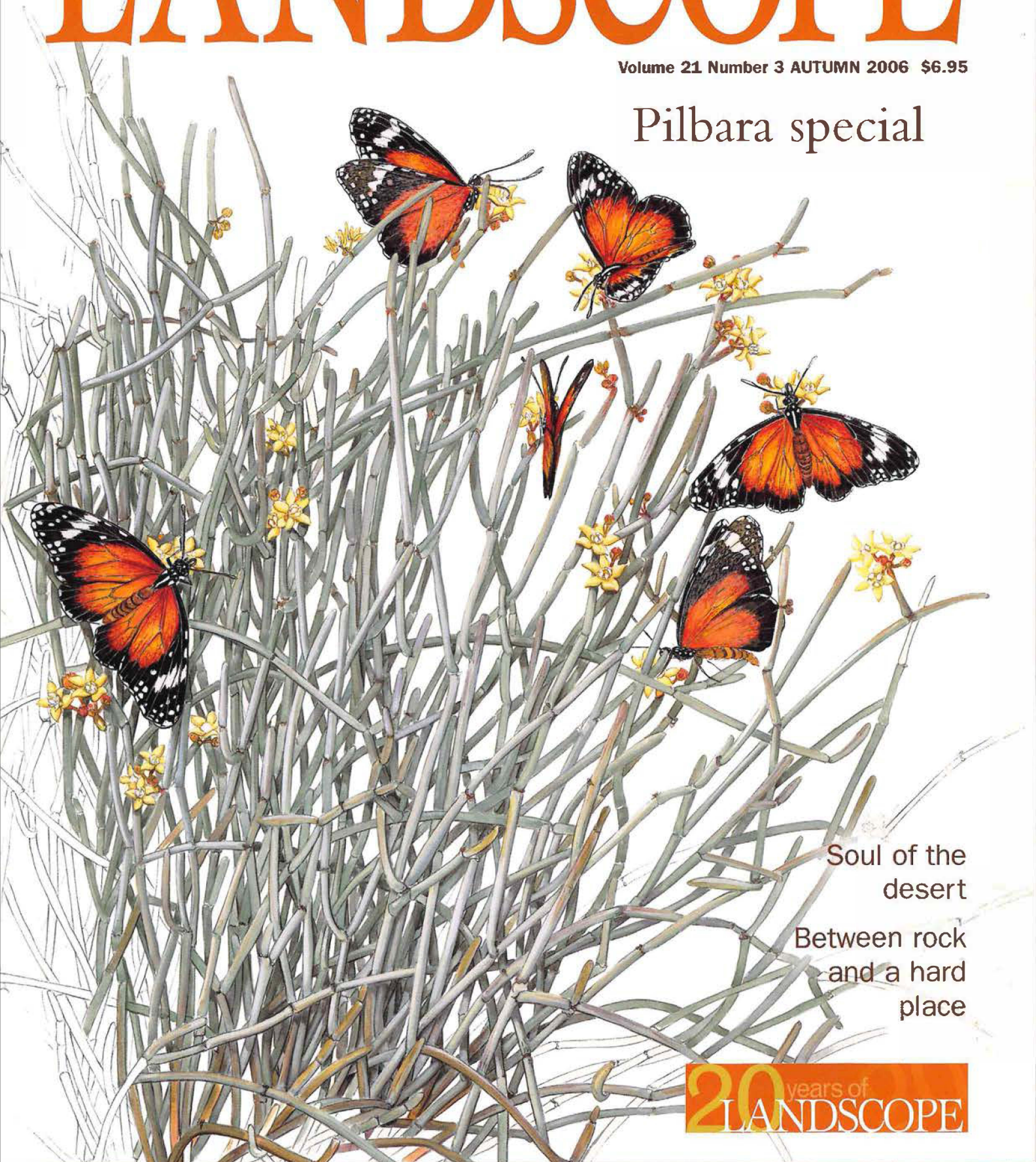


WA's conservation, parks and wildlife magazine

# LANDSCOPE

Volume 21 Number 3 AUTUMN 2006 \$6.95

Pilbara special



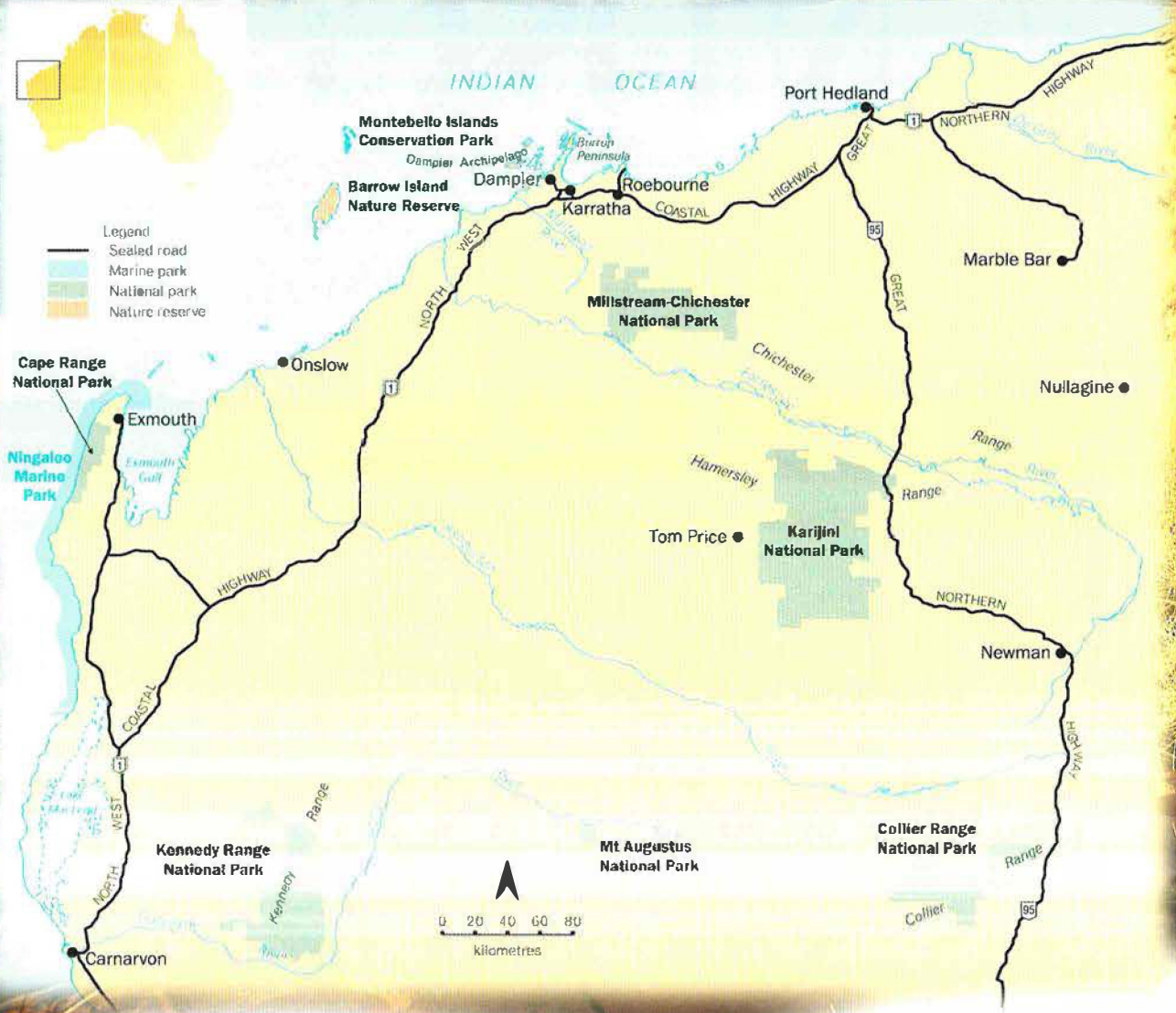
Soul of the  
desert

Between rock  
and a hard  
place

20 years of  
LANDSCOPE

Aboriginal rock art Wetland discoveries Geology of the Pilbara

# Discover the Pilbara



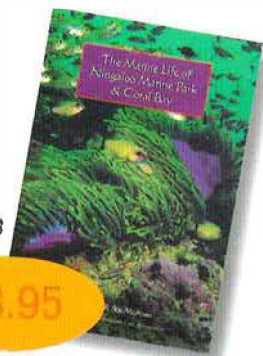
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There's also *The Marine Life of Ningaloo Marine Park and Coral Bay* with its detailed information and stunning photos showcasing the area's unique marine life.



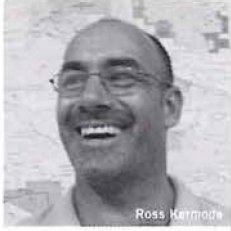
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Ross Kermode



Stuart Halse

# contributors

**Ross Kermode**, a Department of Conservation and Land Management officer, has been involved with joint management at Millstream-Chichester National Park for the past 12 months. Ross acknowledges the contributions of CALM Indigenous Trainee Rangers Ken Sandy and Kingsley Woodley, former Karratha CALM Parks and Visitor Services

Leader Dave Whitelaw, Millstream-Chichester National Park ranger staff, park council members and the Jaluwarlu Aboriginal Corporation for their collaborative effort in producing an article on joint management in the Pilbara and for working positively together to conserve the environmental and cultural significance of the country into the future.

**Stuart Halse** has been with CALM since 1985 and is a Senior Principal Research Scientist. He began his professional career working on bats and ducks, but is now involved in many aspects of wetland policy and ecology, including surveys of aquatic invertebrates and waterbirds across the State and taxonomic work on crustaceans.

## editor's letter

The lure of the Pilbara was summed up for me when a friend described the itinerary planned for an overseas visitor with only a week to spend in Western Australia: a two-day drive to enjoy a day and a half in Karijini National Park, then back to Perth and the airport.

Karijini is spectacular. Stretching over more than 600,000 hectares, the State's second largest national park is well known for its breathtaking gorges and the red earth of its spinifex country. Add the purple mulla-mulla wildflowers and huge termite mounds and the park seems typical Pilbara country.

But as you'd imagine in an area about the same size as Victoria, the Pilbara offers quite a range of destinations and experiences, from coastal areas such as Ningaloo Marine Park with Australia's largest fringing reef, to the Burrup Peninsula, the site of an incredible Aboriginal rock art gallery and also one of the powerhouses of Australia's current resources boom. There are deserts and dramatic rock formations, including some of the oldest geological features on the Australian continent, as well as wetlands and native palm trees that are the remnants of ancient tropical rainforests.

This issue of *LANDSCOPE* focuses on the Pilbara so we can explore the region's diversity in some depth.

Aboriginal artists have been depicting some of this diversity for thousands of years, with rock carvings showing animals, plants, people hunting and ceremonial images. Roz Hagan explains in *Making their mark: Pilbara rock art*, that there are thought to be at least 300,000 and possibly even more than a million motifs in the Dampier Rock Art Precinct.

Our cover depicts the work of another artist, long-time *LANDSCOPE* contributor Philippa Nikulinsky. The article *Soul of the desert* by Steve Hopper and richly illustrated with Philippa's work will help you to understand just what Alex Nikulinsky meant when he said at the end of a field trip: "We are in the front stalls of the universe".

The Department of Conservation and Land Management believes that seeing things from more than one perspective is vital to achieving its role successfully. *Learning together* by Ross Kermode, Ken Sandy, Kingsley Woodley and Judyrae Napier tells how Indigenous community members and CALM staff in the Pilbara are working together in national parks.

*Between a rock and a hard place* is another story about what we're learning in the Pilbara. The authors, Allan Burbidge, Norm McKenzie, Stephen van Leeuwen, Lesley Gibson, Paul Doughty, Nadine Guthrie, Brad Durrant and David Pearson, are part of the team working on a four-year biological survey of the Pilbara. The logistics of the survey are staggering, with 300 sampling sites across a 19 million hectare region. There are 15 pit traps at each site, a network that took five to six people about five months to install in the mostly rocky sites.

And you thought it took passion to drive four days for just a day and a half in Karijini National Park...

*Caris Bailey*

Caris Bailey  
Executive Editor

**Mike Scanlon**, a Senior Technical Officer, began working with CALM in 1993 researching the effects of fox control on red-tailed phascogales and numbas and was subsequently involved in AusRivAS, a program that used aquatic macroinvertebrates to measure river health. He is currently undertaking the stygofaunal work associated with the Pilbara Biological Survey.

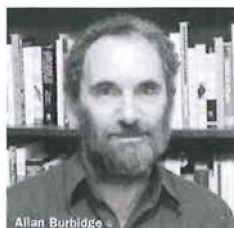
**Allan Burbidge** has been a survey biologist in CALM's Science Division since 1985, during which time he has worked on projects from the Nullarbor to the Kimberley and the south-west of WA. His particular expertise is in birds, but he has also worked with mammals, reptiles and plants. He is internationally recognised in relation to his involvement in research and management of threatened birds, especially on the south coast.

## also contributing . . .

Ian Walker, Philippa Nikulinsky, Steve Hopper, Roz Hagan, Ross Kermode, Ken Sandy, Kingsley Woodley, Judyrae Napier, Verna Costello, John Hunter, Craig Faulkner, Kerry Faulkner, Andrew Burbidge, Mike Scanlon, Jim Cocking, Harley Barron, Stuart Halse, Adrian Pinder, Joan Powling, Jane McRae, Stuart Miller, Norm McKenzie, Stephen van Leeuwen, Lesley Gibson, Paul Doughty, Nadine Guthrie, Brad Durrant and David Pearson.



Mike Scanlon



Allan Burbidge



**Cover illustration by Philippa Nikulinsky**

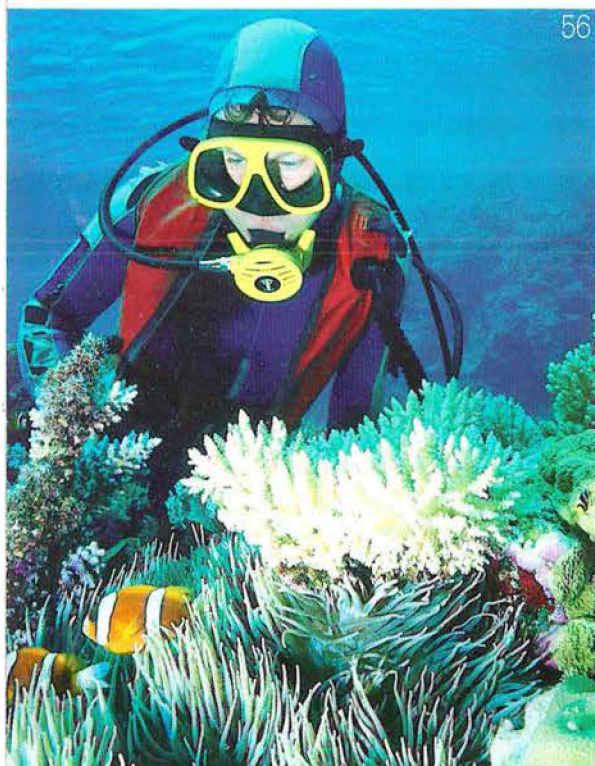
The lesser wanderer butterfly (*Danaus chrysippus* subsp. *petilia*) is known to sip the nectar from the porcelain-like flowers of the caustic bush (*Sarcostemma viminalis* subsp. *australe*), one of the few true succulent shrubs in the Australian desert. The lesser wanderer is a known resident of the Pilbara region and can be highly visible in open country, particularly after rain.

**Back cover photo Michael Pelusey**

Handrail Pool, in Karijini National Park, is the first pool visitors will encounter in Weano Gorge. The pool has a narrow entrance but opens into a shady, echoing cleft in rocks billions of years old.

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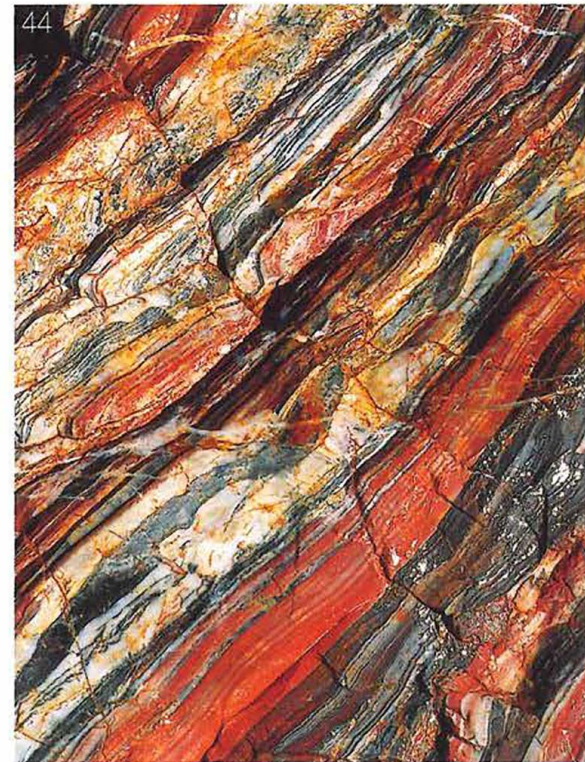
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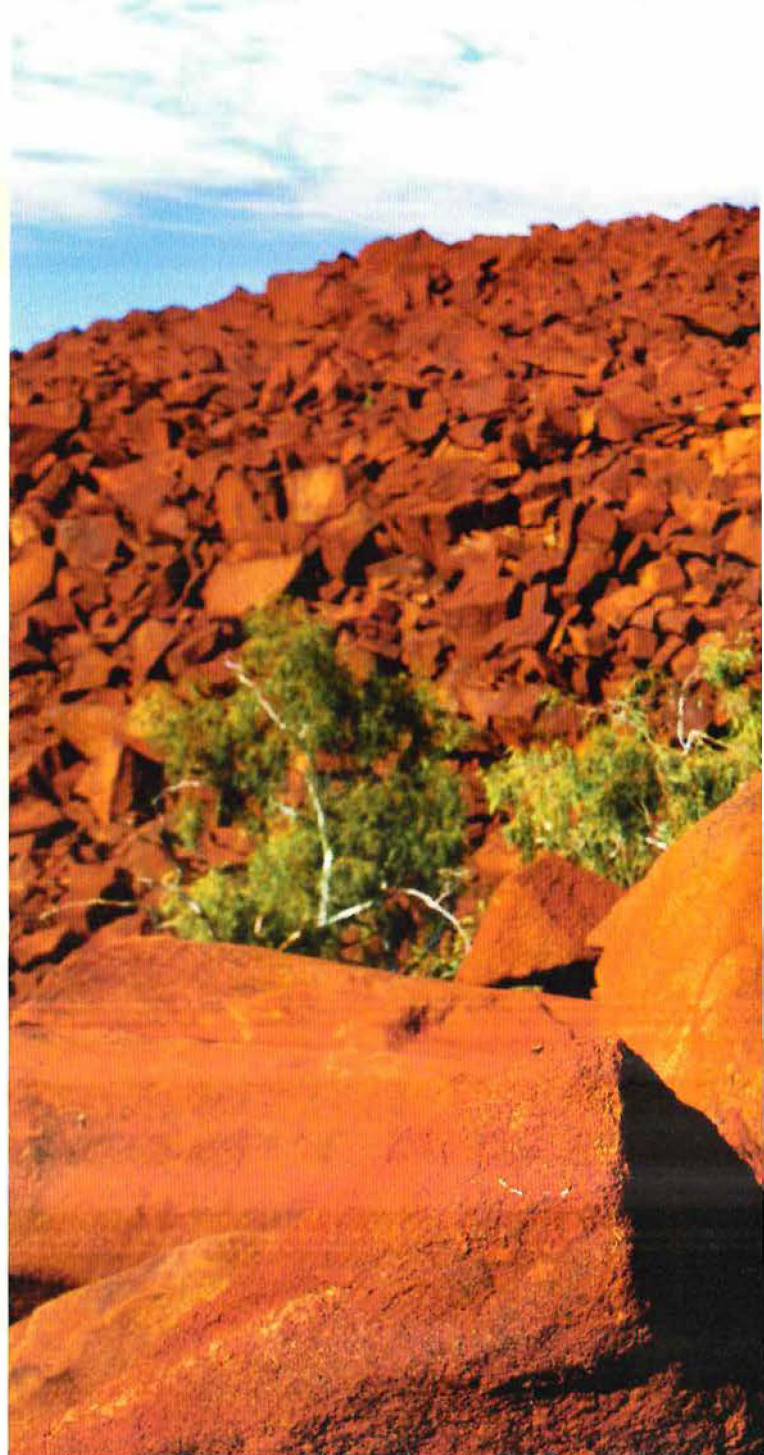
Published by the Department of Conservation and Land Management, 17 Dick Perry Avenue, Kensington, Western Australia.



# Making their mark: Pilbara rock art

The immense open-air rock art gallery of the Dampier Archipelago and Burrup Peninsula, near Karratha and Dampier in Western Australia's Pilbara region, is Australia's largest monument to Indigenous culture.

by Roz Hagan



**T**he Dampier Rock Art Precinct lies within the islands of the Dampier Archipelago including the Burrup Peninsula, where the ancient mountains of the Pilbara meet the Indian Ocean. At about 27 kilometres long and five kilometres wide, the Burrup Peninsula—formerly an island—is the largest landmass in the archipelago. Along with its associated islands and coastal strip, it is home to at least three threatened animal species and 39 threatened or endemic plant species. A variety of habitats exist in this semi-arid region, including sandy beaches, rocky shores, saline mudflats and areas of mangrove swamp. The massive gabbro and granophyre boulder

piles form the archipelago's most distinctive topographic feature, ranging in colour from an orange-red to a deep purple, giving the landscape a unique and characteristic appearance.

## History

From the time when 'the world was soft' (creation) until the 1860s, the Dampier Archipelago was the spiritual and literal home of the Yaburara people, close relations of the Ngarluma. However, because of the archipelago's ceremonial importance and spiritual ambience, many people from other tribes were attracted to the area. In 1868, 26 Yaburara people were murdered on the islands in a series of

raids, which became known as the Flying Foam Massacre. These incidents caused enormous losses to the Yaburara people and, in the following period, the area lay practically abandoned until the early 1960s, when substantial iron-ore deposits were discovered in the Pilbara region. Hamersley Iron subsequently established the town of Dampier, which has a harbour and iron-ore processing facilities. Ironically, the Dampier site was chosen to avoid damaging the smaller rock art concentration at the first choice of Depuch Island, as it was claimed that no rock art existed in the area. The massive concentration of many hundreds of thousands of figures was 'discovered' between 1960 and 1970.



The Burrup Peninsula was originally an island known as 'Dampier Island', and prior to that was known as Murujuga, meaning 'hip bone sticking out'. In the 1960s, a causeway was built connecting the island to the mainland and, in 1979, it was renamed after the island's highest hill, Mount Burrup. During the early 1980s, approximately 1800 decorated boulders were removed from the site of the North West Shelf gas processing facility near Withnell Bay and placed in an enclosure near Hearsons Cove, thus removing them from their historical context and restricting access to them. Since then, construction projects, industrial developments and associated

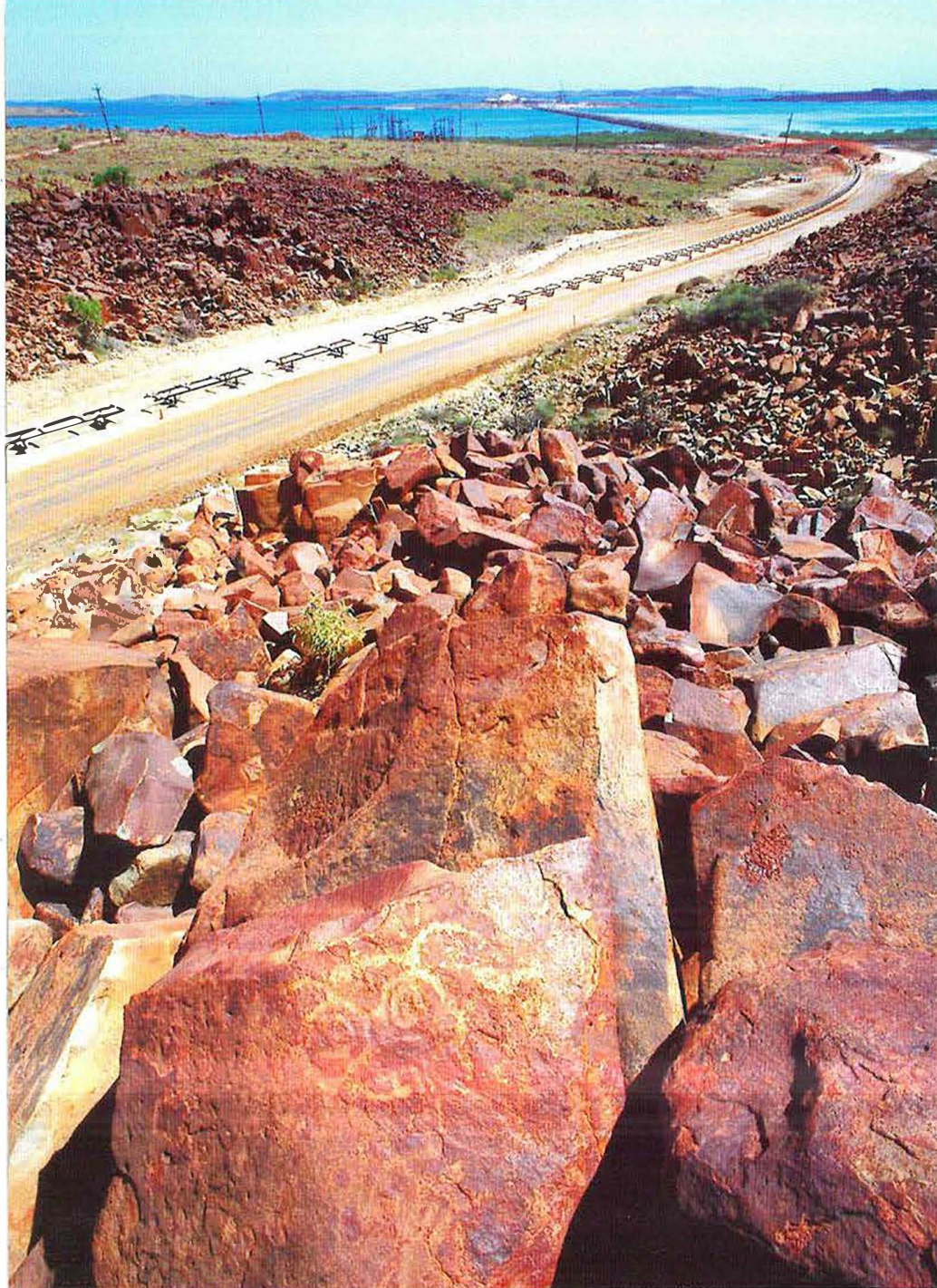
infrastructure have caused the loss of thousands of images.

### The art

The Dampier Rock Art Precinct has the largest concentrations of petroglyphs (rock carvings) in the world, with estimates of the number of motifs ranging from 300,000 to well over a million images. Petroglyphs occur in other parts of Australia, but nowhere do they even remotely approach those of Dampier in terms of sheer numbers. Some of the petroglyphs in the Dampier region may be up to 18,000 years old. Most of the engravings are on boulders near watercourses and rock pools, along

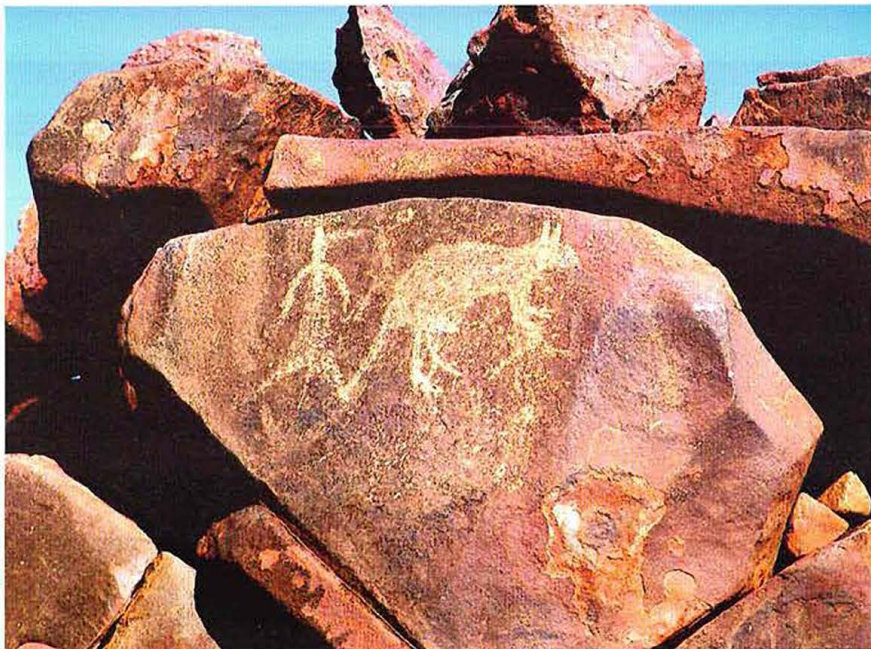
**Above** Petroglyphs decorate many of the rocks of the Dampier Rock Art Precinct in the Burrup Peninsula.  
*Photo – Michael Pelusey*

the shoreline, near stone resources suitable for making artefacts and along geological fracture lines that provide the most practical corridors for movement from one area to another. The majority have been engraved on granophyre, the predominant rock in the area, while only a few gabbro and granite boulders have been used, probably because of their coarser texture.



Petroglyphs are formed using a wide range of tools, from fine points to wide chisels. Art in the Dampier area can be generally divided into two types—shallow graffiti and deeply engraved. The shallow graffiti designs are formed by removing the weathered surface layer or crust of the rock, exposing the lighter colour underneath. Over time, colour gradually returns to the engraved surface (repatination) and, because there is little depth to the engraving, the petroglyphs sometimes become almost invisible. The deeply engraved designs consist of grooves, usually between five and 12 millimetres deep, formed by pecking, scoring or rubbing and, although they also repatinate, the depth to which they are carved means they retain greater visibility.

Images engraved into rocks of the area serve a variety of purposes. Some are part of increase sites for particular species or events. Senior members of the community were responsible for maintaining the sacred significance of sites within their country, and for performing 'increase rites' and other rituals that ensured the perpetuation of the animal and plant species and the continuity of the seasons. Other images relate to Aboriginal ancestral creation beings, spirit figures, ceremonies and rites of passage. Some ceremonial and rites of passage places are specifically for men or women, while others are open to all. Although many engravings have spiritual significance, others were representations of everyday life or events. The Aboriginal artists depicted a wide range of subject matter and the Dampier precinct has a high percentage of marine-based motifs including whales, dugongs, fish, turtles and seabirds. Other designs represent wallabies, kangaroos, snakes, echidnas, people hunting and sacred images.



**Above left** Modern industrial infrastructure skirts a scree pile of ancient art.  
*Photo – Bill Belson/Lochman Transparencies*

**Left** Many rock engravings represent everyday life, like hunting kangaroos.  
*Photo – Michael Pelusey*



The Dampier Rock Art Precinct also features significant stone arrangements (single standing stones or clusters of stones). Standing stones were used to indicate the existence of fresh water, other natural resources, the site of a special event or a place of spiritual significance. Shell deposits (middens) and grinding patches are also scattered throughout the area.

### Industry and monitoring

The Dampier region houses some of Australia's largest industries, including the North West Shelf Project, Pilbara Iron, Dampier Salt and the new Burrup Fertilizers project. A number of other projects are proposed on the Burrup Peninsula. The heritage value of the Dampier Rock Art Precinct is clearly threatened by ongoing industrial development, through direct disturbance and destruction of heritage sites. Despite almost 40 years of industry in the region, no comprehensive study of the cultural heritage assets of the region had been commissioned. However, in 2003 the Western Australian government signed an agreement with three Native Title claimant groups:

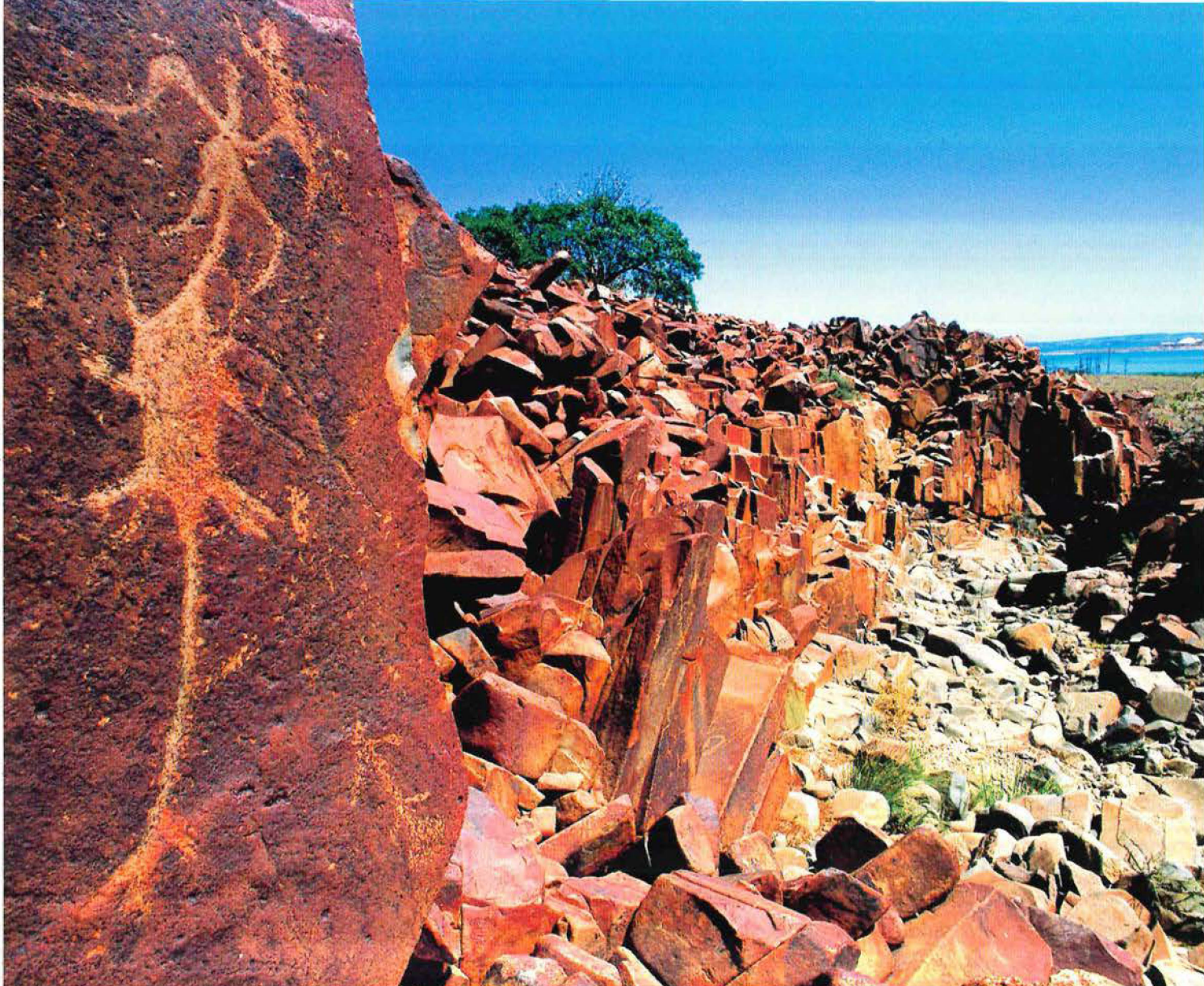
the Wong-Goo-T-Oo, the Ngarluma Yindjibarndi and the Yaburara Mardudhunera people. The agreement extinguished their previous Native Title claims over the industrial and residential areas of the Burrup Peninsula and other land required by the State, but granted them greater control over the non-industrial portions. As a condition of the agreement, the State agreed to commission a Rock Art Study, to identify the impacts of industrial pollution and to prepare a management plan for the area.

As a result, CSIRO, in collaboration with Murdoch University, has been commissioned to complete the first study into the possible effects of industrial emissions on Aboriginal rock art of the Dampier Rock Art Precinct. The project is to be managed by the independent Burrup Rock Art Monitoring Management Committee. The four-year monitoring program, supported by local Aboriginal communities, is interdisciplinary and ambitious in scope. Ambient concentrations and deposition of pollutants will be monitored at seven sites, on the northern Burrup, Gidley

**Above** The iconic spinifex, coolibah and red rocks of the Burrup Peninsula glow orange in the late afternoon.

*Photo – Carolyn Thomson-Dans/CALM*

and Dolphin islands, and at sites closer to sources of industrial pollution. Data collected from each site will include levels of nitrogen dioxide, sulphur dioxide, ammonia, BTEX gases (benzene, toluene, ethylbenzene and xylene), aerosols such as air pollutant particles and dust, as well as rainfall, temperature, humidity, wind speed and wind direction. Microbiologists will examine the role microbes play in rock deterioration, and test whether increased levels of nitrogen or sulphur from emissions promote additional microbial activity. Geochemists and archaeologists will assess the amount of weathering on the rocks by analysing physical, mineralogical and chemical changes of the rocks, using optical and scanning electron microscopes. A mineral mapping tool will also be used to record subtle colour and mineral



**Above** Petroglyphs are created by carving into the weathered surface rock with a range of tools.

*Photo – Bill Belson/Lochman  
Transparencies*



**Left** Aboriginal carvings of emu footprints at Deep Gorge in the Burrup Peninsula.

*Photo – Jiri Lochman*

spectral changes in the surface minerals over time between engravings and the adjacent undisturbed rock surfaces.

The collected gas, particle and weather data will be used to establish the origin of air pollutants and dust, to address concerns about possible effects of current and future industry emissions on the art, and to allow recommendations for the ongoing preservation and

conservation of the rock art of the Dampier Archipelago region.

Although many thousands of images have already been destroyed or moved from the precinct, it is now hoped that, through careful management and cooperation between industry, government and the local community, the rock art will survive for many thousands of years to come.

Roz Hagan is a project officer in CALM's Pilbara regional office. She has a background in environmental science and has been working as part of the Nature Conservation Program team in the Pilbara. She can be contacted through Stephen White, Program Leader for Nature Conservation in the Pilbara, on (08) 9143 1488 or by email ([stephenw@calm.wa.gov.au](mailto:stephenw@calm.wa.gov.au)).

# bookmarks by Verna Costello

## Urban Antics – Tales of an urban naturalist

**Author:** John Hunter  
**Publisher:** WA Naturally Publications  
**148 pages, soft cover**  
**ISBN: 0 7307 5560 6**  
**RRP: \$16.95**

It has long been a matter of debate among CALM's editors regarding where in *LANDSCOPE* regular readers would turn when they first pick it up. It is this editor's contention that it would be *Urban Antics* at the end of the magazine. Here, readers are assured of the same accurate, factual information found elsewhere in *LANDSCOPE*, but *Urban Antics* is laced with the author's inimitable, but irreverent humour and pithy, insightful writing style. Thus fortified, these readers are then agreeably primed for the rest of *LANDSCOPE*'s excellent articles.

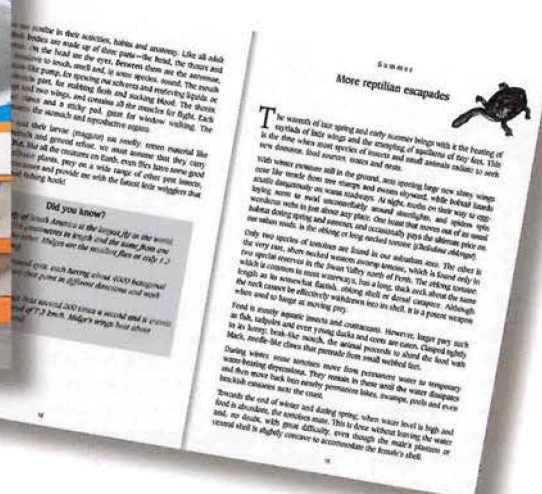
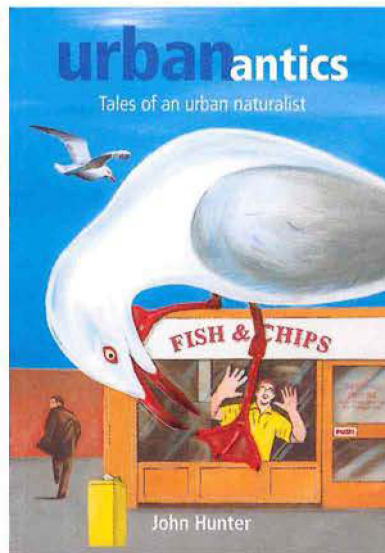
There are 68 tales of Western Australia's native animals and plants and their habitats. These are found under chapters ordered by season and describe what readers are most likely to find in their gardens and backyards.

*Urban Antics* is available from most major bookshops, by phoning WA Naturally Publications on (08) 9334 0333, faxing (08) 0334 0498 or online at CALM's NatureBase website ([www.naturebase.net](http://www.naturebase.net)).

## Garruragan – Yindjibarndi Fauna

**Published and compiled by Juluwarlu Aboriginal Corporation**  
**87 pages, soft cover, full colour**  
**ISBN: 1875 946 543**  
**RRP: \$24.95**

The Juluwarlu Aboriginal Corporation is to be congratulated on this ambitious undertaking, in which the text appears first in the Yindjibarndi language (one of the Aboriginal languages of the Pilbara), then in English. The names of native animals are also indexed separately in Yindjibarndi, English and by their scientific names. Help is also provided with the pronunciation of



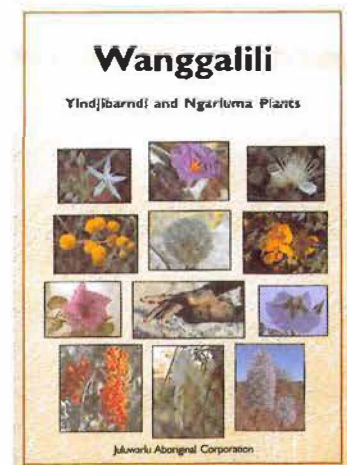
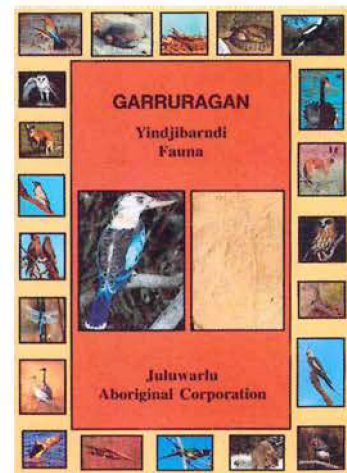
Yindjibarndi words. The animals are separated into sections describing birds, reptiles, mammals, insects, fish and amphibians.

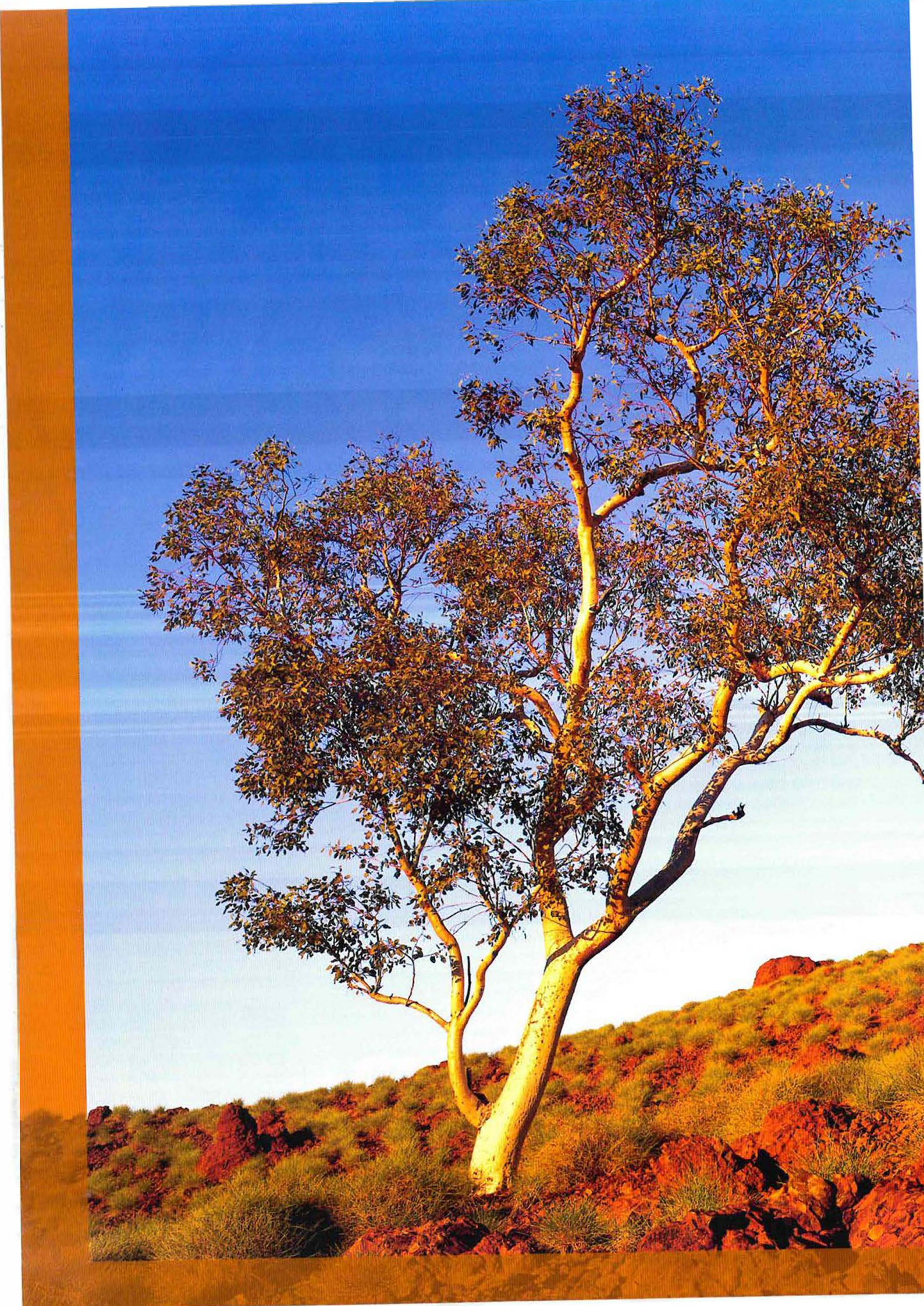
## Wanggalili – Yindjibarndi and Ngarluma Plants

**Published and compiled by Juluwarlu Aboriginal Corporation**  
**128 pages, soft cover, full colour**  
**ISBN: 1875 946 543**  
**RRP: \$24.95**

The text is in English only, except for the headings, which give the Yindjibarndi, Ngarluma and the English plant names. Plants are described under separate headings: artefacts and ceremony, bush medicine, and bush foods. An index of medicinal uses includes remedies for colds, flu, toothache, and heart and blood conditions, among other ailments. Another index details a variety of foods. There are also separate indices of common names and botanical names. To aid identification, these descriptions are supported by numerous colour photographs.

The books are available from Juluwarlu Aboriginal Corporation, PO Box 111, Roebourne WA 6718 ([juluwarlu@bigpond.com](mailto:juluwarlu@bigpond.com)).





# Between rock and a hard place

rich biological patterns amongst ancient red rocks

**A mammoth, four-year survey of plants and animals of the vast Pilbara region is now underway, and many new discoveries have already been made.**

**by Allan Burbidge, Norm McKenzie, Stephen van Leeuwen, Lesley Gibson, Paul Doughty, Nadine Guthrie, Brad Durrant and David Pearson**



**T**he Pilbara is awesome. Much of the Pilbara is rock. Many of these rocks formed during the Archean between 2.5 and 3.6 billion years ago, making them some of the oldest rocks on the planet.

Because of its geological history, and the impact of this history on plants and animals that inhabit the area, the Pilbara is considered a natural region both geologically and biologically—the Pilbara biogeographic region corresponds closely with the Pilbara Craton, one of Australia's major geological building blocks.

Separating the ancient stony ridges, abrupt escarpments and steep scree slopes are geologically more recent areas—rolling stony plains of alluvial clays, silts, sands and gravels. Gorges, picturesque rockholes and grassy

floodplains occur along intermittently active river systems, such as the Fortescue and Oakover, that drain the uplands. Along the mangrove-fringed western margin of the Pilbara there are extensive coastal flats and floodplains, such as the Roebourne Plains and the De Grey River delta.

The Pilbara is enormous, with an area almost the size of Victoria. Almost everywhere, reddish rocks and soils predominate, as does spinifex (*Triodia*) grassland. The 18 *Triodia* species in the Pilbara range from small rounded hummocks up to 20 centimetres high to large domes more than 1.5 metres high and two or more metres across. However, there is also an intriguing mix of tidal flats, mangroves, open plains, grassland savannas, woodlands, mountain ranges, gorges and temporary tropical rivers, resulting in similarly intriguing mixes of plants and animals, many of which are poorly known.

There are about 1730 described plant species in the Pilbara, with another 350 yet to be described. Currently, 150 plant species are known only from the Pilbara ('endemics'), but it is estimated that another 100 are still to be described, which will put the number of Pilbara endemics

somewhere in the vicinity of 250 species. Grasses, peas, daisies and wattles are the most common plant groups, exemplified by the 130 or so wattles recorded in the region. Although most pictorial representations of the Pilbara either capture the iconic white-trunked snappy gum (*Eucalyptus leucophloia*) over spinifex with a turquoise skyline or a tranquil river pool lined with river red gums (*E. camaldulensis*), eucalypts are not well represented.

### Pilbara Biological Survey

Despite numerous biological surveys in the Pilbara over the years, particularly in the iron-rich Hamersley Range, they have been restricted in area, or confined to a relatively narrow range of plants or animals. They have furnished excellent lists of the rich array of flowering plants and vertebrate animals found in the region. However, assemblages of these species are not well documented and the distribution and habitat preferences of many species across the Pilbara are still largely unknown, particularly for invertebrates and short-lived plants.

Despite the considerable work already done by the Department of Conservation and Land Management

*Previous page*

**Main** A snappy gum in the rocky landscape of the Hamersley Range.

*Photo – David Bettini*

**Inset** CALM's Tristan Farmer and Tom Smith adjust a drift fence on a pit trap line.

*Photo – Jim Rolfe*

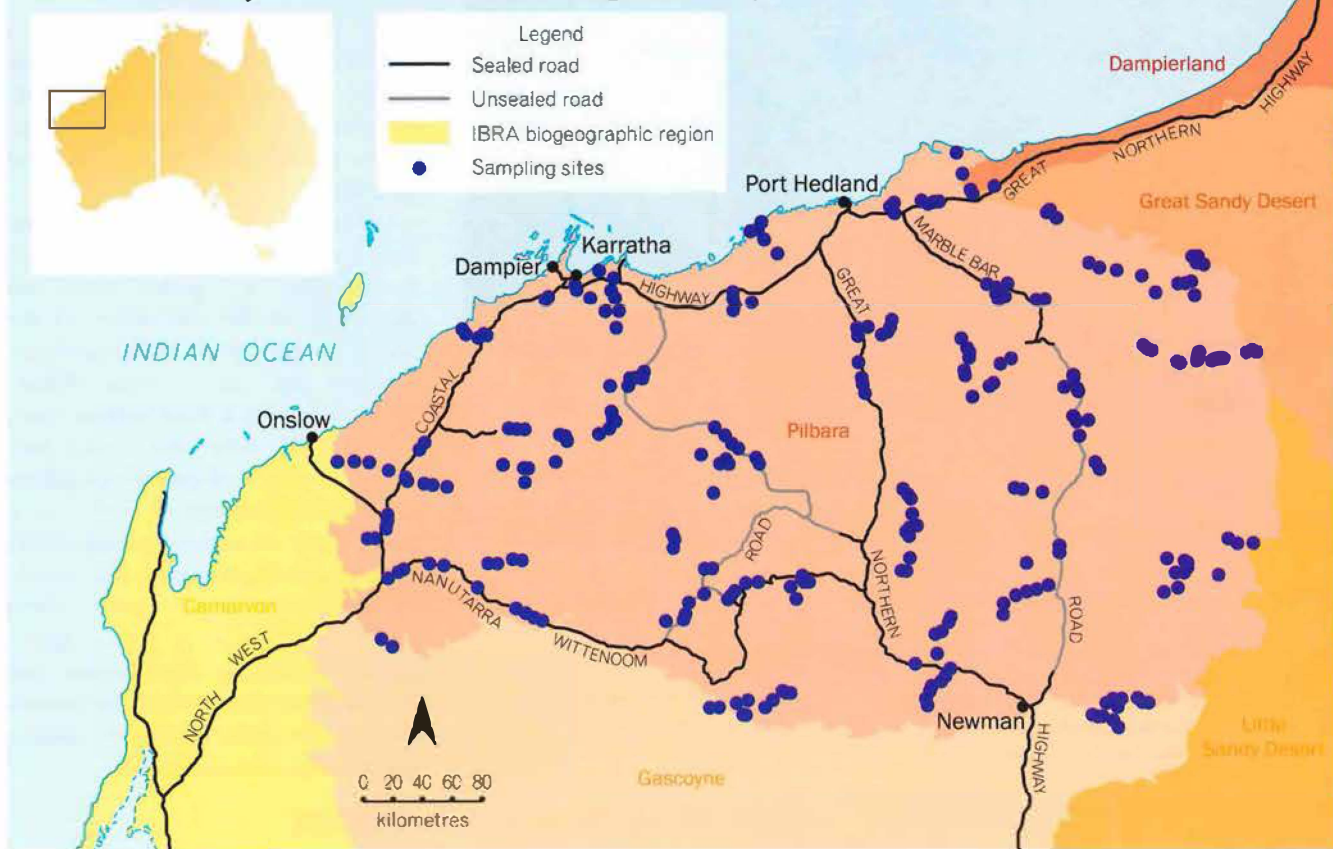
**Below** Spinifex.

*Photo – Jiri Lochman*





## Terrestrial survey sites for the Pilbara Biological Survey



(CALM), the WA Museum and others, there was no regional context in which to assess results of studies at individual sites. This made it difficult, for example, to assess the regional significance of a CALM-managed reserve, or to assess the conservation significance of a site proposed for a resource development. It was time for a major survey across the whole region. The Pilbara Biological Survey commenced in 2003, to survey terrestrial plants and animals, wetland plants and animals (see 'Wetlands of the Pilbara' on pages 24-29) and stygofauna (see 'Beasts of the Underworld' on pages 51-55). It is likely to cost about \$12 million, funded by the State government (primarily through CALM with assistance from the WA Museum), the Commonwealth government (through the Natural Heritage Trust) and industry, in particular Pilbara Iron, Dampier Salt and Straits Resources.

Major regional surveys already completed in other parts of WA include the Wheatbelt, eastern Goldfields, Nullarbor, Kimberley rainforests and southern Carnarvon Basin (see 'Patterns in nature', *LANDSCAPE*, Summer 1995-96).

In previous surveys of the Pilbara, the rocky nature of much of the ground limited pitfall trapping, due to difficulties in digging holes. This survey set out to sample all the major geological and landform surfaces, including the hard ironstones, granites and basalts.

As well as uncovering new information about plants, reptiles, frogs, birds, mammals, spiders, scorpions, beetles and aquatic invertebrates, the survey will allow the development of a framework to guide sustainable land-use and conservation planning in the Pilbara; help to assess the region's conservation reserve system; improve environmental impact assessments; and verify information about distribution of threatened species and ecological communities.

### On the ground

The sheer size of the Pilbara biogeographic region—19 million hectares—provides a huge challenge in establishing sampling sites, undertaking sampling and detecting biogeographic trends (the way plants and animals are distributed in relation to climatic, geological, historical and biotic

characteristics of the landscape). Because of this, and the limited number of skilled staff available at any one time, the survey will take several years. The terrestrial component began in 2003 and aims to report by mid-2007.

Three hundred sampling sites across the Pilbara (map) were selected to represent the major geological formations and landform types, encompassing a cross-section of soils, climate and vegetation types. The sites are on pastoral leases, in national parks including Karijini and Millstream-Chichester (Miliyana), on recently-acquired pastoral leases, newly-created conservation parks, Aboriginal lands and unallocated Crown land. Many are on mining tenements and some are adjacent to active mining operations. Extra sites, including hilltops and other locations, are also being sampled for plants.

Establishing the pit traps took a team of five to six people, led by CALM Senior Technical Officer Jim Rolfe, about five months in mid-2003 and mid-2005, using shovels, crowbars, drills and, often, blasting the hard rock to create holes for pit traps. At each site, they installed two 50-metre rows of



five vertebrate pit traps, with a low wire fence between pits to guide animals in when the sampling teams opened the pits. Five invertebrate pit traps were also installed at each site.

The first 150 sites were sampled for small ground-dwelling frogs, reptiles and mammals in October 2004 and May 2005, and sampling of the second set of 150 sites began in September 2005. In each sampling period, four teams—usually consisting of three to four zoologists—each take responsibility for sampling 35 to 40 quadrats. Each quadrat is trapped for seven days and nights, in each of two seasons. Ground vertebrates are identified and released, or kept as voucher specimens for reference and further study at the WA Museum. Each site is surveyed for birds, and any breeding noted. Terrestrial invertebrates are trapped in pits at the same sites.

Selected sites are surveyed for bats.

At each site, soil samples are collected to determine soil chemistry and structure, and records are made of other physical and biological features, such as landform and vegetation structure.

A project this big has to be a collaborative venture. So far, 40 people have been directly involved in fieldwork for the terrestrial zoology component of the project. Most are CALM staff or consultants, some are from the WA Museum, and eight have been volunteers. In addition, about a dozen experts from other institutions have helped to identify specimens, particularly invertebrates.

### Frogs and reptiles

Nine frogs and more than 120 reptiles are known from the Pilbara. Lizards are exceptionally diverse, with

more than 20 endemic species, a number likely to double when new species from the survey are formally described. One frog species is endemic to the Pilbara, with another awaiting description.

More than 100 species of reptiles have been recorded on the sites so far. A distinctive new gecko species was discovered in the first week of the survey in an area of the large rocky boulders that cap so many Pilbara ranges but which have seldom been sampled. We have also found two endemic species of pebble-mimicking dragons (*Tympanocryptis*) and several new species of sand-swimming skinks (*Lerista* and *Eremiascincus*). The survey has uncovered cryptic species using genetic techniques in several gecko groups, including *Diplodactylus* and *Celhyra*. It has also expanded the known distributions and clarified the habitat relationships of many species.

### Mammals

Mammal bones from sinkholes and caves are being identified by Alex Baynes of the WA Museum, to document the Pilbara's original mammal fauna. At least 57 species were originally present, of which 11 are now extinct in the region—information that is important for reintroduction programs. Three others—the water rat, pale field-rat and western chestnut mouse—persist only on the region's islands. Most of the regionally extinct species are either small macropods, such as the boodie, or large rodents, such as the long-tailed hopping-mouse.

We have so far recorded 17 small mammal species in the Pilbara (excluding bats): nine carnivorous



**Above left** Clare Stevenson, from the WA Museum, checks a pit trap for small vertebrates.

Photo – Allan Burbidge

**Left** Botanist Greg Keighery records plants collected by Sue Patrick and Margaret Langley from a terrestrial biodiversity site on a red sand dune in the Cane River Conservation Park in the south-western Pilbara.

Photo – Stephen van Leeuwen



**Above** The long-tailed dunnart is an uncommon, patchily distributed species found in rocky areas with hummock grasses and shrubs.

Photo – Jiri Lochman

marsupials (dasyurids) and eight rodents (seven native species and the introduced house mouse). The western pebble-mound mouse (*Pseudomys chapmani*) is now largely restricted to the Pilbara. The first indication that a pebble-mound mouse may be in the area is a distinctive mound of small pebbles, which it gathers to form a nest.

Dasyurids include three species endemic to the Pilbara: the commonly caught Pilbara ningauai (*Ningauai timealeyi*), a false antechinus (*Pseudantechinus roryi*) and at least one undescribed planigale species. Ningauis and planigales can be confused, but their behaviour is a first clue: the ferocity of the planigales contrasts with the tranquillity of the ningauai. Another dasyurid, the little red kaluta (*Dasykaluta rosamondae*), resembles a little red bear and behaves like one as well. It is best to be attentive when handling one of these! Its distribution extends just beyond the Pilbara. The long-tailed dunnart (*Sminthopsis longicaudata*), a striking-looking animal, is rarely caught but perhaps its patchy distribution is to blame. Two false antechinus species (*Pseudantechinus roryi* and *P. woolleyae*) previously recorded in the Pilbara also appear scarce, but are

able to jump—having adapted to massive rock outcrops—so can probably escape from pitfall traps.

The occurrence of these mammals appears to be related to characteristics of their local environment. Certain species prefer areas with a cracking clay surface: the Lakeland Downs mouse (*Leggadina lakedownensis*) and striped-face dunnart (*Sminthopsis macroura*) shelter in the deep cracks. Some, such as the common rock-rat (*Zyzomys argurus*), shelter in rocky outcrops. Others, like the ningauai, seem to turn up almost everywhere. Clues to the habitat preferences of some species come from their external anatomy. Rock-dwelling species either have striated footpads (long-tailed dunnart), or large, soft footpads (common rock-rat). In contrast, some species adapted to sandy surfaces, such as the lesser hairy-footed dunnart (*Sminthopsis youngsoni*), have hairy pads that act like running spikes. In the final analysis, we aim to further expose relationships between species occurrences and habitat attributes, including the influence of climate, then use this information to predict where else in the Pilbara these species may be present.

Bats are being surveyed at more than 50 sites, with 17 bat species known from the Pilbara. The two flying-foxes are by far the largest. The others are microbats, which use high frequency calls to avoid obstacles and locate prey during their night-time forays. These search-mode calls are

species-specific and a call dictionary is being collected using minidisc recorders. Night vision equipment, a portable radar gun and a video camera are used to gather data on flight speed, manoeuvres and habitat use, the first ecological study of structure in the region's bat fauna.

We have found that Pilbara microbat communities fall into four ecological types: interceptors that catch their flying prey during a direct high-speed pass, such as the white-striped bat; agile species that can out-turn their prey in open habitats (common sheath-tailed bat) or in cluttered air-spaces (orange leaf-nosed bat); ambushers that wait on a perch then accelerate to overtake prey that flies past or pounce on prey that walks past (greater long-eared bat and ghost bat); and slow, but manoeuvrable, gleaners that take prey from vegetation or the ground (lesser long-eared bat and Arnhem Land long-eared bat). Not all of these occur at any one site. Some species are restricted to the region's mangrove communities, others live close to riverine situations, while one is only present in the region in winter.

## Birds

The Pilbara is home to about 250 non-oceanic bird species, and is especially rich in birds adapted to arid areas. Pilbara birds don't seem to have as close a relationship to the ground surface as the mammals, but vegetation



**Above** The dangerously venomous Pilbara death adder.  
*Photo – Ron Johnstone*



**Left** The painted finch feeds and breeds in rocky areas with spinifex.  
*Photo – Jiri Lochman*

structure is important. For example, singing bushlarks are common on grassy plains on a range of soils. River systems, especially where there are river red gums and cadjeputs, have the greatest number of bird species—they are like elongated oases in a desert of rocks and spinifex. Some species, including peaceful doves, blue-winged kookaburras, black-tailed treecreepers, star finches and Torresian crows, are more or less confined to these areas. Others, such as spinifex pigeons and painted finches, are typically found among spinifex on rocky slopes, but come in to pools to drink. Still others, such as the spinifexbird and striated

grasswren, are normally only found in dense, healthy stands of spinifex.

### **Creeping crawlies**

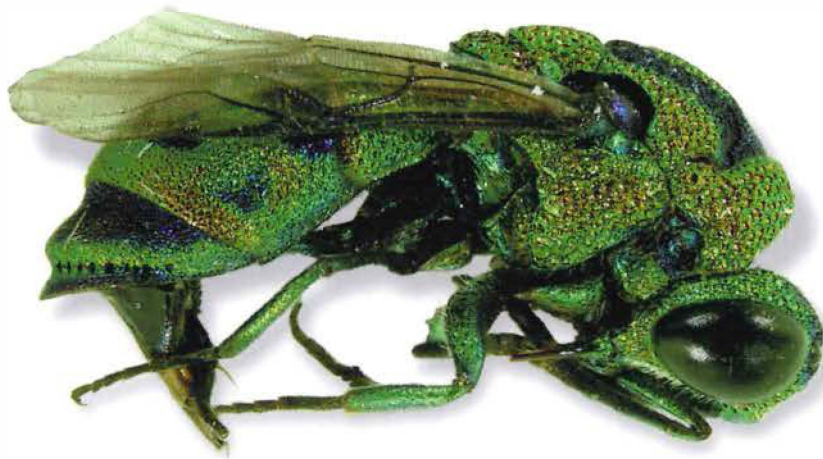
It is already clear that many new species of terrestrial or aquatic invertebrates will be discovered as a result of the survey, and many species are likely to be confined to the Pilbara.

Twelve months of sampling invertebrates at the first 150 sites has produced about 100,000 individual specimens. These need to be sorted into major taxonomic groups in CALM's terrestrial invertebrate survey laboratory. Some of these groups, particularly beetles and spiders, are

then identified with input from the WA Museum and other specialist organisations, such as the Australian National Insect Collection in Canberra. Other groups, such as wasps, are sent directly to specialists in other organisations.

Just sorting this material into major groups has taken about five person years, and we still need to identify the great majority of these animals to species level. A broad range of groups has been caught, including ants, land snails, millipedes, mites, centipedes, pseudoscorpions, mantids, grasshoppers, crickets and termites. These groups, by virtue of their general ground-dwelling habit and fairly low mobility and dispersal capabilities can show highly localised distribution and specific habitat preferences across the Pilbara.

Because the mammoth task of sorting and identifying specimens is not yet complete, we have not yet been able to analyse any data, but there are some interesting preliminary results. The native bee and wasp fauna is highly diverse, with many groups parasitising other insects, spiders and even other wasps! Families represented include bees, stinging wasps, spider



wasps, mud-dauber wasps and magnificent metallic wasps.

More than 35 families are represented in the rich and diverse assemblage of beetles. So far, we have identified the weevils, ground beetles, pie dish beetles and dung beetles (more than 30 species in 12 genera). Several species of dung beetles previously considered rare or restricted in distribution have been found at several localities in large numbers. Many new forms of ground beetles, including charismatic tiger beetles, are turning up regularly. So far, we have identified six species of tiger beetles and at least 80 species of other ground beetles. Many are small and cryptic, with highly restricted ranges within the survey area. Some are only otherwise known from widely disparate localities in the Northern Territory or desert regions of north-east South Australia.

Bugs, slaters, cockroaches and scorpions are yet to be examined in detail, but seem to be diverse across the region if not particularly rich at any one site. Various species also appear to have restricted ranges.

We expect ground-dwelling spiders to comprise 20 to 25 families, with around 250 to 300 species, about half the richness of the Wheatbelt. Jumping spiders (Salticidae) and ant-eating spiders (Zodariidae) have dominated previous surveys, comprising around a third of all spider species recorded. The Pilbara survey is following the same pattern, with at least one of these two families being represented at every site, commonly by more than two species. Other common families include miturgids (large burrowing spiders),

lamponids (which include the white-tailed spider), wolf spiders and oonopids (very small, orange spiders). Local endemism amongst spiders seems to be lower than in previous surveys, with around 15 to 20 per cent of species appearing to be restricted to a local area (compared to 30 per cent in the Wheatbelt). Most species seem to be widespread throughout the Pilbara but many of these are likely to be endemic to the region.

Because there has been so little invertebrate collecting in the Pilbara in the past, large numbers of species across all of the groups examined cannot be easily identified, and most of them will be unknown to science. This makes the process very exciting but also especially time consuming. Many taxonomic issues need to be ironed out before this huge dataset can be analysed.

### Next steps

The survey is also recording plants and vegetation communities of the Pilbara, but results from this extensive program are still some way off due to a rainless summer last year. Nevertheless, the botanical survey team has recorded numerous new populations of Priority flora and species new to the Pilbara and Western Australia, including at least one wattle from the east Pilbara. The team has also extended the known ranges of many other species.

Botanical and zoological sampling will continue until spring 2006. After this, there will be many hours of work sorting and identifying specimens, followed by analysing and interpreting data. By mid-2007, a diverse set of scientific publications will have been



**Above left** A new species of wasp from Millstream-Chichester National Park.  
*Photo – Nicholas Stevens*

**Top** An undescribed weevil species found during the biological survey.  
*Photo – Rolf Oberpreiler*

**Above** Allan Burbidge checks a pit trap.  
*Photo – Allan Burbidge*

prepared, with work underway to further distil the enormous amount of information into a form that can be understood and used by anyone with responsibilities or an interest in land management in the Pilbara. For years to come, the information and specimens collected through the survey will provide researchers at CALM, the WA Museum, and other institutions around Australia with material to further investigate the taxonomy, systematics, ecology and biogeography of the Pilbara plants and animals.

Allan Burbidge, Norm McKenzie, Lesley Gibson, Nadine Guthrie, Brad Durrant and David Pearson are all zoologists based at CALM's Wildlife Research Centre, Woodvale. Stephen van Leeuwen is a CALM botanist based at Karratha. Paul Doughty is Curator of Herpetology at the WA Museum.



A prestigious nature and landscape photography award is inviting entries for its 2006 competition. Initiated by Perth surgeon Stuart Miller in 2004, ANZANG Nature aims to encourage nature and wilderness photography in the region encompassing Australia, New Zealand, Antarctica and New Guinea, raise public awareness of Australasia's unique natural heritage and assist conservation efforts.

**T**he ANZANG competition is tightly focused on Australasia's nature and its wilderness landscape. Now in its third year, the competition's categories include animal behaviour, animal portrait, botanical subject, underwater subject, wilderness landscape, threatened plants or animals, black and white photography and junior photography.

#### **A competition snapshot**

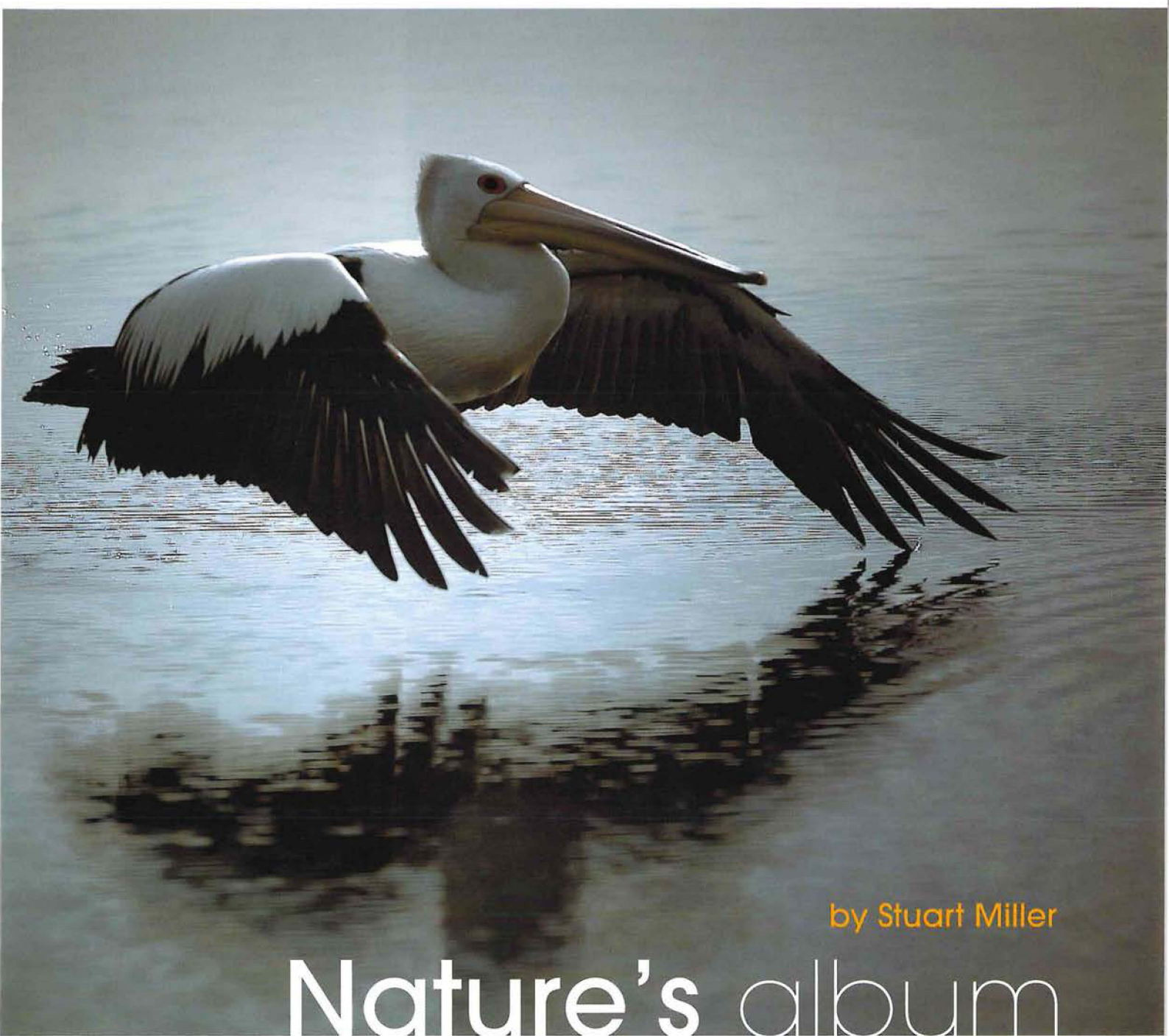
Last year's competition attracted 680 entries from some of the best photographers in Australia, New Zealand, France, the United Kingdom

and the USA. They were judged by a panel of professional photographers specialising in nature photography. ANZANG Nature's Chairman, Perth surgeon Stuart Miller, said that the quality of entries in the nine sections of the competition was very high. The style of many of the winning entries in 2005 was particularly artistic. The 2005 competition included two innovations in format: the new section, Interpretive Photography, where no limitation is placed on image manipulation, and the Portfolio Prize for the best six images entered by any one photographer.

#### **Digital era**

The spread of entries showed that digital photography is becoming an increasingly popular form of capturing images, with almost half of the winning and highly commended photographs taken on digital cameras. The exception was the Wilderness Landscape section, where the winning and highly commended shots were taken with film.

Unlike the year before, all sections of last year's competition were open to film and digital photography. This reflects the major, and ever increasing, impact that digitalisation is having on



by Stuart Miller

# Nature's album

all areas of photography, particularly among amateur and semi-professional photographers. Gone are the days where the cost of film and processing were major considerations for these groups, especially in nature photography, where it can be necessary for many frames to be shot to capture the desired moment.

## A winning shot

Against a field of dingos, pythons, damselflies and spectacular wilderness landscapes, a graceful pelican launching into flight won last year's ANZANG Nature and Landscape Photographer of the Year competition. The winning

pelican photograph, titled 'Flight' by Western Australian Kitchner Bain, was all the more remarkable as Bain took up photography only three years ago. WA photographers dominated in 2005, taking out the overall prize and the Underwater, Interpretive and Junior sections, a total of four out of the possible 11 major prizes.

The touring exhibition of the 63 winning and highly commended photographs, created from the competition, opened at the WA Museum on 15 September 2005, then toured the museum's regional branches before travelling to the eastern states.

**Above** 'Flight' was the overall winner of the ANZANG Nature and Landscape Photographer of the Year Award for 2005. The photographer waited at the edge of Lake Monger for more than an hour, with his camera ready, anticipating the pelican's launch into flight.

*Photo – Kitchner Bain*

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**Top left** 'The Survivors', the winner of the Interpretive Photography section, was taken shortly after a recent intense fire at Mount Manypeaks Nature Reserve, east of Albany, and was manipulated electronically by the photographer.

*Photo – David Boyle*



**Above left** Gideon Mettam took both the equal winning entries for the Junior Photography section, including 'Carpet python on bush'.

*Photo – Gideon Mettam*

**Left** This impressionistic shot of jarrah and wandoo forest took out second prize in the Interpretive section.

*Photo – Andrew Davoll*

**Above** Winner of the Underwater Subject category, which depicts bubble coral and a shrimp. The shrimp, which is only 12 millimetres long, was taken at Christmas Island.

*Photo – Glen Cowans*

### Focused on conservation

The ANZANG competition has three primary aims: to encourage photography of the natural world, to assist in raising public awareness about its wonders and to raise money for conservation. Funds surplus to the cost of each year's competition and travelling exhibitions are donated to conservation organisations in Australia, New Zealand and New Guinea that manage natural habitat for native flora and fauna and are involved in 'bush buy back' schemes. In particular, the competition sponsors the work of Birds Australia, the Australian Wildlife Conservancy, the Australian Bush Heritage Fund and the Royal Forest and Bird Protection Society in New Zealand. This is achieved largely

by the support of the competition sponsors and in-kind support from the WA Museum.

Stuart said the competition was also an appropriate recognition of the skill involved in nature photography, which is often not very commercially viable but done more for the love of the subject.

Information regarding the annual competition, such as prize money, plus all of the winning and highly commended images from the 2005 competition may be seen at [www.anzangnature.com](http://www.anzangnature.com). A book, *ANZANG Nature and Landscape Photographer of the Year: The Second Collection*, which showcases the 2005 competition is available from the website.

Stuart Miller, as well as being a Perth surgeon, is ANZANG Nature's Chairman. He can be contacted on (08) 9481 1238 or by email ([compete@anzangnature.com](mailto:compete@anzangnature.com)).

For more information about ANZANG and the Photographer of the Year competition, and to view the winning and highly commended images from 2005, visit [www.anzangnature.com](http://www.anzangnature.com).

# endangered

by Andrew Burbidge



## Masked booby

The masked booby has a wide distribution in tropical oceans. A subspecies of this bird, the eastern Indian Ocean masked booby (*Sula dactylatra bedouti*), breeds on islands off the Pilbara and Kimberley and is rare and listed as threatened. Perhaps only 1600 breeding adults exist, with breeding on fewer than five islands.

Masked boobies can be distinguished from the more common brown boobies by their predominantly white colour and black face. The flight feathers and tail are also black and the large bill is yellow. Off the Pilbara coast, masked boobies occasionally occur as far south as Exmouth Gulf and may be sighted in the Dampier Archipelago. The largest breeding colonies are on Bedout Island, north of the mouth of the De Grey River, and Adele Island,

north of Cape Leveque. Limited nesting occurs on West Island in the Lacepede Islands, north of Broome. Counts by Department of Conservation and Land Management (CALM) staff and visiting ornithologists suggest there are populations of 300 to 400 breeding pairs on Adele, 120 to 270 pairs on Bedout and less than 10 pairs on West Island. Small numbers nest on islands at Ashmore Reef, where they and their eggs are threatened by illegal hunting by Indonesian fishers.

Masked boobies, like other members of the gannet family, feed mainly on fish obtained by plunging from heights of up to 100 metres above the ocean's surface. Feeding boobies make a spectacular sight as they dive almost vertically into the sea to more than three metres below the surface, before emerging, usually with a fish.

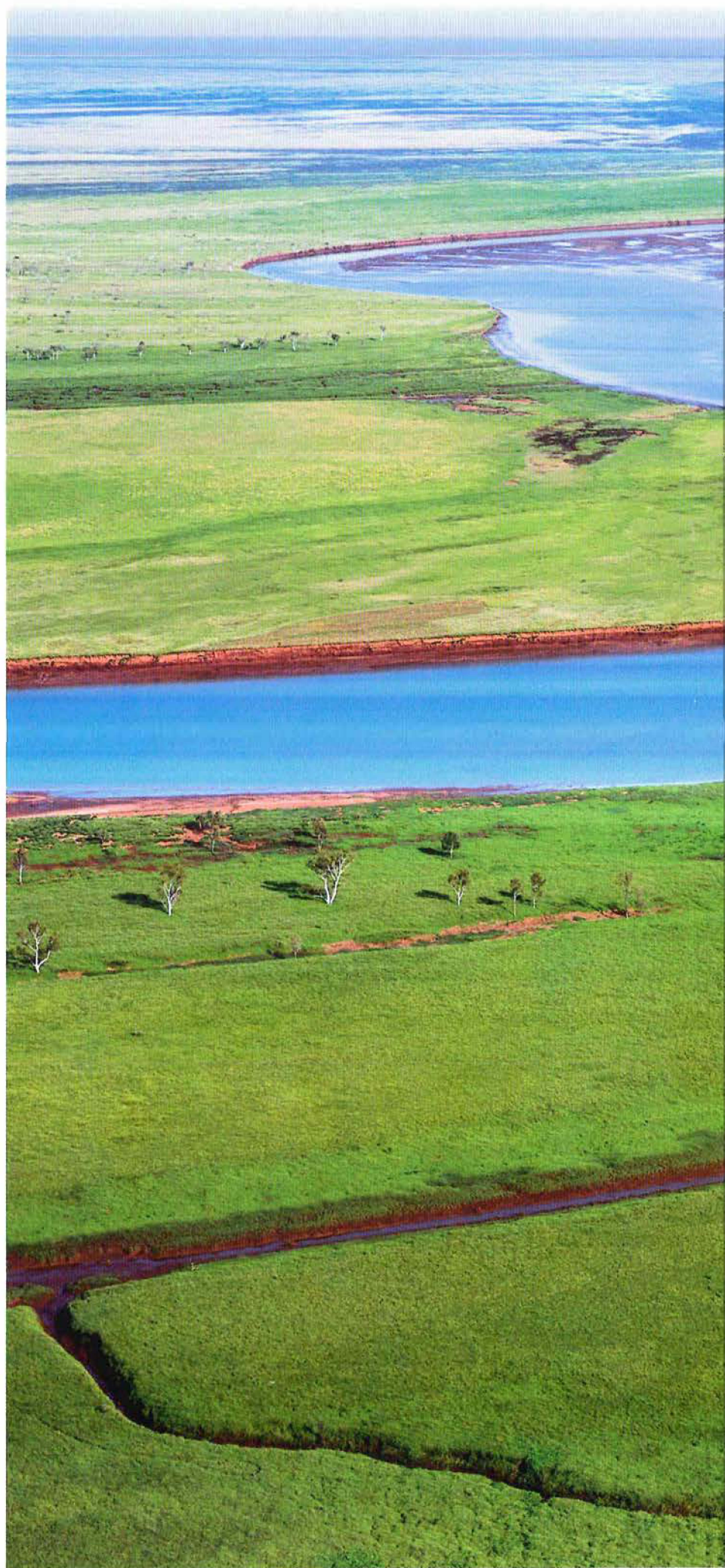
The nest is a scrape in sand,

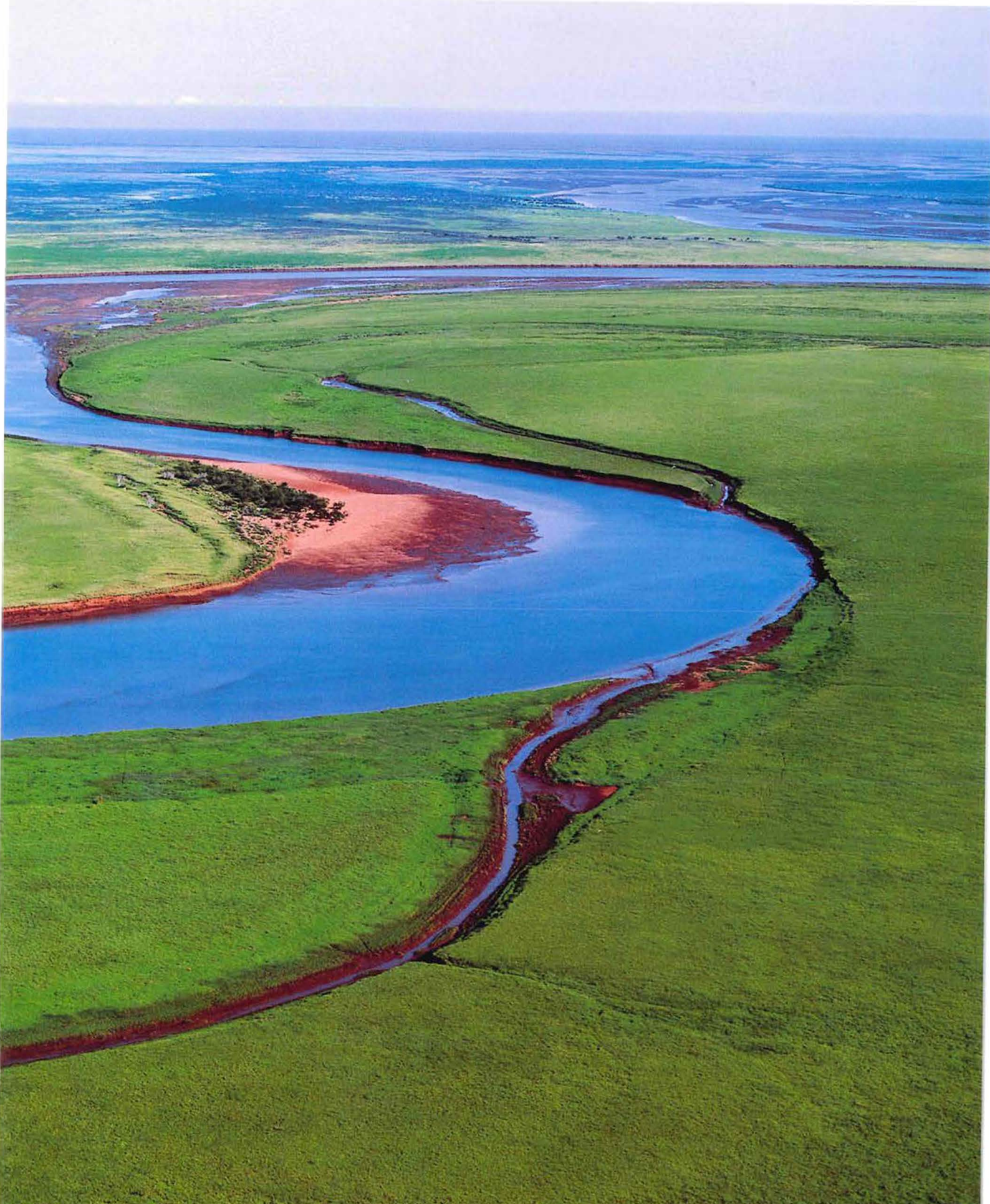
either at the top of the beach or in open areas between vegetation. Two eggs are usually laid. Masked boobies will vigorously defend their nest against intruders, including people.

Bedout Island, after which the subspecies is named, has several other breeding seabirds: brown boobies, least frigatebirds, crested terns, lesser crested terns and silver gulls. In the past, sooty terns and common noddies also nested there. However, predation by black rats probably caused these small terns to abandon the island. In 1981, staff from the former Department of Fisheries and Wildlife conducted the State's first rat eradication project on the 24-hectare island, and it is hoped that breeding by small seabirds will eventually recommence.

Photo by Dave Watts/Lochman  
Transparencies

Though it is surprising given its arid setting, the Pilbara region contains some of the most biologically rich wetlands in Western Australia.





by Stuart Halse, Adrian Pinder, Joan Powling and Jane McRae

# Wetlands of the Pilbara

Whereas most people think of a wetland as containing still water, and perhaps being swamplier than a lake, the scientific definition of wetland includes rivers, springs and groundwater, as well as lakes, swamps, claypans and rock pools. The Pilbara contains all of these wetland types.

A quick glance at any map shows that the Pilbara contains a number of large rivers, such as the Ashburton, Fortescue and De Grey, but these flow only for brief periods at intervals of one to three years. About once a decade in the southern Pilbara, and more frequently in the north, the flow events associated with very heavy cyclonic rain lead to widespread flooding and damage to infrastructure.

An example is the damage caused to the North-West Coastal Highway around the bridge over the Maitland River south of Dampier in early 2004.

Most of the time, however, Pilbara rivers are dry along most of their length. Aquatic life is concentrated in the occasional permanent river pools that are maintained by groundwater flow. Sometimes this groundwater flow is in the form of obvious springs at the upstream end of the pool, but in other cases it is in the form of subtle inflow of water stored in the sandy riverbed. The pools themselves are scoured out by turbulent surface flow during flood events, which prevents sediment from the surrounding landscape slowly filling them. As well as maintaining the

pools, the scouring action sometimes relocates them short distances downstream after flood events. This emphasises the dynamic nature of the Pilbara environment.

The biggest springs in the Pilbara occur at Millstream, on the lower Fortescue River, but springs occur on all Pilbara river systems and provide a variety of permanent aquatic habitats, even when they do not flow into river pools. Springs are often surrounded by relatively dense vegetation but can also emerge as seeps and very shallow, small pools on rocky, spinifex-covered hill slopes. In other situations, especially in gorges, springs and streams flow into deep rock pools. Circular Pool in Karijini National Park and Python Pool in Millstream-Chichester National Park are just two examples of spring-fed rock pools.

### Fortescue Marsh

At the other end of the spectrum in terms of water permanence, many claypans hold water for only a few weeks. As a result, they usually have little fringing vegetation. Most claypans fill irregularly after rain or, if they are on river floodplains, after river spates. The largest claypan in the Pilbara is Fortescue Marsh. It receives drainage from the upper part of the Fortescue River and floods every few years after major cyclones. It contains water for about six months after filling. The main waterbody of the marsh lies just north of Karijini National Park and stretches for 100 kilometres, from the



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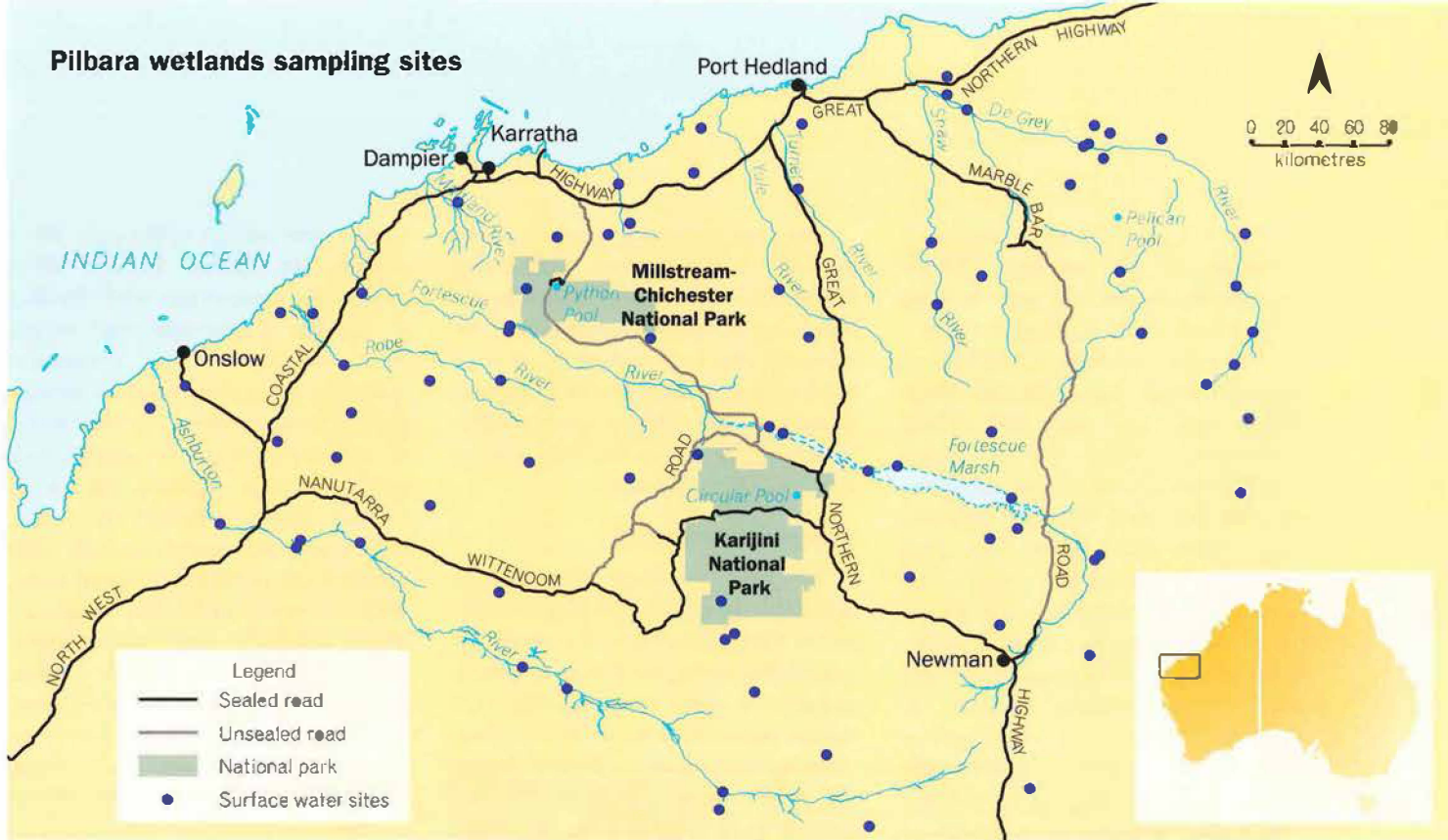
**Main** De Grey River enters the ocean north of Port Hedland.

**Insets from top** Australian pelicans in flight. Photos – David Bettini

A damselfly (*Agriocnemis kunjina*) alights on floating pondweed in a Robe River pool. Photo – Michael Lyons/CALM

**Above left** The central span of the Maitland River Bridge was left standing after the road was washed away in 2004. Photo – Stephen van Leeuwen

**Left** Fortescue Marsh as it dried in August 1999 with Karijini National Park in the background. Photo – Stuart Halse/CALM



Right Ashburton River water carrying red mud after recent rains.  
 Photo – Jiri Lochman

Nullagine–Newman Road to BHP’s Newman–Port Hedland railway line. On the western side of the railway line, the marsh extends for another 70 kilometres as a series of treed swamps, floodways and grassy pans.

Recognition of the biological importance of Fortescue Marsh and other Pilbara wetlands has come about only through the Pilbara Biological Survey (see ‘Between rock and a hard place’ on pages 12–19), which is currently being undertaken by the Department of Conservation and Land Management (CALM). This survey, across the whole Pilbara, is recording the waterbirds, aquatic invertebrates, algae and fringing vegetation at 90 surface-water wetlands. Fieldwork will not be completed until mid-2006, but results have already led to a major reevaluation of the importance of arid-zone wetlands for aquatic invertebrates. Groundwater systems in the Pilbara are included in the survey and have also been found to be extremely rich in species (see ‘Beasts of the underworld’ on pages 51–55).

### Birds, birds and more birds

The survey has shown that, as well as being the largest surface-water



wetland in the Pilbara, Fortescue Marsh perhaps has the highest conservation significance. The marsh filled in 1999, 2000 and 2003 and received a small amount of inflow in 2004. Waterbird counts in August and September showed more than 250,000 waterbirds were present in each year it completely filled. Altogether, 50 species were recorded, with Eurasian coots (maximum count of 80,000 birds), three species of ducks (with up to 80,000 hardheads, 60,000 Pacific black ducks and 30,000 grey teal), little black cormorants (30,000) and black-winged stilts (25,000) being numerically dominant. Australian pelicans breed on the marsh in most years when it floods, and it was estimated that more than 1000 pairs of pelicans nested on islands in the eastern section in 2000.

Waterbird numbers are less impressive at other Pilbara wetlands, with the highest count being 536 birds at a claypan near the mouth of the De Grey River. Of another 165 surveys at 80 wetlands during the last few years, only 11 had more than 100 birds. The greatest number of species was 23 at a river pool south of Port Hedland. However, the value of the Pilbara for waterbirds is greater than results from these individual sites suggest because of the large number of river pools scattered across the Pilbara and, after cyclones, the abundance of small claypans. Some idea of how many waterbirds can occur on small claypans is given by the growth of counts at Fortescue Marsh between late May and August 2000. During these three months, waterbird numbers increased

by 180,000, or 270 per cent, as a consequence of smaller Pilbara claypans drying out and birds moving to the marsh while it still held water.

The most numerous waterbirds at small wetlands were Pacific black ducks, grey teal and little black cormorants. Other species found regularly, but always in low numbers, include the black-fronted dotterel, darter, white-faced heron, little pied cormorant and Australian pelican. The occurrence of pelicans on small inland pools often surprises coastal dwellers, but pelicans are widespread in the arid zone. Less common species of particular interest are the brolga and black-necked stork (colloquially known as jabiru). Both of these large, long-legged birds occur frequently in the Kimberley and occasionally in the Pilbara. The black and white jabiru is nearly always solitary, whereas the more gregarious brolga tends to travel in small groups.

Another interesting group is made up of the migratory palaeartic shorebirds. Two species of interest in the Pilbara are the wood sandpiper and the relatively rare little curlew. Most river pools support a small number of wood sandpipers, and diligent ornithologists will usually be able to find little curlews in the northern Pilbara.

### Spineless wonders

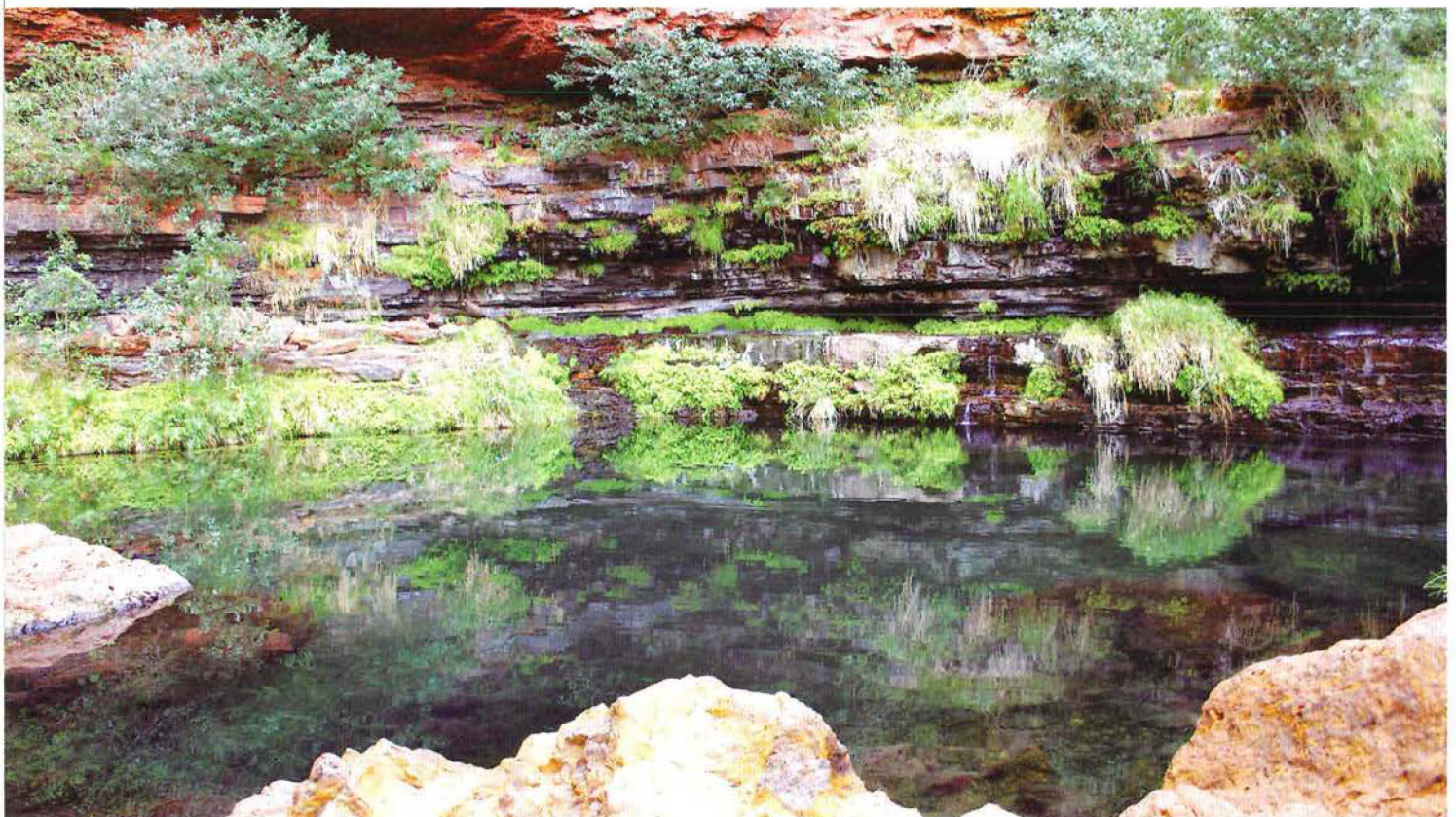
Despite the large numbers of waterbirds found on Fortescue Marsh, and in the Pilbara region as a whole, the outstanding biological feature of Pilbara wetlands is their extraordinarily rich aquatic invertebrate fauna. Many of the 1000 species already collected during the survey occur in other arid and tropical parts of Australia, but some species are restricted to north-western Australia and even to the Pilbara itself. An example of the latter is the black-and-gold damselfly (*Nososticta pilbara*), larvae of which inhabit wetlands at Millstream. So rich is the Pilbara invertebrate fauna that 213 invertebrate species were collected from a single wetland—Pelican Pool on the De Grey River—in a single sampling event. The list included 42 species of beetles, 30

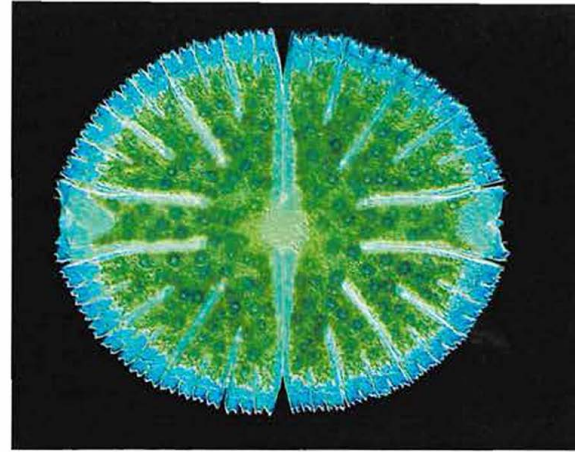
water mites and 30 rotifers, or wheel animals, so named because these microscopic animals spin while feeding.

Aquatic invertebrates were usually most species-rich at permanent wetlands, either river pools or springs. Lowest numbers of species were found in temporary claypans or granite rock pools and saline wetlands (salt always reduces species richness). As a rule, river pools and springs contain large numbers of beetles and water mites, while claypans and other temporary sites have more crustaceans and rotifers. Both crustaceans and rotifers produce drought-resistant eggs that enable them to survive in claypan sediments when water in the claypan dries. Clam shrimps, or conchostracans, are an example of crustaceans that are well adapted to arid environments. Their eggs hatch within days of wetlands flooding. The young feed on newly-wetted organic matter on the floor of the wetland, before laying their own drought-resistant spores within a couple of weeks, to ensure persistence of the species.

The one temporary wetland with high numbers of invertebrate species is the Fortescue Marsh. More than 130

Below Circular Pool in Dales Gorge.  
Photo - Michael Pelusey





**Top** The desmid alga *Micrasterias thomasiana*.

Photo – Jane McRae/CALM

**Above** Clam shrimps (*Lynceus* sp.) lay drought-resistant eggs that hatch only after flood events.

**Left** Black-necked stork.

Photos – Jiri Lochman

**Below** Fortescue Marsh in 2000.

Photo – Stuart Halse/CALM

species were recorded there in late winter 2003. More than a third of these species were crustaceans or rotifers, and several new species were found that are currently being described. Four sites were sampled on Fortescue Marsh to capture the variety of this huge wetland, whereas only a single site was sampled at smaller wetlands. The extra sampling effort at the marsh is likely to be part of the reason such a high number of species were collected, but the good quality habitat within the marsh provides the main explanation. Thus, the invertebrate sampling reinforced the picture that waterbirds provide of Fortescue Marsh as an area of particular conservation importance.

### Array of algae

The biological values of Pilbara wetlands, however, are not restricted to waterbirds and aquatic invertebrates. Fish and frogs are widespread and many terrestrial animal species use the fringes of wetlands. Many plant and several hundred algal species occur in Pilbara wetlands. The algae include some of the most beautiful microscopic plants in the world, the brilliant green algae known

as desmids. An example is *Micrasterias thomasiana*. Desmids are composed of pairs of cells that are mirror images. These cells can occur as a single pair or be united into larger colonies or long filaments. More than 100 species of desmids have been found during the survey, the most common being various species of *Cosmarium*.

Like aquatic invertebrates, algae are sensitive indicators. Some species, such as the desmids, occur only in clean water of low salinity, while other types of algae tolerate waters with high turbidity, high nutrient levels or increased salinity. Hence, species composition varies according to whether wetlands are in a relatively undisturbed condition or are heavily used by stock. Cyanobacteria, more commonly known as blue-green algae, are well known in other parts of Australia as indicators of waters containing a lot of nitrogen and phosphorus. Some of these cyanobacteria are toxic to stock when consumed in large amounts. So far in the Pilbara survey only one, very disturbed, wetland has been found to contain these organisms.

Stuart Halse is a CALM Senior Principal Research Scientist based at Woodvale. He is coordinating the aquatic component of the Pilbara Biological Survey.

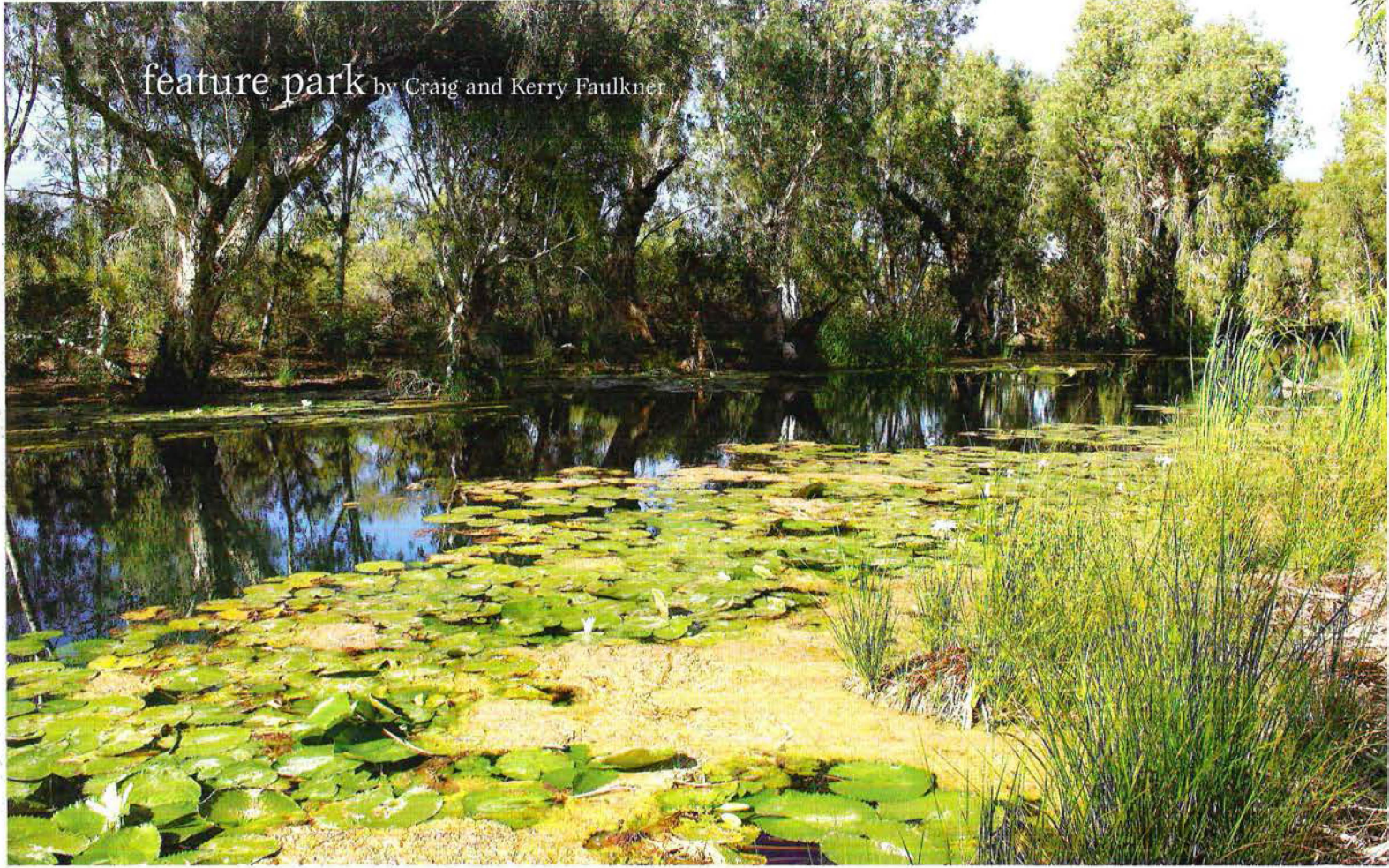
Adrian Pinder, a Research Scientist based at Woodvale, is undertaking the surface-water component of the Pilbara Biological Survey.

Joan Powling, a freelance algologist based in Melbourne, is identifying algae collected as part of the Pilbara Biological Survey.

Jane McRae is a Senior Technical Officer based at Woodvale and is undertaking the surface-water component of the Pilbara Biological Survey.

Stuart, Adrian and Jane can be contacted on (08) 9405 5100.





## Millstream-Chichester National Park

Freshwater pools fringed by swaying palms emerge like an oasis from the red soil of Millstream-Chichester National Park, traditional home of the Yindjibarndi people.

Above Chinderwarriner Pool.  
Photo – Michael Pelusey

Facing page  
Above right Sturt pea.  
Right Kingsley Woodley, one of two trainee rangers at Millstream-Chichester National Park.  
Photos – Kerry Faulkner

For the thousands who visit each year, the park's main attraction amid the hot, harsh Pilbara landscape is that it has fresh water, and lots of it. The Millstream delta is a unique wetland, fed by a natural aquifer within the Fortescue River catchment. The Fortescue is a braided waterway that becomes constricted at Millstream and diverts to the north-west through a series of rocky gorges.

### An ancient land, a living culture

Millstream is characterised by picturesque waterholes (the biggest is up to two kilometres long and the deepest is 14 metres) shaded by cadjeputs (*McKaleuca argentea*), river red gums (*Eucalyptus camakulensis*) and palm trees. According to Yindjibarndi law, these pools were created in the Dreamtime by the great water snake Warlu when it travelled underground and broke to the surface of the then-dry river, in pursuit of two young lieve that the Warlu now rests in Deep Reach Pool (Nhanggangunha).

In recognition of the park's importance to the traditional owners,

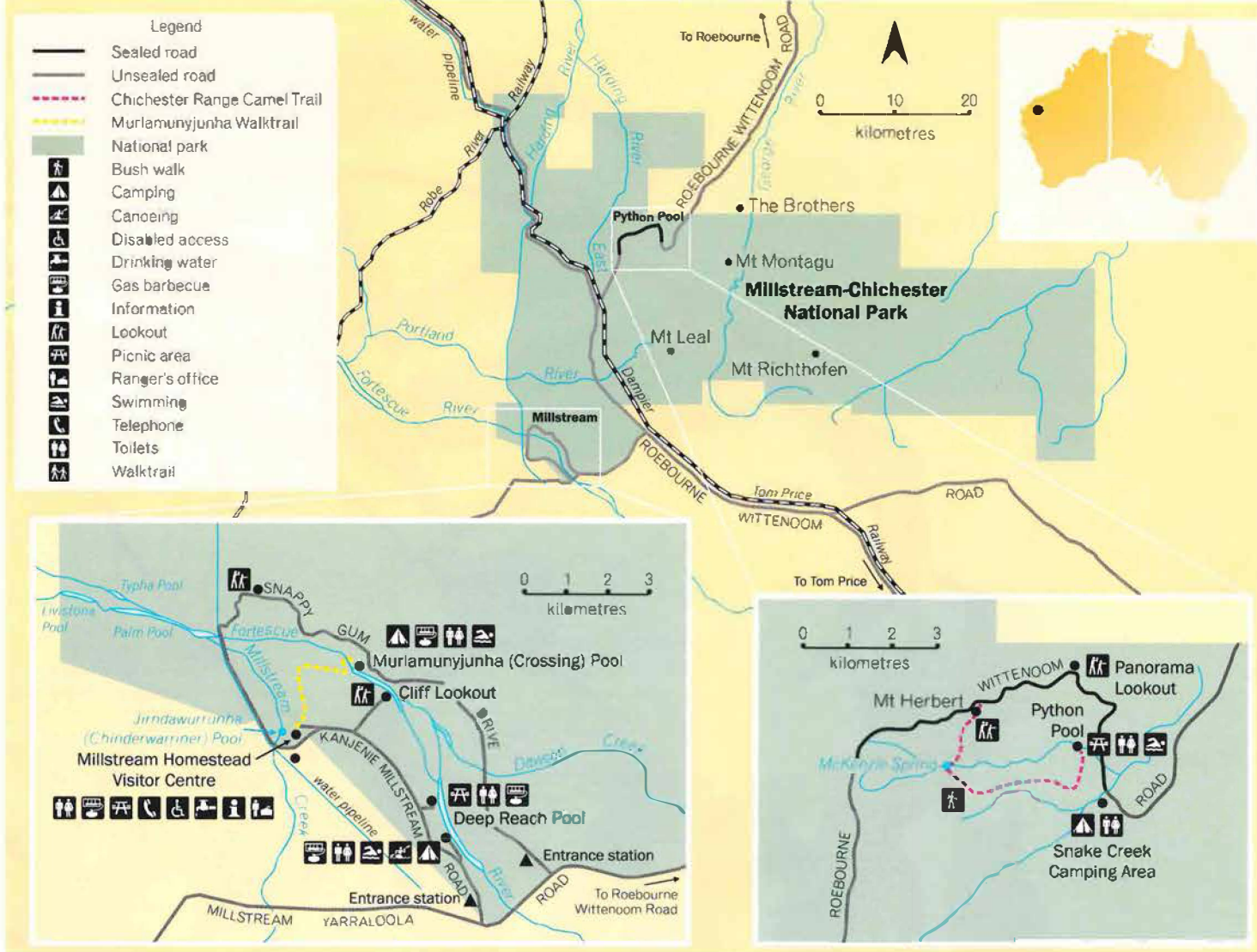
staff from the Department of Conservation and Land Management (CALM) have worked closely with tribal leaders to establish and maintain a park council. The council is made up of 10 Yindjibarndi and two Ngarluma elders who represent their communities at regular 'on country' meetings. CALM also works closely with the Juluwarlu Aboriginal Corporation, a local Indigenous body dedicated to preserving Yindjibarndi culture.

The council has been instrumental in appointing two Yindjibarndi men with long family associations with Millstream as trainee rangers.

### Pastoral history

A rambling homestead (circa 1920) is testimony to the area's pastoral history (the station ran 55,000 sheep in its prime) and today is the Homestead Visitor Centre, an interpretive facility and focal point for its many visitors.

In its early days, the area was traversed by Afghan cameleers carrying goods between the ports and inland stations. Some of their tracks are part of the park's system of walktrails, such as



the Chichester Range Camel Trail. Its views across the coastal plain, pierced with spectacular flat-topped peaks, provide some of the park's most stunning vistas.

### Plants and animals

A walk along the Murlamunyunha Trail, which meanders from the homestead to Crossing Pool, is testament to the diversity of the park's flora. The track weaves its way from spinifex grassland with occasional snappy gum (*Eucalyptus leucophloia*) and bloodwood (*Corymbia hamersleyana*) trees to tall river red gum and cadjeput woodlands that occur nearer the water. The Millstream palm (*Livistona alfredii*), a beautiful species of palm with fan-like leaves, is endemic to this area and dots the trail. Between June and August, the park's wildflowers are at their peak, with species like the Sturt pea (*Clianthus formosus*) adding a splash of vibrant colour.

Euros and red kangaroos graze the lawns of the homestead in abundance and there is a huge diversity of avifauna

ranging from the spectacularly decorated star and zebra finches to the regal black swan. Grey-crowned babbler often frolic in the sprinklers that service the homestead lawn and the mournful cry of the bush stone-curlew is heard most nights. Millstream is home to the magnificent threatened Pilbara olive python (*Morelia olivacea barrovi*), which can grow up to 4.5 metres long. On a slightly smaller scale, the park is also home to more than 30 species of dragonflies and damselflies, some of which can be seen flitting from lily pad to lily pad at Jirndawurrunha (Chinderwarriner) Pool.

Jirndawurrunha Pool is also the main front of CALM's battle against introduced weed species such as the Indian waterfern and the date palm, one of the most damaging pest plant species (see 'Feral Palms', *LANDSCOPE*, Autumn 2005). CALM's eradication of this species began in the early 1990s and continues today with Department of Justice staff and inmates at the Millstream work camp assisting with the program.



### park facts

**Where is it?** Three hours drive (190 km) south-east of Karratha.

**Total area** Nearly 200,000 hectares.

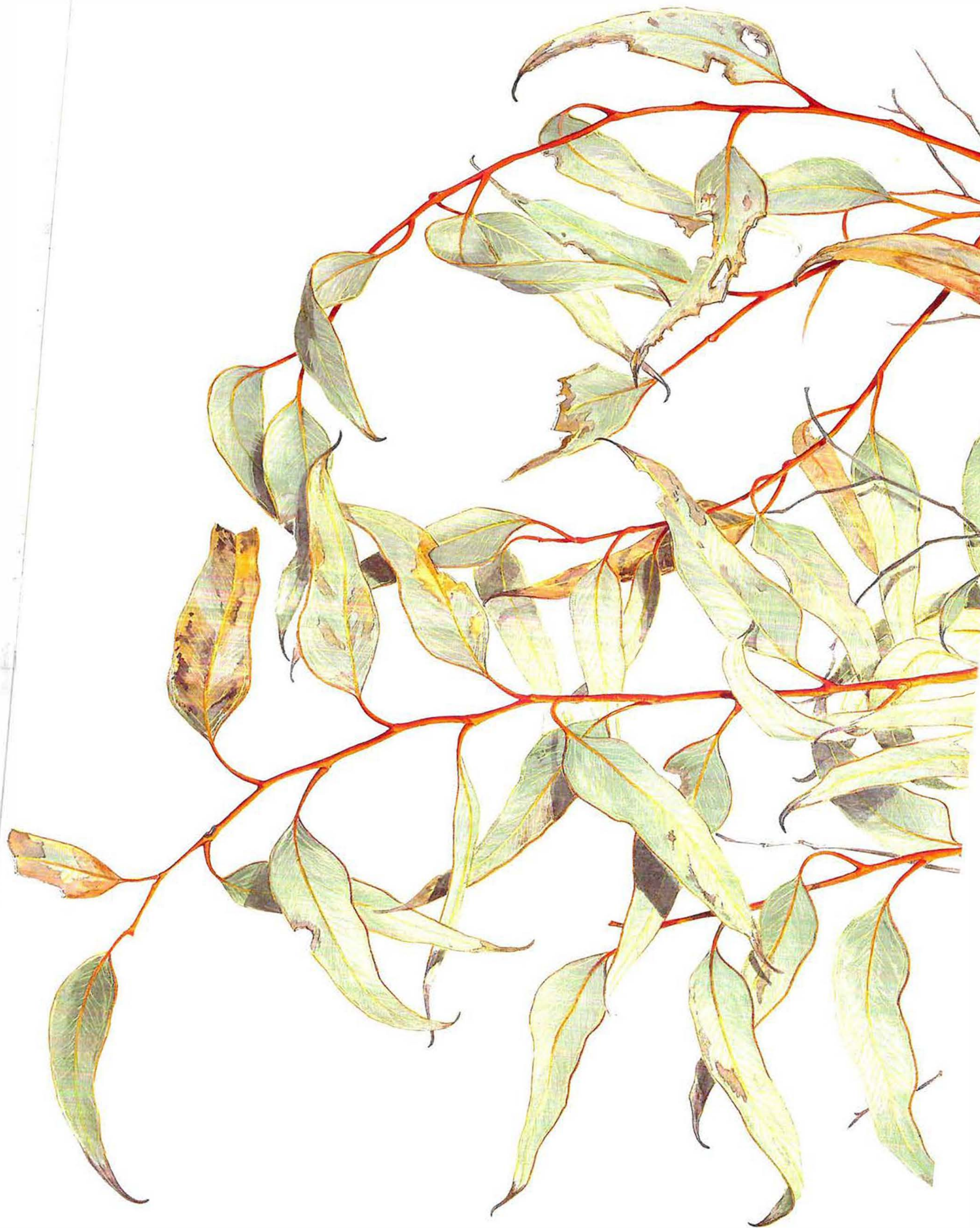
**Naming** The park was formed by the amalgamation of the Millstream (named after the Millstream pastoral lease) and the Chichester Range national parks.

**What to do** Swim in the delta's waterholes; take the Homestead Walk around Jirndawurrunha Pool, one of the park's most photographed sites, or one of seven other walktrails; or explore the two drive trails.

**Must see sites** Jirndawurrunha Pool, sunset from Cliff Lookout, sheer cliff surrounds of Python Pool and the stunning views atop Mount Herbert.

**Nearest CALM office** Pilbara Regional Office, corner Mardie and Lambert Road, Karratha Industrial Estate (08) 9143 1488.







# Soul of the desert

A new book, *Soul of the Desert*,  
by acclaimed Western Australian  
illustrator and long-time *LANDSCOPE*  
contributor Philippa Nikulinsky, with text  
and captions by biologist Steve Hopper,  
was 20 years in the making.

Illustrations by **Philippa Nikulinsky**  
Text by **Steve Hopper**

Australia's deserts differ from those anywhere else in several respects related to the geological and evolutionary history of the continent. The most obvious manifestation of Australia's 'desert soul' is its plant life, Charles Darwin's 'chief embellishment', or, as William Dampier observed in 1688, the dry places producing 'diverse sorts of Trees; but the Woods are not thick, nor the Trees very big'.

Woody plant life must have water, and that, indeed, is a second aspect of the soul—vegetation is far more extensive and better developed than precipitation levels would suggest is possible. Water, mainly underground, is there for the finding in Australia's deserts. These are not the waterless wastes of European explorers'

imaginings or more recent mass-media depictions. A Sahara this is not. As the explorers very quickly realised, Aboriginal people have sophisticated cultural maps of water sources and their daily life, celebrated through song, dance and caring for country. There is 40,000 years of collective wisdom about this country's water sources.



The low relief of the continent facilitates cross-continental movement of monsoonal rain-bearing depressions from the north. Subsurface water retention is facilitated by underlying geology across vast areas, especially the Great Artesian Basin of the east. But precipitation is highly variable. Sometimes the summer monsoon will only touch the northern desert fringe. Prolonged drought prevails in the interior. Most life retreats to permanent refuges. Only perennial plants and hardy animals are evident, parched.

Occasionally, rain will sweep down from the north-west to the Nullarbor and on east to the Central Ranges and Lake Eyre Basin. Or a south-westerly front will sweep up from the Southern Ocean in winter and bring rain as far north as the southern Pilbara, dousing all of southern Australia from west to east. Underground water is recharged as watercourses flood. Salt lakes, rock pools and claypans fill, and invertebrate and fish populations explode into life. Waterbirds arrive for the abundant feast. The desert greens and blooms, with annuals in displays as vast and as stunning as seen anywhere on Earth. Small mammals go through boom and bust cycles. The sky is darkened by flocks of budgerigars, and finches come to feed on abundant seed and drink their fill from myriad temporary pools. Reptiles of a diversity unseen elsewhere grow fat and numerous. Frogs that had lain cocooned away emerge to mate in pools and claypans. Following good rain, the abundance of Australian desert life is a sight to behold.

*Previous page*

Main Large-fruited mallee (*Eucalyptus youngiana*). Blossoms attain five to eight centimetres in diameter, and the handsome ribbed fruits are a similar size. Stamens may be red, pink or yellow.

Left and above Fruits of the blue-flowered bush tomato or ngaru (*Solanum chippendalei*), produced in abundance after fire, are very important to Aboriginal people. The fruits can be eaten raw or kept dried on skewers and transported. Some similar species are toxic, however. Wild capers has fruit with bitter seed and edible yellow pulp. The caper white caterpillars will often consume entire leaves.





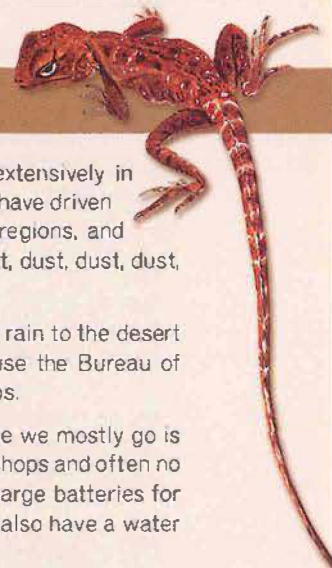
A third aspect of the soul arises from the arid zone's bi-directional winds, from the monsoonal north and cold south-west. These form longitudinal sand dunes almost to the exclusion of other dune types. Australian deserts are home to vast areas of well-vegetated longitudinal dune systems in the Great Sandy, Little Sandy, Great Victoria, Tanami, Simpson, Tirari and Strzelecki deserts.

Biologically, the soul of the desert is embedded first in the old, weathered, quiescent landscape of this island continent, where millions of years of rainfall have stripped the soil of nutrients and transported them to scattered pockets of fertile deposition. These fertile refuges in a matrix of infertility are essential habitats for many organisms when times are tough, especially when they coincide with permanent surface water.

Since inching away from Antarctica 40 million years ago, Australia has required increasingly sophisticated evolutionary adjustment of its inhabitants as the continent drifted north and arid conditions developed. Nutrient deficiency spawned tough, fibrous, perennial plants, low in forage value, favouring an extraordinary abundance of termites as major herbivores, and the co-evolution of remarkable partnerships between plant-eater and gut microorganisms to break down the rough forage. Termites and macropods each enjoy such symbiotic help.

The perennial plants in turn provide a structural habitat for diverse groups of animals, including the greatest variety of desert reptiles and marsupials on Earth. Nectar is relatively inexpensive to produce compared with animal-dispersed fruit, so many desert plants attract nectarivorous honeyeaters to spread their pollen, and produce

## HEAT AND DUST



For the past 30 years, my husband Alex and I have travelled extensively in remote areas of Western Australia. In the past 10 years alone, we have driven around 70,000 kilometres, exploring and painting in the desert regions, and often working in very difficult conditions: wind, flies, midges, heat, dust, dust, dust, mud and rain.

All summer I watch for cyclones and tropical lows that will bring rain to the desert and result in abundant growth and flowering. I also regularly use the Bureau of Meteorology's website and follow the cyclone paths and plot maps.

A field trip takes at least a month of preparation. Because where we mostly go is very remote, we have to be totally self-sufficient, as there are no shops and often no water. We carry solar panels for power to run two fridges, to charge batteries for GPS, radio satellite phone and even my electric toothbrush. We also have a water filter so if we come to a waterhole we can filter the water.

I make the menu, shop and pack up all the food, with fruit wrapped separately in kitchen paper to prevent bruising and sweating. I have meat vacuum packed and buy long lasting vegetables (cabbages, carrots, pumpkin, kumera, onions and potatoes). Where possible, we cook with campfire and camp oven but, for many places like national parks or when weather conditions are bad, we have a gas stove.

I organise the art materials and living arrangements—bedding, food, paper, camera gear, film, microscope and reference books. Alex does all the car stuff and organising all the electronics and camping equipment—chairs, tables, solar panels, water, fuel, wind shelters and all the many things needed for a comfortable working camp. We drive a car each and pull a trailer with one of the cars—a travelling circus really!

Alex has set up one car as a workspace with table and lights so that I can work in all weather conditions. The other car has been modified with a big bed in the back with big pullout drawers underneath.

I was a passenger on two trips to the Little Sandy Desert organised by Stephen van Leeuwen from CALM's Pilbara regional office—exploring and collecting where there were no tracks. On one of these trips we had 77 flat tyres and drinking water only (no washing).

We are fortunate in being able to stay for extended periods in places that many people just pass through, and hope that we can continue to do so for many years to come. Sitting at the end of a working holiday watching a glorious sunset and sipping on a wine, Alex made the memorable comment: "We are in the front stalls of the universe".

Phillippa Nikulinsky

copious seed eaten by ants, birds and mammals alike. And fire continues to play out its dramas, causing setbacks for fire-sensitive plants and animals and opportunities for plants like spinifex to occupy new ground.

So there it is, soul bared, relatively young, diverse, an ever-changing agglomeration of deserts on the planet's oldest and driest mid-latitude continent. Australians are enriched by the presence of their deserts. Although few live within arid terrain, all are touched by it at some time. Many of us would recall those vivid television pictures of the giant wall of desert dust encroaching over Melbourne some years ago.

The soul is there in the dust, the red rocks and blue sky, the wind and rain, in

Above Dragon lizard (*Ctenophorus* sp.) and bull ants (*Myrmecia* sp.).

Above left Spiny-cheeked honeyeater (*Acanthagenys rufogularis*) on the flowers of the honeysuckle grevillea or ultukunpa (*Grevillea juncifolia*). The flowers are rich in nectar, favourites for honeyeaters and desert people alike.



the dunes and salt lakes, in the people, and in the plant and animal life, waiting to be experienced, revealed, revered, by those who would look. Hopefully, recent events have not dimmed 40,000 years of human wisdom accumulated through desert life, and the future holds some promise for these quintessentially Australian landscapes.

## Development of a painting

From the initial idea to the finished work, each painting is the result of many stages of preparation.

I much prefer to paint and draw specimens that I have collected. This is not always possible. I like to see the plant growing in context, with its many variations and idiosyncrasies, to study what other plants, birds and animals live in, on or near it, and any other visually interesting associations. This allows me to bring the painting to life. I spend much time travelling many thousands of kilometres to find and see my subjects in situ.

When in the field, I set off in the early morning with all my gear in a backpack and my binoculars slung around my neck. My backpack has a GPS, a collecting notebook and tags, a walkie-talkie to keep in touch with Alex back at camp, camera, film, water bottle, snacks, secateurs, folding saw and magnifying glass. The specimens are sealed in plastic bags to preserve them for the trip back to camp. For small delicate pieces I carry flat plastic-lidded boxes. I photograph the growing plant as well as the surrounding vegetation. I also take many close-up shots of different sections (leaves, stamens, stem junctions, bark patterns and so on). I walk, looking and collecting, for many hours.

Back at camp, the pieces for drawing are put in a shady place, either in the fridge, or in a jar of water covered with a plastic bag to shield the plant from the drying wind. I carefully study and draw many detailed section drawings. I analyse colour and make detailed colour notes while everything is fresh. These are recorded in a colour diary. At this time, insects, galls or any other interesting features which relate to this specimen are also drawn and photographed, and notes are made.

I find the act of drawing is discovery. By carefully looking and drawing, I try to understand everything about my subject. I press a piece as a voucher specimen between sheets of newspaper into a plant press. I also dissect a flower or a seed pod, which I place under clear tape in my field diary. If it is a woody plant, I keep a piece whole, with fruit, nuts or seeds. I can do only several field drawings a day and often under very difficult conditions—wind, dust, flies, heat, rain or mud. It is difficult to keep paper clean in the field, so most of my work is finished in my studio at home. Many paintings take weeks, even months, to finish.

For example, for a large specimen like Ramel's mallee (*Eucalyptus rameliana*), first I made a large rough drawing of the whole specimen as shown. I then broke it up into suitable sections and drew each piece separately, numbering each drawing and locating it correctly. Back in my studio, I used these drawings to reconstruct the whole branch, using the colour notes and diary, until I gradually completed the painting. I needed the second desert trip to get fresh leaves and flowers in order to complete the work, which will have been on the drawing board for two years.

Philippa Nikulinsky





Very rare and  
 mostly among old  
 trees and very old  
 on hill top. It is  
 found only in  
 the high mountains  
 of the Himalayas  
 and is probably  
 to be distinguished  
 from the other  
 species of the  
 genus.

Very rare and  
 mostly among old  
 trees and very old  
 on hill top.

Very rare and  
 mostly among old  
 trees and very old  
 on hill top.

Very fine with  
 some in full and  
 some in flower in old  
 trees.

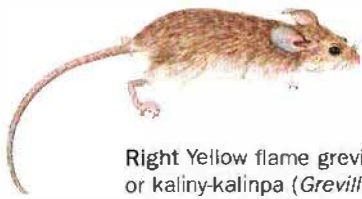
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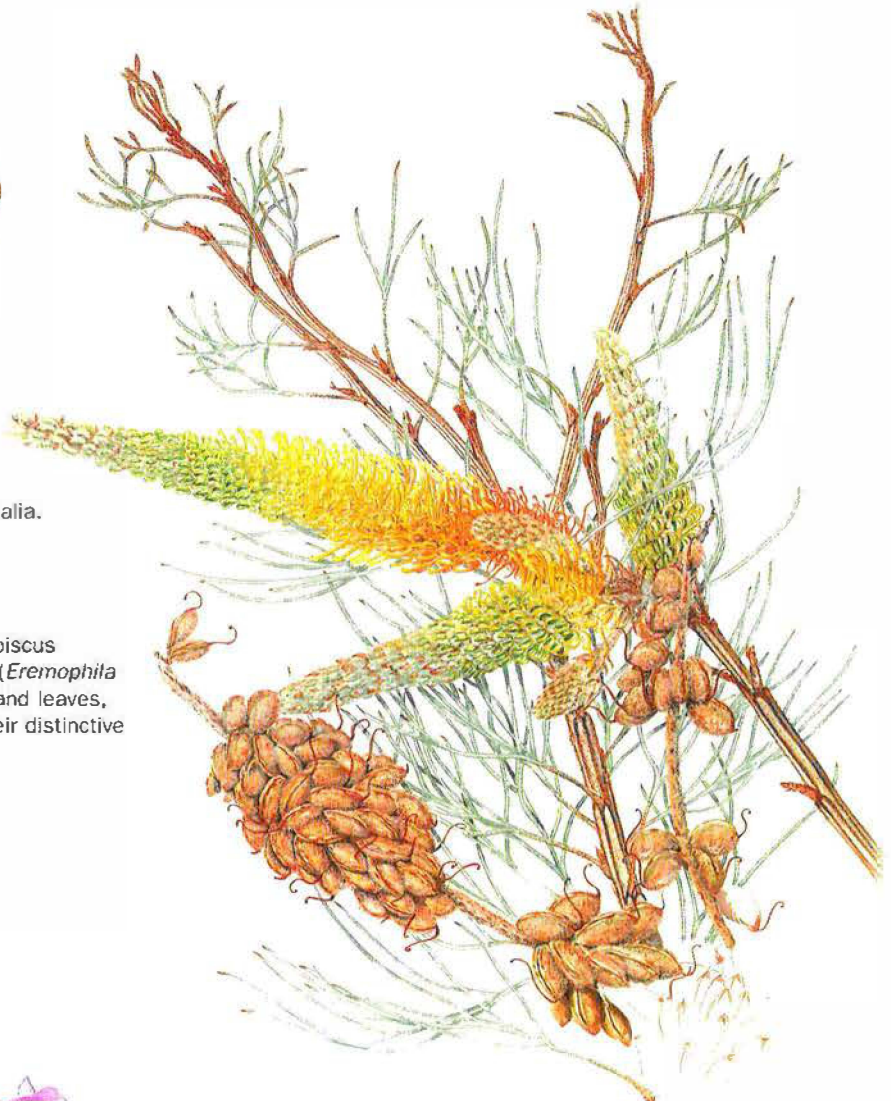




Right Yellow flame grevillea or kaliny-kalinpa (*Grevillea eriostachya*) at Coolbro Creek, in the Great Sandy Desert. This fire-tolerant shrub has large inflorescences often dripping nectar. Desert people seek the sweet elixir, sucking it directly or steeping inflorescences in water to make an enticing drink. Honeyeaters, too, relish the nectar. The species ranges widely in Western Australia, extending into the Northern Territory and north-west South Australia.

Above Inland desert mouse (*Pseudomys hermannsburgensis*).

Below *Hibiscus* species, such as Coates's hibiscus (*Hibiscus coatesii*) and Wills's desert fuchsia (*Eremophila willsii* subsp. *willsii*) with the smaller flowers and leaves, enliven desert hills and watercourses with their distinctive flowers, especially after fire.



Philippa Nikulinsky is a freelance natural history artist. She has illustrated most front covers of *LANDSCOPE* since 1990. Her particular interest is plants and animals existing in harsh and arid environments. *Soul of the Desert*, coauthored with Steve Hopper, is her latest book. Philippa can be contacted on (08) 9386 6375 or (08) 9389 9125 or by email (Philippa.Nikulinsky@Nikulinsky.net).

Steve Hopper is Foundation Professor of Plant Conservation Biology at The University of Western Australia, following several years as Chief Executive Officer for the Botanic Gardens and Parks Authority. He can be contacted by email (steve.hopper@uwa.edu.au).

*Soul of the Desert* is published by Fremantle Arts Press and is available for \$59.95 from most good bookshops.



# Learning together



"wanggaljarri  
nhantharriyarndu  
ngurrayi talk for our  
country"

Sylvia Allan, Yindjibarndi Elder

Indigenous community members  
and conservation managers in the  
Pilbara are working and learning  
together in national parks,  
producing many positive outcomes.



by Ross Kermode, Ken Sandy, Kingsley Woodley and Judymae Napier

There is depth and ageless beauty in the Pilbara. This is a landscape of diverse environments. It comprises idyllic islands, hidden shores and coastal waterways. A vast array of ranges and gorges are interspersed with spinifex country and contrasted by the tranquillity of palm-lined natural springs. Snappy gums stand before a backdrop of mountains floating in the heat haze. Deep inland is a sea of red desert dunes.

It is a living contrast of colour and texture, commerce and culture, escapism and adventure, labour and lifestyle, beneath seemingly endless blue skies. There is a mystique in this land that writers, artists and poets can only try to make us understand.

Perhaps here, where there exists knowledge, ancient language, stories and songs passed down through generations, we can hope to gain some insight into a deeper understanding and appreciation of our natural environment. Anyone who has shared time with traditional owners may agree; when community opens up country and shares stories of the significance of sites, you begin to see and feel the people and country in a new light.



Whether it is the old man in the back of a Land Cruiser softly singing his way through country, or the laughter and tears of the old women reminiscing about their childhoods beside a mirrored pool, it is a deeper connection to country that is heartwarming and real. Australia is a very old place; full of very old stories in hundreds of languages.

Within national parks in the Pilbara, the formation of park councils and joint management policies are allowing Indigenous communities and the Department of Conservation and Land Management (CALM) to work together to care for country.

"Nhaarndu ngurra uncle-yarndu nhaarndu yabijiyanndu Jinagurduthunba. Ganagarri nhauwayi nhaa ngurra.

This is my country belonging to my uncle and my grandfather Jinagurduthunba. This is our knowledge in this place; we have feeling in this country."

Dora Solomon, Yindjibarndi Elder

### Joint management through park councils

Throughout the Pilbara, Aboriginal people are involved in the management of conservation lands, especially national parks. This is achieved through the establishment of park councils. Park councils include representatives of local Aboriginal language groups and CALM staff.

Park councils are the forums by which local Aboriginal language groups take part in the decision-making processes on national park management issues, and contribute

*Previous page*

**Main** Millstream-Chichester National Park. Photo – Simon Nevill/Lochman Transparencies.

**Inset** Children have an active role in their own future at the park council.

**Above** Creation story spoken by Sylvia Allan along the Fortescue River. Photos – Ross Kermode

**Left** Wildflowers at Mount Bruce, Karijini National Park. Photo – Rob Oliver





**Above** Jirndawurrunha (the lily pool) is a very special place in the Pilbara for us all.  
*Photo – Karen Prosser*

their knowledge of the areas to direct and assist CALM. Four park councils are established in the Pilbara region: Karijini Park Council, Ningaloo/Cape Range Park Council, Jirndawurrunha Park Council (Millstream-Chichester) and the Karlamilyi Park Council (Rudall River).

Park councils meet on a regular basis. Topics of discussion include feral animal and weed control, protection of historic and cultural sites, new park developments (including improved signage and the establishment of new visitor facilities like walktrails, lookouts and campgrounds) and, importantly, Indigenous employment opportunities.

Aboriginal Elders contribute significantly to park councils. They share stories of their past, including changes that have taken place to the surrounding landscape and wildlife. This information can help scientists analyse wildlife population stability and changes that may have led to the extinction of some species, and to other species becoming threatened. Many Aboriginal people were born on land that is now vested as national parks. There is significant value in providing the opportunity for Elders and younger generations to return to their ancestral country, meeting up with family and friends, talking about

the old days, sharing their concerns for the future of the land and their people, and just spending time in their country.

An example of the type of outcome generated by park councils includes the development of the visitor centre in Karijini National Park, in which the local Aboriginal communities provided their cultural knowledge and artefacts to drive the design and final product, which is now an award-winning visitor interpretation facility. Aboriginal people manage the visitor centre, giving visitor information and advice about the national park. Opportunities exist for the general public to interact with local Aboriginal people and learn about their association with the country.

Aboriginal rangers are employed by CALM in the Millstream-Chichester and Karijini national parks. They contribute their knowledge of culture and their cultural responsibility to care for the country, and incorporate this into their broader role as conservation managers of State lands and waters.

### **Common ground**

“Engaging at a meaningful level.”  
Dave Whitelaw, CALM

On the ground, at the interface with Indigenous communities, it is a

constant learning curve. Cross-cultural awareness is a necessity on all sides. Government language is often as difficult to translate as traditional language. Communication and understanding require time.

Consultation is dynamic and can involve a myriad of stakeholders: multiple Native Title claimants, industry, legal representatives, numerous government agencies, and Indigenous corporations and foundations. There often exists a history that may not always encourage openness of communication.

The key to the success of park councils is in finding common ground and mutual interest. At the simplest level, the common ground is the country itself. The process is in meeting the people, learning the protocols, respecting them, building trust and finding a path forward. In reality, this takes a number of years of building relationships to achieve outcomes, making occasional mistakes but learning from them and sharing with community the challenges as well as the rewards.

The Millstream-Chichester National Park Council is a collective of two Ngarluma and 10 Yindjibarndi representatives. It's all about time on the country, learning together.

### People and places

The park council has assisted in appointing trainee rangers Ken Sandy and Kingsley Woodley, who undertake daily management of the park, engage with visitors and continue their study programs in conservation and land management. Park council members also provide the trainees with knowledge, cultural training, mentoring and the support they require to be able to confidently speak about country.

Both Ken and Kingsley live in Millstream on the land of their people, the Yindjibarndi. Their connection to the land runs deep. Ken lives at Millstream, where his mother was born, and Kingsley's grandfather's father, Winiya King, walked and travelled through this land, teaching his children techniques in hunting and gathering bush foods, bush medicine and the cultural ways and understandings of his people.

"My knowledge of this land has been passed on to me by my father. The knowledge was passed on to him by his father and grandfather," says Kingsley.

Ken and Kingsley were selected by their people to become trainee rangers

at Millstream. Ken says that he is proud to be working for CALM and Yindjibarndi people on the park council and joint management team. He knows he was chosen because of his knowledge of the land and his ability to do what is expected for his people.

A vital role Ken and Kingsley play is to lead the discussions at park council. "At these meetings, it is good to be able to get up in front of my country's people and put it in ways that are easier for them to understand where and what CALM is trying to make out of this whole land and national park. Being able to confront matters on both sides is a challenge, and nobody told me it would be this hard, but it has been such a success," says Kingsley.

Importantly, Ken knows his role in Millstream is to protect the land and cultural sites from damage, by speaking with tourists about country and ensuring sites are not damaged by vehicles or people.

As Aboriginal trainee rangers, Ken and Kingsley are an important link in the chain of joint management. Kingsley is sure "there are others like us somewhere who can talk with Elders and make it right and make it better for the younger generation".

"When the door swings open, it's your turn to walk right through and make something of yourself and your people. Joint management is great because it is good for societies, black and white, to have a greater respect for each other and their countries, no matter where they are from," he says.

Many members of the community were born in this area and, having lived and worked on the homestead, are able to give visitors a deeper insight into the natural, cultural and historical importance of the area, in particular, the pastoral days, as well as pre-settlement significance.



Left CALM trainee rangers Ken Sandy and Kingsley Woodley and men at a Welcoming Ceremony in 2005. Photo - Ross Kermode

**Right** Children at the park council create banners to celebrate their culture.  
 Photo – Ross Kermode

**Below** A native fig at Weano Gorge in Karijini National Park.  
 Photo – Alex Bond

### Shared vision for the future

“Garrimarda nhaa Wimiya wangganha nhauwayi Jirndawurrunha! Mirda gundi! Nyindawa barni. Banggarrima nhauwayi!

Used to stand here and my old uncle of mine, Wimiya, used to say; go see Jirndawurrunha (lily pond)! Don't forget it! All of you are the next carriers, stay. Go and see! We are getting old now our generation, but we got the young generation—want to teach those too.”

Dora Solomon, Yindjibarndi Elder

Joint management at Millstream has enabled developments that add value to the national park and generate opportunities into the future. Elders have identified a real need for kids to be able to learn about their culture on their country and have helped Roebourne Primary School hold cultural lessons at Millstream, with Elders leading the traditional welcome. To encourage ongoing involvement with schools, a new campground near the Millstream homestead has been developed to accommodate the requirements specific for school camps.

We have been able to develop accommodation for park council and community members in the form of men's and women's camps, and identify



future living areas and sites that need to be protected.

Juluwarlu Aboriginal Corporation has facilitated cross-cultural awareness courses for schoolteachers from Roebourne and Karratha. The Cossack Artists and Indigenous art groups are actively involved in the future look of signage for the park. Gallery pieces will be included in an upgrade of the visitor centre, creating enterprise initiatives for the community.

Park councils are also assisting in the implementation of cultural walktrails, with the view of establishing guided and self-guided tours, along with other community and visitor-based opportunities that are being placed in the management plan for Millstream-Chichester National Park.

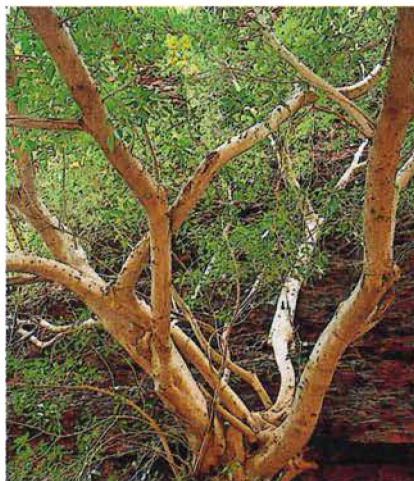
We are all working and learning together. Communication is open, we are on a journey and the direction is positive.

“We love our country, it's in our hearts.

Beautiful country trees, marba (silver

cadjeput), bawa (water), yidjirri wilarnu (waters running), ngarli garri wangarrayi (water lily standing alive). We used to walk with the old people here telling us stories about our country; thalu bawangga barni (sites in the water), potatoes... wild potatoes growing in the water. But we can't see them anymore now. Mirda nhau nhangharri nhaluwayin wagarrayi bawangga bunggarimarda nhunggirrila (we don't see any more wild water chestnuts alive in the water always going with them). Not this road been here before; we used to walk anywhere here. Sit down marlungga (in the shade), listen to the old people wanggayiyangu showmmangarli marda nhandharri warndayi (talking always showing us the tree). Old people, old fella, used to show us the rainmaking tree there, Yundu Thalu (rain site). But it's still there, Yundu Thalu (rain site). It's beautiful country. We all come here, have a meeting here, sit down and wanggayjarri nhandharriyarndu ngurrayi (talk for our country).”

Sylvia Allan, Yindjibarndi Elder



Ross Kermode, a CALM officer, was involved with joint management at Millstream-Chichester National Park for the past 12 months. He enjoyed the challenges and rewards of working together with the community to conserve the environmental and cultural significance of the country and is now sharing the culture of the south-west, based at Yanchep National Park.

This article is a collaborative effort by CALM staff, Jirndawurrunha Park Council members, the Juluwarlu Aboriginal Corporation, the Ngarluma and Yindjibarndi communities, rangers and Aboriginal trainee rangers involved with Millstream-Chichester National Park.

Thanks to Judymae Napier, Ken Sandy, Kingsley Woodley, Craig Faulkner, Tony Coyle, Wendy Bebbington, Dave Whitelaw and park council members Elsie Adams, Jimmy Horace, Maudie Jerrold, Joyce Hubert, Sylvia Allan, Bruce Woodley, Jill Tucker, Dora Solomon, Bruce Monadee, Lyn Cheedy, Trevor Solomon and Ricky Smith. Special thanks to Michael Woodley and staff at Juluwarlu Aboriginal Corporation for assistance with linguistics and translation and ongoing involvement with park council and community engagement at Millstream, Jirndawurrunha. For more information about the Juluwarlu Aboriginal Corporation, visit [www.juluwarlu.pilbara.net](http://www.juluwarlu.pilbara.net).





## Geology and landforms of the Pilbara

The Pilbara is geologically one of the oldest regions in Australia. Most of the rocks in the Pilbara were formed between 2500 and 3600 million years ago during the Archean period, when the Earth's crust was still very young. This represents one of the world's best preserved fragments of ancient continental crust—one of the Earth's earliest continents. **by Iain Copp**

**T**he oldest part of the Pilbara Craton is made of greenstones, a mixture of volcanic and sedimentary rocks, intruded by granite magma to form 'granite-greenstone terrain'. The greenstones continued to be deposited, and were intruded by more granite throughout the following 800 million years. During this time, huge stresses within this newly formed crust caused many rocks to be severely sheared, folded and faulted. Large volumes of hot fluid were generated deep within the craton as a result, and many rocks and faults became mineralised with gold, copper, nickel, zinc, tin and tantalum.

### Granite-greenstone country

Today, the landscape of much of the northern Pilbara is still dominated by distinct granite and greenstone landforms. Granite-greenstone country tends to form a mixture of low undulating hills, monadnocks (large isolated hills that stand above a

generally flat plain), sandy plains, and rugged hills and ridges with narrow valleys that may be very steep-sided.

Granite, the dominant rock type of the two in the northern part of the Pilbara, forms several vast ovoid intrusions, up to 120 kilometres in diameter. Granite is mostly a coarse-grained rock consisting of quartz, feldspar and mica, and commonly weathers to a smooth surface.

Greenstones are a mixture of volcanic and sedimentary rocks, which in the Pilbara include rhyolite, basalt, komatiite, banded iron formation (BIF), shale, siltstone, conglomerate and chert. The greenstones lie between the large granite intrusions, as linear or curved belts, tens of kilometres long. In cross-section, these belts are commonly v-shaped folds, or synclines, and have very steeply dipping beds.

There is an excellent exposure of greenstones at Maree Pool, where the North West Coastal Highway crosses the Maitland River. At the southern

end of the pool is a highly flattened and stretched rock type called mylonite. It formed when a major fault, called the Sholl Shear Zone, sheared and ground the granite and greenstones deep within the Earth's crust under extreme pressure. This is one of the major faults within the Pilbara, extending for at least 250 to 350 kilometres in a roughly north-east to south-west direction. Geologists believe that, at one stage, movement along this fault zone caused the rocks on the northern side to be displaced 150 to 200 kilometres to the left, relative to those on the southern side.

### Marble Bar

About three kilometres west of Marble Bar is a spectacular outcrop of Marble Bar Chert, after which the town was named. It is an unusually large and impressive water-polished rock bar across the Coongan River, surrounded by rugged hills and ridges. Marble Bar Chert is a sedimentary rock composed of microscopic silica grains. It is part of the Marble Bar greenstone belt, a 12-kilometre-thick succession of volcanic and sedimentary rocks that formed during the Archean, about 3490 to 3350 million years ago.

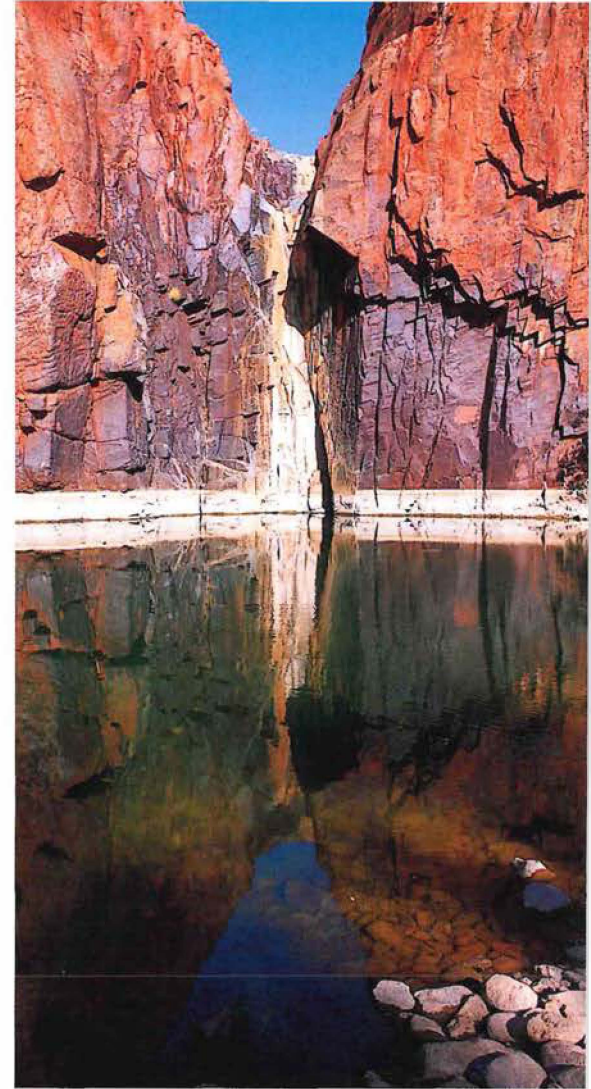
Evidence of volcanic activity can be seen on the southern side of the bar, just south of the parking lot and on the eastern side of the river. Here, basalt overlying the chert contains beautifully preserved 'pillow structures'. These formed when lava was extruded in deep water then quickly cooled to form 'pods' of basalt.

During the time that the granite-greenstones seen throughout the Pilbara were forming, the Earth's surface was a hostile place, with little oxygen in the atmosphere, and only simple microbial life that formed stromatolites. Some of these are up to



*Previous page*  
**Main Handrail Gorge.**  
*Photo – Michael Pelusey*

**Left Jasper outcrop at Marble Bar in the Pilbara.**  
*Photo – Dennis Sarson/Lochman Transparencies*



3490 million years old—the world's oldest fossils and the first visible evidence of life on Earth. The world's oldest evidence of meteorite impacts also occurred in the Pilbara during this time (3460 to 2490 million years ago).

### Uplift and erosion

By around 2800 million years ago, the formation of granite-greenstone terrain had ended, and a major period of uplift and erosion took place throughout the Pilbara. The Pilbara Craton at this time was part of a larger continent that began to break apart along what is today its southern margin. As the crust stretched and became thinner, an extensive rift was formed that ran in a west-north-westerly direction. Consequently, around 2770 million years ago, a huge volume of molten rock from the underlying mantle was extruded along this zone, forming a 'sea of basalt lava' that buried the older granite-greenstone terrain. These lava flows are preserved as part of a thick succession of volcanic and sedimentary rocks, known as the Fortescue Group. This was the beginning of the deposition of

the vast Hamersley Basin, the youngest part of the Pilbara Craton.

As the main period of crustal extension came to an end by about 2690 million years ago, the Hamersley Basin then began to fill with sediments deposited on a shelf or platform that opened to an ocean. During this time, extensive deposits of banded iron formation were laid down, such as those in the Hamersley Range.

### Continents collide

Between about 2200 and 1800 million years ago (during the Proterozoic), the ocean that lay to the south of the Pilbara Craton was closed during a series of collisions with other ancient continents that included the Yilgarn Craton. This caused the rocks of the Hamersley Basin to be deformed into large folds, as they were squeezed between two continents. Together, the landmasses formed the vast new West Australian Craton. Extensive mountain building took place along this collision zone, leading to another major period of erosion and the formation of a sedimentary basin called the Ashburton Basin.

**Above left** Fortescue Falls, Karijini National Park.  
*Photo – David Bettini*

**Above** Python Pool at Millstream-Chichester National Park.  
*Photo – Alex Bond*

Soon after, at around 1760 million years ago, the West Australian Craton collided with another continent to the north-east, called the North Australian Craton. This continental collision brought together most of what is now the western and central parts of the Australian continental landmass. Further collisions brought together a much bigger assemblage of cratons that formed the supercontinent of Rodinia by 1000 million years ago.

Following the collisions, the crust then sagged over the junction between the cratons, allowing an immense basin to develop that filled with sediments deposited by shallow seas, rivers and glaciers. In the eastern part of the Pilbara, where the Little Sandy Desert



is today, this part of the basin is called the Officer Basin. By about 750 million years ago, towards the end of the Proterozoic, Rodinia began to break apart and, although the Australian continent remained mostly intact, old "joins" between cratons were reactivated. Consequently, about 550 million years ago, substantial faulting and folding took place in the Rudall River area.

North-east of the Pilbara, where the Great Sandy Desert is today, a huge basin called the Canning Basin began to form around 490 million years ago. As it slowly filled with marine and continental sediments, it partly covered older rocks at the edge of the Pilbara Craton and in the Rudall River area. Glaciers formed some of these deposits around 295 million years ago during the Permian. Australia was then part of the Gondwanan supercontinent and lay close to the South Pole. The glaciers deeply scoured the landscape, carving huge glacial valleys that are recognisable today in the north-eastern part of the Pilbara.

### Glaciers

One of the largest such valleys in the Pilbara is the Wallal Embayment. This wedge-shaped area, nearly 150 kilometres long, extends in a south-easterly direction from east of Shay Gap, where it is about 50 kilometres wide, and ends just south of Carawine Pool, roughly paralleling today's Oakover River valley. The ancestral Oakover River may have in fact originated when the Permian glaciers began to melt.



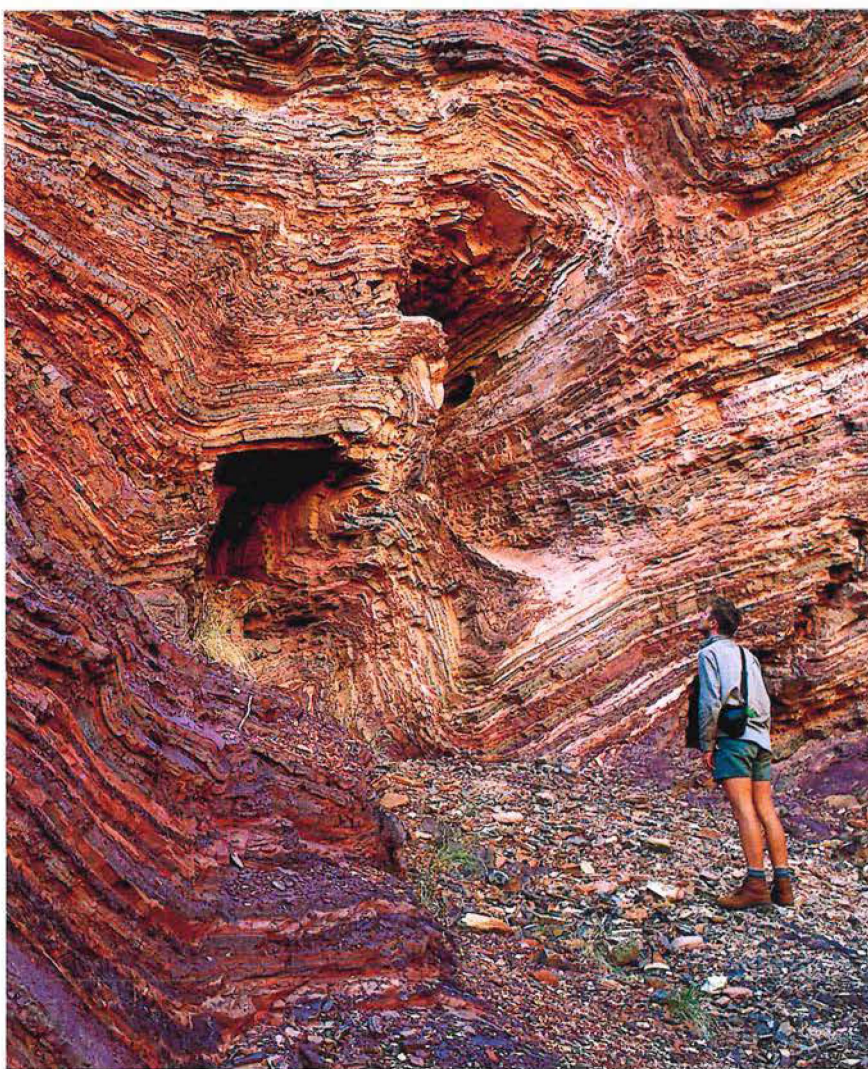
**Top left** Aerial view of Lake Disappointment in the Little Sandy Desert.

*Photo – Jiri Lochman*

**Centre left** Rooney Valley, in Rudall River National Park, was carved by glaciers.

**Left** Carawine Gorge.

*Photos – Marie Lochman*



**Above** Rock formations in Hancock Gorge.  
 Photo – Dennis Sarson/Lochman  
 Transparencies

**Above right** Hancock Gorge, Karijini  
 National Park.  
 Photo – Jiri Lochman

The great weight and force of moving ice ground up rocks from the valley floor and walls, redepositing them as beds of sediments, or tillite, when the ice melted. For instance, beds of scattered pebbles, cobbles and boulders up to two metres across can be seen along the four-wheel-drive track into Carawine Pool, and also at Shay Gap and Rudall River. Some of the rock surfaces near Carawine Pool are highly polished with sets of parallel grooves, called striations. These resulted from scouring by rocks embedded in the moving glaciers.

### Rocky rift

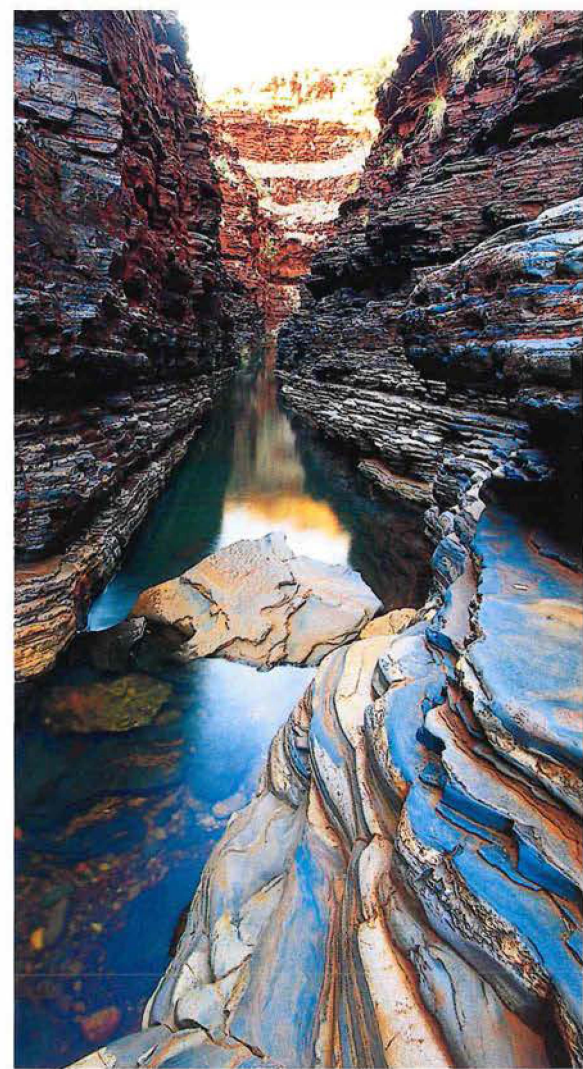
Around 170 million years ago, a large rift developed within the crust off the northern side of the Pilbara, at the site of the present day North West Shelf. This marked the beginning of the break-up of Australia from

Gondwana and, as the continental crust pulled apart, a sedimentary basin called the Northern Carnarvon Basin developed along this rift. Slowly, it filled with an enormous thickness of sediment, some of which was transported by rivers from the eroding rocks of the nearby Pilbara Craton.

During the last 90 million years, thick deposits of limestone have accumulated over the North West Shelf, some of which is now exposed as islands and coastal ranges.

### Evolution of the Pilbara landscape

Today, the Pilbara region has a spectacular landscape of plateaus, gorges, ranges, razor-backed hills and ridges, narrow steep-sided valleys, low hills, plains, dunefields, coastal flatlands and islands. The diverse landscape is very old, and much of it probably began to form at least 295 million years ago when Australia was part of Gondwana. Glaciers carved broad deep valleys into the landscape, particularly on the north-eastern side of the Pilbara. After the glaciers retreated, the surface continued to be eroded as rivers cut down through the landscape.



Around the late Jurassic (about 170 million years ago), as Australia began to break apart from Gondwana, the Pilbara was probably gently uplifted. This caused an extensive interior drainage system—the ancestral Ashburton River—to develop. By the late Cretaceous (around 100 million years ago), warm and humid climatic conditions prevailed over the Pilbara region, and the underlying rocks consequently underwent deep weathering.

### Karijini gorges

There are many gorges in the Hamersley Range, but the most spectacular are in Karijini National Park. Here, the plateau that forms the range has been deeply dissected to reveal magnificent vertical exposures of the 2500-million-year-old banded iron formation (BIF). Although these rocks are ancient, most of the landscape has formed in the last tens of millions of years. It is uncertain when and how this erosion took place, but it was probably during the Late Cretaceous and Early Cainozoic, when the Pilbara was gently tilted towards the north-west. This caused rivers in the range to

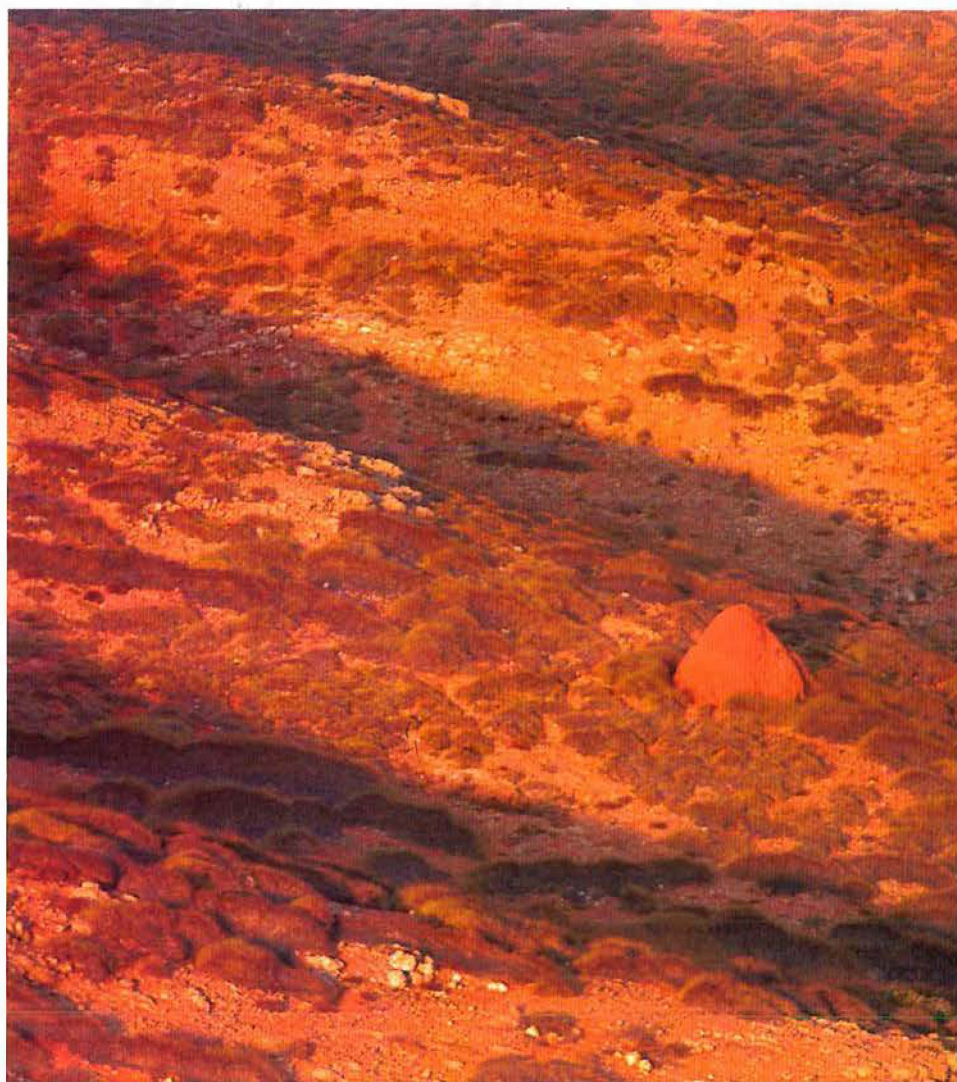


**Above** View of Red Gorge from Oxers Lookout.

Photo – Jiri Lochman

**Above right** Undulating inland landscape with scattered termite mounds.

Photo – Marie Lochman



downcut through the rocks, rapidly eroding the softer shale and dolomite beneath the BIF, giving rise to spectacular gorges and waterfalls. Lines of weakness within these rocks, such as faults and joints, would have aided this erosion. This process was enhanced by the onset of an arid climate in WA, depleting the vegetation able to cover and protect the valley sides.

Material that was eroded at the higher levels was transported to the sides and floors of valleys, to form thick, iron-rich deposits. As erosion continued, these deposits were themselves dissected, and are now preserved as mesas and tablelands, like those at Deepdale near Pannawonica. By around 40 million years ago, as Australia began to drift northwards

after separating from Antarctica, the Pilbara probably began to dry out, leading to lakes forming in old river valleys, such as those of the Fortescue and the Oakover.

During the last two million years, successive ice ages made the climate throughout Western Australia extremely arid. Between 25,000 and 13,000 years ago during the last ice age, aridity was at a peak, probably causing the last significant activity of the dune fields in the Great Sandy Desert and Little Sandy Desert. As the polar ice caps contracted for the last time, about 18,000 years ago, and the climate became warmer and more humid, sea level began to rise and coastal areas were flooded, leaving behind higher areas as islands, like the Dampier Archipelago and Barrow Island.

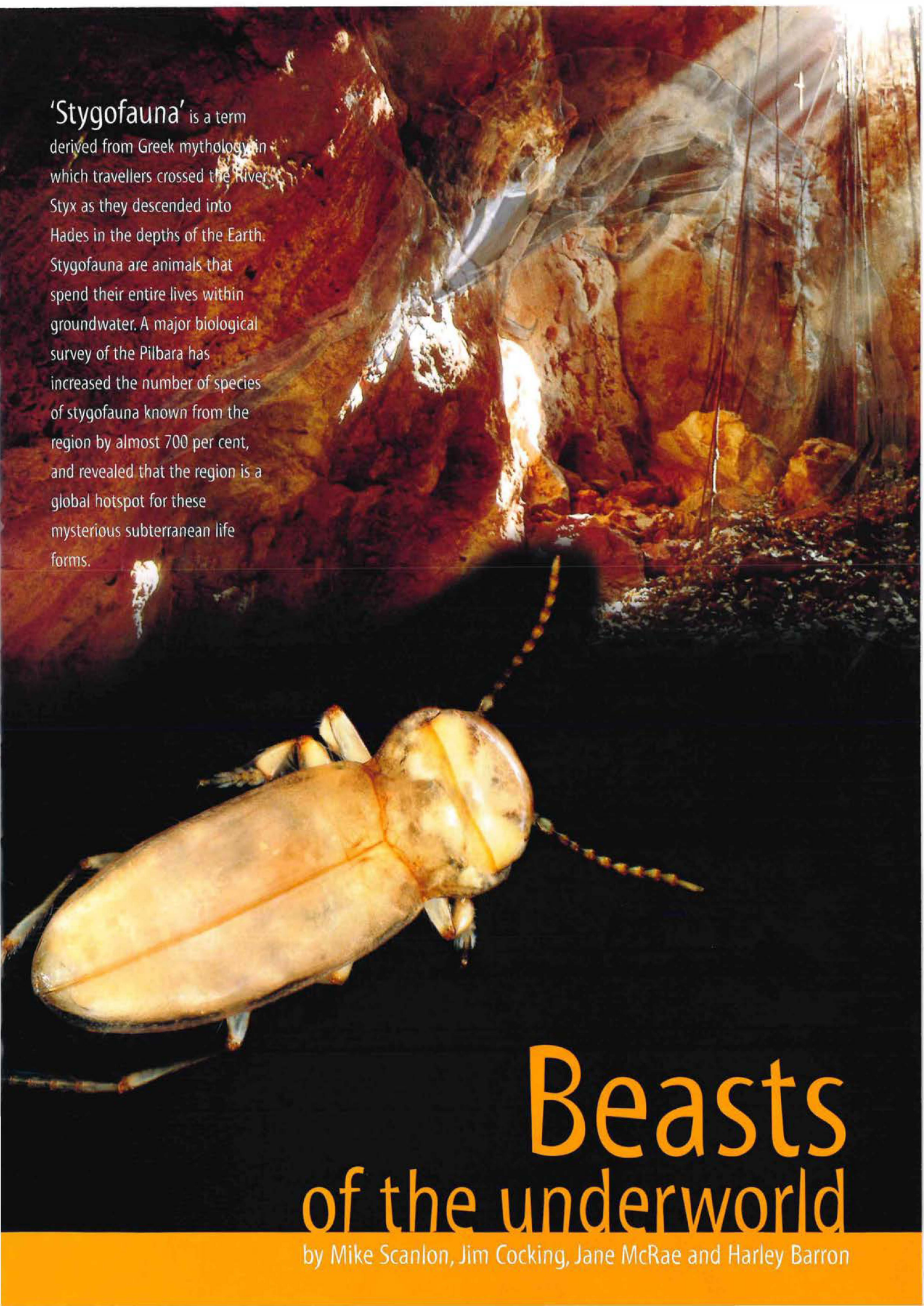
### Huge field laboratory

With such ancient rocks, the Pilbara is now internationally known as the best 'field laboratory' for studying the early history of the Earth. Research is carried out by scientists from Japan, France, the USA (including NASA), the United Kingdom and Australia.

This field laboratory is equally available to the public. So why not take a copy of the Bush Book *Geology and Landforms of the Pilbara* on your next holiday to the region and discover some of this history for yourselves, whether you are visiting some of the vast vistas of Karijini National Park and its famous gorges or the chert of Marble Bar.

Iain Copp is an interpreter in the Department of Conservation and Land Management's Interpretation and Visitor Information Unit. A geologist, Iain also wrote the Bush Book *Geology and Landforms of the South-West*. He can be contacted on (08) 9334 0553 or by email ([iainc@calm.wa.gov.au](mailto:iainc@calm.wa.gov.au)).

This article is based on the full-colour, pocket-sized Bush Book *Geology and Landforms of the Pilbara*, also by Iain Copp, which can be purchased from CALM or from most bookshops for \$6.50. The author acknowledges the assistance of Kath Grey, Ian Williams, Arthur Hickman, Ian Tyler, Alan Thorne, Roger Hocking and Leon Bagas in writing the Bush Book.



'Stygofauna' is a term derived from Greek mythology in which travellers crossed the River Styx as they descended into Hades in the depths of the Earth. Stygofauna are animals that spend their entire lives within groundwater. A major biological survey of the Pilbara has increased the number of species of stygofauna known from the region by almost 700 per cent, and revealed that the region is a global hotspot for these mysterious subterranean life forms.

# Beasts of the underworld

by Mike Scanlon, Jim Cocking, Jane McRae and Harley Barron

**S**tygofauna are animals living permanently underground in water. They occur in all sorts of groundwater habitats, from the tiny spaces between sand grains to large subterranean caves that have been formed over thousands of years as more soluble rocks have dissolved. Because stygofauna live in the dark, they lack eyes and pigmentation, and they also tend to be fragile and elongated in shape. Although some species are fish—including two threatened species found at Cape Range near Exmouth, the blind cave eel (*Ophisternon candidum*) and the blind gudgeon (*Milyeringa veritas*)—most are small crustaceans that vary from about 0.3 to 10 millimetres in length.

Stygofauna have great scientific and conservation significance. They have a

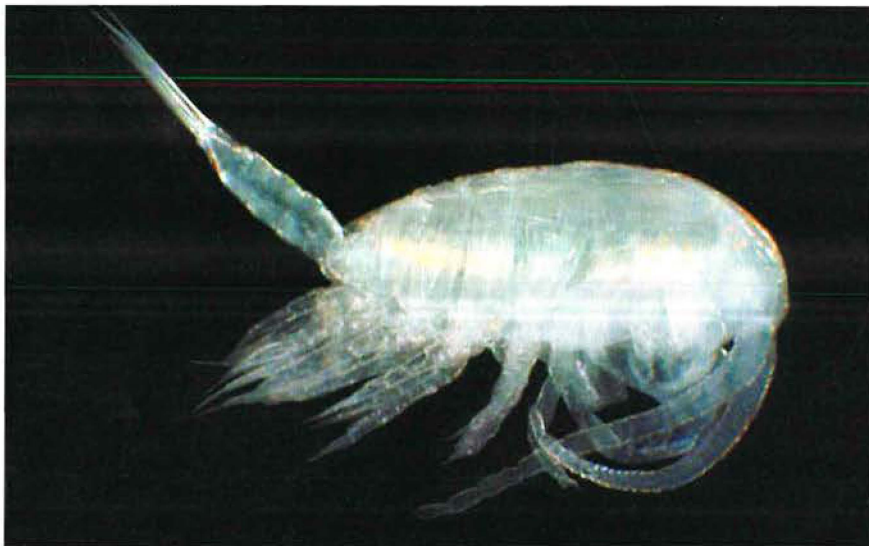
significant role in maintaining water quality, which is likely to be increasingly important as Western Australia relies more heavily on groundwater for domestic and industrial water supply. As nutrients and organic matter percolate down from the surface, grazing stygofauna reduce concentrations of this matter. Stygofauna also keep spaces between soil particles open, to maintain groundwater flow, which is a critical factor in determining the amount of water that can be abstracted from an aquifer. Although stygofauna do a lot of engineering to maintain stable groundwater conditions, they can be overwhelmed by pollution events, such as major petroleum and sewage spills. Groundwater abstraction and

dewatering of aquifers, usually to enable mining below the water table, are other important threats.

### First discoveries

Scientific interest in stygofauna first gathered momentum in WA when Bill Humphreys and Brenton Knott, from the WA Museum and The University of Western Australia, undertook systematic collecting in pools of subterranean caves at Cape Range in the late 1980s. Subsequently, Bill Humphreys collected many new species on Barrow Island and in the Pilbara, and suggested that north-western Australia had particular scientific and conservation significance for stygofauna. The Environmental Protection Authority supported this view and began to consider likely impacts on stygofauna when assessing resource development projects in the Pilbara.

As soon as stygofauna were included in impact assessments, it became apparent how little was known about the distribution of individual species. One of the problems was that nearly all assessments appeared to collect new, restricted species that were potentially at risk of extinction if developments proceeded. Was this pattern real or the result of so little information on distributions of stygofauna species being available? Was the same species being identified as different (and restricted) in each impact assessment because of an uncoordinated identification process?



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**Main top** Surveys of caves on Cape Range peninsula helped raise awareness about the conservation significance of stygofauna in north-western Australia.

*Photo – Geoff Taylor/Lochman*

*Transparencies*

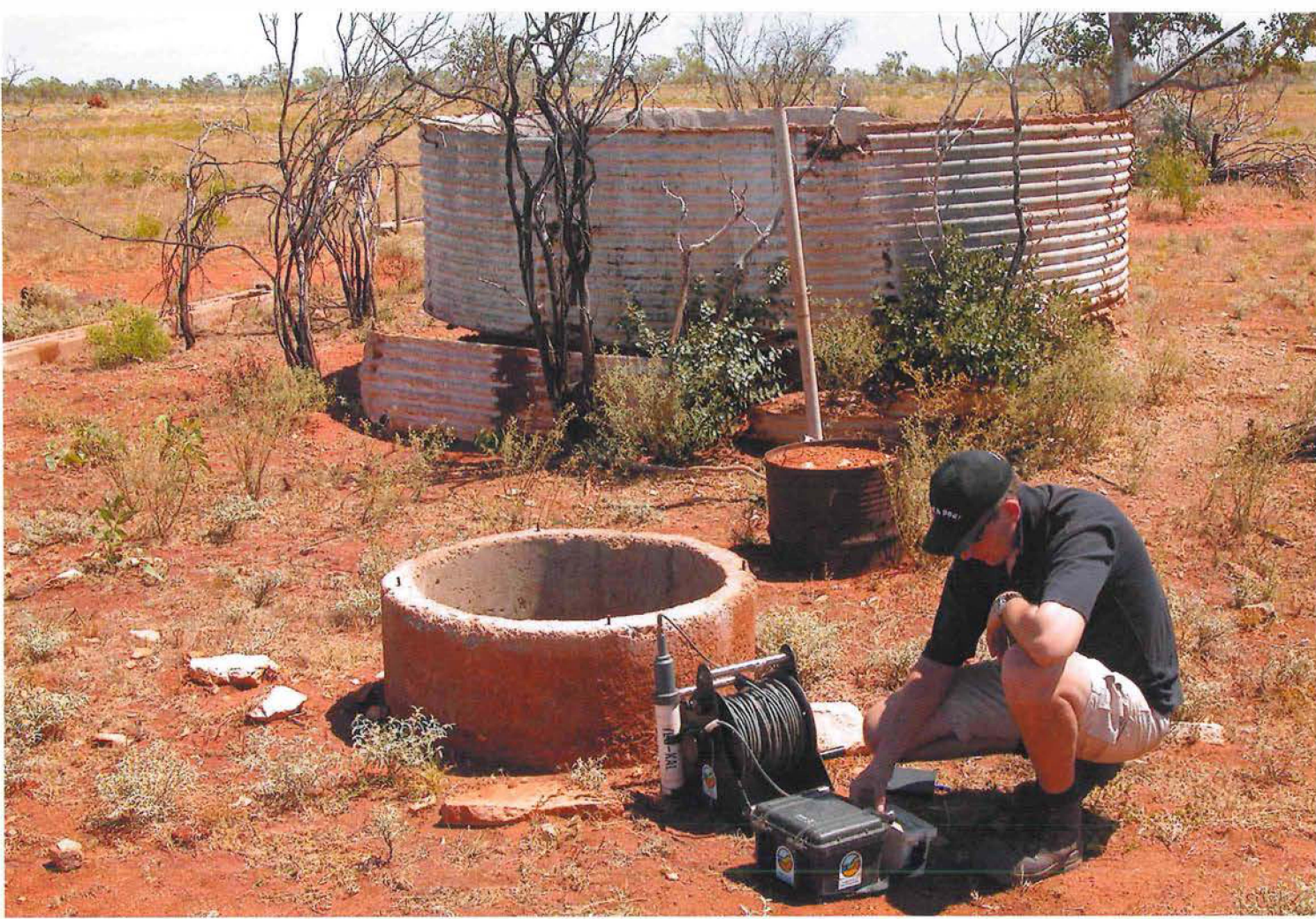
**Below** A stygofaunal beetle (*Liodessus harleyi*) from just east of the Pilbara.

**Inset top** A new genus of melitid amphipod is one of several being studied by DNA analysis to determine its origins.

**Above left** A copepod belonging to a new family from the mainland Pilbara and Barrow Island.

**Left** A new species of syncarid, one of 18 found during the survey.

*Photos – Jane McRae/CALM*



**Above** CALM technical officer Jim Cocking measures water chemistry at Nimingarra Well on Muccan Station.  
*Photo – Mike Scanlon/CALM*

**Right** Berringarra Claypan in August 2004, several weeks after receiving runoff from local rainfall.  
*Photo – Adrian Pinder/CALM*



Published taxonomic descriptions and keys to all known species would overcome this problem.

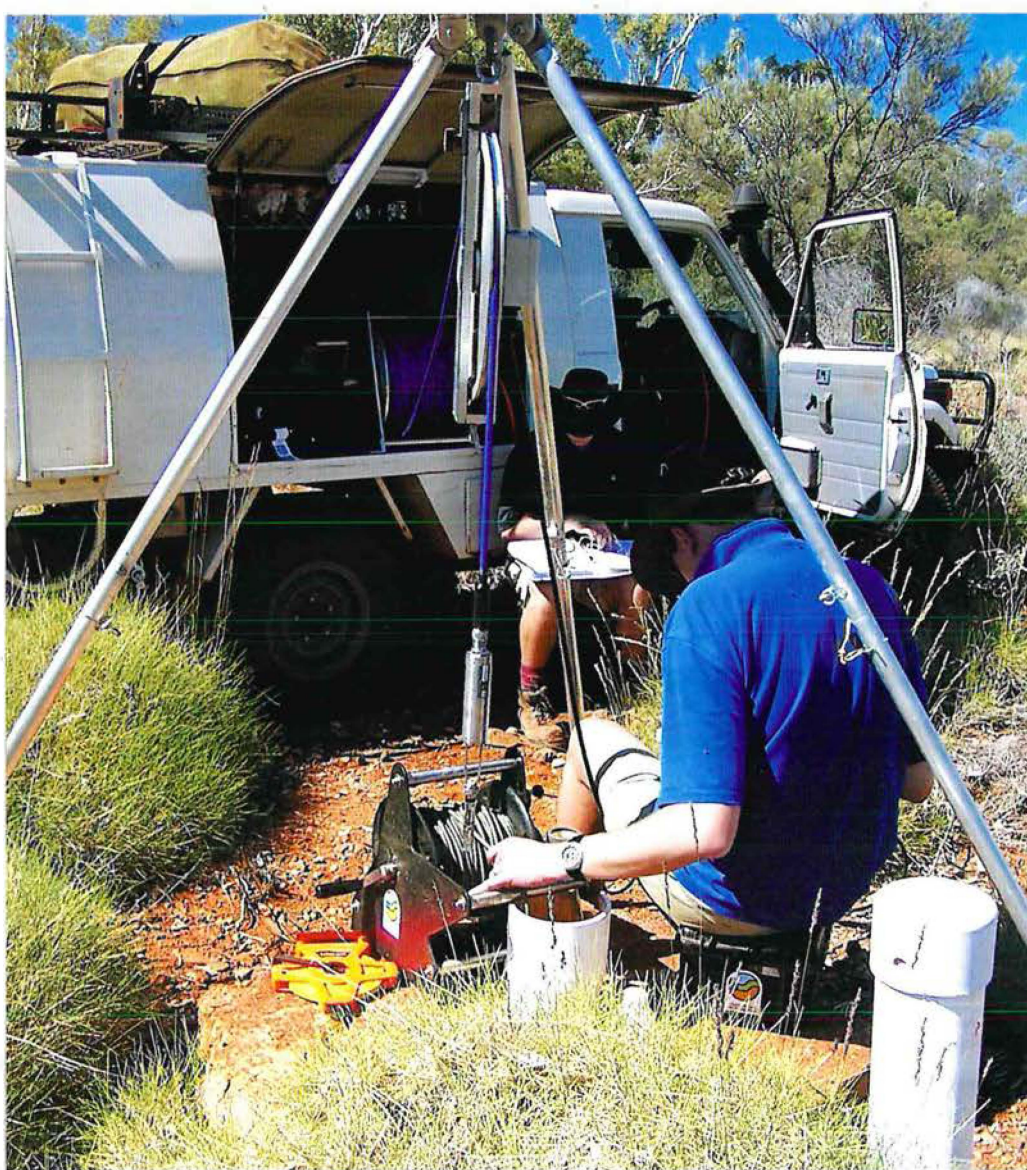
### Survey in the Pilbara

In 2002, the Department of Conservation and Land Management (CALM) began a biological survey of the Pilbara as part of an ongoing inventory of Western Australian plants and animals, designed to provide information on species distributions and their conservation status. It will also enable efficient identification of areas suitable for nature reserves to conserve as much of the plants and animals as possible in a given area of land. Most survey effort is being directed towards terrestrial species, and the aquatic wildlife of river pools and other surface water bodies, but for the first time stygofauna have been included.

Including stygofauna will enable development of a framework for proper assessment of impacts of groundwater extraction and mining below the water table, and allow scientists to identify areas of particularly high stygofaunal richness, where special measures to protect groundwater habitat may be necessary. Describing new species of stygofauna is a major focus of the work, because until species are named and illustrated

there is no basis for consistent identifications or accumulating information about them.

Collecting stygofauna is difficult because there is limited access to the groundwater where they occur. Although some species occur near the surface in springs (which represent groundwater discharge at the surface), such areas are usually awkward to sample because they are associated with bedrock. Pastoral wells, which are



Left CALM technical officers Jim Cocking and Harley Barron video down a bore.  
Photo – supplied by Harley Barron/CALM

usually more than a metre in diameter and not much more than 12 metres deep, offer easier access to groundwater. However, wells are limited in number, and narrow, deep bores are much more common (50 to 400 millimetres in diameter, with average depths of 40 metres, and the deepest bore sampled being 160 metres). Most bores are cased in PVC or steel. Slots in the casing allow water exchange, so that the groundwater level inside the bore reflects outside conditions. Stygofauna move into bores through the slots.

Sampling consists of dropping a small net, with a brass weight attached, to the bottom of the bore and then hauling it back up through the water column to catch stygofauna. This is repeated several times. To date, 378 bores and 122 wells have each been sampled twice during the survey. Sampling is a blind process and the operator has no idea whether there are animals in the bore escaping the net. Preliminary work suggests that only a third of the species in the bore and its immediate surrounds

are collected each time a bore is sampled. About two thirds of bores yield stygofauna on first sampling, with an average of 5.4 species.

### Staggering results

Before the survey, about 40 species of stygofauna were known from the Pilbara, but now it is clear that at least 275 species exist. The most common stygofauna are copepod and ostracod crustaceans. Forty-four species of copepods have been collected, including one that belongs to a new family so far known only from Barrow Island and the Pilbara.

About 73 new species of ostracod have been discovered. Ostracods are small seed-like animals with a calcified bivalved carapace that is sometimes highly ornamented. The different shapes and patterns on the valves of each species mean that, even after death, these animals can often be identified from a preserved valve of their carapace.

Another important group of crustaceans are the amphipods. These

rather shrimp-like animals have traditionally been regarded as having very localised distributions and being difficult to distinguish at species level. One of the major challenges of the survey will be improving taxonomic knowledge of this group.

The survey has found at least four new species of isopod crustaceans, which are closely related to the slaters found in domestic gardens. Pilbara isopods belonging to the genus *Pilbarophreatoicus* are Gondwanan relicts. Their closest relatives are in India, reflecting the joining of Western Australia and India 80 million years ago.

Other interesting crustaceans include syncarids. This species-rich group of rather tubular animals with poorly differentiated legs has representatives throughout the world and they are common in groundwater in Australia. Despite their ubiquity in Australia, few have been described, and the 18 species found during the survey are all undescribed.

Not all stygofaunal invertebrates are crustaceans, however, and 15 species of water mites have been collected during the survey. Various worm species have been collected, including an undescribed marine polychaete 400 kilometres inland south of Paraburdoo. Two new species of snail have been found, including one in which the shell is shaped like a small cow's horn to enable the snails to move between sand grains. Stygofaunal beetles, which are common in the Goldfields, appear not to occur in the Pilbara, although they have been found immediately to the east.

### Global hotspot

There is clear evidence that the Pilbara is a global hotspot for stygofauna. South-western Australia has long been renowned for plant diversity, and is now being recognised as a hotspot for crustacean diversity in surface waters. Thus, the stygofaunal

**Right** The bed of Palm Creek, Millstream, has yielded several stygofauna species.  
*Photo – Stuart Halse/CALM*

**Below right** A never-before-collected marine polychaete worm was found 400 kilometres inland.

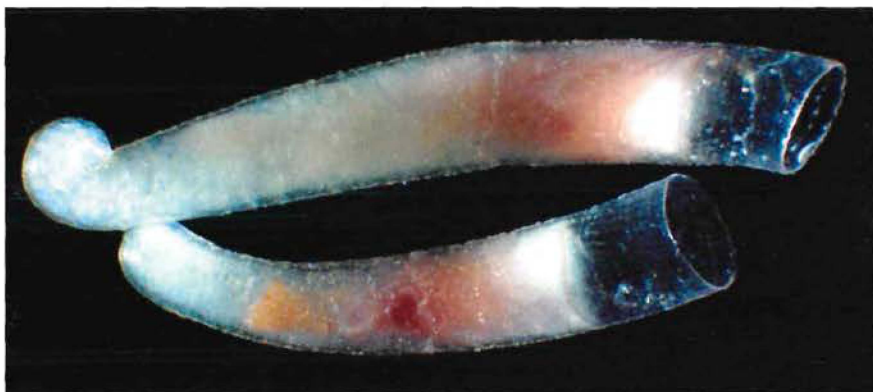
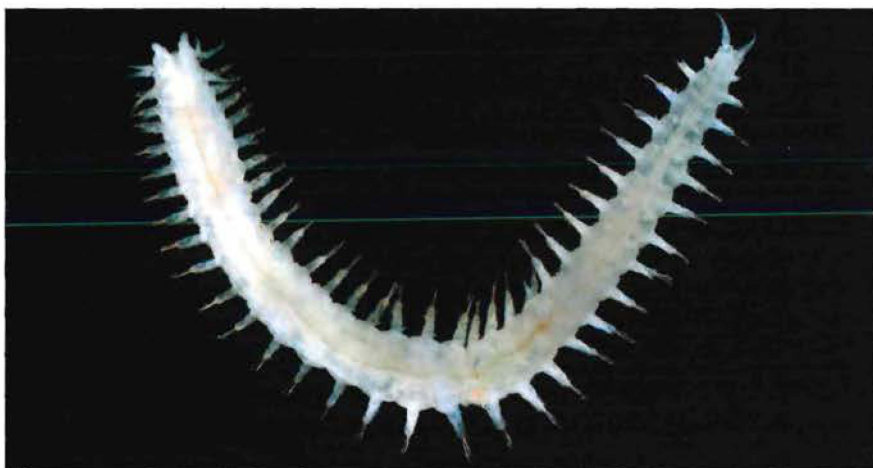
**Bottom right** A completely new species of snail, with a shell shaped like a small horn, was located during the Pilbara survey.  
*Photos – Jane McRae/CALM*



story is adding to an already established pattern of internationally important biological values in WA.

The full explanation for this biological richness is still being researched. One likely reason for high richness and scientific interest of Pilbara stygofauna is related to the region's geological history. The central Pilbara has remained above sea level for more than 550 million years, while the Australian continent has joined and separated from other landmasses (Pangea and Gondwana) because of tectonic movement. As a result, it shares species lineages with many other parts of the world and these lineages appear to have radiated in the Pilbara over time, without the waves of extinction that have characterised most parts of the world with less stable land surfaces.

Now that we recognise the antiquity of much of the Pilbara stygofauna, the challenge is to ensure the survival of these animals into the future. The current survey is only the first step in planning a conservation strategy. Habitat protection, which in this case is the maintenance of groundwater quantity and quality, is an essential component of conservation. Understanding the ecology of individual species is also important, as to formulate a comprehensive conservation plan we need information about their lifespans, the number of young produced, the distances that individual animals are able to travel, and their ability to withstand periods of low water tables as a result of drought or periods of dewatering by industry. Hopefully, ecological studies will continue once the survey is completed.



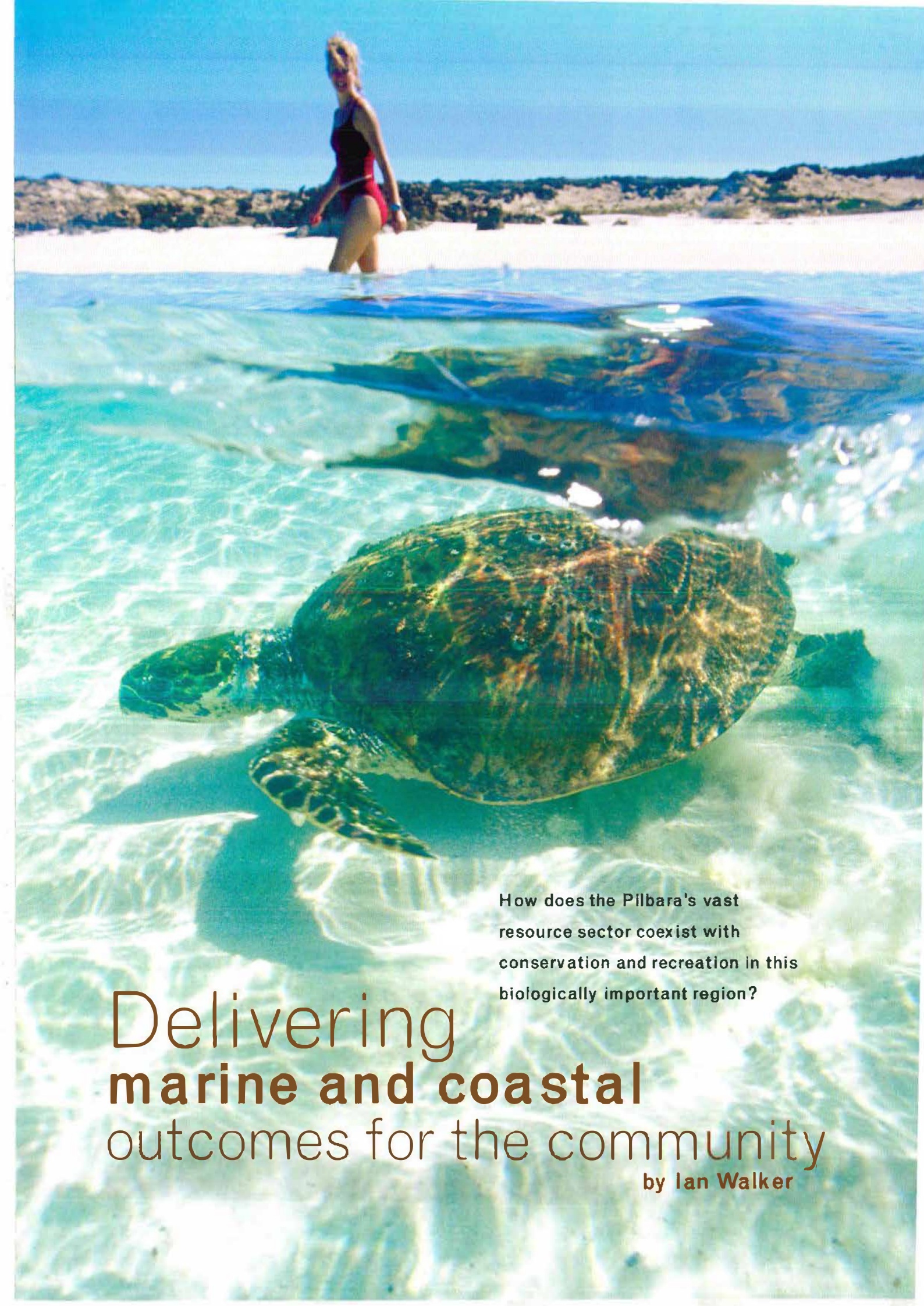
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How does the Pilbara's vast resource sector coexist with conservation and recreation in this biologically important region?

# Delivering **marine and coastal** outcomes for the community

by Ian Walker



The Pilbara is often regarded as the engine room of the nation, with 20 per cent of Australia's gross domestic product derived from the region. Iron-ore, liquid natural gas, petroleum, gold and other minerals are all products of the Pilbara. Nowhere else in Australia do the terms 'multiple use' come face to face with conservation as they do in the Pilbara. The region contains Australia's largest ports, longest private railway, largest gold mine and largest iron-ore production areas. The vast resource sector coexists with cultural and environmental gems such as Western Australia's largest and second largest national parks, Rudall River (Kardamilyi) and Karijini; Australia's largest fringing reef at Ningaloo Marine Park; the Montebello and Barrow islands; the Dampier Archipelago; and Millstream-Chichester National Park, to name a few.

### Connection to country

The Indigenous people have a strong connection to this country and describe their origins in the Pilbara as 'when the earth was soft'. In many areas, native title rights have been granted. Others are jointly managed with the traditional owners and the Department of Conservation and Land Management (CALM). All of the region's major parks are jointly managed through park councils (see 'Learning together' on pages 39–43). This passion and connection to country is highlighted in the DVD *An ancient land, a living culture: a vision for Millstream-Chichester National Park*. You can view this

DVD on CALM's NatureBase website ([www.naturebase.net](http://www.naturebase.net)), Juluwarlu TV or by contacting CALM's Karratha office.

This coexistence of people and industry collides in our marine and coastal areas, where mining, industries and conservation have to exist symbiotically. Then throw into the mix commercial and recreational fishing, commercial tour operators such as whale shark operators, pastoralists and increasing numbers of tourists. Working collaboratively with many people and industries to conserve and sustainably manage these unique areas is a challenge for the whole community.

### Marine and coastal protected areas

Protected areas in the region have increased over the last decade, consistent with national and international trends. For example, the Convention of Biological Diversity set a target of conserving 10 per cent of the world's oceans in fully protected ('no take') areas by 2012. WA is progressing towards these targets, with 2.5 per cent of State waters fully protected in 'no take' zones (with 12.2 per cent of State waters now in marine conservation reserves). Considerable efforts are still required to reach these targets to ensure the world's marine areas are conserved.

Our marine and coastal areas are home to whales, whale sharks, manta rays, turtles and sharks, along with thousands of other plants and animals including corals. The marine protected

### Opposite page

Green turtles in the shallows at the Montebello Islands.

Photo – Peter and Margy Nicholas/  
Lochman Transparencies

### Above

Aerial view of the Montebello Islands.  
Photo – Col Roberts/Lochman  
Transparencies

areas off the Pilbara coast contain the majority of the State's coral reef habitats. The waters around the Dampier Archipelago have the richest marine biological diversity known in WA, and greater than the Great Barrier Reef (see 'Dampier Archipelago down under', *LANDSCOPE*, Summer 2003–04!)

### Proposed Dampier Archipelago Marine Park

The proposed Dampier Archipelago Marine Park (about 122,170 hectares) and Cape Preston Marine Management Area (92,750 hectares) lie in the Pilbara nearshore marine bioregion. The 12 major and 30 minor islands in the Dampier Archipelago represent peaks of a drowned landmass. The waters of the proposed reserves are relatively pristine, although there are areas of localised species and habitat depletion.

Marine habitats here are extremely varied, and include algae-covered limestone reefs, coral reefs, beaches and rocky shores. The marine plants and animals are predominantly tropical, with a number of regionally endemic species. Intertidal soft sediment habitats generally support a species-rich invertebrate fauna—an important food source for migratory birds. Coral and fish species are also diverse. Mangrove areas support



Above Dolphin Island in the Dampier Archipelago.  
Photo – David Bettini

many invertebrate species, and provide nursery areas or shelter for vertebrates. Four marine turtle species nest on the beaches, and the area is a significant rookery site for many species of seabirds.

Dampier has the second largest tonnage port in Australia, with most cargo being salt, iron-ore, liquefied natural gas and condensate. Processing and other industries are likely to significantly increase. The productive and sheltered waters provide a range of recreational fishing and diving opportunities.

### Islands of the Pilbara coast

More than 300 islands, ranging from small sand cays to the 23,000-hectare Barrow Island, lie between Exmouth Gulf and Port Hedland. Most are conservation reserves. The islands are mostly limestone, with low coastal cliffs, white sandy beaches and occasional pale orange-brown alluvial sandplains. However, those of the Dampier Archipelago are composed of basalts, granophyres and granites.

Vegetation is similar to that on the mainland coast. Islands of the Dampier Archipelago are the most floristically diverse, with sandplain and drainage line associations being particularly varied. Mangroves are more prevalent on islands closer to the coast.

Many of the islands are home to endemic species or subspecies of mammals, reptiles and birds. Most larger islands support mammal populations

(mostly rodents), with Barrow Island having 14 terrestrial mammal species and no feral animals. Feral rats, cats, foxes and mice have now been eradicated from many Pilbara islands, however, the house mouse remains on Thevenard Island, and the Montebello Islands are now depopulated in native mammals as a result of cats and rats.

Reptiles thrive on the islands. Of particular significance are the Hermite Island worm lizard (*Aptasia rostrata rostrata*), which is threatened, and endemic reptiles on Barrow Island (*Ctenotus pantherinus acripes* and *Rhamphotyphlops longissimus*). Rosemary Island in the Dampier Archipelago supports the largest hawksbill rookery in the Indian Ocean. Barrow Island, Legendre and Delambre Islands in the Dampier Archipelago, and the Montebello Islands also have significant turtle nesting areas.

The earliest known European shipwreck in Australia, the *Tryal*, lies north-west of the Montebello Islands. Early maritime industries in the region included whaling, pearling and turtle hunting. In the 1950s, the British undertook atomic weapons testing on the Montebello Islands, exploding three atomic devices. During the testing, roads and other facilities were constructed. Structures and a considerable amount of rubbish remain from this period. There is residual, low-level radiation on Trimouille and Alpha islands around the test sites.

There are gas and oil processing facilities on Barrow, Varanus and Thevenard islands.

### Ageless stories in stone

The Burrup Peninsula contains the world's largest concentration of rock engravings (see 'Making their mark: Pilbara rock art' on pages 6–10)—thought to be up to 18,000 years old, older than the Ancient Egyptian Pyramids—and the world's largest collection of standing stones and other stone arrangements. Some of the shell middens date from 4000 years ago.

The rocky scree of the Burrup (Murujuga) varies in colour from orange red to deep purple. The coastal strip comprises sandy beaches, rocky shores, saline mudflats and areas of mangrove swamp. Spinifex hummock grasslands dominate, with emergent shrubs and open low woodland. Most trees are found in gullies, gorges and creeklines or in rock pockets. The peninsula has a richer diversity of wildlife than any equivalent sized area of the Pilbara, with 32 mammal species (four introduced), 168 birds (one introduced) and 60 reptiles and frogs. The threatened Pilbara olive python (*Liasis olivaceus barroni*), Rothschild's rock-wallaby (*Petrogale rothschildi*), an undescribed species of planigale and



two undescribed reptiles, both belonging to the *Lerista muelleri* complex, are of particular interest.

The Burrup Peninsula also contains Australia's premium industrial estate for the natural gas industry and major port facilities. While most of the landscape is intact, areas with industrial developments and related infrastructure have been significantly disturbed. A historic native title settlement in 2003 saw the State return freehold title of some 60 per cent of the Burrup Peninsula to Aboriginal ownership. This area is to be jointly managed as a conservation reserve by the Indigenous owners and CALM, which will provide new opportunities for local Indigenous people and greater recognition of their unique place in the region.

### Montebello/Barrow Islands

The Montebello Islands Marine Park (59,240 hectares), Barrow Island Marine Park (4530 hectares) and Barrow Island Marine Management Area (148,540 hectares) are in the Pilbara offshore marine bioregion.

Of more than 300 islands and islets in the area, there are 265 in the

Montebello complex, 40 in the Lowendal group and nine in the Barrow Island region. The mainly limestone islands have convoluted coastlines with many embayments, lagoons and channels and exceptional habitat diversity. The Montebello/Barrow Islands lie in an area considered to be the headwaters of the Leeuwin Current, so the reserves may be an important source of recruitment for tropical species along the west coast.

Mangrove communities on the Montebello Islands are of international significance due to their distance from the mainland. Four species of marine turtles and at least 15 species of seabirds nest on the islands.

Some of the highest quality pearls in the world are produced within the reserves. The major commercial fishing activities in the region are fish trawling and line fishing. Recreational fishers target abundant prized table fish species.

### Ningaloo Marine Park

The world renowned Ningaloo Marine Park, about 1200 kilometres north of Perth, protects the largest fringing reef in Australia. The park is globally significant, due to its close proximity to the continental shelf and deeper oceanic waters.

Most of the park's waters, plants and animals are in pristine condition. The corals of Ningaloo Reef are diverse and

**Above** Fishing at Hearsen Cove on the Burrup Peninsula.  
Photo – Jiri Lochman

**Right** Cowrie Cove in the Burrup Peninsula Nature Reserve.  
Photo – David Bettini





abundant, with changes in species richness occurring within relatively short distances. Hundreds of fish and coral species can be observed including coral trout, pipefish, clownfish, rays and the odd reef shark. Turtles often swim amongst the coral reef habitats, which form about two thirds of the park.

Ningaloo Reef and its adjacent foreshore are popular for camping and water-based activities. The reef's proximity to the shore means visitors can easily view the lagoon and reef communities without a boat. Recreational line, spear and net fishing are popular. However, over the last decade, the community has gained greater understanding of the ecological values of the park, and the need to protect the park's marine environment. This is evident in the increasing numbers of visitors to the park who primarily enjoy nature-based tourism activities such as snorkelling and diving.

The annual aggregation of whale sharks at Ningaloo was first documented in the early 1980s. Ningaloo is now a world-renowned hotspot for whale shark interaction and a model for successful nature-based tourism. Tourism along the Ningaloo-Carnarvon coast is increasing rapidly, with visitation to Ningaloo increasing at approximately 10 per cent each year and contributing around \$127 million to the State's economy. Ningaloo Marine Park has more than 160 licensed tour operators, up from 52 five years ago.

### **Cape Range National Park**

Cape Range National Park encompasses 50,581 hectares of the Cape Range peninsula, a heavily dissected limestone range and fringing coastal plain adjacent to the northern part of Ningaloo Marine Park.

The park supports a range of flora and internationally significant wildlife, values recognised by its inclusion on the Register of the National Estate and the

**Above left** Perentie seeking food at Coral Bay.

*Photo – Bill Belson/Lochman Transparencies*

**Left** Snorkelling at Coral Bay in Ningaloo Marine Park.

*Photo – Peter and Margy Nicholas/Lochman Transparencies*



**Above** Mangroves near the mouth of Yardie Creek, Cape Range National Park. Photo – Brett Dennis/Lochman Transparencies

current proposal to nominate the area for World Heritage listing. The park protects a diversity of landforms (such as karst, protected gorges, the anchialine system and coastal plain), and many species at the limits of their geographical range or in geographically isolated populations.

The park is particularly rich in flora for an arid limestone environment, with 630 species, subspecies and varieties recorded. The diverse wildlife can be attributed to the range of habitats (from mangrove and intertidal marine to sandy ridges, subterranean wetlands, alluvial plains, rocky ranges and caves). Internationally significant stygofauna (animals that live in groundwater) live in the caves and there are important turtle rookeries along the coast. Rich fossil deposits include Pleistocene coral reefs that represent several periods of coral reef development.

Cape Range National Park contains the earliest known (Pleistocene) occupation site based on a marine economy in Australia. Sites within the park have potential to reveal significant insights into regional changes to climate, flora and fauna, and the lifestyles of Indigenous people.

Recreation and tourism opportunities available to the growing number of visitors include outstanding scenic landscapes, remote camping and nature-based experiences such as watching wildlife like kangaroos, ●prey and bustards.

### **Giralia**

The former Giralia pastoral lease covers about 230,889 hectares at the

southern end of the Exmouth Gulf, one of the largest embayments on the WA coast. The eastern and southern shores of the bay are dominated by mangroves and mudflat habitats of great significance.

The area is rich in fossils. Those discovered include Archosaurian reptiles (*Pterosaurius*) dating back to the late Cretaceous (from 70 to 66 million years ago). The area abounds with well preserved examples of marine animals, including ammonites, corals and large shark teeth.

Pastoral stay accommodation is available at the homestead for visitors wanting to make the most of the natural environment and the hospitality of the managers.

### **Integrated marine and coastal program**

To ensure that our natural areas are conserved for future generations, CALM is undertaking a range of strategies with other government and non-government agencies and, importantly, with the community.

We need a change in approach and focus, where community needs are considered equally in decision making while protecting natural and cultural values. As a result, a five-year marine and coastal program has been established, identifying strategies across the Pilbara region to increase understanding and management of our unique and outstanding natural areas. Key themes of the program include planning, community engagement, research and monitoring, compliance, park maintenance and capital development.

A communication plan has been developed to encourage and engage the community and involve them in management and conservation of the region. Working with the community and winning their hearts and minds is fundamental to the long-term sustainability of the area.

At the recent International Marine Protected Area Congress, Director General of the IUCN (World Conservation Union) Achim Steiner made the point that 'we cannot manage biodiversity, however, we can manage the people, their understanding and effects on it'.

A real Australian experience, where the desert meets the sea, awaits you along the marine and coastal environments of the Pilbara. Together we can ensure that the amazing diversity of marine and coastal environments and opportunities will be available for our children's children.

Ian Walker is CALM's Pilbara regional manager. He is based at the Karratha regional office and can be contacted on (08) 9143 1488.

For further information on the region's Marine and Coastal Program contact CALM's Karratha or Exmouth Offices.

# urban antics

by John Hunter

## Desert tree frog

Urbanites in our State's northern towns and communities also experience antics and have wild times and unusual stories to tell.

Creatures often drift into town and, like their human counterparts, prefer to coexist in newfound, sophisticated comfort and accommodation.

If there is one wild thing that is tolerated by people, it is that universally admired amphibian, the frog. They don't bite, they don't fight, and they're mostly out at night. They sing and don't sting and, most acceptably, knock off insects like mosquitos. My Mum loves them, so long as she doesn't have to pick them up and that's a bonus for the frog, because soaps and household chemicals on our hands are not good for Freddy's skin.

One of the most common animals found across the mid to northern Australian continent—a place where the majority of our population isn't—is the small, robust and short-legged desert tree frog (*Litoria rubella*).

Before human settlement the frogs were found in a wide range of habitats, from eastern wet forests through central deserts to the arid western coastal scrub of WA. Here they usually hung out with their mates, calling from trees and shrubs beside watercourses or from temporary or permanent swamps and lagoons.

Then came human settlement and all those buildings with protected nooks and crannies, artificial light that attracted insect food, plumbing lines, and the dream accommodation of a cool, smooth, accommodating porcelain toilet bowl with human visitors who 'pull the chain', providing instant tropical flash flooding. A frog Heaven on Earth.

And so started the northern urban antics and local name



change of *L. rubella* to that of the 'northern dunny frog'.

In the late 1970s, the Northern Superintendent of National Parks and the ranger for Millstream National Park (as it was then named) were inspecting a new 'kit' toilet that had just been erected at Crossing Pool. The ranger, a man of considerable size, attended the call of nature, but he had to leave the door open to accommodate his knees and feet. While the facility was being thoroughly put to the test, his boss wandered off to observe corella acrobatics in the nearby paperbark trees. A little while later, the tranquillity was shattered by a horrendous bellow. There was the man-mountain, well outside the privacy of the closet, eyes bulging, hopping around and furiously trying to pull his pants down. He'd pulled up his daks only to experience a cold wriggling object in his nether regions. A tree frog had jumped into his undies while they were down and

was only discovered after a few strides down the track.

There was also the tale of the mining camp silky terrier that loved to hunt tree frogs in the ablution block. The frogs loved the rows of pedestals, hand basins and lips, where they hid in the cavities to gorge on moths attracted by the permanent lighting. Every time someone pressed the flush button, a bunch of frogs would somehow survive going down the gurgler and, while they were 'shooting the rapids', Bimbo would rush past, dive in head first, and give the frogs the 'tom-tits' until his terrier urge was satisfied. Where else could you get such theatre at a loo near you?

Frogs are considered by many as an indicator species to the wellbeing of the environment around us. Let's look after them, they are such wonderful creatures to have around.

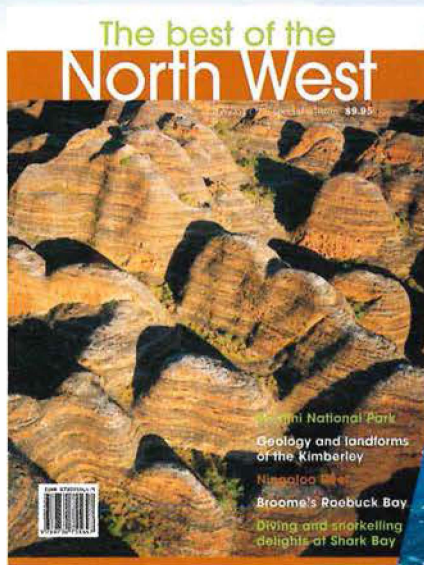
### DID YOU KNOW?

- *Litoria* is one of the most diverse genus of frogs in the world. Some of the 61 species recognised in Australian habit trees, some are ground dwellers, one burrows and another skips upon the surface of water.
- The little desert tree frog's screaming chorus is like that of a flock of silver gulls. To avoid excessive water loss, while basking in direct sunlight, it changes colour from the typical grey-brown to a bright white.

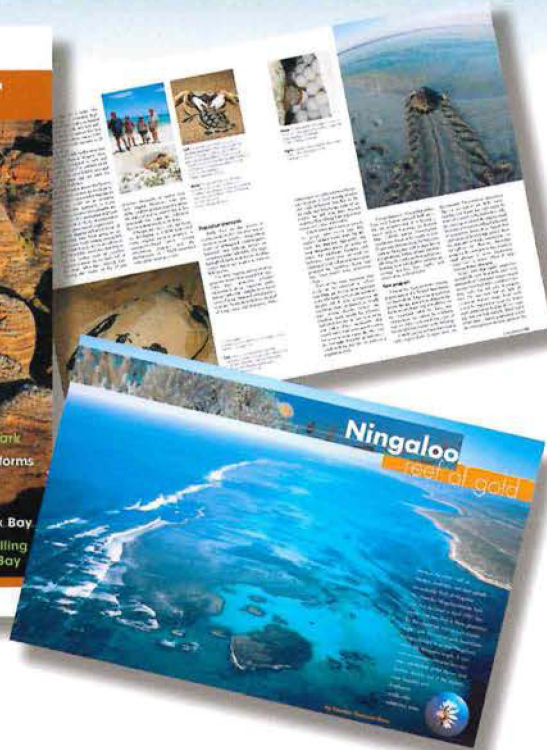
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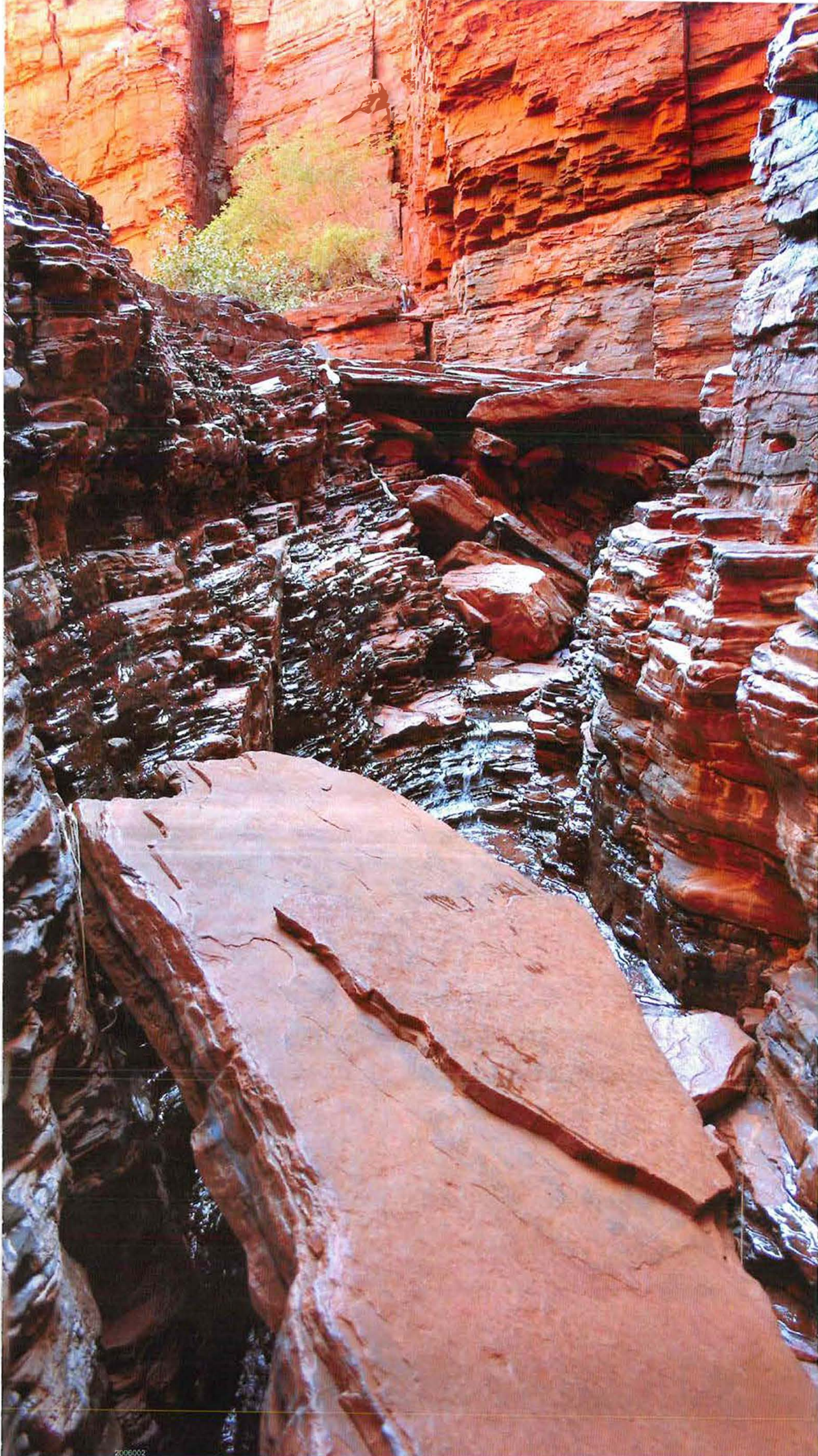
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Tel: (08) 9334 0333, Fax: (08) 9334 0498, TTY (hearing impaired) facility available (08) 9334 0546 or order online through CALM's NatureBase website ([www.naturebase.net](http://www.naturebase.net)).





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