continental submergence. They are now spread throughout sub-tropical and tropical regions worldwide. However, recent human-related impacts have caused declines in all species of turtles, resulting in many species being listed as threatened. Major impacts on marine turtles include by-catch in fisheries, harvest for consumption and trade of turtle shell, predation on turtle eggs by native and introduced animals, coastal development, deteriorating water quality, entanglement in nets and ropes, ingestion of marine debris, loss of habitat and lights from residental and industrial development disturbing turtle nesting and hatchling behaviour. However, the remoteness of the Kimberley coast provides an excellent refuge for marine turtles from many of these threats.

Flatback turtles

The flatback turtle (*Natator depressus*) has a low domed fleshy carapace (shell) with slightly recurved margins, which can be grey, pale grey-green or olive in colour. Adults can grow up to 1.2 metres in length. The species is listed as 'vulnerable' under Commonwealth legislation. In Western Australia, it is recognised as 'schedule one fauna'—fauna that is rare or is likely to become extinct—under the *Wildlife Conservation Act 1950*. However, the species remains on a list of reptiles, including other marine turtles and crocodiles, that are allowed to be taken by Indigenous people for food. The turtles are carnivorous, dining on a range of sea cucumbers, soft corals and jellyfish. They appear to prefer foraging on soft-bottomed habitat at a depth between 10 and 40 metres.

Important nesting habitat

Perched atop Cambridge Gulf in the far north-east Kimberley region, Cape Domett provides an important nesting area for the flatback turtle. Cape Domett, Cape Dussijour to the west and Lacross Island form a barrier to waters surging into the Joseph Bonaparte Gulf that in turn ultimately merge with the Timor Sea. Located about 110 kilometres north-north-west of Kununurra, the cape is a curious mix of delicate Devonian-period sandstone spires and geologically younger coastal silt, sand and alluvium. Today, the area is classified as unallocated Crown land. Road access is limited to one, narrow and frequently tide-damaged four-wheel drive track emerging from Carlton Hill Station further to the south. The track is impassable during the wet season due to large expanses of clay soil and tidal flats that rapidly become quagmires. The track brings vehicles to a small, elevated headland, from which the cape can be reached by a 10-kilometre boat journey across shallow water.

For some time, local residents, researchers and tour operators have known that the flatback turtle occurred in appreciable numbers in the region but the extent of the population was unknown. The flatback is one of six marine turtles known to occupy coastal areas around northern Australia. Flatback turtles are one of two species of marine turtle, the other being the Kemp's Ridley turtle, that do not have a global distribution and are found only in the tropical waters of northern Australia, Papua New Guinea and Indonesia. Flatback turtle nesting appears to be confined to Australian shores, with four major nesting stocks recognised: the southern Great Barrier Reef, Gulf of Carpentaria, Western Arnhem Land to the northern Kimberley and the North West Shelf from the far-west Kimberley to Barrow Island in WA.

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Flatback turtle hatchlings emerge from beneath up to half metre of sand.
Photo – Jiri Lochman

Left Cape Domett offers an important flatback turtle nesting habitat.
Photo – Allan Thomson

Above Aerial view of Cape Domett.
Photo – Col Roberts/Lochman Transparencies

Right Camping at Cape Domett.

Studying Cape Domett flatbacks

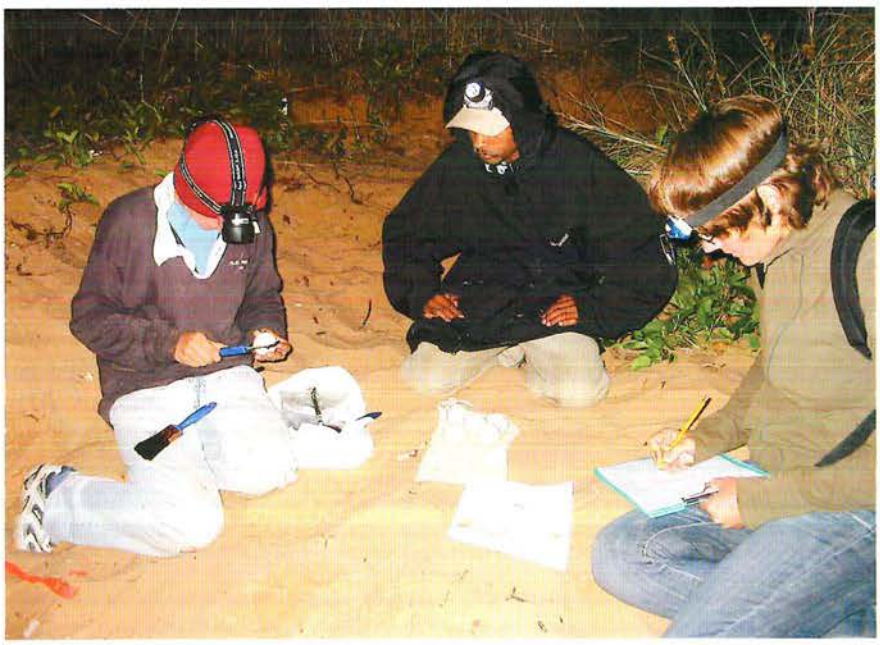
Nesting habitat for flatbacks is at a premium in the north-east Kimberley. Typically, the coastline and islands in the region are rocky and rugged, or mud lined, with only small pockets of suitable sandy beaches available. A two-kilometre stretch of beach and sand dunes immediately bordering 'the Needles' at Cape Domett provides an extremely important area for flatbacks to come ashore and lay eggs.

Before 2006, only 44 turtles had been tagged on this beach from expeditions in 1988, 1994 and 1995. In 2006, Andrea Whiting, a PhD student supervised by Col Limpus and Milani Chaloupka and co-funded by Charles Darwin University and the Department of Environment and Conservation (DEC), started research at Cape Domett in an effort to determine the best techniques to monitor the year-round nesting populations.

Supported by DEC staff and, at one point, a large and enthusiastic group from Conservation Volunteers Australia, Andrea visited Cape Domett nine times in 2006 and 2007. Armed with mosquito domes and large quantities of insect spray and ointment, the teams camped behind the beach in a set of low dunes. Shade and fresh water were in short supply at the site, so tarpaulins and large plastic containers full of water had to be transported in.

The beach at Cape Domett is accessible only by boat. A rough four-wheel drive track allows research teams to reach an elevated rocky area about 10 kilometres east of Cape Domett. DEC's East Kimberley District's 4.5-metre, aluminium, custom-built vessel was towed to this point and launched on good tides in the shallow waters of the silt and mud beach below. With the vessel packed with people and equipment, it was a 20-minute journey to the beach around the cape. The boat was then unloaded and moored with several anchor ropes to cope with the large tidal range, strong currents and winds. Cape Domett has a tidal range of more than seven metres during spring tides.

In September 2006, a 14-day field trip was conducted to gain a



better appreciation of nightly nesting fluctuations over both spring and neap tides. The team found massive fluctuations in turtle numbers, ranging from seven to 290 turtles a night—a much larger variation in numbers than observed on previous or subsequent field trips.

Turtle tactics

A range of techniques was employed to record turtle activity and nesting behaviour. Track counts, conducted very early each morning, revealed total numbers of turtles visiting the beach the previous night. Turtles encountered on the beach at night were tagged with durable titanium tags on the tough leathery inner section of their front flipper. Skin samples were taken to reveal the DNA characteristics of Cape Domett turtles. The team measured adult turtles' curved and straight carapace lengths, widths, mass, plastron (the underbelly shell) length, and counted carapace and head scales.

Turtle nests that contained freshly laid eggs were marked and carefully excavated to check clutch size and the size of the eggs. Frequently, hatchlings were encountered emerging from the sand at night. These were counted, measured and weighed before being released into the ocean.

Hatchling tracks, characterised by tiny train track-like markings in the sand, were often observed originating from a small depression in the sand. Nankeen night heron and dingo tracks were also observed in abundance near these hatchling tracks, testament to hungry opportunists.

To encounter turtles on the beach each night, the research teams waited until high tides in the late afternoon or night when the flatbacks typically came

Top left Turtle tracks mark the beach at Cape Domett.
Photo – Allan Thomson

Centre left Flatback turtles lay leathery-shelled white eggs in the sand.
Photo – Jiri Lochman

Left Measuring egg size and shape.
Photo – Alex Bowlay/DEC

ashore. In the setting sun the turtles' carapaces glistened as they slowly made their way up the beach. The beach was divided up into sectors, with small teams responsible for observing and detailing turtle behaviour in their sector. The team noted the time at which each turtle began excavation and how long they spent on each stage of digging their nest, as well as when the turtle left the beach.

Excavating a nest has two stages: pitting and chambering. Firstly, the female turtle excavates a large shallow pit by actively pushing aside sand with all four flippers. It then begins a more focused excavation involving dexterously digging a chamber straight down in the sand with its hind flippers. Reaching down with a curved hind flipper, sand is scooped up and lifted out of the hole. The sand is then placed to the side, away from the chamber. The turtle shifts its body sideways, positioning the other hind flipper over the chamber, which is then delicately lowered to repeat the action. Digging using body shifting and alternating hind flippers continues until the hole is deep enough and no more sand can be removed. The tiring female then becomes still before laying leathery-shelled white eggs covered in a clear fluid.

Flatback turtles lay the fewest eggs of any marine turtle, with about 50 eggs laid at one time. The turtles fling sand back into the hole with their rear and front flippers, before heaving themselves back down the beach to the water. The total time taken from leaving the water, digging a nest, laying and covering the nest averages 100 minutes. Turtles lay several clutches of eggs during the nesting season.

New findings

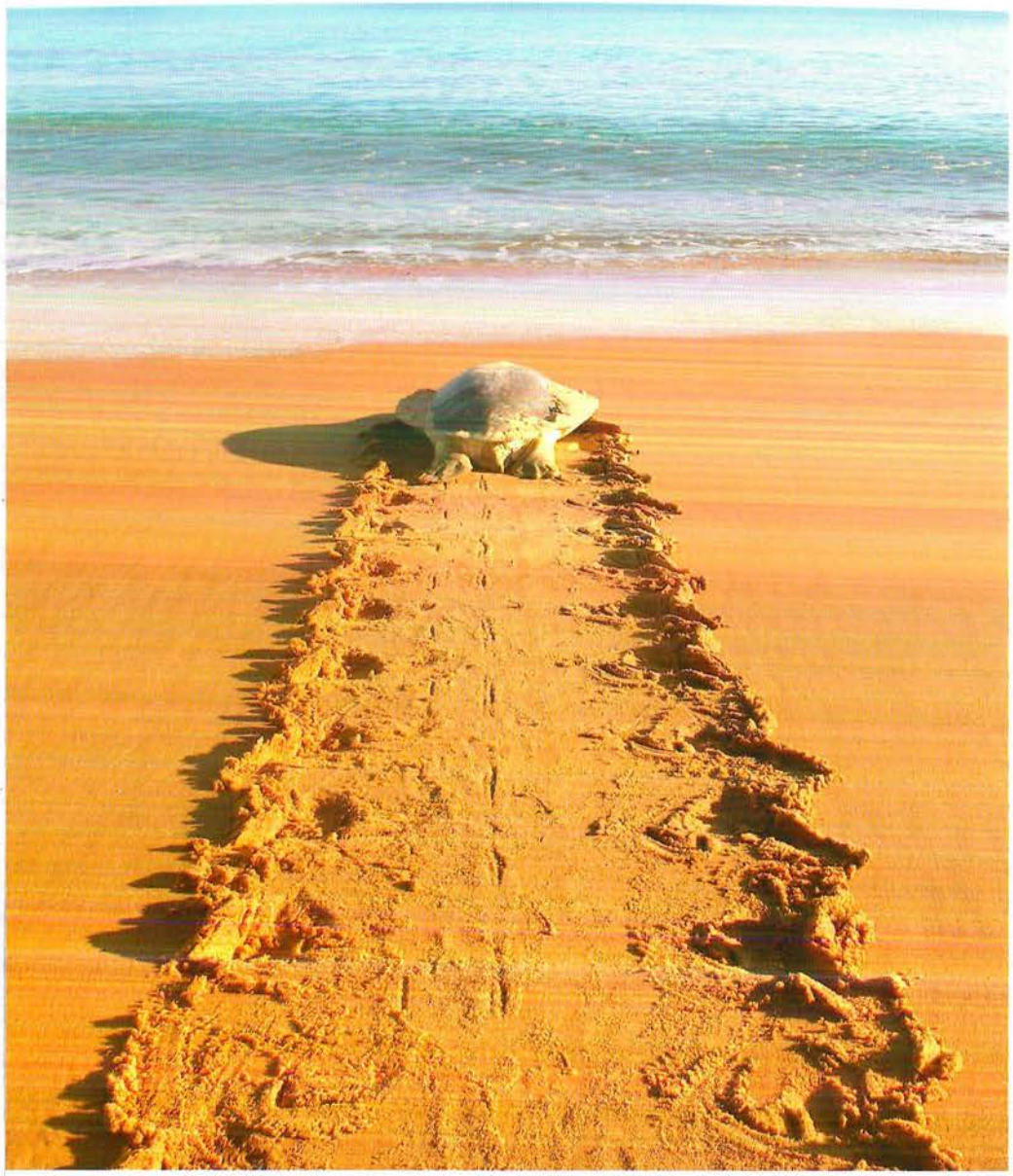
The observations at Cape Domett have revealed some extremely important insights into flatback turtles in the region. For example, it is now known that Cape Domett is home to a major population of nesting flatback turtles and is one of the biggest known flatback rookeries in the world. The beach can receive up to 290 turtles a night. The area was previously thought to receive about 30 to 50 turtles a night.

The new research also determined that nesting at Cape Domett appears to be year-round, with peak nesting occurring between June and October. What's more, particular barnacles found on the carapace of some turtles indicate previously unknown habitats. They may be spending time in mangrove or rocky-reef habitats—areas not previously known to be visited by flatback turtles.

In addition to these findings, the project confirmed that flatback turtle adults and hatchlings face many dangers at Cape Domett. As adult female turtles emerge and re-enter the water, large estuarine (saltwater) crocodiles often lie in wait. The menacing sight of crocodiles taking turtles was witnessed several times during the year, the powerful crocodiles restraining 70-kilogram turtles with ease. The team also found remains of adult turtles

Above right Proof crocodiles attack flatback turtles.
Photo – Allan Thomson

Right Hatchling flatback turtles make a dash for the ocean.
Photo – Andrea Whiting



Left Female flatback turtle returning to the ocean after laying its eggs.
Photo – Andrea Whiting

in nearby mangroves with rows of puncture marks in their carapace left by powerful snapping crocodile jaws. Thanks to these observations, it is now believed that estuarine crocodiles take an average of one to two adult turtles a week at Cape Domett.

Hatchlings are especially prone to predation. They run the gauntlet of many predators at Cape Domett. From the moment they struggle to release themselves from over half a metre of sand above their heads, dingoes and nankeen night herons are poised to collect and devour them by night, with a myriad of opportunistic birds of prey including whistling kites and white-bellied sea eagles present if they hatch during the day. Even saltwater crocodiles get in on the act, often seen at the waters edge scooping up hatchlings in their mouth as they enter, or even at the nest site itself where they snatch emerging hatchlings with a deft tilt of their massive heads. Despite the threats, the turtle nests at Cape Domett appear to experience little predation in comparison with other populations and are not under threat by introduced predators.

However, like other turtle species, it is estimated that only one in a thousand hatchlings make it to maturity. And even if hatchlings reach the relative safety of the ocean, they are still faced with many hazards. Fish and other sea creatures consume the vulnerable and exposed.

Flatback future

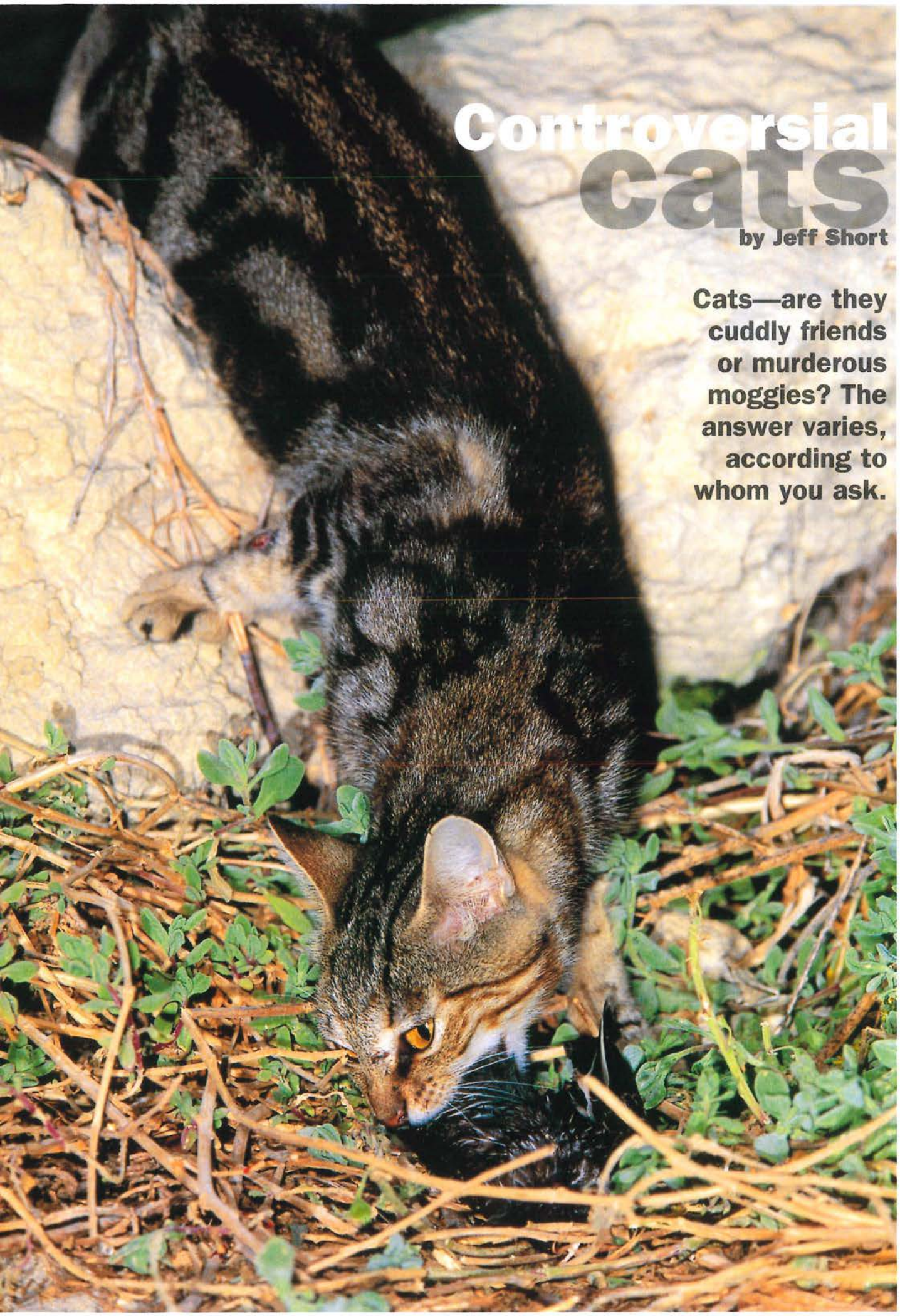
The remoteness of Cape Domett is no doubt its greatest protection, with access limited to boat or helicopter. This has enabled the sizeable population of flatback turtles to persist in relative isolation from pressures associated with human development in other areas in WA. They are, however, still threatened from coastal development, climate change, spread of introduced predators, fishery by-catch and entanglement and ingestion of marine debris. Given the magnitude of this turtle population, it no doubt requires future protection and research.

Future research directions at Cape Domett include the continued monitoring of flatback turtles and identifying unknown population parameters such as defining the peak of the nesting season, and determining female turtle re-nesting intervals and numbers of nests laid per year. Future research will be based on cost-effective monitoring protocols developed using this research and research from beaches worldwide.

Alex Bowlay is DEC's District Wildlife Officer in the East Kimberley District. Alex has worked as a National Park Ranger since 1998 and, after working as a Senior Ranger near Dwellingup, returned to the East Kimberley in 2006. He can be contacted on (08) 9168 4200 or by email (alex.bowlay@dec.wa.gov.au).

Andrea Whiting is currently completing a PhD at Charles Darwin University on monitoring methodologies for nesting sea turtle populations. Andrea has considerable experience with other marine turtle research, having being involved with several Australian and international projects. She can be contacted on (08) 8946 6814 or by email (andrea.koch@cdu.edu.au).

For more information about marine turtles visit the 'Marine turtles in Western Australia' section of DEC's NatureBase website at www.naturebase.net/marineturtles.



Controversial cats

by Jeff Short

Cats—are they cuddly friends or murderous moggies? The answer varies, according to whom you ask.

Cats are revered as a companion animal and are kept by many of us as domestic pets, yet some scientists believe they are one of the scourges of the Australian bush, responsible for many of the early extinctions of Australian mammals. Feral cats and their role in the Australian bush were largely ignored by scientists until about 15 years ago, in part because they believed their impact was minimal. Indeed, some scientists believe cats are being unjustly demonised. Perhaps the strongest defender of cats in recent times has been Tim Flannery, well-known author, palaeontologist, Director of the South Australian Museum and 2007 Australian of the Year. In a published essay in 2003, he poured scorn on the belief that cats may have played a role in mammalian extinctions in the early years of European settlement. This belief, according to Flannery, takes pride of place as one of Australia's "environmental lies". Strong words from a highly respected scientist.

Flannery argued that cats had been introduced to Australia at the time of European settlement and would have reached the zenith of their distribution on the continent by the 1840s—well before major extinctions of native mammals. Moreover, cats and native mammals have co-existed on two of Australia's largest islands, Kangaroo Island and Tasmania, and by extension should also have done so on the mainland. Flannery conceded that cats may have played a role in eliminating small and isolated populations such as on Faure Island at Shark Bay. Cats may also be effective, according to Flannery, in eliminating newly reintroduced mammals as they are captive-bred and naïve, have no experience of complex natural environments, and are "sitting ducks for any half-competent predator". Just how true are these assertions?

Colonisation by cats

There has been doubt about the origin of cats in Australia, with some researchers suggesting that they may have arrived before European settlement as a result of Dutch shipwrecks or visits by Macassan fishermen. However, recent research by Department of Environment and Conservation (DEC) Scientist Ian Abbott has done much to resolve the debate. His detailed and comprehensive search for historical records of the occurrence of cats across Australia enabled him to date the arrival and spread of cats. He concluded that cats established from a British origin and from multiple nodes around the coast as settlers established pastoral and other enterprises. Close to two-thirds of Australia was still unoccupied by cats in 1860, and it was not until after 1890 that cats had largely colonised the continent. This is some 20 to 50 years after that hypothesised by Flannery, coinciding with a first wave of extinctions of native mammals from arid Australia.

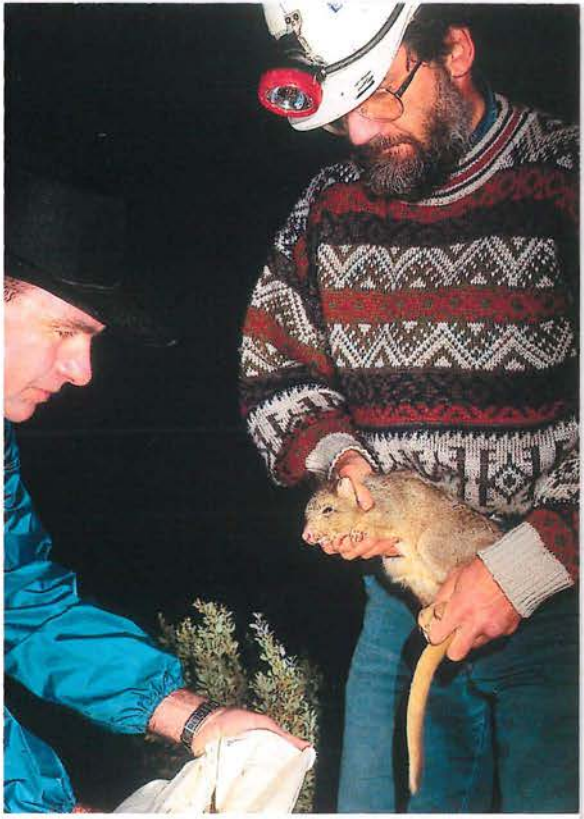
Cats and climate

DEC Research Fellow Andrew Burbidge examined the loss of mammals on Australian islands and found that climate appeared to play a role—the effectiveness of cats in eliminating mammals was highly dependent on rainfall. The apparent lack of impact of feral cats on mammals on islands in high rainfall areas may be explained by a combination of dense vegetation providing refuges from predation, lower incidence of severe drought that limits reproduction in prey species, and (in Tasmania) the suppression of feral cats by Tasmanian devils. By extension, the role of cats is likely to have been greatest in arid Australia.

Previous page
Feral cat devouring a native bird.
Photo – Jiri Lochman

Above Feral kitten litter on Heirisson Prong, Shark Bay.
Photo – Andrew Hide

Left Feral cat.
Photo – Jiri Lochman



Above Rufous hare-wallaby or mala.

Above right Jeff Short at Heirisson Prong, Shark Bay, studying burrowing bettongs.
Photos – Jiri Lochman

Failure of reintroductions

Feral cats have been identified as the primary cause for the failure of reintroductions of native mammals to arid and semi-arid Australia. Researchers have successfully controlled foxes at these sites but their valiant efforts to control feral cats have been unsuccessful. Boodies, or burrowing bettongs, (*Bettongia lesueur*) and golden bandicoots (*Isoodon auratus*) reintroduced to the Gibson Desert in the early 1990s were wild animals sourced from Barrow Island. Once introduced, the animals persisted for less than three months, with most deaths attributed to cats. Barrow Island lacks a mammalian predator so the native animals may have been naïve.

Rufous hare-wallabies, or mala, (*Lagorchestes hirsutus*) reintroduced to the Tanami Desert were captive bred in a 100-hectare enclosure from wild mainland stock. Again, cats killed most released animals. Could it be that their wild heritage was over ridden by their immediate experience of captivity making them easy targets for feral cats?

Woylies (*Bettongia penicillata*) reintroduced to Yathong Nature Reserve in central New South Wales originated largely from the wild population at Dryandra Woodland in Western Australia. All 31 radio-collared bettongs were dead within 13 months, with most deaths attributed to cat predation. In this case a wild heritage without a period of captive breeding was not sufficient to permit survival.

These reintroductions failed quickly, allowing little time for individual animals to acclimatise to their new surroundings and the new predatory regime.

In contrast is the reintroduction of threatened mammals to Heirisson Prong at Shark Bay—a peninsula that a community group from the small mining town of Useless Loop fenced to exclude predators. CSIRO's Principal Research Scientist Jeff Short reintroduced burrowing bettongs and western barred bandicoots (*Perameles bougainville*) to the peninsula in 1992 and 1996 respectively. In the absence of cats, both established large populations of 300 to 500 animals and these have persisted for many years and many generations. The bettongs developed a burrow network and had additional shelter in rabbit warrens while the bandicoots established nests in leaf litter under dense low prickly kurara bushes. Despite this, after some time reinvading cats were able to eliminate both species as free-range populations. Both survived only because a small handful of animals were transferred at the eleventh hour to a high-security enclosure to re-start the population once cats were removed.

Contributing factors

So were reintroduced stock captive-bred and naïve, with no experience of complex natural environments as claimed by Flannery? Only one of the reintroductions described above used captive stock (albeit raised in a 100-hectare enclosure of natural habitat). Two others used animals sourced from offshore islands free of mammalian predators and this may have contributed to a naïvety to novel predators. However, bettongs and bandicoots at Heirisson Prong were exposed to feral cats over a 10-to-15-year period. Was this still insufficient exposure to override their island heritage of naïvety? The reintroduction of woylies to Yathong used wild-caught stock with a mainland heritage. Hence, in this last case the notion of naïvety cannot be invoked. Clearly, cats can eliminate medium-sized mammals under some circumstances.

Both Heirisson Prong and Yathong have abundant prey of European rabbits and house mice. This generates higher feral cat populations and higher densities. This increased predation due to the inflated density of a predator built on an abundant alternate prey is known as 'hyper-predation'.

Another contributing factor in the loss of populations of bettongs at

Above Red-tailed phascogale.

Left Western barred bandicoot.
Photos – Jeff Short

both Yathong and Heirisson Prong was drought. Australian marsupials occupying arid habitats are typically resilient to drought, but a part of this process is shutting down all reproduction. Females begin by losing young in the pouch from lactation failure and progress to anoestrous (sexual inactivity) as conditions deteriorate further. Unfortunately, drought is a time of plenty for carnivores that feast on dead and dying animals. Rabbit numbers collapse early in drought at Shark Bay allowing cats to persist in numbers. These cats switch to native mammals when rabbit numbers are exhausted. In the absence of breeding, populations of native mammals are quickly overwhelmed.

Predation by feral cats is considered a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Species declared at risk by cat predation include 37 mammal, 35 bird, seven reptile and three amphibian species or sub-species. In WA these include species such as the Gilbert's potoroo (*Potorous gilbertii*), burrowing bettong, red-tailed phascogale (*Phascogale calura*), malleefowl, western ground parrot, and purple-crowned fairy-wren.

Control of feral cats

Despite considerable effort, feral cats have proved to be very difficult to control. Most success has come from targeting smaller sites with high biodiversity values and with the possibility of limiting reinvasion by cats once control has been successfully achieved. This has required an island or peninsula or a site capable of being fenced. Major victories in WA have come from DEC's eradication of cats from the Australian Wildlife Conservancy's Faure Island at Shark Bay (see 'Return to Faure Island', *LANDSCOPE*, Autumn 2007) and Hermite Island in the Montebello Islands. These were sites with a limited prey base for cats—importantly, neither had rabbits. In contrast, peninsula sites such as Heirisson Prong and Peron Peninsula at Shark Bay have experienced difficulties in eradicating cats because of the high densities and rate of increase of cats, fuelled by high rabbit and house mouse numbers. Key methods of control are exclusion fencing, trapping and baiting. The first WA example of the large-scale use

Above left Jeff Short at Heirisson Prong, Shark Bay, radiotracking burrowing bettongs.
Photo – Jiri Lochman

Above Cage traps tend to catch younger feral cats.
Photo – Jeff Short

Left Shark Bay DEC's *Project Eden* program has led to the installation of a solar powered vermin-proof electric fence.
Photo – Jiri Lochman

of a protective fence to re-establish threatened mammals was that by the Useless Loop community, which erected a fence across the narrow neck of Heirisson Prong in 1990 to exclude foxes and feral cats from a 1200-hectare area. Since then, fence designs have steadily improved and have been used by DEC to protect the endangered western swamp tortoise on the Swan Coastal Plain as well as other native animals through *Project Eden* at Shark Bay, which, despite many achievements, has been largely unsuccessful in excluding predators from the 1000-square kilometre Peron Peninsula.

In addition to fencing, trapping is also used to control cats. CSIRO introduced the use of humane foot-hold traps to capture cats at its reintroduction site at Heirisson Prong in 1993. CSIRO research indicated a difference in the ease with which adult and juvenile cats were trapped. Juveniles were typically easily caught using cage traps, but catching experienced adults usually required the use of concealed foot-hold traps with food or scent lures.

Baiting is the third major cat control method. In 1995 CSIRO began testing the use of mouse carcases poisoned with the toxin, 1080, to control cats. This achieved a total kill of all radio-collared cats and there was a 74 per cent reduction in spotlight sightings. However, subsequent baitings were far less successful and this was linked to the abundance of rabbits as food for cats. This work suggested that cats were only likely to be effectively controlled every four out of seven years on average at Shark Bay, and that the 'window of opportunity' for effective baiting was most likely to be in autumn or early winter before the emergence of the annual crop of rabbit kittens.

DEC also uses baits containing 1080 across 3.9 million hectares of the State's conservation estate in a bid to control foxes and cats as part of its *Western Shield* program. In addition, DEC has developed a sausage bait effective at controlling cats under certain circumstances (see 'Taking the bait', *LANDSCOPE*, Winter 2007).

Cats as part of a predator–prey system

Greater understanding of the role of cats as part of a predator–prey system comes from CSIRO's work at Heirisson Prong. Feral cats occur

Above left Heirisson Prong at Shark Bay is site of a native mammal reintroduction program.
Photo – Sally O'Neil

Top Concealed foot-hold traps are used to capture cats and foxes.
Photo – Blair Parsons

Above Rabbits are a major food source for feral cats at Shark Bay.
Photo – Marie Lochman

there at densities of up to three per square kilometre and have the ability to double in population size in less than nine months. Cats reach highest population densities in the absence in foxes, with cats on Heirisson Prong reaching densities of nearly twice that of an adjacent area with no fox control. The high rate of increase in cat numbers means that cats are rapidly replaced following control, requiring persistent high-intensity effort to make any headway.

The super-abundant rabbit population on mainland Shark Bay (estimated as peaking at an unsustainable 3700 per square kilometre on Heirisson Prong, but more typically less than 800 per square kilometre), is reflected in the diet of feral cats—rabbit made up some 88 per cent of their diet by weight. One suggestion to control cats is to first deal with the rabbit population, but this is difficult at Shark Bay because of the vast area and low value of the land, the high expense of control and the low prognosis for success. Such approaches have worked elsewhere with much lower rabbit densities, sparser vegetation, and different soil types that concentrate rabbits in localised large warrens that are amenable to ripping.

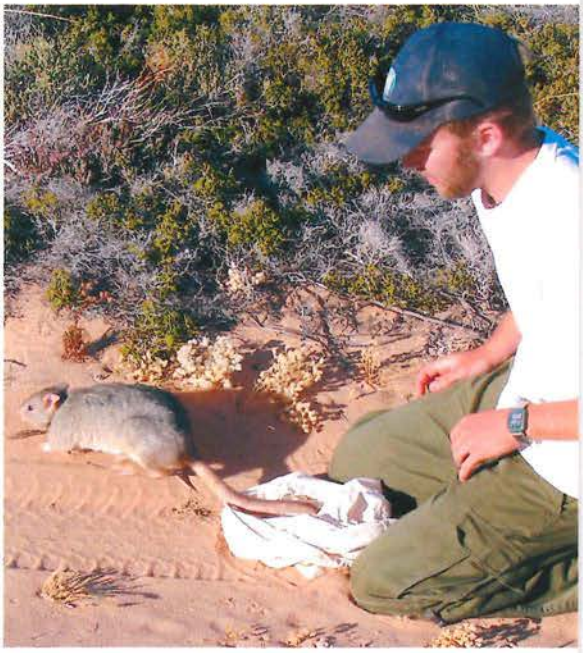
Research on food-based lures and baits by CSIRO at Shark Bay has shown that a high uptake depends largely on a relative scarcity of alternative foods. Unfortunately, most effective cat control techniques are rendered ineffective by the presence of abundant mammal populations. On Heirisson Prong, reinvading cats were difficult to control because the abundant bettong populations precluded the use of foot-hold traps and their availability as a food source meant that cats were less likely to take baits. Hence, control techniques that worked before the re-establishment of native mammals were ineffective afterwards.

Even worse in terms of cat control was that populations of re-established native mammals did not rise and fall in synchrony with the rabbit population. Hence, when rabbit populations collapsed native mammals remained available as a food source for cats, bridging the food gap until the return of the rains brought more rabbits. Hence, the cat population was supported through dry times by the newly established native mammals, until these collapsed under the weight of predation.

The future

Progress on cat control has been frustratingly slow, but despite setbacks there have been significant conservation gains. These include the eradication of cats from Faure and Hermite islands and the persistence of reintroduced bettongs and bandicoots for up to 15 years at Heirisson Prong in the presence of feral cats.

Future research and management will be directed at new cat baits (including a cat-specific toxin) and



Top left Juvenile western barred bandicoot caught on Heirisson Prong.
Photo – Jeff Short

Top A burrowing bettong is released.
Photo – Bruce Turner

Above left Juvenile burrowing bettong.
Photo – Blair Parsons

Above Useless Loop resident Scott Malasits helps monitor western barred bandicoots.
Photo – Jeff Short

new ways of dispensing them (such as high density aerial drops), better knowledge of how to time control efforts, improved and more extensive use of predator-proof fencing, the creative use of secure refuges, and a better appreciation of where cat control might work.

However, despite the successes, the goal of maintaining populations of cat-vulnerable mammals on mainland Australia over the long-term remains elusive. The major challenge on the horizon is to create a cat-free Dirk Hartog Island at Shark Bay (See 'Dirk Hartog Island: inscribed in history'on page 32). This will permit the reconstruction of Australia's pre-European fauna at an unprecedented scale.

Friend or foe?

While there is still much to be learned, it appears that feral cats have played an historic role in the extinction of Australia's mammals and a current role in limiting reconstruction of our native fauna. Their historic impact was likely greatest prior to the invasion of WA by the fox. Their impact, more subtle and less widespread than that of the fox, was likely tempered by climate (being strongest in dry and drought-prone areas), food base (being greatest in the presence of introduced rabbits and house mice), suppression by more dominant predators (foxes, dingoes and Aboriginal people), and the innate characteristics of some prey (being most effective against small, slow-reproducing species occupying open habitat).

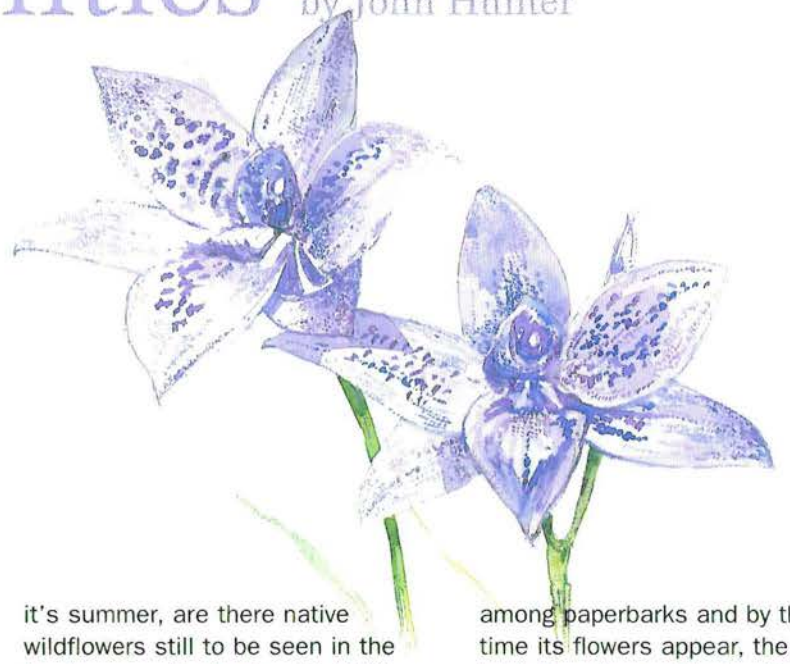
In contrast to this conclusion is Tim Flannery's claim that the majority of those who assert that cats have caused extinctions in Australia are simply cat-haters who have allowed their prejudice to override their scientific reason. You be the judge.

Dr Jeff Short provides ecological advice and practical support to remote and regional communities engaged in biodiversity conservation. He worked for CSIRO Sustainable Ecosystems and its predecessors for 25 years and now operates the consultancy company Wildlife Research and Management (www.wildliferesearchmanagement.com.au).

urban antics

by John Hunter

Hot babes



It's one thing to enjoy the seasons of any one year, but it's especially nice to get the relief of a change, for change's sake, as you grow older. And so, now it's summer 2007–2008, the heat from a lucky old sun ripples the air as it sears the back of your neck in the walk from an air-conditioned office to an automobile oven. Then, for about two minutes, one is narcotised by solar power. Oh, it's soooo good.

What about the wildflower spotters, you say? What are they going to do 'til next winter–spring? Withdrawal symptoms are cruel, so here's a little medicine.

Western Australia is the wildflower bowl of the planet. With the State spanning the northern tropics through to the southern Mediterranean climate zone, there is probably no time when there are not wildflowers blooming somewhere.

The general spring season of the southern half of the State, around September, is when the majority of blooms erupt across the sandplains, woodlands, swamps and scrub. More than 750 native and exotic plants are found in the inner suburban bush reserves of Kings Park and Bold Park alone. Along with the urban and outer areas of other south-west towns and cities in the Greater Perth Floristic District between Guilderton, Chittering, Collie and Bunbury, there are a staggering 2135 native species and some 764 exotic weed species.

From about June to December each year, in a growth wave starting from the Kimberley to the South Coast, WA becomes a 'Mecca' for serious botanists and tourists alike. Urbanites, country folk and foreigners are all eager to see at least some of the State's 12,000-plus wildflowers.

"What about the workers... er walkers", I hear you say. "Now it's summer, are there native wildflowers still to be seen in the bush areas of suburban Perth?" Yes there are.

Depending on location, water, fire, soil quality and disturbance to an otherwise normal life cycle, there are probably quite a few, but the following four are my choice for your summer flora fix.

The blue lace flower (*Trachymene coerulea*) is an erect annual thistle-like herb which is found on Quindalup coastal soils near Perth. It has a pompom of showy, tiny flowers ranging from pale to deep blue that attract butterflies, jewel beetles and hoverflies. The flower is also found on Rottnest and Garden islands.

The babe-in-the cradle orchid (*Epiblema grandiflorum*) has attractive purple flowers with spotted-like appearance. It inhabits wet peaty swamps often among paperbarks and by the time its flowers appear, the water table has dropped below the soil surface allowing for good close-up photography.

Chenille honey-myrtle (*Melaleuca huegelii*) has small white bottle brush clusters or spikes and is a common shrub-come-bush of coastal limestone. It is now commonly found in many gardens both locally and overseas. The plants attract many bees, wasps, beetles and the Klug's xenica and painted lady butterflies.

The slipper orchid (*Cryptostylis ovata*) has a strange looking reddish–brown, slipper-like labellum with prominent net veins. The plant can resemble a handful of gum leaves stuck in the ground or a strong sturdy specimen 60 centimetres tall. Best obtain a photo of this babe.

Be off with you now, enjoy!

DID YOU KNOW?

- It is always advisable to take a reference book when flower spotting.
- You might find a new or rare specimen.
- Orchids are those plants where the sexual organs are made up from one of the petals.
- The blue lace flower, also called Rottnest Island daisy, always appears each year on the island, but on the mainland, only a few plants germinate unless affected by fire. They are then found in profusion.

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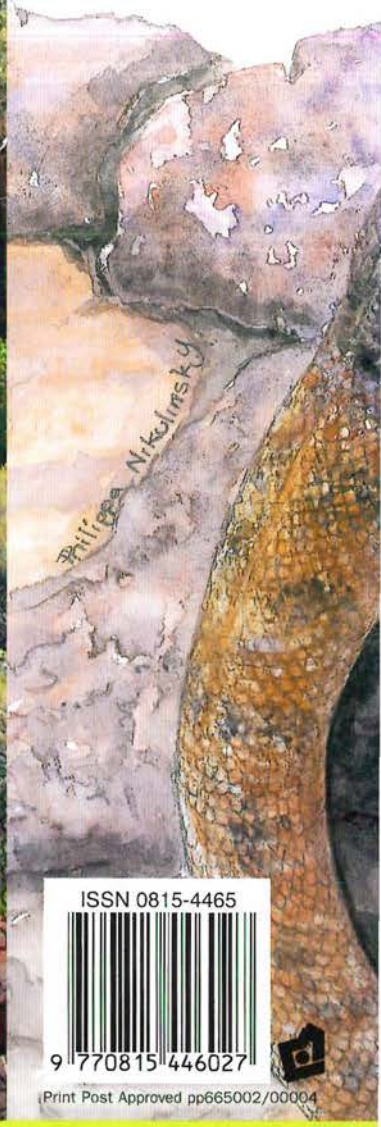
Our environment, our future



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