

LANDSCOPE

W.A.'S CONSERVATION, FORESTS AND WILDLIFE MAGAZINE



P. Mikulinsky

**Geology
and landforms
of the South-West**

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of delights**

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Leschenaultias

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Winner of the 1998 Alex Harris Medal for excellence in science and environment reporting.



LANDSCOPE

VOLUME SEVENTEEN, NUMBER 1, SPRING 2001



Within 40 years, the numbat has risen from near extinction to endangered with 10 populations in WA and interstate. See 'Numbats Forever' (page 17).



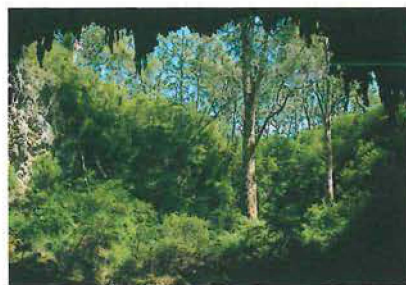
The forces that shaped the geology and landforms of the south-west began more than 3,500 million years ago. Read the fascinating story on page 10.



The Marine Community Monitoring Program is a new and ambitious program to involve the community in keeping our oceans clean. See page 35.



Shark Bay Marine Park provides spectacular opportunities for divers and snorkellers. No wonder it is called Bay of Delights. See page 23.



The history of Aboriginal occupation in the Leeuwin-Naturaliste region spans 50,000 years. Find out more in 'History from the Caves' (page 40).

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COVER

Leschenaultias are some of the most widely known and recognisable plants in Western Australia. They have fantastic horticultural value and provide glorious floral displays. The wreath leschenaultia is a favourite with visitors during our wildflower season. See page 23.



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CONSERVING BIOLOGICAL DIVERSITY IN WA

It is difficult to exaggerate the environmental impact we have had on the natural biological diversity of Western Australia. While human activity has been changing Australian ecosystems for approximately 50,000 years, the pace and extent of change has increased since European settlement about 200 years ago. Coastal ecosystems have been extensively altered, many wetlands have been degraded, and most other parts of the bush have been modified to some extent by various factors, including introduced animals and plants. The result has been dramatic declines in the distribution and abundance of many species.

The latest scientific information we have is that a total of 502 wildlife species and subspecies are considered to be threatened or extinct in Western Australia. This includes 13 presumed extinct animals and 17 presumed extinct plants. The encouraging news is that Western Australia is having success in preventing the extinction of native wildlife through the conservation work of individuals, organisations, governments, and the private sector and community groups.

In the last issue of LANDSCOPE, we reported on conserving the genetic diversity of our unique and diverse flora. In this issue, we provide insights into conserving biological diversity at the species and ecosystem levels.

There is little that's more Western Australian than the numbat. Just 40 years ago, the State's mammal emblem was common in WA, but by 1985, loss of habitat and predation by introduced foxes had caused this dainty, termite-eating and day-active marsupial to dwindle to two small populations on the edge of extinction. In 'Numbats Forever!', Tony Friend and Neil Thomas take us through the research, experimental management and collaboration that has now produced more than 10 self-sustaining populations of numbats in three states.

In 'Saving Threatened Communities', Sheila Hamilton-Brown and Sally Black from the department's WA Threatened Species and Communities Unit, describe how, all over the State, recovery teams, community groups, landowners and wildlife enthusiasts are helping to save threatened ecological communities. By conserving ecological communities, or groups of species that inhabit a particular area, we can eliminate some of the difficulties inherent in preserving numerous individual species.

Once again, we hope you'll find some encouragement and inspiration in this issue of LANDSCOPE. And some delight in the natural biological diversity of our State. Enjoy the spring and we'll see you in summer.



Ron Kawatitak

Executive Editor

DIBBLERS 'ESCAPE' TO ISLAND



The threatened dibbler is a small marsupial found only in Western Australia.

Populations of these attractive carnivores are known only from Fitzgerald River National Park, and Boullanger and Whitlock Islands nature reserves near Jurien. As part of the recovery of this species, and because of the high risk to the island populations associated with high house mouse numbers and people visiting these islands, it was considered important to establish a secure population on Escape Island, also near Jurien.

The Native Species Breeding Program at Perth Zoo has successfully bred about 90 dibblers in captivity. These dibblers were released in three stages onto Escape Island from 1998 to 2000, and their progress between breeding and non-breeding seasons has been monitored by Dr Dorian Moro, formerly from the Department of Conservation and Land Management and now at Edith Cowan University, using radio-tracking and trapping techniques.

Escape Island was considered to be an optimal place to establish another

Dorian Moro holding one of the dibblers born on Escape Island.

Photo - Ute Goett

population of dibblers because of its close proximity to the other islands, and because it has a very similar vegetation type. The island is also free from disturbance, exotic predators or competitors. After the first breeding season in 1999, females were found to have given birth on the island, indicating that conditions there were suitable for breeding.

In 2000, the results were even more promising. In addition to the original dibblers placed on the island, those born on the island were also found to have bred and produced young. Now, in 2001, recent field trips have confirmed that breeding by the first and second generations of dibblers is continuing.

With the knowledge gained from the success of captive breeding and release of dibblers on to Escape Island, the Recovery Team can now focus its efforts on protecting and expanding the population of dibblers found in Fitzgerald River National Park.

FEAST OR FAMINE?



Can you imagine eating something as heavy as yourself in one sitting? That would be difficult enough, but imagine having no hands to manipulate that meal and no way of cutting it up. Pythons face this problem throughout their lives!

These ambush predators wait patiently for prey in places where they can detect animal odours, such as along pathways through

thick bush or near water sources. When prey moves into range, a python will lash out with incredible speed, its mouth spread wide exposing many sharp long teeth. These teeth can puncture through reptile scales, feathers or mammal fur, providing a strong grip. It cannot afford to let go, since it lacks the speed to chase prey.

Once it has struck, the python has to move quickly,

as the teeth or claws of its struggling prey can easily inflict damage. Coils are rapidly thrown around the prey to prevent this and, with each breath, the python tightens its coils further and further until the prey is asphyxiated.

Without hands or sharp cutting teeth to tear or slice up their meals, pythons are obliged to swallow them whole. This is quite an achievement when the meal may be as large as a wallaby! The python stretches its jaws wide apart and eases loose the locking mechanism of the lower jaw. It then starts to ingest the prey, usually head-first. One side of the upper jaw is moved forwards, and then the other, with the head swinging from side to side as the python 'drags' itself over the prey. This may take considerable time, sometimes more than an hour. A meal like a wallaby may last the python many months, such is their economy of energy use.

However, pythons can choose prey items that are

Above: Pythons can kill and consume prey as large as this tamar wallaby.

Photo - David Pearson

Left: A carpet python with a western rosella it ambushed after hiding in a gutter.

Photo - Paul Ensor

too large. One small python, found during a radio-tracking study, died after swallowing a large dove that split open its oesophagus and stomach. Another ate a possum and then became stuck trying to fit through a hole in a log.

Sometimes, pythons eat unusual items by mistake. There are records of pythons eating electric blankets, jumpers, hessian bags and raincoats. One family camping in Karijini National Park was amazed to find a three metre Pilbara olive python lying near their campsite with a huge meal in its stomach. The next morning, the python regurgitated their canvas tent bag! See 'Urban Antics' on page 54 for more about these amazing snakes.

MAGIC MOMENTS AT MONKEY MIA

Imagine being able to share the thrill of seeing the famous Monkey Mia dolphins with your friends and relatives overseas—and prove you were there!

DolphinCam, the Department of Conservation and Land Management's first live webcam, is hosted on the NatureBase website and was officially launched in June 2001. It provides live coverage of an area of beach at Monkey Mia, on WA's far-west coast, favoured by dolphins that come inshore to interact with people.

The camera operates from 6 am to 6 pm and refreshes

its image every 30 seconds.

The best time for seeing dolphins is between 7.30 am and 11 am, but there is often other activity outside those hours. Visitors who are unable to log on during the 12 daylight hours the camera is active can view a selection of our favourite camera images, like that of an emu strolling along the foreshore, or browse the previous day's archive.

DolphinCam was developed by the department's eMedia unit, which also set up the NatureBase web kiosk and interactive multimedia displays in the Monkey Mia Visitor Centre.



"Monkey Mia DolphinCam (03) www.naturebase.net 2001-07-29 11:24:14"

Visitors to NatureBase can view the DolphinCam page at www.naturebase.net/webcams/dolphincam.html

NEW MONKEY MIA VISITOR CENTRE



The official opening of the new million-dollar Monkey Mia Visitor Centre by Minister for the Environment and Heritage Judy Edwards took place on 19 June, 2001. Visitors on the day were able to view the static and interactive displays in the new centre, as well as enjoy music in the adjoining beach-front amphitheatre, which will be used for a

range of educational and other relevant activities.

The Monkey Mia Visitor Centre is an important example of cooperative promotion of a world-class nature-based tourism destination. It provides a base for interpretation and conservation of the bottlenose dolphins, the Monkey Mia Reserve and the Shark Bay Marine Park.

Designed by Perth Architect James Edwardes, formerly of Cox Howlett and Bailey Woodland, the centre is built along angular lines with a rough, unfinished timber look. The display was conceptualised and written by the department's Senior Interpretation Officer Gil Field, with assistance from Monkey Mia Reserve staff, international researchers and others. Under the art direction of Insight Communication and Design, the careful crafting of text, images, sounds, lights and shapes provide a special insight into the fascinating bottlenose dolphins and the world around them.

The exhibits include colourful static panels with evocative graphic images and photos and an informative text that thematically interprets dolphins and their environment. A replica of the much loved dolphin

'Holey Fin', along with her skeleton and a profile of her internal anatomy, contrasts with an intriguing sculpture of a dugong constructed from metal and seagrass fibre. A touch table, multimedia station and NatureBase web kiosk provide hands on and minds-on activities—an immersing experience for the visitor, linked by the painted floor, simulating a transect from the red dunes to the ocean floor complete with illustrations of wildlife inhabitants.

Construction of the centre, by Geraldton Building Company, began in July 2000 and funding for the project was provided by the Department of Conservation and Land Management, the federal Department of Industry, Science and Tourism, the Monkey Mia Trust and the Department of Workplace Relations and Small Business.

SEEKING SPOON-WINGS

Each November, some of Australia's strangest winged insects appear. The 'spoon-winged lacewing' (*Chasmoptera* species) of south-western Australia take their common name from the strange, ladle-shaped hind wings, which contrast with the rather ordinary fore wings.

Spoon-winged lacewings are related to the more familiar antlions, which construct conical pits in dry sand or dusty soil in sheltered places (see 'Urban Antics' *LANDSCOPE*, Winter, 1997).

Antlions are a wingless larval stage and lie submerged in sand at the bases of their pits awaiting the arrival of clumsy ants, sucking their body juices through their hollow pincer-like jaws.

Once an antlion is fully grown, it pupates and metamorphoses into a winged insect called a 'lacewing'. Antlion lacewings are slender, usually drab insects and are seldom seen. Their two pairs of slender wings are clear (or mostly so) with a complex network of veins.

The spoon-winged lacewings' highly modified hind wings vary from species to species and, in some cases, are different in males and females of the one species. However, in all cases, the hind wing is slender and ribbon-like, broadening towards the tip into a vane of various shapes. In the Western Australian species, the vane has two pairs of lobes, which are twisted 90 degrees relative to one another, and ends in a curious little white appendage. The hind wings

do not contribute any power to the insects' flight, being merely trailed behind them.

Apart from Australia, spoon-wings also occur in Mediterranean countries, and South America, but the insects are most diverse in the western Cape Province of South Africa, where there are 56 species in 11 genera (the world total is 90 species in 19 genera).

The sole Australian genus, *Chasmoptera*, is represented by at least seven species, only three of which have been named so far. These seven species are confined to the south-west, ranging from Shark Bay to Perth and inland to the Wheatbelt at Cunderdin and Lake Grace. Two species are still known only from single specimens and others from just a few specimens. Attempts to rediscover these species have so far failed. Perhaps some are now extinct because their habitat has been destroyed.

Alternatively, their short flight seasons and restricted

distributions may mean they are difficult to encounter and maybe they do not emerge every year. Terry Houston of the WA Museum would like to be informed of any sightings or, better still, receive specimens from beyond the Perth region.

Little is known about the lives of spoon-winged lacewings. Adults of some of them have been observed visiting flowers during the day, presumably to feed on nectar (and possibly pollen). The head of the adult insect is drawn into a long 'snout' with a correspondingly long proboscis that assists it to probe into the nectaries of flowers.

Larvae of only one species of *Chasmoptera* have been discovered so far. In 1947, a Perth naturalist, Mr Wallace Mathews, reported that he had sieved a number of larvae, which he presumed to be *C. hutti*, from a sandy rise at South Perth. A tiny, first instar larva, hatched

from an egg, matches Wallace's figured specimen well enough that he was undoubtedly correct.

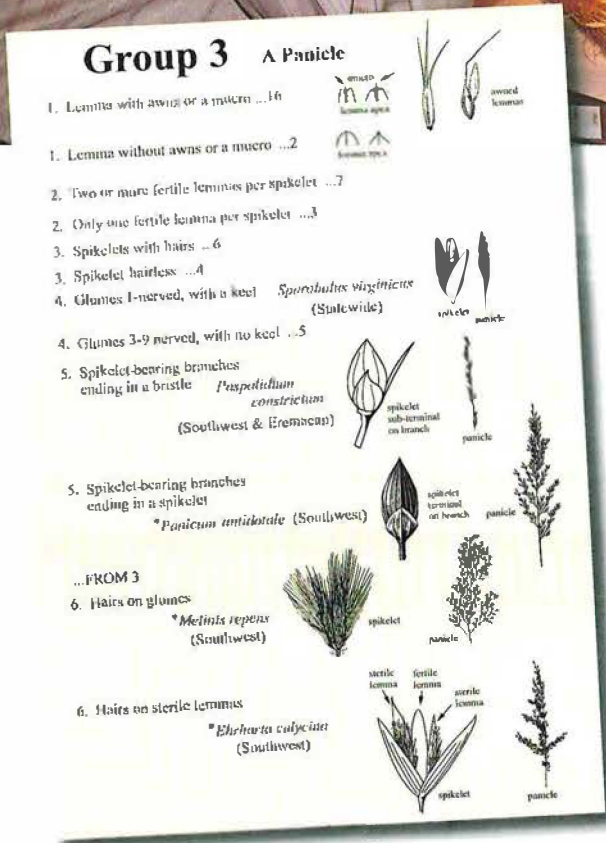
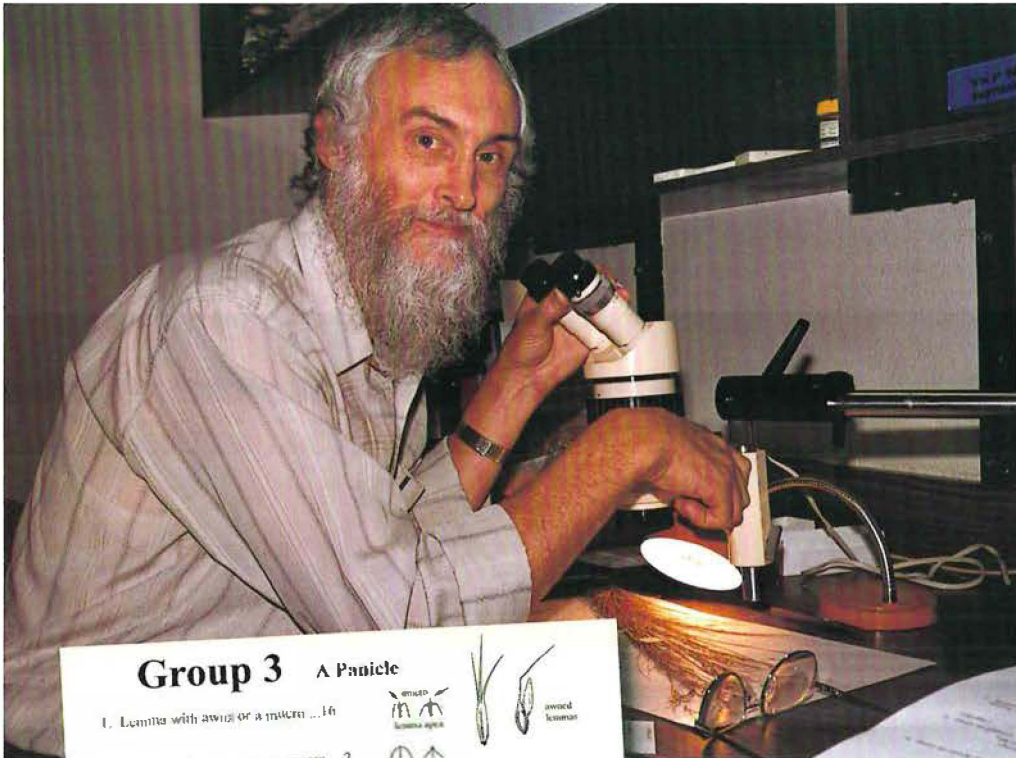
Although somewhat like an antlion in body form, these larvae have relatively short mandibles. The known larvae of some exotic spoon-wings also have relatively short mandibles and this suggests that, as a group, spoon-wing larvae feed in a manner different from the majority of neuropteran larvae. A recent report has provided some evidence of an association with ants for two Spanish spoon-wings. It was discovered that the spoon-wings' eggs were harvested by ants and taken into their nests. Moreover, the spoon-wing larvae only prospered when fed on larvae of ants. Perhaps, in time, we will find similar habits in our WA species.

Below: A female spoon-winged lacewing.

Photo - Terry Houston



GREENER GRASSES FOR ALEX



untrained eye, by which to identify them. The flowers are so small and specialised that you can't see them with the naked eye,' he said.

'What I've done is to illustrate each step in the key so that people who need to identify them can easily distinguish and classify them.'

His book is the first to combine illustrations with words instead of the traditional written key and is designed for use by herbarium volunteers, farmers, shire council staff and land care groups. It also gives the grasses' common names as well as their scientific names, and names that have been changed since Gardner's time.

Alex started working at the department by coincidence two years ago when he drove a disabled volunteer to the WA Herbarium at Kensington and was invited to join them. His career as a botanical researcher, an environmental delegate to the United Nations, an author of two books on the environmental impact of uranium mining and seven years of missionary work had ended because of chronic fatigue syndrome.

The rest is history: Alex's fascination and expertise with plants saw him donate his skills to the department and the people of Western Australia.

'I value the work I do for the department very much. I enjoy it because it's wonderful to come to work and be appreciated for your knowledge,' he said.

His next step is to produce a similar book on the 347 grass species in WA's south-west.

An 'unemployed botanist' has become one of the Department of Conservation and Land Management's treasures by identifying and illustrating 84 species of Wheatbelt grasses in a new book.

Alex Williams, formerly with the Atomic Energy Commission at Lucas Heights in NSW, describes himself as an unemployed botanist, but works zealously as a Western Australia Herbarium volunteer three days a week. His book, *An Illustrated Key to the Perennial Grasses of the Avon Wheatbelt*, is a partial update of an edition published more than 50 years ago by the then Government botanist, Charles Gardner.

'Grasses are notoriously difficult to identify because they have no colourful flowers or distinctive features, obvious to the



Top: WA Herbarium volunteer Alex Williams at the microscope.

Above: Extract from the book *An Illustrated Key to the Perennial Grasses of the Avon Wheatbelt*.

Photo - Verna Costello

ENDANGERED PLANTS TRANSPLANTED FOR SURVIVAL

Five critically endangered plants are being or have been transplanted into nature reserves near Busselton in a bid to save each species from extinction.

The project is part of an overall nature conservation initiative to conserve the 353 declared rare plants in Western Australia, of which 102 are considered to be critically endangered. The plants include the western prickly honeysuckle, McCutcheon's grevillea, the ironstone petrophile, the butterfly brachysema and the Abba bell. All five once grew on the Abba Wet Ironstone Flats near Busselton—a

vegetation structure listed as a critically endangered ecological community because more than 90 per cent has been cleared. The plants existed in areas threatened by dieback, weed infestation, development and mining, so they were likely to become extinct in the near future.

The new translocation sites, 20 kilometres east of Busselton, both have ironstone soils, but the vegetation has been altered by past land uses.

The sites were recently bought and declared Class A nature reserves.

The western prickly

honeysuckle, McCutcheon's grevillea, butterfly brachysema and Abba Bell grew in only one area and were ranked as critically endangered between 1995 and 1998. The plants currently have populations of between 15 and 170 plants. The ironstone petrophile had 170 plants, located in three areas, and was ranked as critically endangered in 1994.

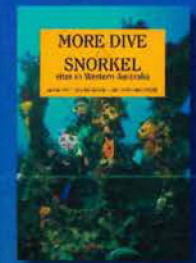
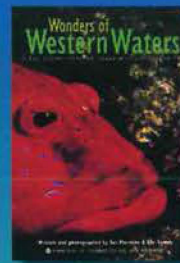
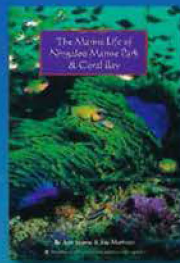
In 2000, the Department of Conservation and Land Management carried out preliminary translocations of McCutcheon's grevillea and western prickly honeysuckle, with an 86 per cent survival rate.



Graham Fisher planting McCutcheon's grevillea.

Photo – Meredith Soutar

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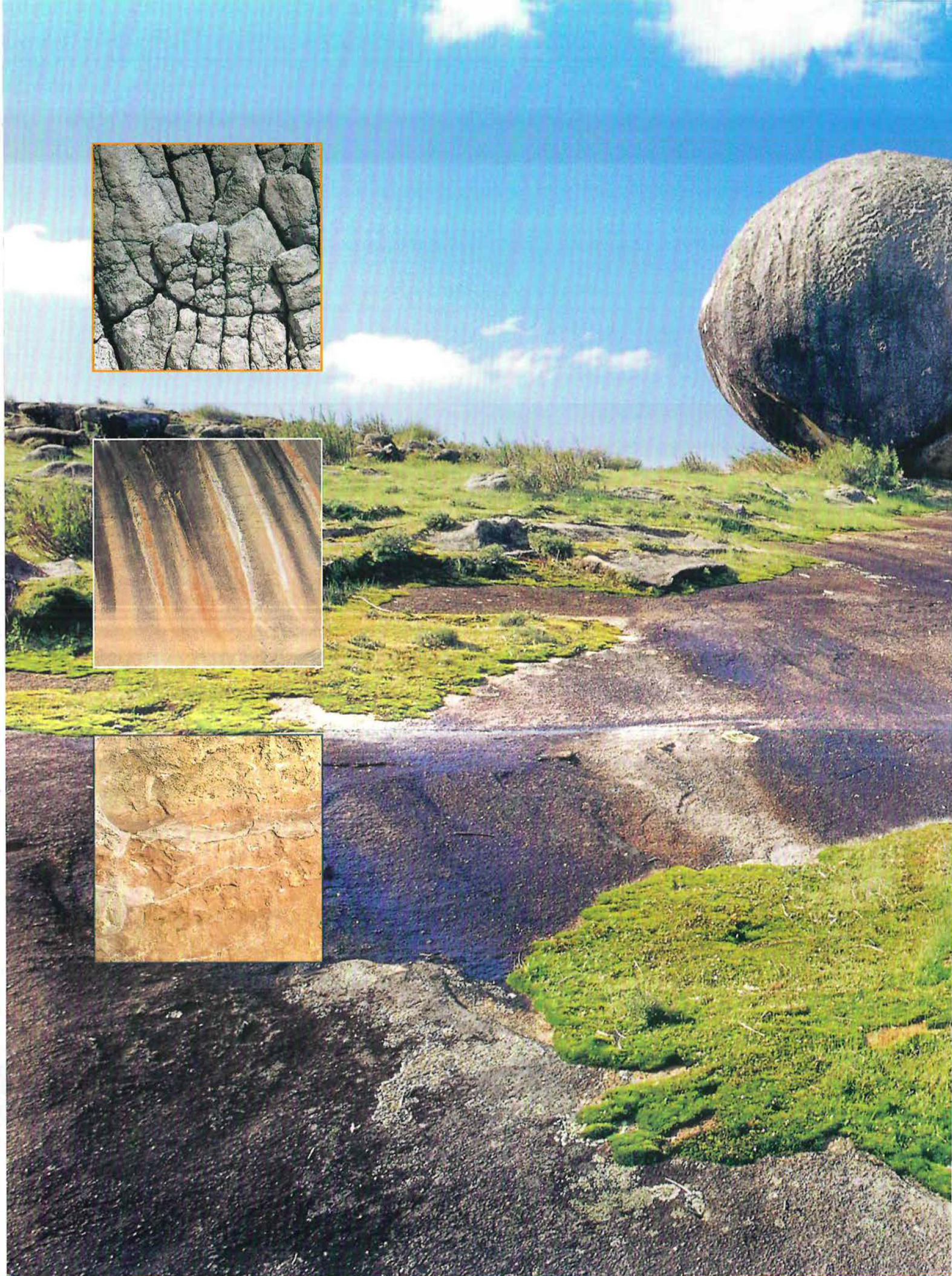
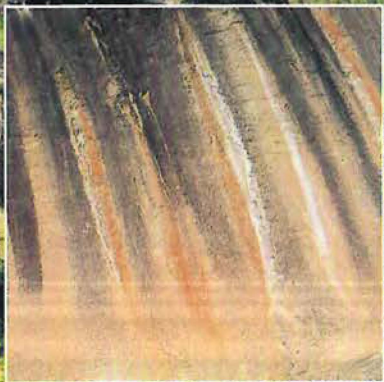
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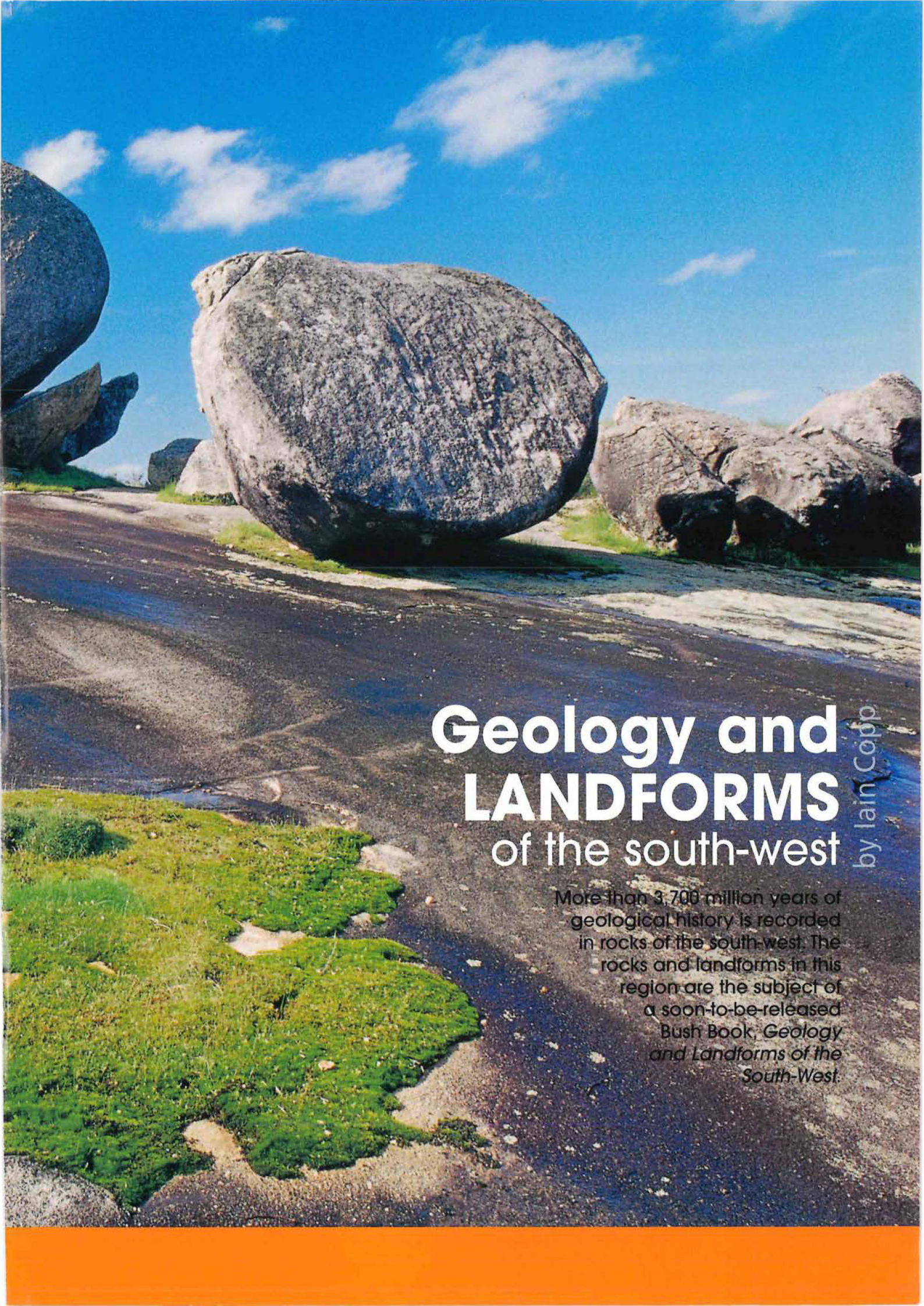
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Geology and LANDFORMS of the south-west

by Iain Copp

More than 3,700 million years of geological history is recorded in rocks of the south-west. The rocks and landforms in this region are the subject of a soon-to-be-released Bush Book, *Geology and Landforms of the South-West*.

The oldest rocks are found in the Yilgarn Craton, a large piece of the Earth's crust that underlies most of the south-west. It formed between about 3,700 and 2,400 million years ago by the joining together of several smaller pieces of crust, resulting in a vast geologically stable new continent. Huge volumes of molten rock (magma) were produced during this time, either finding their way to the surface to be erupted from volcanoes, or crystallising many kilometres below the surface. Other parts of the craton were subject to extreme pressures and temperatures and were transformed, or

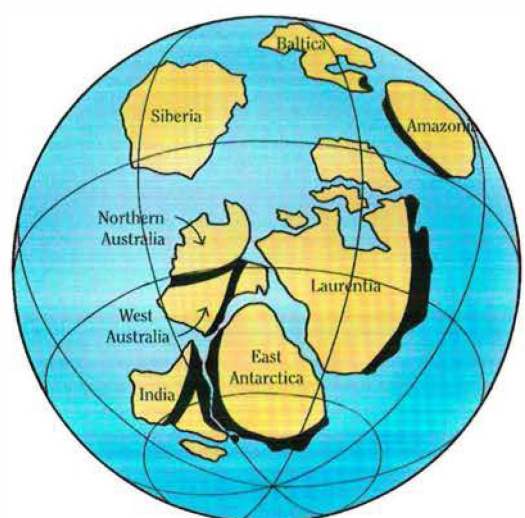
metamorphosed, into other types of rocks, such as gneiss. Under the most extreme conditions, some rocks began to melt and form migmatites. All these types of rocks can be found throughout the Darling Range and the Wheatbelt.

BREAK-UPS AND LIAISONS

Between about 2,000 and 1,800 million years ago, the Yilgarn Craton collided with the Pilbara Craton to the north, forming a large new continent known as the West Australian Craton. This slowly drifted north-eastward until, 450 million years later, it collided with another large continent, the

Mawson Craton (comprising the South Australian Craton and East Antarctica), which was drifting westward. This collision took place about 1,345 million years ago along most of what is now the south coast. The Mawson Craton was thrust over the West Australian Craton, producing a huge thickness of crumpled crust, similar to the way that the Himalayas formed when India collided with Asia. Igneous rocks such as granite were formed during this upheaval and older granites were metamorphosed into gneiss. Slices of crust containing sedimentary rocks, such as the Barren Ranges, were buried within this collision zone. The roots of this mountain range are known as the Albany-Fraser Orogen, and can be traced into Antarctica. The collision of the West Australian and Mawson Cratons took place as part of the assembly of a supercontinent called Rodinia.

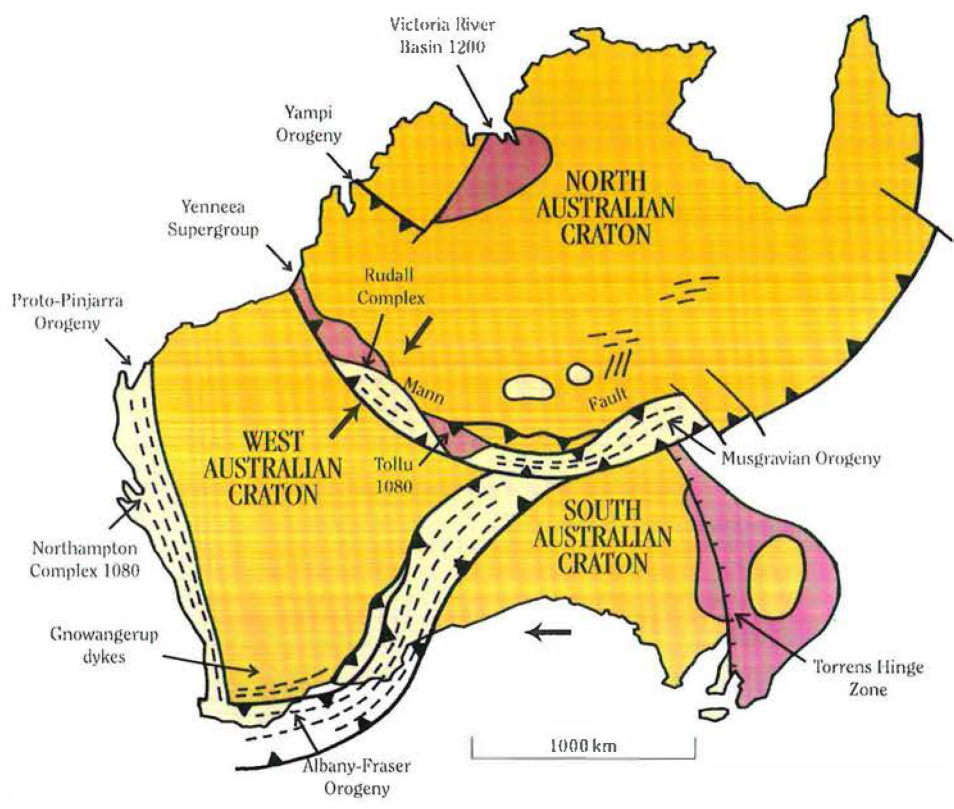
Another continent probably collided with the West Australian Craton about 1,100 million years ago, and a similar mountain range, called the Pinjarra Orogen, began to form along the western edge of the Yilgarn Craton. Most of the rocks that formed then now lie buried deep beneath today's coastal plains. The Darling Fault, which can be traced from near Shark Bay down to the south coast, marked the edge of this mountain range. During the following 500 million years, magma was periodically squeezed into surrounding rocks, which between Cape Naturaliste and Cape Leeuwin were then slowly metamorphosed into gneiss. About 750 million years ago Rodinia began to break up into smaller plates. These reassembled into a new supercontinent called Gondwana about 250 million years later. It included Australia, Antarctica, Greater India, New Zealand, South America, Africa and parts of south-east Asia.



Previous page
Main: Boulder rock.
 Photo - Chris Garnett
Insets from top: Basalt.
 Photo - Gordon Roberts
 Granite.
 Photo - Ashley de Prazier
 Limestone.
 Photo - Bill Bachman

Left: The supercontinent Rodinia, about 750 million years ago, showing the main areas of mountain building (in black).

Below: The assembly of Australian cratons between 1,300 and 1,000 million years ago.
 Illustrations - Ian Dickinson



GLACIERS AND LAVA FLOWS

About 430 million years ago, the Darling Fault became very active again and formed an elongate trough called the Perth Basin. Over the next 300 million years, the basin filled up with more than 10 kilometres of sedimentary rocks. During part of this time, around 295 million years ago,



Above: The rocks that now make up the Stirling Range were originally laid down as sand, silt and clay in water. Hence, ripple marks can be seen in rocks on some peaks.

Right: The hexagonal columns at Black Point, in D'Entrecasteaux National Park, were formed by a lava flow around 135 million years ago.
Photos – Jiri Lochman

Australia was close to the South Pole and extensive ice caps covered the south-west. Glaciers carved valleys in the landscape and blankets of broken and ground-up rocks were deposited as the ice melted.

A rift developed within Gondwana's crust around 135 million years ago, slowly tearing from north to south, and Greater India drifted away from Australia as a result. Magma was generated as the crust split, reaching the Earth's surface and forming extensive flows of basalt lava in the south-west (known as Bunbury Basalt). The only outcrops can be seen on the beach at the northern end of Ocean Beach in Bunbury and at Black Point in D'Entrecasteaux National Park, south-east of Augusta. The basalt at Bunbury is fairly unspectacular but nonetheless fascinating and, being close to a road, easy to see. It formed a flow about two kilometres long and 100 metres wide. The hexagonal columns at Black Point, however, are stunning, even more so as



they are constantly buffeted by waves of the Southern Ocean. Access to this remote area is by four-wheel-drive only.

Rifting then commenced along the present day south coast about 15 million years later, as Antarctica separated from Australia. This splitting of the Earth's crust caused the southern part of the south-west to be gently uplifted several times over about the next 35 million years.

RISE AND FALL

Following the separation, the newly formed coastline of the south-west was then subject to periodic changes in sea level, the hinterland being sometimes

covered by warm shallow seas. During the Eocene, about 40 million years ago, such a sea covered much of the south-west and was rich in sponges and other marine organisms. During this time, the sea level was about 300 metres higher than its present level. The coast was up to 65 kilometres inland, forming a huge embayment that extended from near Albany to Israelite Bay and up to Norseman. Many islands were left within this new warm shallow sea, including the Barren Ranges, Porongurup Range and Mount Manypeaks. Sediment, rich with the skeletons of sponges, slowly settled onto the new seabed forming a blanket

SEQUENCE OF EVENTS IN GEOLOGICAL INTERVALS

| | | | |
|-------------------------|---|------------------|--------------------------|
| Swan Coastal plain | Yalgorup Lake system | Quaternary | younger than 130,000 yrs |
| | drowning of the coastline (e.g. Stokes Inlet) | Quaternary | younger than 130,000 yrs |
| | Leeuwin-Naturaliste caves | Quaternary | younger than 1 m yrs |
| | Pinnacles | Quaternary | younger than 1 m yrs |
| | coastal limestone deposits | Quaternary | younger than 1 m yrs |
| | mineral sands | Pleistocene | 300,000–100,000 yrs |
| | aluminium and gold deposits in laterite | Eocene-Oligocene | 40–25 m yrs |
| | laterite formation | Eocene-Oligocene | 40–25 m yrs |
| Perth and Collie basins | Australia split from Greater India | Cretaceous | 135 m yrs |
| | Bunbury Basalt | Cretaceous | 135 m yrs |
| | Collie coal | Permian | 280 m yrs |
| | glaciation | Permian | 295 m yrs |
| Leeuwin complex | gneiss and granites | Proterozoic | 1,100–530 m yrs |
| Albany-Fraser orogen | sponge-rich ocean sediments | Eocene | 40 m yrs |
| | Australia split from Antarctica | Cretaceous | 120 m yrs |
| | Stirling Range | Proterozoic | 590 m yrs |
| | Porongurup Range | Proterozoic | 1,200 m yrs |
| | continental collision along the south coast | Proterozoic | 1,345–1,140 m yrs |
| | Barren Ranges | Proterozoic | 1,830 m yrs |
| | Peak Charles | Proterozoic | 2,350 m yrs |
| Yilgarn craton | Greenbushes tantalum, lithium and tin | Archaean | 2,530 m yrs |
| | Darling Fault formed | Archaean | 2,600 m yrs |
| | Monadnocks (Darling Range Batholith) | Archaean | 2,650 m yrs |
| | Boddington volcanic rocks | Archaean | 2,700 m yrs |
| | Yilgarn Craton formed | Archaean | 3,700–2,400 m yrs |

over the area. Over time and due to the pressure of overlying sediments, this material was consolidated into a rock known as spongelite. As the sea level fell again, the rivers draining the hinterland cut deeply into the soft spongelite, forming colourful gorges now exposed along the Fitzgerald and Hamersley Rivers in the Fitzgerald River National Park.

In the last two million years, during the Pleistocene, the polar ice caps have contracted and expanded many times, making the sea level rise and fall repeatedly. Belts of coastal sand dunes

have followed this forever-changing coastline, and have been preserved as limestone in the cliffs around the south-west's coastline.

EVOLUTION OF THE LANDSCAPE

The landscape of the south-west is very old, having probably begun to develop about 295 million years ago when a large ice cap covered most of its surface. During this time, Australia was close to the South Pole and glaciers carved broad deep valleys into the landscape. Over the next 200 million

years, the Darling Fault was very active and parts of the Yilgarn Craton were uplifted, forming a hinterland to the Perth Basin, which was mostly under water. The effects of heat, cold and rain on this ancient land surface weathered and eroded the hills and valleys that were formed by glacial action. Slowly, the gently undulating hills that characterise the Darling Plateau began to form. Around 95 million years ago, an extensive system of rivers was established over much of the south-west, further eroding the underlying rocks and forming the drainage pattern that we see today.

The south-west experienced a moist, temperate to tropical climate about 65 million years ago, resulting in deep inland penetration of rain-bearing westerly winds. This lasted for about 30 million years (to the end of the Eocene), with the rain and surface run-off continuing to erode the rocks. It was during this period that a huge rise in sea level occurred, flooding large areas of the hinterland along the south coast with a warm sea rich in sponges. Only the highest points, such as the Stirling Range, Porongurup Range and the Barren Ranges, remained above sea level, forming islands and peninsulas. Over several million years, the continuous buffeting action by waves gradually reduced their size and cut platforms into their slopes. Between about 40 and 25 million years ago, a tropical climate allowed deep weathering of the rocks to take place. Alternating wet and dry periods leached out the more soluble minerals, leaving behind deeply weathered rocks overlain by mottled soils and an iron-rich capping called duricrust.

When the climate finally changed and started to dry out, most of the major river systems stopped flowing regularly. During the last two million years, the coastline changed position many times in response to the expansion and contraction of the polar icecaps.

RECENT TIMES

Just before the last ice age, 130,000 years ago, the Swan Coastal Plain was narrower than it is today. Thus, even though the sea level was roughly the same as it is at present, the coast lay 10

Right: The south-west and Perth coast was subject to periodic changes in sea level.

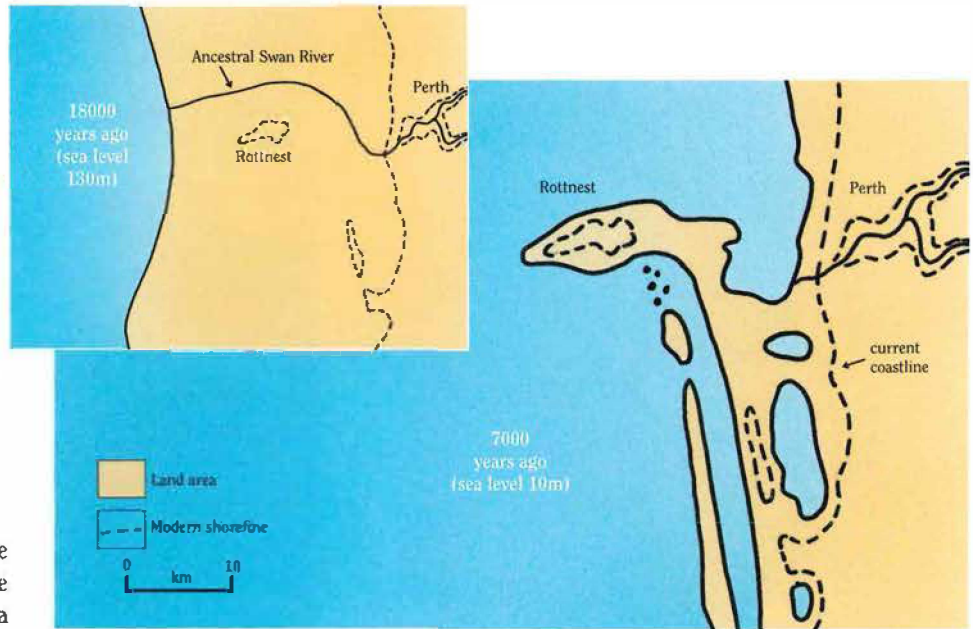
Illustration – Ian Dickinson

Below: The Monadnocks—large, rounded, bald hills that reach up to 585 metres above sea level, form the highest point of the Darling Plateau.

Photo – Ian Copp

Below right: Rottnest Island was once connected to the mainland.

Photo – Dennis Sarson/Lochman
Transparencies



kilometres further inland, and what are now the grey soils at Bassendean were the coastal sand dunes. Rottnest was a coral reef 30 kilometres offshore.

The Würm Ice Age then set in, and as the Earth's ice caps grew, the sea level fell, fluctuating as it did so. The coastline gradually moved westward as the sea level dropped. Today you can still discern a series of barrier dunes parallel to the coast, and they mark the successive shorelines in this retreat. Finally, 18,000 years ago, the sea level reached its lowest point—130 metres below the present sea level. At that time, the coastline in this region lay 40 kilometres west of the present position. The barrier dunes formed a central spine down the wide coastal plain, with a branch out towards Rottnest.

The sands making up these dunes contained a high proportion of lime sand, derived from sea shells and minute marine organisms. This lime was dissolved by the acid in rainwater, then deposited again when the water

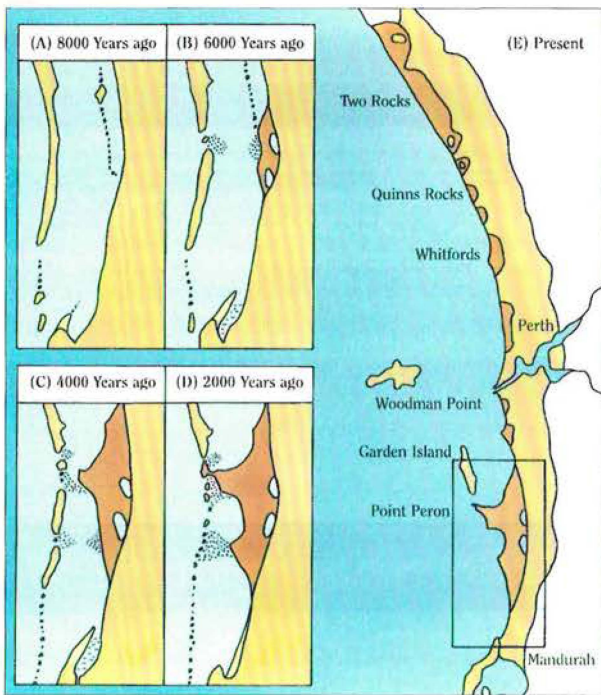
evaporated, cementing the sand grains together and turning the dunes into limestone. This limestone, which occurs from Shark Bay to the South Coast of Western Australia, is called Tamala Limestone, and forms the Spearwood Dune System. At Penguin Island and other places you can see obvious cross-bedding in the coastal limestone, which is evidence of its origin as wind-blown sand dunes. The thin strata are inclined at various oblique angles, often set abruptly juxtaposed with others, reflecting the original pattern of sand accumulation and changes in wind action. Some of this limestone was partly dissolved by percolating rainwater and groundwater, forming caves and pinnacles.

The last ice age ended 10,000 years ago, heralding the start of the Holocene period and the end of the

Pleistocene geological era (which lasted from about 2.5 million years ago to 10,000 years ago). Rising temperatures and melting ice sheets caused the sea level to rise, and it reached its present height about 6,500 years ago. As a result, the westernmost ridges of the Spearwood Dunes were partially or wholly drowned, forming a series of shallow reefs and long islands separated by linear troughs. The higher eastern ridges formed the mainland coastline. Old river valleys were slowly flooded and formed inlets along the coast, some finally being cut off from the ocean by the migration of recent sand dunes.

With the higher sea levels, a new regime of dune building began. Sand was swept across the newly drowned coastal plain and washed ashore. In addition, the south-westerly winds and





Point Peron at Rockingham was once an offshore island that was 'captured' by an outgrowth of sand. Illustration – Ian Dickinson



Penguin Island, offshore from Rockingham, is composed of Tamala Limestone. It has consolidated from wind-blown dune deposits of shell fragments and quartz. Photo – Michael James

waves eroded the offshore ridges, reducing them over 6,500 years to the chains of islands and reefs off the present Perth coast. In the Shoalwater Islands Marine Park, for instance, features such as the Murray Reef, The Sisters, Passage Rock, Penguin Island, Seal Island, Bird Island and Peron Peninsula make up a definite north-south line that can be clearly seen in aerial photographs.

The eroded sediments deposited onshore formed the young Holocene sand dunes, known as the Quindalup

Dunes, that make up most of the shoreline today. Onshore winds blew sand from the beaches to form foredunes along the new coastline.

Where the coast was sheltered by an island or shallow reef, the force of the waves was reduced and sediment was preferentially deposited, as the islands and reefs eroded. A triangular spit built out from the mainland towards the adjacent island, and formed a low promontory consisting of line after line of low parallel dunes. The land surrounding Rockingham is made up of

such a structure (see diagram above). Row after row of dunes (two to five metres high and 50–100 metres apart) have been built out seawards from the original limestone coastline, which lay along the eastern sides of Lakes Coolongup and Walyungup. Point Peron was once an offshore island that was 'captured' by the advancing outgrowth of sand.

To find out more about the fascinating formations of this part of WA, look out for the new Bush Book *Geology and Landforms of the South-West*.



Left: Wave Rock's unusual shape is probably the result of weathering by groundwater when most of it was covered by sand and soil. Photo – Ashley de Prazier

Iain Copp is a geologist and freelance writer/photographer. He worked for many years with the Geological Survey of Western Australia and also in exploration for mineral and petroleum companies.

The author would like to acknowledge Ian Tyler and the Geological Survey of Western Australia for their assistance in producing the forthcoming Bush Book *Geology and Landforms of the South-West*.

A photograph of two numbat marsupials in their natural habitat. The numbat on the left is standing upright on its hind legs, looking towards the right. It has dark brown fur with lighter, almost white, horizontal stripes. The numbat on the right is sitting or lying down, also looking towards the right. It has reddish-brown fur with lighter stripes. The background is a dense thicket of dry grass and green plants.

numbats

FOREVER!

by Tony Friend and Neil Thomas

Just 40 years ago the numbat was common in Western Australia but, by 1985, loss of habitat and predation by introduced foxes had caused the species to dwindle to two small populations. Now, as a result of research, experimental management and collaboration between government, private and corporate sectors, there are more than 10 self-sustaining populations of numbats in three states.

In 1960, distinguished wildlife biologist John Calaby described the dainty, day-active numbat as 'among the more abundant of the small mammals of south-western Australia'. Although clearing of native vegetation was in full swing in the numbat's last stronghold, the Great Southern region of Western Australia, frequent and widespread sightings gave the impression that the termite-eating marsupials were going to survive.

ON THE BRINK

But, during the late 1970s, the rate of sightings dropped suddenly—even in the best-known numbat areas at Dryandra Woodland near Narrogin and Perup Nature Reserve near Manjimup. There was sudden, deep concern that WA's mammal emblem was on the edge of extinction. This prompted new surveys for numbats and intensive studies of numbat biology and ecology at Perup and Dryandra. Early results of the Dryandra study focused attention on the predation of numbats by the introduced red fox and led to a three-year experiment in which foxes were removed by 1080 baiting in one part of the woodland. Numbat numbers were monitored closely in baited and unbaited areas. By the end of the experiment in 1985, numbat numbers had risen rapidly in the baited area, while remaining static where foxes



persisted. Following the dramatic increase in the numbat population in the baited area, 33 wild animals were transferred from Dryandra to Boyagin Nature Reserve—40 kilometres to the north—where numbats had become extinct during the early 1970s (see 'Numbat Dawn', *LANDSCOPE*, Winter 1990). This trial reintroduction was successful and numbats spread rapidly throughout the reserve.

Unfortunately, as we learned how to put numbat recovery into action in the agricultural areas, the last populations in the northern jarrah forest became extinct. Surveys during the early 1980s recorded sporadic numbat sightings in large tracts of forest between Collie and Bedfordale and even on the outskirts of Perth, near Canning Vale and Forrestdale. In 1985, a forest worker made the last verified sighting of a numbat in wandoo woodland east of Mundaring.



RAISING NUMBATS

From January 1989, monthly baiting with 1080 in dried meat was extended to cover 13,000 hectares of Dryandra Woodland. The expansion in the Dryandra numbat population stimulated a reintroduction program based on taking young animals from the wild. The box on page 19 shows the history of numbat translocation under the Numbat Recovery Plan.

From 1993, improved breeding of numbats in captivity at Perth Zoo resulted in captive-bred animals being available for release. This was fortuitous because in 1993, after 10 years of rapid growth under fox control, the numbers of numbats peaked and started to fall. A year earlier, in November 1992, numbat sightings rose to 11 for every 100 kilometres driven—about twice the calculated carrying capacity of Dryandra Woodland. By November 1993, the sighting rate had fallen to five for every 100 kilometres driven. There has been no return to the high numbers of 1992; in fact, sighting rates have tended to oscillate around lower levels. As a result, other sources of numbats, including Perth Zoo, have been used in translocations in preference to numbats from Dryandra, to reduce the impact on that precious population.

Numbats were first bred in captivity at Taronga Zoo in Sydney, New South Wales, in 1975, but the young did not survive to weaning. A captive-breeding colony was set up at the Department of Conservation and Land Management's Wildlife Research Centre at Woodvale in 1984. A female numbat with four attached young and an adult male, all from Dryandra, were maintained on an artificial diet based on eggs and low-lactose milk developed by their carer, marsupial breeding expert Dick Whitford. This is still the standard

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Young numbats in front of their burrow at Dryandra.
Photo - Jiri Lochman

Above: A numbat finishing a yawn at Alice Springs Desert Park.
Photo - Bill Bachman

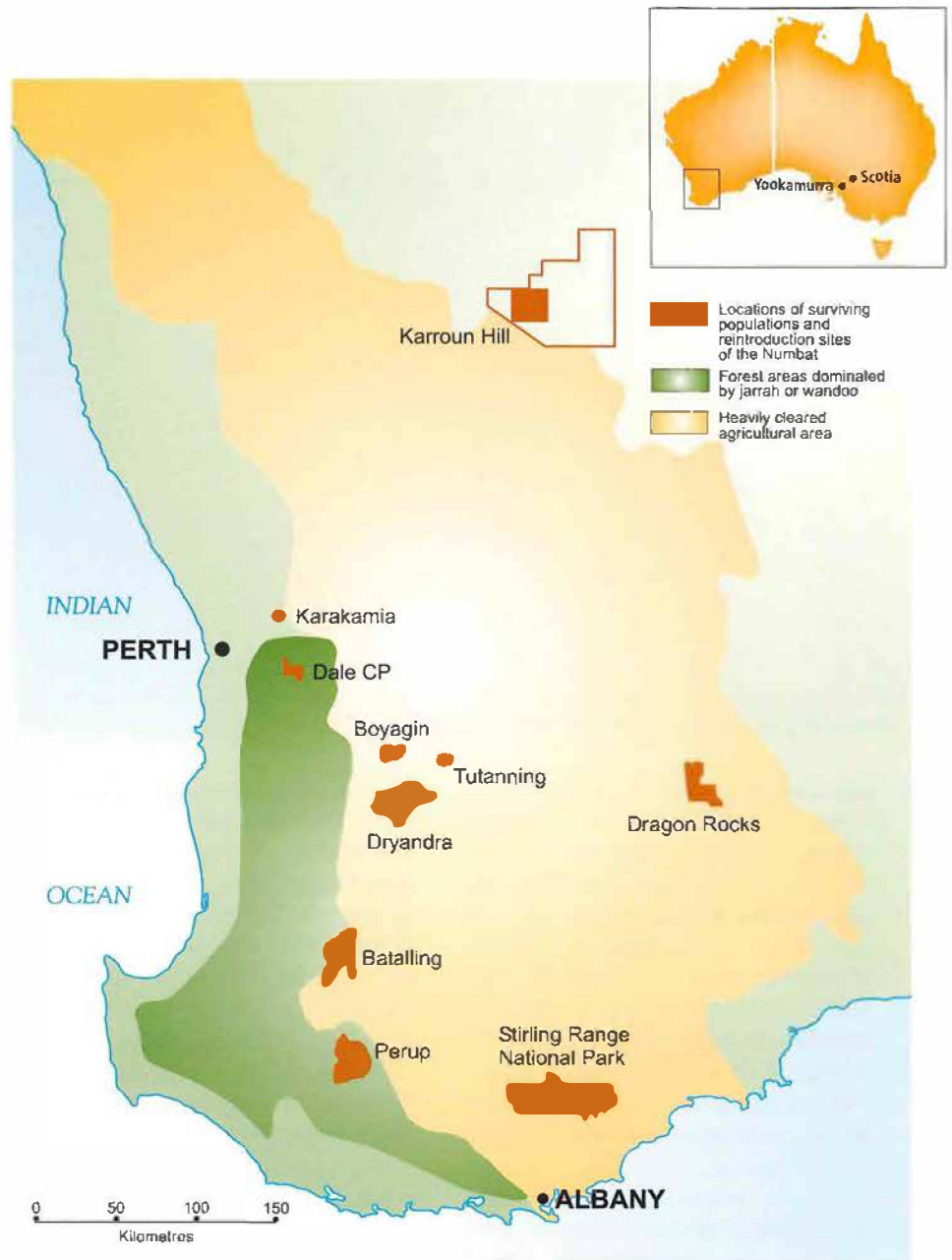
Left: Juvenile numbats emerging from their nest log, Dryandra Woodland.
Photo - Jiri Lochman

diet used in captive numbat colonies. When the two young females reached breeding age, all three females produced litters and raised them to independence under Dick's management. The World Wide Fund for Nature Australia (WWFA) funded this breeding colony for two years and, after a further year, the colony was transferred to Perth Zoo.

NEW HORIZONS

The reintroduction program continued after the success at Boyagin. This site had been chosen because its soils, climate and vegetation were similar to those of Dryandra. However, numbats previously inhabited a wide range of vegetation types across southern Australia, so the second reintroduction was to different country: woodland on the boundary between the Wheatbelt and the Goldfields, at Karroun Hill Nature Reserve in the Shire of Mount Marshall (see 'Paradise on the Edge', *LANDSCOPE*, Spring 1991). In this 300,000-hectare area, large tracts of woodland dominated by salmon gum, gimlet, York gum and wandoo are interspersed with extensive areas of acacia scrub and low granite outcrops. A translocation program between 1986 and 1993 established numbat colonies at sites where woodlands abutted dense vegetation. Numbats were able to find termites in the woodland areas and shelter from predators in the nearby thickets. This translocation tested the numbats' adaptability as they moved from Dryandra, with annual rainfall of over 500 millimetres, to a new site with less than 250 millimetres of rainfall at Karroun Hill.

Compared with the releases at Boyagin Nature Reserve, a 5,000-hectare remnant surrounded by farmland, the translocation to the vast Karroun Hill area was a whole new ballgame. Numbats dispersed widely (one male ended up 25 kilometres from the release site) and could only be found with the use of a light aircraft fitted with radio-tracking aeri-als. Lack of access tracks through much of the reserve necessitated long walks to check numbats and change radio-collars. A fascinating insight into the numbat's navigational abilities was



NUMBAT REINTRODUCTION SITES AND RELEASE DETAILS

| Destination | Area (ha) | Release years | Number released | Source |
|----------------------|-----------|------------------|-----------------|---------------------------------|
| Boyagin, WA | 5,000 | 1985-87 | 35 | Dryandra, Woodvale |
| Karroun Hill, WA | 300,000* | 1986-93 | 97 | Dryandra |
| Tutanning, WA | 2,000 | 1987-96 | 35 | Dryandra, Perth Zoo, Karakamia |
| Batalling, WA | *** | 1992-95 | 60 | Dryandra, Perth Zoo |
| Yookamurra, SA | 1,100 | 1993 | 15 | Dryandra |
| Karakamia, WA | 250 | 1994, 1996, 1999 | 6 | Dryandra |
| Dragon Rocks, WA | 33,000 | 1995-96 | 37 | Dryandra |
| Dale CP, WA | *** | 1996-98 | 62 | Dryandra, Perth Zoo, Boyagin |
| Stirling Range, WA | 100,000 | 1998-2000 | 48 | Dryandra, Perth Zoo, Yookamurra |
| Scotia, NSW, Stage 1 | 4,000 | 1999-2000 | 43 | Yookamurra |

*Only 40,000 hectares baited ***Part of the 2 million hectare forest belt, now mostly under fox control



provided by an adult female found (from the air) 15 kilometres from her release site, that turned up later only 500 metres from the original site! Male numbats demonstrated their drive to reproduce, as females several kilometres from the nearest male unfailingly produced young right on schedule. Radio-tracking from the air during the brief mating period showed males making long dashes between females, in an attempt to be first on the scene at oestrus.

As the emphasis in the numbat conservation program moved from research to management, more individuals and agencies became involved. The Numbat Recovery Team was established in 1993 and now

includes representatives from the Department of Conservation and Land Management, Perth Zoo, the conservation community and wildlife agencies in South Australia and New South Wales. The team produced a recovery plan, setting out broad aims and detailed actions to achieve the recovery of the species. One of the most important actions was, and is, the translocation program, the details of which are shown in the box on page 19.

Our experience in re-establishing numbat populations increased with further reintroductions to Tutanning Nature Reserve near Pingelly and Batalling Forest near Darkan; to Dragon Rocks Nature Reserve south of Hyden and Dale Conservation Park in

the northern jarrah forest. Although all translocations resulted in new, self-sustaining colonies, reserves surrounded by farmland restricted the dispersal of numbats and therefore assisted in the rapid establishment of populations. Under the Western Shield program, which began in 1996, areas of conservation land baited for foxes increased and provided many new possibilities for the numbat's reintroduction.

The Dryandra population was the main source for translocations for many years because of the relative ease of capturing animals there. Recent genetic research showed this was a fortuitous choice. The Perup animals had lost more genetic variability through population bottlenecks than those at Dryandra, since the two populations had become separated by land clearing. The recovery plan proposes to incorporate Perup stock into captive breeding or reintroduction groups, to maximise the genetic variation within new populations.

MOVING INTERSTATE

In 1993, the numbat's recovery moved interstate when Earth Sanctuaries Limited (ESL) became involved. The company's founder, John Wamsley, selected an area of old mallee woodland in the Murray Mallee lands of South Australia for purchase, because of its suitability for numbats and other mammals previously recorded in that part of the continent. A 14-kilometre-long electric fence was constructed around the 1,100-hectare property, and Yookamurra Sanctuary was opened in a fence-closing ceremony in 1991. Feral animals were removed from the sanctuary during the next two years. By the time the last rabbit was ousted, with the help of a Jack Russell terrier, negotiations with the Department of Conservation and Land Management about the acquisition of numbat breeding stock were well under way.

Above left: Their eyes are still tightly closed, but at six months of age the young can move from one teat to another.
Photo – Tony Friend

Left: Female numbat, fitted with a radio-collar, at the mouth of her burrow.
Photo – Jiri Lochman



The first five numbats to enter Yookamurra were captured at Dryandra in November 1993, fitted with radio-collars and taken as accompanied air freight to South Australia. Four males and a female without young were released into specially positioned logs late in the afternoon of 9 November 1993, just 24 hours after they had been captured. During the next few days, Yookamurra staff were trained to monitor the numbats, so their progress could be followed. Using methods developed in Western Australia, all numbats were monitored regularly for the first few weeks. All went well, and on 7 December, nine females and another male made the trip from Dryandra to Yookamurra to be released into the Sanctuary.

The Yookamurra reintroduction was so successful that the rapidly growing population was able to provide stock for a transfer to another of ESL's properties. Ten numbats were released into a feral-free fenced area of 4,000 hectares at Scotia Sanctuary in western New South Wales, 100 kilometres north of the Murray River, on 25 November 1999. Feral animal eradication is being

carried out in an adjacent 4,000-hectare area and will then proceed to the next 19,000-hectare block, so the prospects for expansion of the numbat colony are good. Scotia is largely dominated by east-west sand ridges, with open mallee scrub and a spinifex understorey, but the numbats were released into old mallee woodland with good shrub cover, in sites selected with the Department of Conservation and Land Management's assistance.

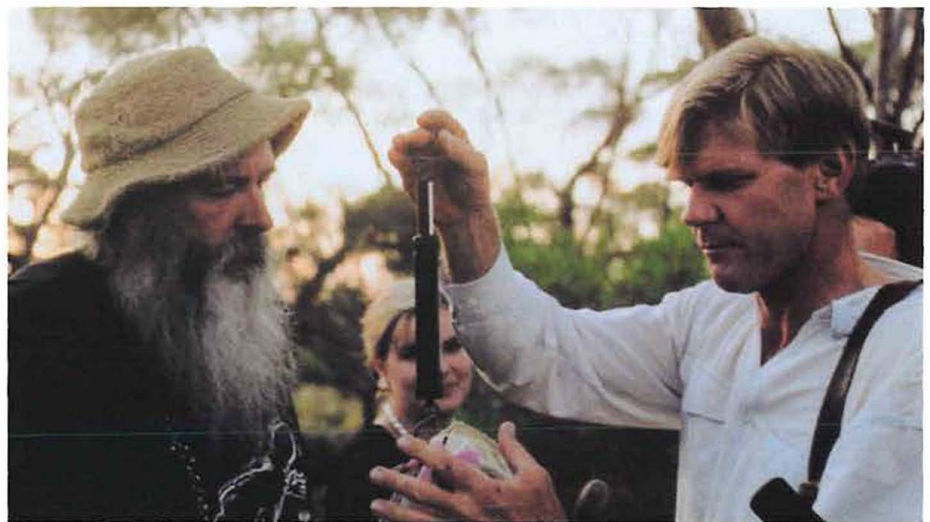
FURTHER RECOVERY

In WA, in another privately funded conservation project, numbats were released at Karakamia—a fenced, feral-free, 250-hectare jarrah forest area near

Gidgegannup, north-east of Perth, in November 1994. Because the site could only support a small number of numbats, the occasional exchange of animals has been carried out to enable Karakamia to contribute to the translocation program and maintain genetic quality. Karakamia staff also track radio-collared numbats regularly to monitor the colony's progress.

The involvement of Perth Zoo and ESL in the numbat recovery program relieved Dryandra's wild population of its role as the sole source of numbats for translocation. The most recent new WA population, in the Stirling Range National Park, in the south of the State, illustrates this point. Three annual

Right: The founder of Earth Sanctuaries Limited, John Wamsley (left), and Department of Conservation and Land Management principal research scientist, Tony Friend, weigh a numbat before its release as part of the first numbat reintroduction to old mallee woodland at Yookamurra in 1993.



Below right: Department of Conservation and Land Management senior technical officer, Neil Thomas, releases a numbat into a hollow log at Karroun Hill Nature Reserve. Photo – Tony Friend



Below: Karakamia Sanctuary feral proof fence. Photo – Marie Lochman





releases there have, so far, involved 14 Dryandra numbats, 26 numbats bred at Perth Zoo and eight Yookamurra Sanctuary numbats.

But the Stirling Range reintroduction has not been free of problems. Translocated numbats have been taken by birds of prey at most sites, but this predation was particularly prevalent in the first year at the Stirling Range. To counteract the threat, staff at Perth Zoo's Native Species Breeding Program began training captive-bred numbats to be wary of raptors. The results of the release in December 2000 indicated that this training—using trained birds and alarm sounds—increased the rate of survival of numbats after release.

TWENTY YEARS OF WORK

Numbat recovery has been the result of intensive work over 20 years. A number of funding bodies supported this

project for various periods: five years of support from WWFA and three years of support each from MacDonaldis Family Restaurants and ANCA/Environment Australia. The institutions directly involved have provided the necessary long-term support that recovery programs need: the Department of Conservation and Land Management (and one of its predecessors, the Department of Fisheries and Wildlife), Perth Zoo and Earth Sanctuaries Limited.

In 1983, the numbat was listed in the IUCN Red List of Endangered Species as Endangered. In 1994, the criteria for listing were revised and, as a result, species with several populations in which decline had been halted for five years or more, such as the numbat, dropped down to Vulnerable. So, with the stroke of a pen, the conservation status of the numbat improved! Even so, the numbat's numbers were low—even ambitious

Above left: Stirling Range National Park, site of WA's most recent numbat reintroduction.

Photo – Jiri Lochman

Above: Wedge-tailed eagles and other raptors have preyed on numbats in the Stirling Range National Park.

Photo – Marie Lochman

Below left: A numbat in old mallee woodland at Yookamurra Sanctuary.

Photo – Bill Bachman

estimates put the total world population at around 2,000. Is this enough? By comparison, the giant panda, an icon of endangerment, numbers approximately 1,500. Although the security of the numbat is now enhanced by the existence of widely dispersed populations, its persistence depends on continued fox control or fenced sanctuaries. The numbat's survival depends on continued support for conservation programs from the community, the corporate sector and from federal and State agencies across Australia.



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Leschenaultias

true blue Australians

by Leigh Sage



Leschenaultias (*Lechenaultia* species) are some of the most widely known and recognisable members of an intriguing and attractive family of plants called the Goodeniaceae. Leschenaultias are mostly restricted to Western Australia and have fantastic horticultural value, an intriguing method of pollination and an interesting botanical history. Many are either threatened with extinction or poorly known.



The Goodeniaceae family is known for its colourful and attractive flowers. Apart from *Lechenaultia*, ten other genera make up this diverse family. They include *Goodenia*, *Dampiera*, *Velleia*, *Scaevola* and *Anthotium*, collectively totalling more than 400 individual species. A few species occur throughout the Pacific and into Asia but this is primarily an Australian group of plants that forms a common component of our native flora.

Of the 26 species known within the genus *Lechenaultia*, 20 are endemic to south-western Australia. Most of these occur on the sandplain heaths and shrublands of the South West Botanical Province. There are two tropical species (*L. filiformis* and *L. ovata*), two central Australian species (*L. aphylla* and *L. lutescens*) and one species found in eastern central Australia (*L. divaricata*). An addition to this is an intriguing recently discovered grass-like species from the Gibson Desert. All are perennial subshrubs (low plants with a woody



base) or herbs. They are distinguished by having a corolla (floral tube with lobed petals) that is split on one side to the ovary, an indusium (modified style end or pollen cup) with two lips and an elongated fruit that breaks up into single-seeded articles. The genus has very attractive, showy and colourful flowers with high horticultural value.

DIVERSE SPECIES

Species such as wreath *lechenaultia* (*L. macrantha*) are often drawcards for wildflower enthusiasts and tourists visiting Western Australia for the spectacular floral displays that occur in our bushland during spring. As its common name suggests, wreath *lechenaultia* is a wreath-like, almost prostrate perennial shrub reminiscent of the floral wreaths used in memorial services. The species produces large yellow and pink or yellow and red photogenic flowers—the largest flowers of any *lechenaultia*.

Red *lechenaultia* (*L. formosa*) is a small subshrub that occurs in two forms in the wild. The Avon Wheatbelt form is prostrate and the south coast (from Albany to east of Esperance) form is erect. Red *lechenaultia* has primarily red flowers, but yellow, orange and cream shades also occur.



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From top: Blue *lechenaultia*, a common component of the jarrah forest, can produce magnificent floral displays in spring.

Photo – Andrew Brown

There are two forms of red *lechenaultia* in the wild, a prostrate form in the Wheatbelt and an erect shrub near the south coast.

Photo – Bill Bachman

Wreath *lechenaultia* has the largest and possibly the most spectacular flowers of the genus.

Photo – G Saueracker/Lochman Transparencies



Above: Scarlet *lechenaultia* is currently listed as threatened by the Department of Conservation and Land Management.

Photo – Andrew Brown

Above left: Blue *lechenaultia*.

A number of *lechenaultia* species have been found to be insect pollinated (though more likely by native bees than beetles).

Photo – Ann Storrie

Left: Heath *lechenaultia*. An atypical collection of this species was mistakenly identified and named as a new species of *Ericaceae*.

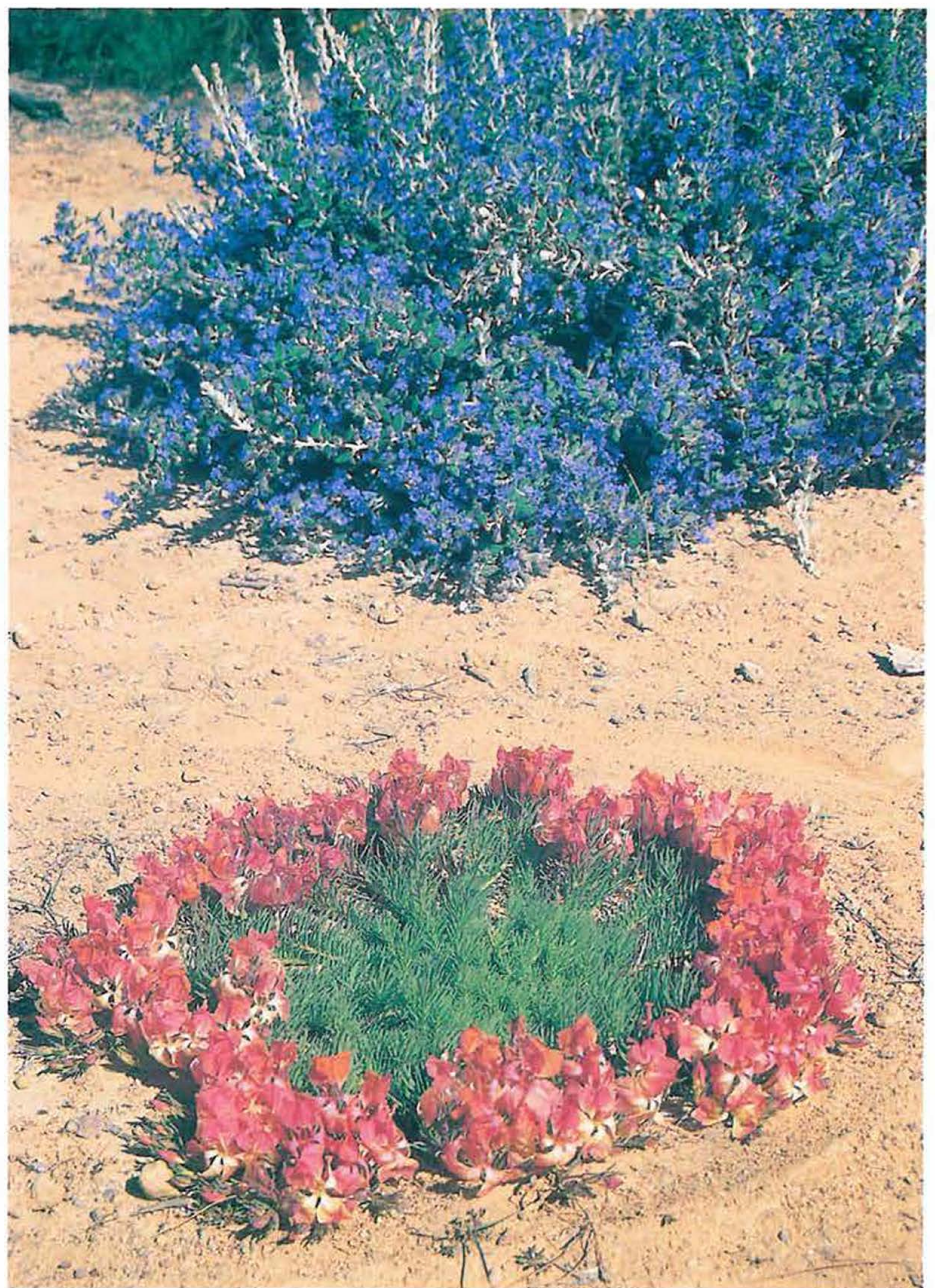
Photo – Babs & Bert Wells

Aboriginal people are said to have called blue leschenaultia (*L. biloba*) 'the floor of the sky', a most appropriate name as during spring, in parts of the Darling Range near Perth, the ground is carpeted with the blue flowers of this magnificent species. It grows mostly in the jarrah forest and throughout the south-west, producing attractive floral displays when found in dense clumps (often with suckering roots). The flower colour is primarily blue, but white variants also occur in this diffuse perennial subshrub.

Other *Lechenaultia* species of similar form include: Goldfields blue leschenaultia (*L. brevifolia*), which has blue flowers and a white centre; free-flowering leschenaultia (*L. floribunda*) with its pale blue or white flowers; a recently recognised species from the eastern Avon Wheatbelt with white or pale blue flowers (*L. "galactites"*); claw leschenaultia (*L. heteromera*), displaying blue or blue and white flowers; and scarlet leschenaultia (*L. laricina*) with scarlet to orange flowers. These species can produce magnificent floral displays.

HISTORY

Robert Brown, the naturalist-botanist on Matthew Flinders expedition, first named *Lechenaultia* in 1810 after Jean-Bapiste Louis-Claude-Theodore Leschenault de Tour. Leschenault was a naturalist-botanist on Nicholas Baudin's expedition of 1800 to 1804, visiting Cape Naturaliste, the Swan River and Shark Bay in WA. Brown and Leschenault met at Encounter Bay in South Australia while both were on their respective epic voyages. Unfortunately, Brown misspelt Leschenault in naming the genus, believing that the 's' would be absent according to the typical French spelling. George Bentham, the author of the first published *Flora of Australia*, added the 's' in 1837 in an attempt at a correction, and this spelling continued until the middle of last century when the original was restored. The accepted rules of naming plant species state that the published spelling holds priority over any later changes or attempts at correction. Common names have no such rules and the use of the 's' is acceptable. Brown holds a high place in Australian botany, being the first to collect and name many hundreds of



species. In naming *Lechenaultia* in 1810, he described crowded leschenaultia (*L. expansa*), slender leschenaultia (*L. filiformis*), heath leschenaultia (*L. tubiflora*) and red leschenaultia.

In 1923, Charles Gardner, WA's pre-eminent botanist during the first half of the twentieth century, gave the name *Ericopsis formosus* to what he thought was a new species of the Ericaceae family. No other species of Ericaceae is known to occur in this State, so imagine Gardner's excitement when he believed that he had discovered the first and only one. Ericaceae are common in South Africa and Europe. Unfortunately, Gardner had collected an atypical form of heath leschenaultia without fruit, which would have alluded to the actual identity of the species.

Wreath leschenaultia, pictured in the foreground, is a major drawcard for tourists keen to visit the spring time floral displays in Western Australia. Photo – Neville Passmore

CLEVER SEX

"Dear Jim . . . I would very much like to know whether the flowers of *Leschenaultia* (or other Goodeniaceae) are visited by Bees or other insects . . ." asked the famous naturalist Charles Darwin in a letter to James Drummond, the first Colonial botanist in WA. Darwin's interest in the pollinators involved in fertilising *Lechenaultia* and the Goodeniaceae was an interesting question. In recent years, botanists have discovered it is carried out by insects in some species and birds in others. Yellow leschenaultia (*L. linarioides*), for example,



is thought to be bird pollinated and blue lechenaultia is thought to be insect pollinated. The white centre of its blue flower helps the bee to find the nectar at the base of the tubular petals.

The mechanism involved in delivering pollen to the visiting insect or bird pollinator is via the pollen indusium (or cup) in the Goodeniaceae. This structure is located at the top of the style and forms a cup with two lips surrounding the surface of the stigma. Before the flower opens, pollen is received into the indusium from the maturing anthers as the style grows and pushes forward. The pollen stored in the indusium is held until a pollinator visits the flower. The pollen load is deposited on the pollinator as it brushes against the opening of the indusium on entering the flower. The maturing stigma then continues to grow out through the indusium ready to receive pollen from another plant when brought by another pollinator. In *Lechenaultia*, however, the process seems to be slightly different, with the pollen usually being deposited on the outside of the indusium. But the specific mechanism of the process in the *Lechenaultia* is still poorly known.

ORIGINS

Evolutionary studies in *Lechenaultia* have shown that the central Australian species and the tropical species most likely have their origin in the south-west of WA. This is also believed to be true of the related genus *Dampiera*, and initial studies indicate the same for *Goodenia*. The South West Botanical Province is a world 'hot spot' of plant diversity, and this is reflected in the high numbers of *Lechenaultia* and the Goodeniaceae in general that are found

Top left: Kalbarri lechenaultia, restricted to rocky ledges and gullies in the Kalbarri area, is listed as threatened by the Department of Conservation and Land Management.
Photo – Andrew Brown

Above left: Barrens lechenaultia is entirely restricted to the Fitzgerald River National Park.
Photo – Babs & Bert Wells

Left: A hybrid lechenaultia from breeding work by the Botanic Gardens and Parks Authority.
Photo – Neville Passmore



only in this region. More than 60 per cent of *Goodenia*, 90 per cent of *Dampiera* and 95 per cent of *Scaevola* species have natural distributions that are restricted to WA.

HORTICULTURAL VALUE

Because of their bright, showy and colourful flowers, many species of *Lechenaultia* have high horticultural value. Blue lechenaultia, free-flowering lechenaultia, red lechenaultia, hairy lechenaultia (*L. hirsuta*), wreath lechenaultia, heath lechenaultia and *Lechenaultia* hybrids have all been cultivated commercially. Forms of blue lechenaultia and red lechenaultia have proved to be the most popular and reliable. The Botanic Gardens and Parks Authority has been developing a number of new hybrids for the commercial market based on the species of *Lechenaultia* in the park's living collection. Commercial response to the new hybrids is being tested throughout Australia, and in Europe and America. Four or five varieties are expected to remain viable for marketing at the end of the year.

CONSERVATION STATUS

Currently, Kalbarri lechenaultia (*L. chlorantha*), scarlet lechenaultia

and cushion lechenaultia (*L. pulvinaris*) are listed as threatened by the Department of Conservation and Land Management. Wingless lechenaultia (*L. acutiloba*), white lechenaultia (*L. "galactites"*), Irwin lechenaultia (*L. longiloba*) and Barrens lechenaultia (*L. superba*) have priority conservation status listing. This means that these species are possibly threatened, but require further survey and assessment in the wild. The higher the priority, the greater the urgency needed to survey these species. Cushion lechenaultia and scarlet lechenaultia have been the subject of translocation efforts by departmental scientists in recent years in the Avon Wheatbelt bioregion, in an attempt to increase the number of plants in the wild. This involves collecting seed, cultivating the species in a nursery and establishing the cultivated plants in the field as a viable population.

MORE WORK TO DO

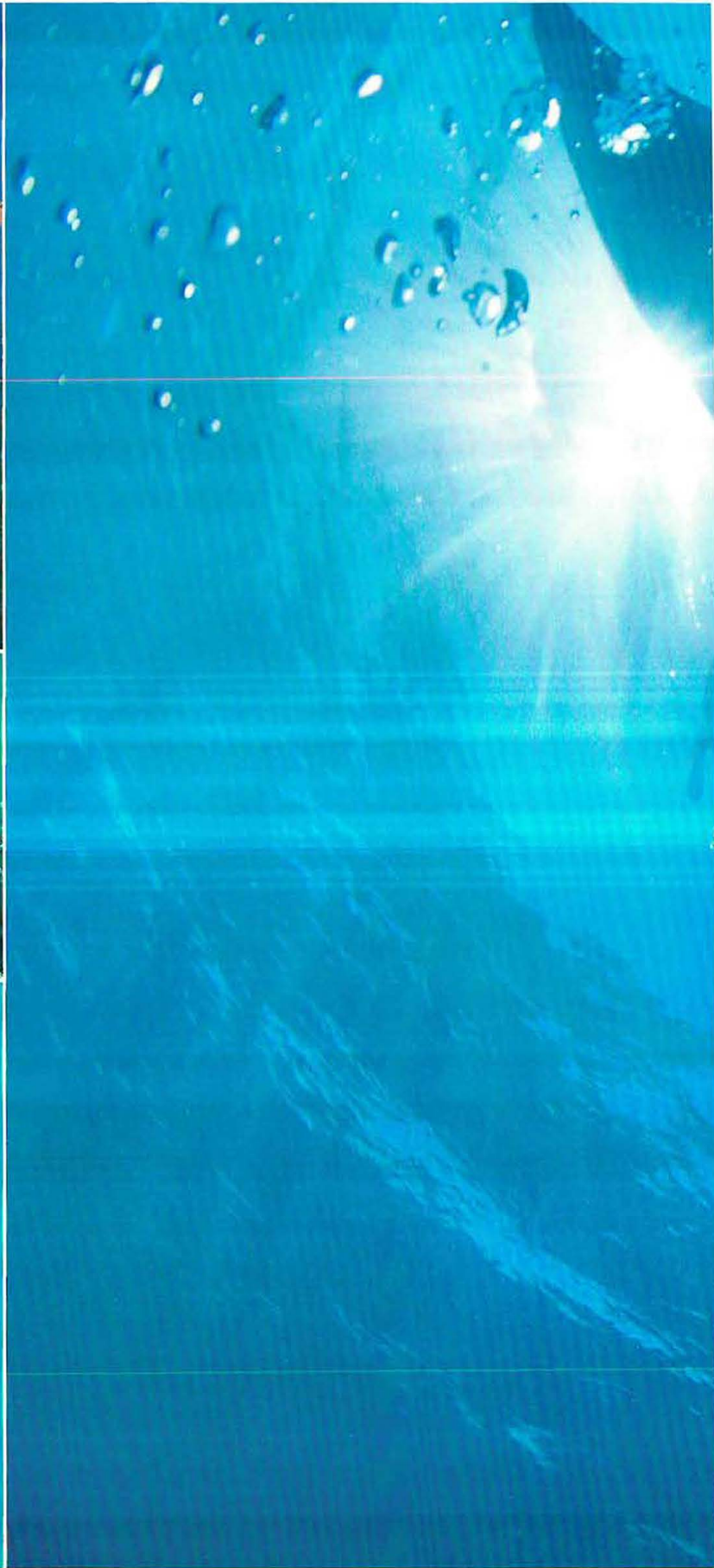
The attractive and interesting genus *Lechenaultia* and the Goodeniaceae family in general still remain poorly known and understood in many areas. Examples of the benefits of research into the family include the compounds that were found in the related currant bush

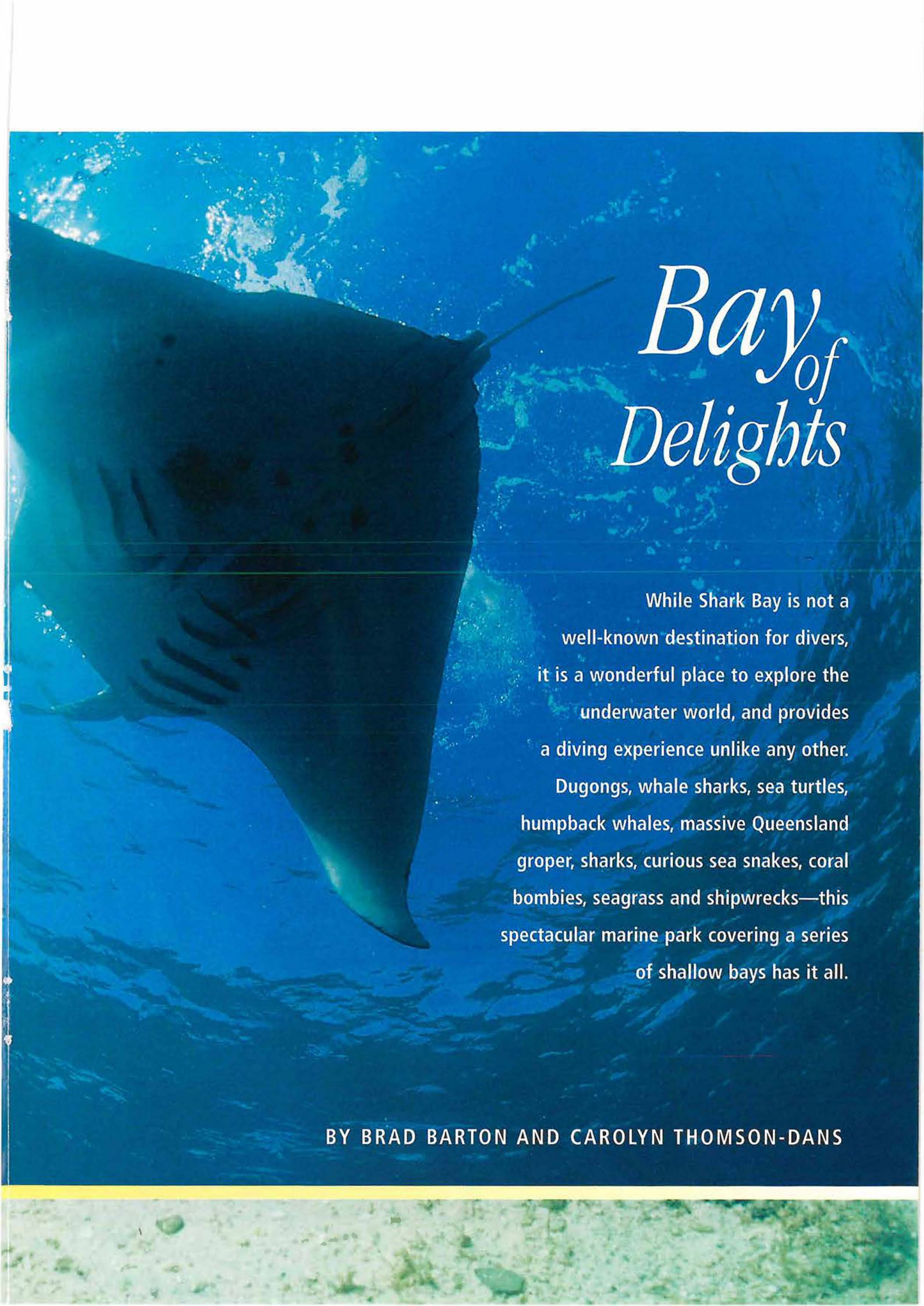
Above left: Hairy lechenaultia (*L. hirsuta*) is a straggling shrub producing bright red flowers. It occurs between Perth and Shark Bay. Photo – Babs & Bert Wells

Above: Yellow lechenaultia (*L. linarioides*) is a commonly encountered, mostly coastal species producing large attractive yellow and red flowers. Photo – Andrew Davoll/Lochman Transparencies

(*Scaevola spinescens*), and a species of *Goodenia* that have potential uses in the treatment of cancer and diabetes. Future work in the related *Lechenaultia* species may also prove to be fruitful and, hopefully, will help with the conservation of this wonderful group of plants.

Leigh Sage works from the Department of Conservation and Land Management's Forest Management Branch at Bunbury. As a botanist, he has been researching the taxonomy and conservation biology of the Western Australian Goodeniaceae. He can be contacted on (08) 9725 4300 or by email (leighs@calm.wa.gov.au).





Bay of Delights

While Shark Bay is not a well-known destination for divers, it is a wonderful place to explore the underwater world, and provides a diving experience unlike any other.

Dugongs, whale sharks, sea turtles, humpback whales, massive Queensland groper, sharks, curious sea snakes, coral bobbies, seagrass and shipwrecks—this spectacular marine park covering a series of shallow bays has it all.

BY BRAD BARTON AND CAROLYN THOMSON-DANS



The embayments of Shark Bay Marine Park offer many shallow, but highly recommended, dive and snorkel sites. While there are many sites that experienced divers would find challenging, there are numerous very pretty coral gardens that you can easily explore equipped only with mask, snorkel and fins. Some of these are accessible from shore, so you don't even need a boat to discover the many marine delights of Shark Bay.

LARGE SEA CREATURES

One of the greatest thrills of diving is to encounter large and mysterious sea creatures. As well as being famous for its sociable dolphins, divers in Shark Bay may come face to face with turtles, dugongs, whale sharks and other large fish.

Divers and boaters frequently see marine turtles and dugongs. Green and loggerhead turtles are common in Shark Bay all year round. From October onwards, congregations of loggerhead turtles can be seen in the waters around Dirk Hartog Island as they prepare for the start of the breeding season. At mating time, males usually cluster around and compete for females, which inevitably breed with more than one male. The shallow marine environment of Shark Bay has one of the largest and most secure populations of dugongs in the world, with an estimated 10,000



animals. Their hearing is excellent, allowing them to detect boats and other disturbances at a distance, and they may respond to the presence of a boat by coming to investigate. They are extremely shy, however, and will move away at the slightest hint of a threat.

A number of whales enter the bay during winter, when you may be able to see them on the way to various dive sites. From December to July, whale sharks are a common sight in the deeper, warmer oceanic waters surrounding Dirk Hartog Island. One may even join you on the Monkey Rock dive in South Passage.

Queensland groper can weigh in excess of 300 kilograms and reach more than two-and-a-half metres in length. They are often curious and may even

Previous page

Main: Manta ray.

Insets from top: boating in the park; diving in a staghorn coral garden; yellow tail angelfish.

Photos – Clay Bryce

Left: A diver photographing Clark's anemonefish at Shark Bay.

Photo – Eva Boogaard/Lochman Transparencies

Below: A dugong calf stays close to its mother.

Photo – Geoff Taylor/Lochman Transparencies

approach you. These large predators lurk in caves and other good hiding spots. They are one of our marine wonders and conservation-minded divers will leave them unmolested for others to enjoy. They may live for up to 50 years so, because there are few in any location, large animals would take many years to be replaced.

THE WRECK OF THE GUDRUN

The *Gudrun*, the biggest wooden shipwreck found off Western Australia, sank at Shark Bay in 1901, carrying a load of jarrah from Bunbury to England. It was deliberately scuttled with more than a metre of water in its hold, after being sabotaged by the ship's carpenter. He admitted drilling a hole through its bottom. The wreck was rediscovered in 1989, when Paul Anderson, a Canadian studying dugongs in Shark Bay, found it on the





sand flats north of Cape Peron. Today, the wreck lies in about six metres of water. A special sanctuary zone extends for 500 metres around the wreck to protect the site. Artefacts can't be removed and line fishing and spearfishing are not permitted.

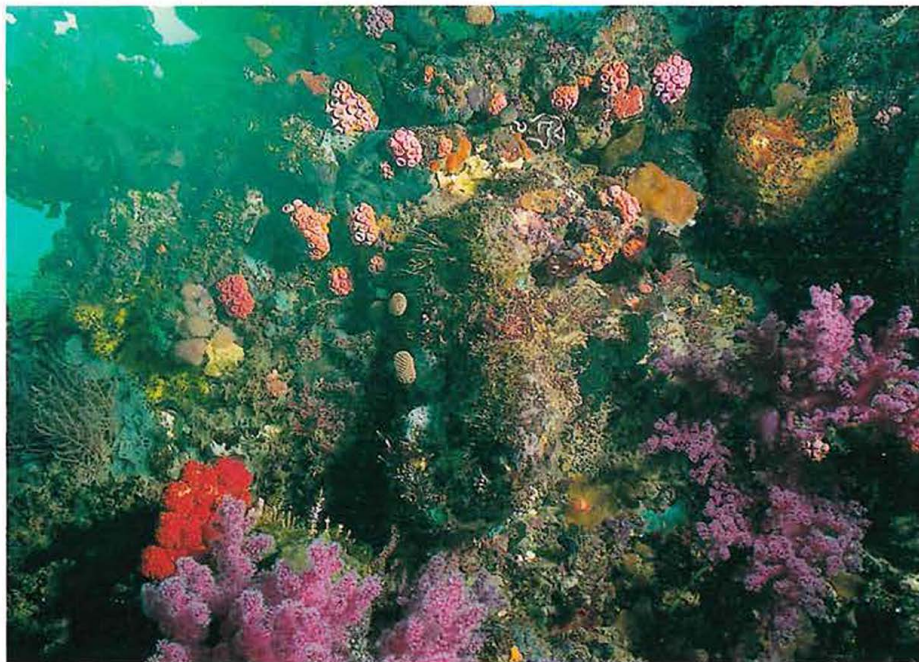
The wreck is 65 by 20 metres, with another 20-by-eight-metre section nearby, making it one of Western Australia's largest untouched wrecks in shallow waters. The hull is buried largely intact up to a metre in the soft sands, but anchors, fastenings, deck knees and so on are still visible. The remains, however, do not project much more than a metre from the seabed. Because of its relatively untouched wreckage, stunning marine life, remote location and history, Maritime Museum archaeologists rate it as one of the State's best wreck dives. It is now home to a rich variety of fish and marine animals, including turtles, giant groper and stingrays.

MONKEY ROCK

The fault line that runs from Steep Point out and around Monkey Rock is one of Shark Bay's best known dive sites, and can be reached by boat or from the land. However, the dive should not be attempted in other than optimum weather conditions. Due to the strong tidal movement in South Passage, the site should only be dived on a slack tide or incoming change. It is a difficult dive and definitely not for novices.

The site has a large swimthrough, starting at six metres and descending to 18 metres. This cavern is full of lionfish and other tropical fish. Lionfish are strikingly attractive, but their venomous spines can cause painful wounds, so divers need to look but not touch. This area is also home to two large wobbegong sharks that can be seen lazing in their crevices.

As the edge of the reef turns to the



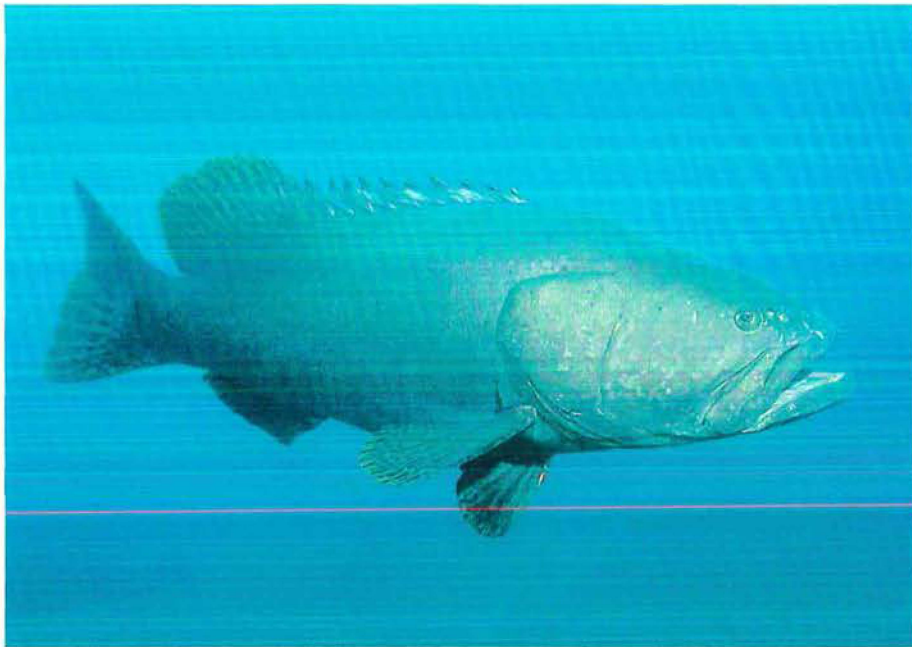
east, some large coral bobbies rise from the bottom. Large cod and groper are usually seen here. The coral along the next section of reef is some of the best at the site, and here divers often encounter mackerel, samson fish, sailfish and manta rays. Manta rays can weigh more than two tonnes and are able to leap from the water.

Dive charters are available (by prior arrangement) and this is the recommended way to dive the site. It is a 60-kilometre boat trip from Denham and should only be undertaken in a boat at least five metres long. If you plan to

Top: Colourful invertebrates coat underwater surfaces within the marine park.
Photo – Eva Boogaard/Lochman Transparencies

Above: The zebra lionfish, or butterfly scorpionfish, has venomous spines that can cause painful stings.
Photo – Peter & Margy Nicholas/Lochman Transparencies

dive from the shore, you will need a four-wheel-drive. Steep Point is a long and rugged drive from Denham via the Useless Loop Road and would involve camping overnight.



BAR FLATS

Only three metres in depth, Bar Flats is a popular dive and snorkel site for Denham-based boats. Small fish species are abundant and, like many other dive sites in Shark Bay, a dugong could be encountered here.

This area is dominated by cabbage corals (*Turbinaria* species), staghorn corals and soft corals. Like reef-building corals, soft corals also have supporting structures of calcium carbonate, but this takes a different form from hard corals. They contain small spicules within their tissue, rather than a continuous skeleton. Other invertebrate marine life is abundant, and includes

sponges, sea anemones and yellow tubeworms, which live in tubes within corals or other underwater surfaces or animals. Divers do not see the body of these worms, just the feather-like feeding tentacles that protrude from their tube. The tentacles trap plankton, which is moved down grooves to the animal's mouth.

EAGLE BLUFF

Only 20 minutes drive from Denham, Eagle Bluff is one of the most prominent coastal features in the Shark Bay World Heritage Area. Expansive views of Henri Freycinet Harbour are available from the cliff top. Clear,

shallow (one to five-metre) waters around the base of the bluff are ideal for beginners and novice divers to view marine creatures close up. It is perfect for snorkelling.

You enter the water from the beach on the eastern side of the bluff. The shallow sandy bottom extends 30 metres out, where it meets the seagrass bed. People snorkelling along quietly can often get quite close to shovelnose rays and small school sharks, which cruise along the sand looking for food.

The seagrass beds are the driving force behind the diversity of marine life in Shark Bay. Here, watch for sea snakes, western butterfish and leatherjackets. About 100 metres from the south-eastern point is a sand patch with a number of coral bombies. Small wrasse, blue-lined emperor and tusk fish seek shelter and food around these outcrops. Sea stars, sea cucumbers and sea urchins hide among the rocks and coral.

Above left: The massive Queensland groper, which can weigh in excess of 300 kilograms, lives in caves within the Shark Bay Marine Park.

Photo – Peter & Margy Nicholas/Lochman Transparencies

Below: The shallow marine embayments of Shark Bay offer some excellent dive sites.

Photo – Clay Bryce



GREGORIES REEF

Gregories Reef lies offshore from Gregories camping area in Francois Peron National Park. It can only be reached by four-wheel-drive, but the limestone platform reef is accessible to snorkellers from the shore.

While the reef (in only two to three metres of water) supports only small areas of coral and some invertebrates, it abounds in fish life. Moon wrasse, black-spot tusk fish, dart, yellowfin bream and gold-spotted sweetlips are common. Schools of mullet swim along the seaward edge of the reef, ever wary of the bottlenose dolphins that frequent this area. Black sponges and fish, such as tusk fish, shelter in the caves and crevices along the front of the limestone platform. The boat channel often has schools of dart and yellowfin bream.

Many fish species also shelter in the lagoon, feeding opportunistically on organisms washed off or over the reef. Baldchin groper, distinguished by their white chin, often frequent the inside of the reef. Dolphins and dugongs are infrequent visitors. Dugongs are most likely to be seen in the scattered seagrass beds inside the lagoon, while dolphins prefer the deeper water outside the reef. Sea urchins often hide in the caves, while sea cucumbers and stingrays secrete themselves among the rubble in front of the reef.

BOTTLE BAY

Bottle Bay also lies offshore from Francois Peron National Park. There is beach access from the most northerly campsite at Bottle Bay (four-wheel-drive only). Although quite shallow (two to four metres), Bottle Bay has a small but lovely patch of corals and sponges, replete with tropical fish and crustaceans. Only 50 to 80 metres off the beach, it offers an easy dive or snorkel. Turtles and an occasional pod of dolphins may be seen in the area, if you are lucky enough to be there at the right time.

The largest patch of scattered coral lies about 80 metres offshore, and extends north-south for about 80 metres. It is made up of an array of fluorescent green and orange cabbage corals. There are also several pale pink



brain corals, small plate corals and the very occasional staghorn. There are also large, rubbery black sponges. The coral garden is populated by numerous species of bright parrotfish and wrasse, butterflyfish, angelfish and sergeant majors.

South of this patch, a large bank of seagrass harbours the odd small shark. Heading back inshore, about 30 metres from the beach, are two small rocky outcrops. Closer in, the rubble is covered by only a metre or two of water at high tide. This area is full of fish feeding, including many juvenile snapper, butterflyfish, mullet, garfish, parrotfish by the dozen, bullseyes, sweetlip and blue-lined emperor.

Top: The red and green wrasse inhabits rocky reefs and inshore coral reefs. Males are very colourful.
Photo – John & Val Butier/Lochman Transparencies

Above: Eagle Bluff is a good place to see the white-spotted shovelnose ray.
Photo – Clay Bryce/Lochman Transparencies

Snorkellers willing to spend time looking under, and lifting rocks, can find sleepy wobbegongs and timid crabs hiding in nooks and crannies.

The occasional anemone and its resident anemonefish can be seen among the coral, and stirred up silt can indicate a blue-spotted ray or a group of goatfish sifting diligently over the sandy bottom.



SAFETY

Tidal movements throughout Shark Bay Marine Park are very strong, particularly in South Passage and at the northern tip of Dirk Hartog Island. Thus, it is important to note that all sites within the marine park should be dived or snorkelled only on a slack tide.

Dive charters are available for groups by prior arrangement, and this is recommended as the safest way to dive most of the sites, as the charter operators are intimate with local tides, danger spots and conditions. If you intend to dive from your own boat, it is recommended that you first purchase two books produced by the Department of Conservation and Land Management. *Dive and Snorkel Sites in Western*

Australia and More Dive and Snorkel Sites in Western Australia contain useful information, descriptions and mud maps of all the dive sites described in this article. Compressed air is available in Denham, but no diving equipment is available for hire, so you will have to bring your own.

There are also a few dangerous animals to watch out for. Rules to obey for sea snakes are the same as for their land-based relatives: look but don't touch. Although sea snakes are highly venomous, they are placid and rarely attack people unless provoked and, even when they do, they do not always release venom. Watch out for stonefish in the shallows. They are highly venomous.

Above: The loggerhead, considered to be the most endangered turtle that nests in the Australian region, inhabits the waters of Shark Bay.

Below left: The olive sea snake is largely confined to Shark Bay. They are quite curious and sometimes approach divers.

Photos – Eva Boogaard/Lochman Transparencies

TAKING THE PLUNGE

It should now be clear that the unique Shark Bay Marine Park has much more to offer visitors than just the famed Monkey Mia dolphins. In future, it is hoped that more people will be tempted to take the plunge so they can appreciate the diversity and beauty of this amazing marine area where it counts the most—actually under the water!

Brad Barton, a keen diver, was formerly the Operations Officer for CALM's Gascoyne District. He can be contacted on (08) 9021 2677.

Carolyn Thomson-Dans is a co-editor of *LANDSCOPE* magazine and has compiled CALM's books *Dive and Snorkel Sites in Western Australia* and *More Dive and Snorkel Sites in Western Australia*. She can be contacted on (08) 9389 8644 or by email (carolynt@calm.wa.gov.au).

The authors wish to acknowledge the many contributors to the Shark Bay section of the abovementioned books.



Watching over our oceans: involving community in marine monitoring

It is important to monitor the marine environment so we can ensure it stays as pristine as possible, but how do you effectively monitor a coastline that is 12,500 kilometres long without unlimited financial resources?

The Marine Community Monitoring Program, a new and ambitious project, aims to involve all interested Western Australians in helping to conserve our unique marine environment.



BY JENNIE CARY AND TIM GRUBBA

The mainland coast of Western Australia is about 12,500 kilometres long and there are 3,424 offshore islands. Our coastal waters contain coral reefs, mangrove forests, seagrass meadows, rocky reefs, extensive areas of soft sediment and open ocean. These ecosystems are home to a rich array of plants and animals such as seagrasses, corals, fish, starfish, shells, dugongs, turtles, whales, dolphins, sea-lions, penguins, sharks and crocodiles. Some of these animals are rare and in need of special protection, while some sea and shorebirds found along our coastline migrate from Asia and are protected by international conservation treaties.

WA's Ningaloo Marine Park protects Australia's largest fringing coral reef. The Shark Bay Marine Park, within the World Heritage Area, has the world's most extensive seagrass meadows, the famous Monkey Mia dolphins and rare communities of stromatolites. Many of the State's marine plants and animals, particularly those in southern

temperate waters, are found nowhere else in the world.

Unlike many places elsewhere, our marine environment is generally in excellent condition. Seagrasses are in good condition except for those in Albany's harbours, Cockburn Sound and parts of Geographe Bay. Most coral reefs are in pristine condition and most mangrove forests are in good condition except for some loss through industrial and landfill activities and coastal development. Around metropolitan Perth, the marine environment has been contaminated by sewage and other run-off. About 27 exotic species have been introduced into WA waters. Commercial fishing stocks are generally being managed at sustainable levels, though intensive fishing around highly populated areas has resulted in depletion of key target species, such as dhufish, from the more accessible areas and, at Shark Bay, snapper stocks have been depleted by overfishing.

POPULATION PRESSURES

The marine environment of this State is owned by all Western Australians. Unlike the land, where usage rights are defined by titles and boundaries, the sea is a common asset available to all users. The flip side of this is that as our population increases, so too does pressure on our ocean and its inhabitants. Much of the degradation of marine environments elsewhere in the world has resulted simply from

increased human usage, often with limited knowledge and understanding that it is actually happening until it is too late.

It is important, therefore, to monitor our marine environment closely so we can understand the implications of our activities. Good indicators of the state of the ocean may include water quality and coral, seagrass and fish 'health'. If these vary from what is 'normal', something can be done to investigate the causes of such changes and, if necessary, to take action to rectify the problem before it is too late.

Management agencies and scientists recognise that they cannot do this enormous task on their own and need to involve the broader community. Many local communities also recognise that everyone (including Government agencies, scientists and community members) has a mutual responsibility to protect our marine environment and are keen to help.

DEVELOPING PARTNERSHIPS

In WA, the government has sought to tap into this enthusiasm through a new project known as the Marine Community Monitoring Program. The program was developed by the Department of Conservation and Land Management and the Australian Marine Conservation Society WA (AMCS), with significant assistance from the WA Museum and Marine Education Society of Australia.

Previous page

Top: Seagrass meadow.

Photo - Eva Boogaard/Lochman Transparencies

Main: Getting ready to monitor mangroves and water quality.

Photo - Clay Bryce

Below: Data collected by the community on dugong sightings will help in understanding their distribution and habitat preferences.

Photo - Geoff Taylor/Lochman Transparencies



The Marine Community Monitoring Program is at the 'cutting edge' of community programs providing data for marine management agencies. It is similar to programs such as 'Eye on the Reef' (coral reef) in Queensland, 'Reef Watch' (temperate reefs and fish) in South Australia and 'REEF', which collects data on fish diversity and abundance in the USA and Caribbean. However, WA's Marine Community Monitoring Program is the most extensive and ambitious program of its kind in the world.

The main aim of the program is to develop partnerships between managers, scientists and the community. It will result in an early warning system to detect and rectify any changes in the marine environment. The program provides the tools for community members to help monitor and manage the health of marine and coastal areas. The monitoring methods are easy to use and mostly fun to do, although there are some more complex methods for those who have more time and interest to develop greater expertise. The data that are collected will complement the monitoring data gathered by Government agencies and scientists. Together, these data will be used by management agencies and local communities to help manage human impacts on their local marine environments.

The Marine Community Monitoring Program has been designed to overcome several fundamental obstacles to successful community involvement in marine management. The first obstacle is the difficulty in positively identifying all but the most common marine plants and animals. The program has responded to this challenge by developing an easy-to-use CD-ROM, entitled *Marine life in Western Australia*. The CD-ROM, developed in 1998, is an aid to identifying about 400 marine plants and animals commonly found in WA tropical and temperate coastal waters. Copies of the CD-ROM can be purchased from the Department of Conservation and Land Management's NatureBase website or from its headquarters in Kensington.



Other obstacles are the public's limited knowledge of scientific methods and experience in data collection, along with the difficulty of maintaining community enthusiasm over the long time scales needed to obtain meaningful data. To address these concerns, the program developed a manual of user-friendly monitoring methods and a database. The database is linked to the WA Atlas website to allow easy access to the data and, hence, provide the feedback necessary to maintain community interest. Both the CD-ROM and manual have been completed, with both projects winning National and State awards for excellence. The program, even before it has been completed, has been in demand

Top: Data collected by the community on whale sightings will complement data collected by scientists.

Photo – Geoff Taylor/Lochman Transparencies

Above: A diver records coral predators on coral reefs, contributing to the understanding of natural versus human activities.

Photo – Sue Morrison

from government and non-government agencies throughout Australia.

The final obstacle is the public's limited operational training and experience in monitoring the marine environment. To address this, a training program is being developed to ensure such activities are carried out effectively and safely.



Above: A diver takes an underwater video along a marked transect, to provide baseline data for detecting future changes.



Left: Local knowledge and enthusiasm are underutilised in the management of our marine environment.

Photos – Sue Morrison

WHO CAN TAKE PART?

All Western Australians with an interest in the marine and coastal environment can take part in the Marine Community Monitoring Program, either as part of a community group or as an individual. Invaluable data can be collected from people from all walks of life, who are living, working or holidaying along the WA coastline. You may be working on a pearl farm or an oil rig in a remote area, or perhaps you are a recreational fisher living in a city. You may collect some data while

on holiday, or monitor the health of your local environment regularly. Local residents, indigenous communities, neighbouring land owners, recreational boating, diving and fishing clubs, nature study enthusiasts and collectors, scientists, conservationists, school groups, local government employees, commercial fishing operators, aquaculturists, commercial tourism operators and members of the mining and petroleum industries have all expressed an interest in participating.

WHAT YOU CAN MONITOR

A manual of monitoring methods has been developed. The manual provides background information on each method and describes its relevance to management agencies. It tells you how to select and describe your site,

advises how and when to monitor, and how to collect and store the data. The manual also describes the level of difficulty of each method, outlines equipment and safety measures required, tells you how to be environmentally sensitive, shows you how to find your data on the web, describes existing community monitoring programs and includes a list of further references.

The 33 monitoring methods in the manual cover the physical, biological and social environment. The methods were developed in conjunction with marine scientists and managers to ensure they were scientifically sound.

Methods to monitor the physical environment cover parameters such as beach width, beach structure, water clarity and water temperature. The biological environment includes coral, seagrass and mangrove health, algal blooms, fish, marine mammals and introduced marine pests. The social environment includes beach and underwater litter and human usage.

After the Department of Conservation and Land Management has received your data, it is checked for errors and inconsistencies and then entered into the Community Monitoring Database. Maps showing the results of your data will be produced as part of the community monitoring data analysis process. These give a very good overview of data collected for each method. The maps will be available on the Internet via the WA Atlas (<http://www.walis.wa.gov.au/atlas>)—linked from NatureBase.

Once the data is collated, it becomes an important component of the information-base that community groups, scientists, government departments such as the Department of Conservation and Land Management, and the Department of Environmental Protection and local government authorities can use to identify and remedy undesirable trends.

WHO'S ALREADY INVOLVED?

Many community groups have already helped to trial the methods from the monitoring manual in the field. These groups have selected methods from the manual that address



Underwater photographic clubs are an important source of expertise in marine conservation.

Photo – Clay Bryce

environmental issues that concern them in their area.

Students from North Albany Senior High School are monitoring the health of seagrass communities in Princess Royal Harbour. Large areas of seagrass have been lost from the harbour over the last 30 years as a result of nutrient discharges. Information collected by the school is being used by the Albany Waterways Management Authority, the local agency monitoring the recovery of the seagrass meadows since nutrient loads into the harbour were reduced. Science teacher Jim Kneale's involvement in seagrass monitoring was recently recognised with an award from Coastwest/Coastcare.

Chris Gibbs, a science teacher from Bunbury Cathedral Grammar School, is using methods from the manual to monitor the health of the marine environment off Dalyellup Beach, which is under increasing pressure from urban development. He is collecting water temperature data using temperature loggers. The information is being used by oceanographers from the Department of Conservation and Land Management and CSIRO to study ocean currents in the area and 'ground truth' satellite images. Chris is hoping to involve his science students in the project once he has developed a safe study site.

The Department of Conservation and Land Management Bush Ranger cadets from John Septimus Roe Anglican Community School are using methods from the manual to monitor the health of

Mettams Pool in Perth's Marmion Marine Park. A protected pool within a barrier reef, that lies adjacent to West Coast Highway, Mettams is one of the most accessible snorkelling sites in the marine park. Information collected by the cadets, which includes beach litter surveys, will be used by the Department of Conservation and Land Management to help manage the marine park.

Two dive clubs, The University of Western Australia Underwater Dive Club and the Dive Buddy Club of Rockingham, have been collecting information on coral predators, including the crown of thorns starfish and marine snails, in the Ningaloo Marine Park and Dampier Archipelago. The data is being used by the Department of Conservation and Land Management to better understand the impacts of natural influences on coral communities and to help separate natural impacts from human impacts.

Students from Fremantle Primary School are undertaking beach litter surveys on Bathers Beach in Fremantle, using the beach litter method from the manual. The information collected is sent to the Department of Conservation and Land Management so the beach litter at Fremantle can be compared with beach litter from other areas monitored in WA.

One thousand volunteers monitored beach litter at 45 sites during the Coastal Clean-up 2001 in May. The event was organised by AMCS and Keep Australia Beautiful. The event used the beach and underwater litter methods from the manual to collect data on litter type and

densities. The data will be displayed shortly on the WA Atlas website.

GETTING INVOLVED

The Marine Community Monitoring Program is developing partnerships between the community, managers and scientists. The community contributes local knowledge, expertise, energy and commitment, resources and access to almost all our coastal waters. Managers and scientists will continue to implement complementary monitoring programs and will also provide training, scientific expertise, support, advice, feedback, data interpretation and management decisions.

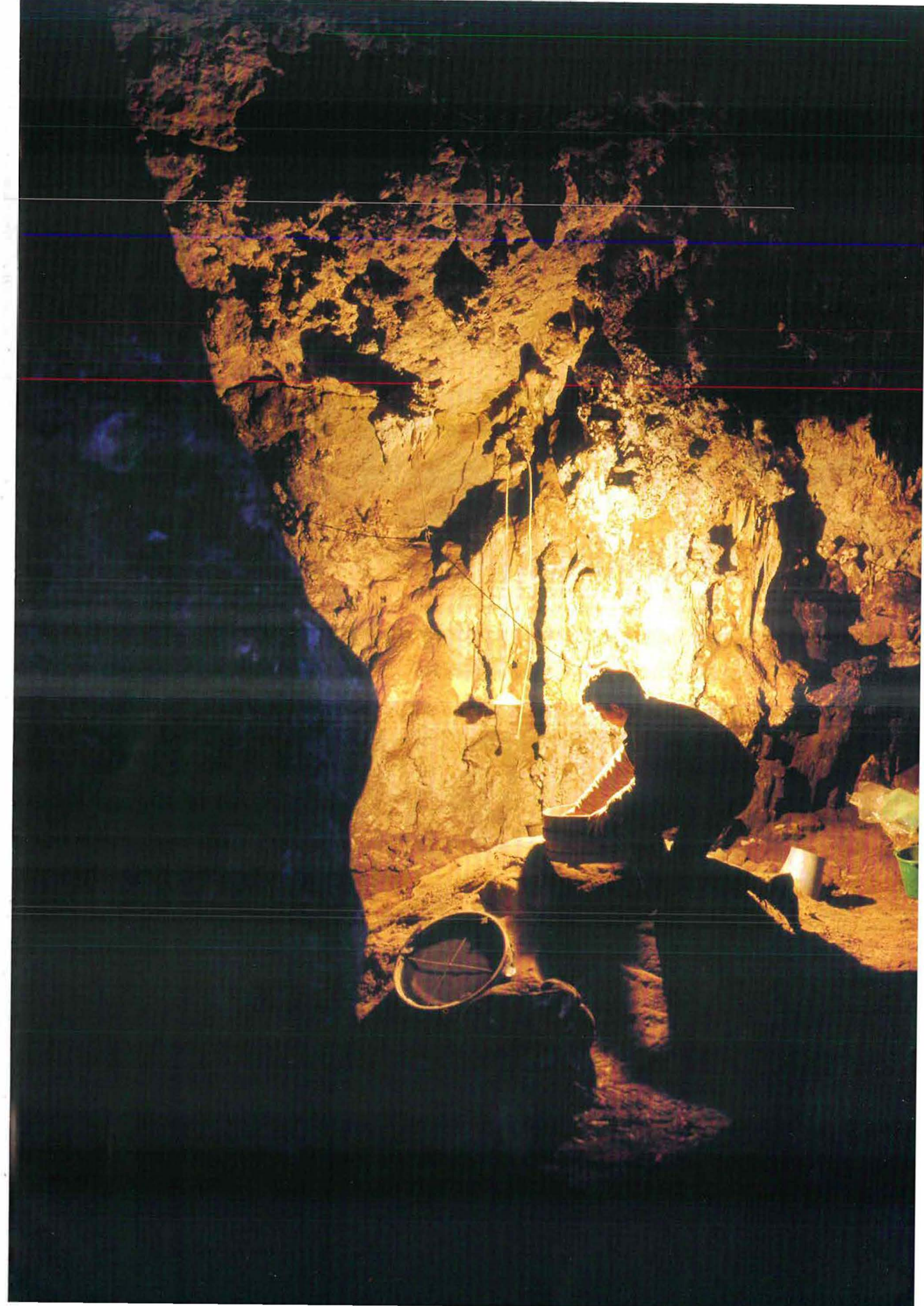
Once the training program has been developed, it is expected that the Marine Community Monitoring Program will become fully operational and made available to many more groups throughout WA. If we work together, the program will give us all the chance to give something priceless to ourselves and future generations—healthy oceans and beaches. The more individuals and community groups become involved, the more successful the program will be.

Jennie Cary is Senior Marine Ecologist at the Department of Conservation and Land Management's Marine Conservation Branch, based in Fremantle. She can be contacted on (08) 9432 5100.

Tim Grubba is a Marine Conservation Officer at the Department's Marine Conservation Branch. He can be contacted on (08) 9432 5100.

Funding for the Marine Community Monitoring Program was provided by Coastwest Coastcare, an initiative of the Natural Heritage Trust, and the Department of Conservation and Land Management.

You can find out the latest information about the Marine Community Monitoring Program and how to register your interest by visiting the NatureBase website at <http://www.naturebase.net>.

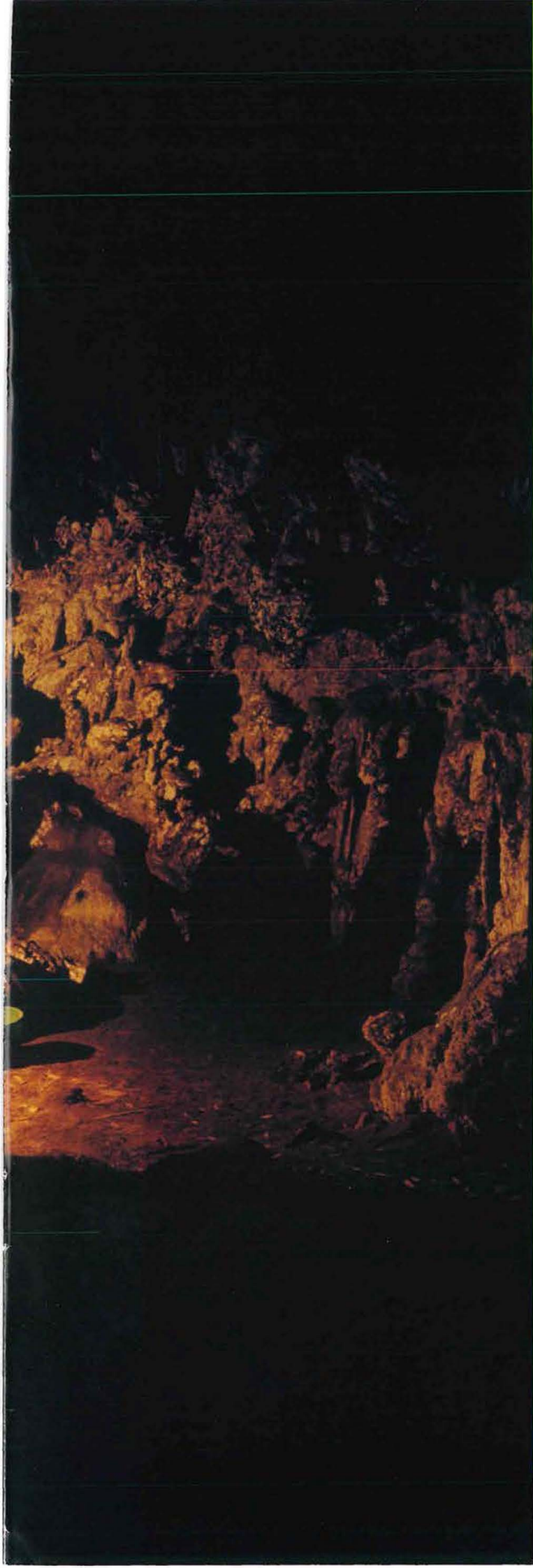


History from the caves

50,000 years of Aboriginal occupation
in the Leeuwin-Naturaliste region

by Joe Dortch and Charles Dortch

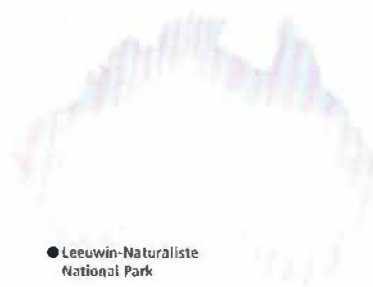
Limestone caves and rock shelters in
the Leeuwin-Naturaliste National Park,
in Western Australia's south-west,
have yielded a wealth of information
relating to ancient Aboriginal
occupation, dating back around
50,000 years.



Information about Aboriginal occupation of the Leeuwin-Naturaliste region derives mainly from excavations and other investigations carried out by archaeologists, palaeontologists and other scientists. This prehistoric record is beginning to shed some light on the complexity of past Aboriginal populations' interactions with the south-western Australian environment, from more than 47,000 years ago until relatively recently.

EXCAVATIONS OLD AND NEW

Archaeology, the study of past human life, and palaeontology, the study of plant or animal life in the past, rely on excavation and study of fossils or artefacts in their stratigraphic and geological context. The dating methods used are techniques based on the decay of radioactive isotopes (e.g. radiocarbon dating) or the accumulation of a radioactive dosage in ancient sediments from natural background radiation (e.g. luminescence dating). Artefacts (objects made or modified by people) constitute the major difference between archaeological and palaeontological evidence.

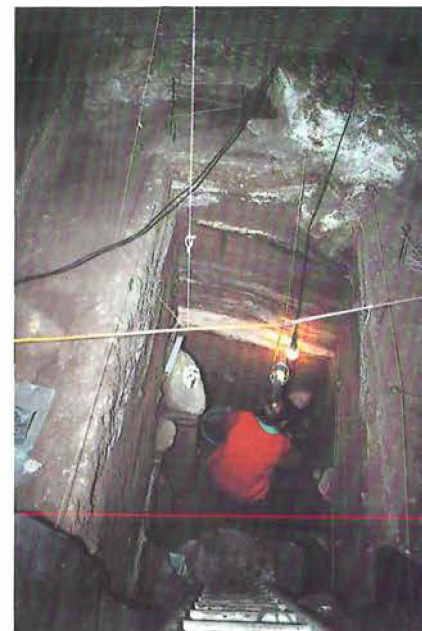


● Leeuwin-Naturaliste National Park

The palaeontological importance of limestone caves in the Leeuwin-Naturaliste region was recognised a century ago when abundant vertebrate remains, including extinct 'megafauna' species, were excavated from the floor of Mammoth Cave, near Margaret River. The archaeological potential of the caves was only recognised in the late 1960s, with the identification of a human tooth and stone tools collected a decade earlier during palaeontological sampling of the Devil's Lair cave. At about this time, probable artefacts were recognised among the bones recovered from Mammoth Cave.

IN THE DEVIL'S LAIR

In 1970, following the Devil's Lair finds, a team from the WA Museum undertook archaeological excavations



in the cave's floor deposit. Within a few years, the team had compiled a record of radiocarbon-dated stone and bone artefacts, intact hearths (campfire beds) and enormous quantities of mammal and other bone. This showed that Aboriginal groups had first occupied this cave more than 30,000 years ago (in radiocarbon years, 'before present' or BP).

Most recently, the Devil's Lair deposit has been 're-dated' in a project using several new radiometric dating methods. As a result, the estimated age of first human occupation of the cave has been significantly revised from 31,000 years to 47,000 years BP, making Devil's Lair one of the oldest, and probably the most reliably dated, early occupation sites in Australia.



Previous page

Main: Recovering archaeological material by sieving sediment excavated from a Leeuwin-Naturaliste region cave.
Bottom right: Recording the positions of campfires and archaeological remains in an excavation.

Photos – Noel Holly/Illustrations

Small inset: Stone artefacts recovered from excavations at Devil's Lair.

Photo – Douglas Elford/Western Australian Museum

Top: Profile of the Tunnel Cave excavation. The white bands above the excavator are ash layers from campfires.
Photo – Joe Dortch

Left: Archaeological excavation at Tunnel Cave. The sandbags protect water run-off from entering the excavation.
Photo – Noel Holly/Illustrations



NEW SITES, NEW EVIDENCE

During the 1990s, this record of prolonged cave occupation at Devil's Lair was supplemented by similar evidence from excavations at other prehistoric sites among the region's hundreds of limestone caves and rock shelters.

Several exceptional ancient Aboriginal occupation sites have now been recorded within or on the boundaries of the Leeuwin-Naturaliste National Park. All of the best preserved sites are in caves or rock shelters formed in the Tamala Limestone. This limestone caps the Proterozoic granitic gneiss of the Leeuwin Block, running from Cape Naturaliste 100 kilometres southward to Cape Leeuwin (see 'Caves of the Cape', *LANDSCOPE*, Summer 2000–2001). The sandy floor deposits in limestone caves are chosen for excavation because they are alkaline, allowing good preservation of animal bone and mollusc shell. Much of this material is identifiable as Aboriginal food remains, since it is charred and occurs in undisturbed hearths. Many of the larger mammal bones have been deliberately smashed.

Excavation inside the wide entrance to Tunnel Cave, located within a small stand of karri forest growing around the cave's doline, revealed numerous hearths, stone artefacts and animal remains derived from many episodes of human occupation. Charcoal samples collected from the lower two metres of the three-metre-deep deposit are dated by conventional radiocarbon method. The 'dates' obtained from these samples

BONE POINTS

Bone points are common finds in prehistoric excavations in many parts of the world. In Australia, points were typically made on the fibulae (smaller lower leg bones) of kangaroos and wallabies. The process was simple: the fibula shaft was snapped in half and the broken ends were then whittled or ground down, in this way converting each half of the shaft into a sharp point.

In historic times, Aboriginal people in southern Australia used bone points as pegs for stretching macropod and possum skins being processed for use as cloaks and bags, and as awls or bodkins in stitching skins together for cloaks and 'dilly' bags. Bone points were sometimes used as cloak fasteners. In coastal districts of south-eastern Australia, small, double-ended points served as barbs on fishing spears. Some tiny points were probably used as ornaments.

In many parts of Australia, bone points were used for piercing the septum of the nose, which was part of male initiation. Points or non-pointed lengths of limb bone fitted into the septum were ornamental and also indicators of status. The bone points from Devil's Lair (shown here), and those from Tunnel Cave, could have been variously used for any of the above practical, ornamental or symbolic purposes.



Bone points from Devil's Lair, dated 12,000 to 40,000 years BP.
Photo - Douglas Elford/Western Australian Museum

range in age from 22,000 to 8,000 years BP. This record supplements the far longer but much sparser occupational record from Devil's Lair, which provides the earliest evidence of human occupation of the region. One small hearth at Tunnel Cave is dated 1,400 years BP. It is not associated with many artefacts or food remains, and suggests only a fleeting visit.

Nearer to the coast, at Witchcliffe Rock Shelter and Rainbow Cave, archaeologists identified more hearths, and collected quartz artefacts, vertebrate remains (including those of fish), and marine and freshwater mollusc shell. Each site features a charcoal-rich deposit radiocarbon-dated to less than 800 years BP. Such sites show that in recent centuries Aboriginal people were still using the Leeuwin-Naturaliste caves as overnight and meal-time camps.

Top left: Karri forest in the Tunnel Cave doline.
Photo - Joe Dortch

Other regional caves have so far yielded only limited evidence of prehistoric human occupation. Stone artefacts and human skeletal material have been recovered from a cone-shaped deposit at the base of the vertical shaft at Skull Cave. A few human bones have also been collected from the sediment cone below the vertical entrance to Strong's Cave near Devil's Lair. Most tantalising is the possibility that limb bones among the remains of megafauna excavated from Mammoth Cave early last century were cut, broken or burnt by people, though that cave has yielded no other archaeological evidence.



Left: View over an Aboriginal campsite in the Leeuwin-Naturaliste National Park. When the site was occupied, 18,000 to 10,000 years ago, sea levels were significantly lower. The site's occupiers would have overlooked an expanse of land to the west. Photo – Joe Dortch



Below left: Excavation in progress at a Leeuwin-Naturaliste region cave. Photo – Joe Dortch

hearths at Tunnel Cave. One group of hearths in this cave, radiocarbon dated at 16,000–17,000 years BP, did yield four 'points' shaped on macropod fibulae. These resemble some of the dozen bone points from Devil's Lair, dated 12,000 to more than 40,000 years BP.

Megafauna remains are absent from the archaeological sequences at Devil's Lair and Tunnel Cave, though a handful of bones derived from large macropods and other extinct marsupials were recovered from the basal part of the Devil's Lair deposit. This part of the deposit, radiometrically dated from more than 47,000 to approximately 55,000 years BP, is lacking in archaeological remains.

Rock engravings and paintings are almost unknown in the Leeuwin-Naturaliste region, although some have been recorded at a handful of other places in the south-west. Yet, the region is not entirely lacking in rock art. Twenty years ago, two cavers identified a pair of very faint, adult-size hand marks outlined in red ochre near the entrance to one cave. Hand-stencils of this kind are commonly found at art sites elsewhere in Australia and in many other parts of the world.

STONES AND BONES

Several dozen retouched (that is, purposely edge-trimmed) stone artefacts from Pleistocene layers at Devil's Lair were probably used as tools. The presence of these tools indicates that the families or other groups occupying the cave were preparing food, making wooden implements and carrying out other 'hearthside' activities.

Three bone beads, made from polished sections of naturally perforated limb bone, and a perforated marl (lacustrine limestone) object, believed to be a pendant, have also been excavated from these layers. For reasons unknown, almost no formal tools are present among approximately 1,500 mostly very small flakes and other stone artefacts associated with the numerous

Moderate climate, but generally cooler and drier than present.

Climate becomes much colder and drier.

47,000 years ago: oldest known artefacts in south-western Australia (found at Devil's Lair).

41,500 years ago: oldest known hearth at Devil's Lair.

40,000 years ago: Aboriginal occupation known at numerous sites around Australia.

30,000 years ago: intermittent occupation continues at Devil's Lair.



OCCUPATION PATTERNS

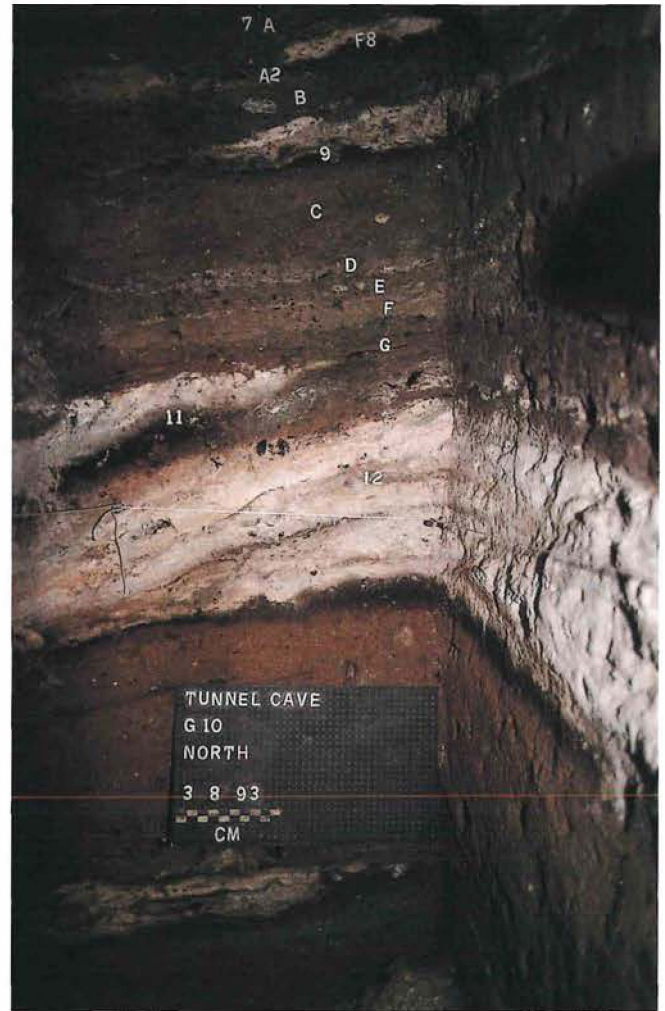
Occupation at Devil's Lair and Tunnel Cave seems to have been very occasional, perhaps taking place only during wet or cold weather. Numerous fragments of emu eggshell present in many layers in the floor deposits at both sites are evidence of repeated occupation in winter or early spring. Occasional human juvenile teeth recovered at both caves imply that the human occupiers were sometimes in family groups.

Despite many thousands of years of intermittent use, cave occupation sites may never have been crucially important within regional hunter-gatherer land-use systems. Over many thousands of years, Aboriginal foragers probably exploited a wide variety of environmental zones both within and outside the Leeuwin-Naturaliste region. During the last glacial period, when expansion of polar ice caps led to lower sea levels, human groups almost certainly occupied the emergent continental shelves to the north, west and south of the region.

Presently available radiocarbon dates show a gap of several thousand years

Above: Uncovering campfires dating to 12,000 years ago. The layers are revealed by carefully scraping the surface with a small trowel.

Right: Close-up view of campfire ash-beds in section. The lowermost thick white layer is dated to the approximate time of the last glacial maximum, 17,000 years ago. Photos – Joe Dortch



between the mainly Late Pleistocene occupational sequence at Tunnel Cave (22,000–8,000 years BP) and the most recent occupational evidence for this site. It is not clear whether the apparent gap in Aboriginal occupation at Tunnel Cave of more than 6,000 radiocarbon years is regionally significant.

Several open-air sites in the Leeuwin-Naturaliste region—including at Calgardup Brook, Dunsborough and Ellen Brook—have yielded radiocarbon dates ranging between 4,000 and 5,000 years BP. These dates show that human

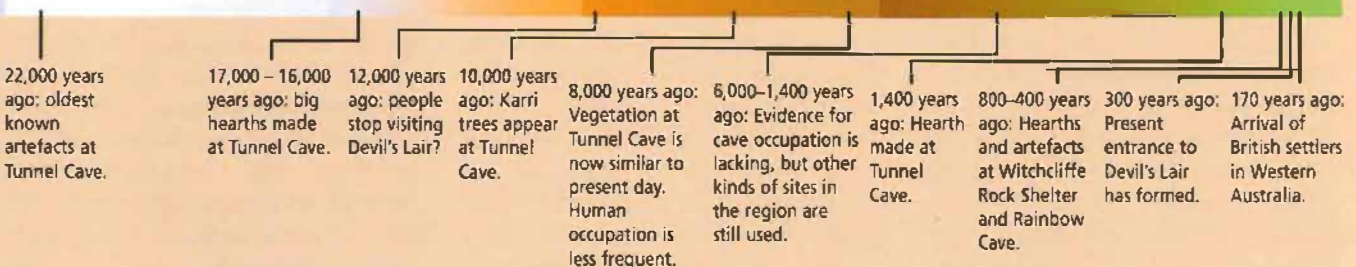
groups were present in the region during the period when evidence for cave occupation is lacking. Yet it should be remembered that the region's archaeological record is still very limited, and that absence of evidence for any aspect of past activities or occupation patterns may not be significant.

The Devil's Lair occupational sequence has no bearing on this question as, sometime after 12,000 years ago, a former entrance became blocked, preventing people from entering the cave chamber. Devil's Lair

Peak of cold dry climate worldwide—the Last Glacial Maximum.

Climate starts warming up—end of the Pleistocene Period.

Relatively warm, wet climate, like that of present day. Start of the Holocene Period.





Left: Many caves in the Leeuwin-Naturaliste National Park are located in deep dolines, or sinkholes. They act as pit-traps, collecting the remains of plants and animals that lived around them. Cave conditions then preserve the remains for millennia.

Photo – Brett Dennis/Lochman
Transparencies

the Devil's Lair archaeological sequence are in an eroded zone, which is overlain by a very thick, apparently uneroded layer. The half-dozen artefacts in the eroded zone are older than those in the uneroded zone and may be re-deposited from an even older part of the deposit. However, this suggested older deposit would not seem much older than the oldest part of the eroded zone, since absolutely no stones or bones resembling artefacts have been identified in the fairly extensive excavations carried out in the underlying layers.

Devil's Lair almost certainly is not the oldest occupation site in the region. How likely is it that the cave deposit chosen for excavation in 1970 would be the region's very oldest site? In short, Devil's Lair is simply the oldest known site yet investigated in this region or anywhere else in WA.

INTERPRETING THE ANCIENT PAST

Historic accounts, mainly dating to the early decades of the 19th century, attest to the wide variety of plant and animal foods eaten by Nyoongar hunter-gatherers at the time of European colonisation (see 'Hunters and Gatherers', *LANDSCOPE*, Spring 1992). These accounts provide an intriguing picture of Aboriginal life in the western and southern fringes of the jarrah forest and in the woodlands of the coastal plains. In contrast, there are few historical accounts of Aboriginal activities in the karri or jarrah forests further inland. Thus, the only way to assess past Aboriginal use of these forests is to investigate non-literary records. This is best done through excavating archaeological sites where people lived and carried out their daily activities. The information thus obtained has the potential to reach back tens of thousands of years (see timeline on pages 44 and 45).

may have remained entirely sealed until a few centuries ago, when roof collapse created the present doline, again opening up the existing chamber. Nor do the occupational histories recorded at Rainbow Cave and Witchcliffe Rock Shelter throw any light on this problem, since both sites were in use only during the past millennium.

Aboriginal artefacts flaked from European bottle glass, have been found at Ellen Brook and elsewhere in the region. A number of British and French accounts, mainly dating to the early 19th century, and one 17th century Dutch account describe encounters with Aboriginal people in the Leeuwin-

Naturaliste region. These accounts are complemented by an oral tradition of the sightings of 19th century or earlier European sailing ships recounted by Aboriginal elders still living in the region.

● OCCUPATION AT 50,000 YEARS AGO?

On the basis of the radiometric chronology from Devil's Lair, we think that people were in the Leeuwin-Naturaliste region as early as 50,000 years ago. Radiometric years in the age range 40,000–50,000 years BP are 1,000–2,000 years 'younger' than their equivalent in astronomical years.

The lowermost stone artefacts in



Above left: Excavating a campsite floor in Devil's Lair.
Photo – Alex Baynes/Western Australian Museum

Above: Some of the bones recovered from a single layer at Devil's Lair. As many bones as possible are identified to species level, so that researchers can infer past environmental conditions.
Photo – Jenny Porter/Western Australian Museum

Left: A bone point, made on macropod fibula, recovered from the sieve during the Tunnel Cave excavation.
Photo – Joe Dortch

Three decades of archaeological investigation has shown that cave occupation sites were components in hunter-gatherer land use systems in the Leeuwin-Naturaliste region from Late Pleistocene times until recent centuries. One of the benefits of this development is that, since the early 1980s, Nyoongar communities in the south-west have come to regard sites like Devil's Lair and Tunnel Cave as highly significant components of their cultural heritage. A number of young people from these communities have participated in the excavations at Devil's Lair, Tunnel Cave, Witchcliffe Rock Shelter and other sites in the lower south-west.

The Devil's Lair and Tunnel Cave investigations are good examples of

inter-disciplinary investigations aimed at reconstructing the prehistoric past, based mainly on the findings of archaeologists, palaeontologists, geologists and radiometric dating specialists. Excavations and other

investigations in limestone cave and rock shelter sites, such as the ones in the Leeuwin-Naturaliste region, should continue to make a significant contribution to the nation's cultural and natural heritage.

Joe Dortch, an archaeologist, carried out some of the work described here while a doctoral student at the Centre for Archaeology, The University of Western Australia, Nedlands.

Charles Dortch is Curator, Archaeology in the Anthropology Department, Western Australian Museum, Francis Street, Perth.

The authors are grateful for the support and assistance of Nyoongar communities in Busselton and other south-west towns. They also thank the Australian Institute of Aboriginal and Torres Strait Islander Studies, the Western Australian Museum, The University of Western Australia, and the South-Western Development Commission, who financed field work and radiocarbon analyses. They acknowledge the help and support of Department of Conservation and Land Management rangers and park managers who facilitated many of the archaeological surveys and excavations in the Leeuwin-Naturaliste region caves.



ENDANGERED!



Subterranean animals of North West Cape

Cape Range and nearby limestones contain numerous caves and other subterranean features, which harbour a wide range of specialised animals. These animals are both troglobitic (terrestrial cave-dwelling) and stygobitic (groundwater dwelling).

In all, 14 species of subterranean animals from North West Cape have been declared as threatened under the Wildlife Conservation Act. They include two species of fish—the blind gudgeon (*Milyeringa veritas*) and blind cave eel (*Ophisternon candidum*), three species of millipede, five species of schizomids (bizarre spider-like animals), one species of pseudoscorpion and three species of crustacean. Three additional species are on the Department of Conservation and Land Management Fauna Priority List—the Cape Range blind cockroach (*Nocticola fiabella*), a blind shrimp and a schizomid.

Two ecological communities from

North West Cape have been informally listed as threatened and ranked as critically endangered—the Camerons Cave Troglobitic Community and the Cape Range Remipede Community (Bundera Sinkhole). Several of the threatened animals occur only in one of these two communities.

Possibly the most interesting species is the Cape Range remipede (*Lasionectes exleyi*). The crustacean Subclass Remipedia contains very few species, and the Cape Range remipede is the only one known from the southern hemisphere. It is a primitive crustacean and inhabits a particular layer in a thermo-halocline in Bundera Sinkhole on the western coastal plain of the peninsula.

The Department of Conservation and Land Management has recently

completed interim recovery plans for the conservation of the ecological communities and the species that form them. They were prepared with the support of a grant from the Natural Heritage Trust and overseen by the North West Cape Karst Management Advisory Committee. The committee has members from the Shire of Exmouth, the Department of Defence, the Western Australian Speleological Group (Exmouth), the Western Australian Museum, the Water and Rivers Commission and the Department. The recovery plans will guide the conservation of these unique animals and the communities they form.

Posters have been produced to help people understand more about the communities and what is needed to conserve them.

The posters can be downloaded from the NatureBase website at http://www.naturebase.net/plants_animals/critical_communities.html.

by Andrew Burbidge

Photo Douglas Elford

SAVING threatened COMMUNITIES

by Sheila Hamilton-Brown and Sally Black



All over the State, recovery teams, community groups, landowners and wildlife enthusiasts are helping to save Western Australia's threatened ecological communities.



Species, genes, ecosystem—different layers in the hierarchy of biological diversity—all require conservation effort.

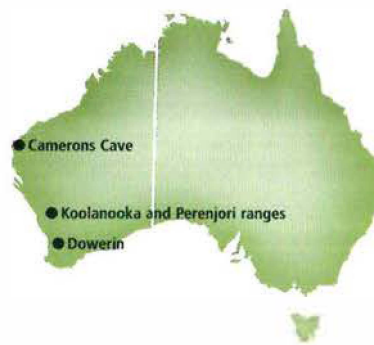
Until recently, most effort aimed at conserving threatened elements of biodiversity focused on saving individual species. Individual species exist within communities; if the community is disturbed or altered, the species within it may be threatened. So, by conserving ecological communities, or groups of species that inhabit a particular area, we can eliminate some of the difficulties inherent in preserving numerous individual species.

The Department of Conservation and Land Management's WA Threatened Species and Communities Unit (WATSCU) has been identifying, coordinating and promoting the conservation of threatened ecological communities since 1992. After a successful project to identify and conserve threatened ecological communities in the South West Botanical Province (see *LANDSCOPE*, Spring 1996), two more projects were funded jointly by the Natural Heritage Trust and the department. These projects concentrated on identifying and conserving threatened ecological communities in the Wheatbelt and the area outside south-west WA (the rangelands).

UNDER THREAT

In general, threatened ecological communities fall into two categories of scale.

The first is where species assemblages were once widespread or locally



common, but have declined greatly in distribution and area occupied. This broad-scale decline in extent is largely brought about through clearing for agriculture and other development. These communities may also be threatened by degrading processes such as salinity and grazing. An example of this is the summer scented wattle (*Acacia rostelifera*) forest with scattered river red gum (*Eucalyptus camaldulensis*) on the Greenough River alluvial flats, south of Geraldton, that once covered 133,000 hectares. Because this community occurred on very fertile soils, most of it has been cleared, and only three tiny, weed-infested examples totalling 2.2 hectares remain. The integrity of these tiny communities is threatened by increasing weed invasion, grazing and frequent fire.

Secondly, some threatened ecological communities occur within ecosystems that are naturally restricted; although small in area, they may be rich in species not found elsewhere. As a consequence of their small extent, such communities may be highly vulnerable to disturbance. For

example, two fauna communities on Cape Range Peninsula comprise subterranean invertebrates such as small crustaceans and arachnids, and each is confined to a single known site; one in a cave and the other a water-filled sinkhole. Threatened plant communities scattered across the Kimberley region include several types of monsoon forest on spring-fed soaks, scree slopes, and coastal sand dunes, as well as forests and sedgelands associated with organic mound springs (peaty soaks). Most occurrences are in the process of degradation due to grazing and trampling by domestic cattle or feral animals, frequent hot fires, and competition from weeds and exotic animals.

The approaches used to identify threatened ecological communities are similar to those used to identify threatened species: information is gleaned from literature, wildlife enthusiasts, landcare groups, scientists, government and non-government organisations, and field research. The Department of Conservation and Land Management has established a Threatened Ecological Communities Scientific Advisory Committee. The committee assesses all the information gathered on a proposed community (evidence that it is a distinct community, thoroughness of survey and threatening processes) and assigns it a conservation category (see box on page 53). If it is identified and endorsed as threatened (either critically endangered, endangered



Previous page

Background: Summer scented wattle populations, south of Geraldton, have been reduced to tiny communities through clearing.

Photo – Jiri Lochman

Insets clockwise from top left: A troglobitic harvestman (*Glennhuntia glennhunti*) that occurs only in Camerons Cave as part of the Camerons Cave troglobitic community.

A blind gudgeon fish (*Milyeringa veritas*) from Camerons Cave troglobitic community. Photos – Douglas Elford/WA Museum

An isolated patch of monsoon forest on a mound spring complex in the Kimberley region.

Photo – Sally Black

Left: Members of the local catchment and Merredin Threatened Flora Recovery Team monitoring tree health. Photo – Sheila Hamilton-Brown

or vulnerable), the conservation program begins. This includes writing recovery plans and finding resources for research and on-ground works. On-ground work is coordinated by recovery teams, and mostly carried out by catchment groups, wildlife enthusiasts, school groups and the owners of land on which threatened communities occur, as well as by departmental staff.

Recovery teams advise, develop and oversee the implementation of recovery plans for threatened ecological communities. Recovery team members include district staff from the Department of Conservation and Land Management, WATSCU staff, representatives from State government agencies such as Main Roads WA or Westrail, local government representatives, Catchment or Land Care District Committee (I.CDC) representatives including landowners, and members of non-government conservation groups. While most vegetation-based threatened ecological communities are dealt with by the Department of Conservation and Land Management's District Threatened Flora Recovery Teams, other threatened ecological communities may have a separate recovery team.

WHEATBELT WETLANDS

Wooded wetlands with extensive stands of swamp sheoak (*Casuarina obesa*) and swamp paperbark (*Melaleuca strobophylla*) were once widespread throughout the Wheatbelt. However, these communities are now very rare, owing to increasing salinity and higher groundwater levels. Toolibin Lake—a critically endangered threatened ecological community—(see *LANDSCOPE*, Spring 1994) was long thought to be the only example of this community left. The actions taken, under a recovery plan intended to restore this wetland community and its catchment, have received much publicity. Partly as a consequence of this publicity, another occurrence was found near Dowerin, 200 kilometres to the north.

This small, 20-hectare wetland is the only wetland in its catchment to remain predominantly fresh. It fills only after the main creek overflows following heavy rainfall. The landholders fenced the wetland to prevent grazing and erected a diversion bank to prevent



salty water from entering it. This bank was only breached during significant floods. Presumably, under natural conditions, the wetland would have filled more regularly: both the landholders and WATSCU staff were concerned about the health of the lake bed vegetation and/or adequate regeneration.

WATSCU staff discussed ideas with the landholders and, with money provided by the National Heritage Trust, contracted an independent hydrologist to design an adjustable barrier controlling inflow to the lake. The barrier will keep out highly saline water (usually early in the flow cycle) and can then be opened to allow fresher water to inundate the wetland. The landholders liked the idea so much that they funded and erected the diversion

Top: Paperbarks (*Melaleuca cajuputi*) over mangrove ferns (*Acrostichum speciosum*) occur in the centre of a mound spring on the edge of the Great Sandy Desert.

Above: This mound spring community occurs within an ecosystem that is naturally restricted.
Photos – Sally Black

barrier themselves! WATSCU also obtained funds from BankWest's *LANDSCOPE* Conservation Visa Card Trust fund to monitor surface water and groundwater.

To interpret the effects of surface water and groundwater on the wetland vegetation, members of the local catchment group and the Merredin Threatened Flora Recovery Team are monitoring the wetland vegetation,



measuring tree size, diameter and canopy condition, and establishing a number of understorey monitoring plots. Meanwhile, the catchment group has just completed an intensive catchment revegetation program that began in 1992 and included revegetating the creekline. This program is intended to overcome long-term salinity problems in the catchment and will, hopefully, help the threatened wetland near Dowerin by reducing the amount of salt being carried in creek flows.

Some beneficial results are already evident in the catchment in that the spread of salt patches has been halted.

BANDED IRONSTONE HILLS

The 5,500-hectare Koolanooka and Perenjori banded ironstone hill ranges are part of the 'vulnerable' Koolanooka System, originally described by plant ecologist John Beard. The hills have specific plant associations peculiar to the soil type and profile of the hills. A subspecies of sandplain mallee

(*Eucalyptus ebbanoensis* subsp. *ebbanensis*) over mixed *Acacia* scrub occurs on the summits and upper slopes of the hills. Tamma (*Allocasuarina campestris*) and rock sheoak (*Allocasuarina huegeliana*) scrub grows on the middle and lower slopes, and York gum (*Eucalyptus loxophleba*) woodlands are seen on the footslopes.

Little detailed survey work has occurred on these mainly privately-owned hills, although the landholders were very supportive of attempts to determine the suites of plants found within them. One of us (Sheila) planned to establish 10 quadrats in two days; but because of the rocky and rough terrain, only succeeded in establishing two. Fortunately, the Central West College Land Management class had recently located a new population of Hoffman's spider orchid (*Caladenia hoffmanii* subsp. *hoffmanii*) and, buoyed by their success, were keen to assist, so they helped to establish nine more quadrats on the hills. Surveys of these quadrats are helping to better define the plant associations, and the data collected will aid rehabilitation and restoration work. As a result of this work, another association was found—a gimlet (*Eucalyptus salubris*) woodland associated with gullies.

TROGLOBITES

A threatened community of troglobites—blind, sometimes white, translucent or colourless, cave-dwelling creatures—inhabits Camerons Cave near Exmouth on the eastern coastal plain of Cape Range Peninsula. This unique community, described by scientists from



Top left: Swamp sheoak and swamp paperbark wetland in Dowerin. Photo – Rebecca Evans

Above far left: Dowerin Wetland diversion banner.

Above left: Central West College Land Management class erecting quadrats on Koolanooka Hills. Photos – Sheila Hamilton-Brown

Left: Swamp Sheoak and swamp paperbark wetland—Toolibin Lake. Photo – John Blyth



the WA Museum, is made up of at least 10 small aquatic and terrestrial invertebrates that are not known to occur together anywhere else. Four of these—blind gudgeon (*Milyeringa veritas*); Camerons Cave pseudoscorpion (*Hyella* sp.); Camerons Cave millipede (*Stygiochiropus peculiaris*); and Barrow Island draculoidea (*Draculoidea bramstokeri*), an ancient spider-like creature with large ‘teeth’—are themselves listed as threatened species because of their highly restricted distribution (see ‘Endangered’ on page 48). Some of the animals in the cave probably had ancestors that lived five million years ago, when rainforest occurred in the area.

Camerons Cave extends down to the water table, which here consists of a narrow freshwater layer above salt water. The fresh water maintains high levels of humidity in the cave, on which the animals depend. Threats to the community include uncontrolled access to the cave, modification to or pollution of the area’s groundwater or surface flows, and pollution or rubbish dumping in the cave. Last year, a local member of the WA Speleological Group, in cooperation with the Department of Conservation and Land Management and funded by a BankWest LANDSCOPE Conservation Visa Card grant, installed a new lockable and inconspicuous gate on the cave to protect the community inside. A new reserve to protect the cave and its surrounds has now been agreed to by the Shire of Exmouth.

FUTURE HOPE

These stories are encouraging. Successful programs have engendered further discoveries. Different kinds of support from many sectors of the community have meant that this important work continues.

And it’s exciting! Biological diversity can be maintained. Numerous community members from all over WA have proven this. Their enthusiasm, energy and dedication in generously



Above left: Camerons Cave pseudoscorpion (*Hyella* sp.).

Above: A troglitic micro-whipscorpion (*Draculoidea* sp.).

Right: A troglitic leaf hopper (*Phaconeura* sp.) from Camerons Cave community.

Photos – Douglas Elford/WA Museum



CONSERVATION CATEGORIES FOR THREATENED ECOLOGICAL COMMUNITIES

| | |
|-----------------------|---|
| Critically endangered | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. |
| Endangered | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. |
| Vulnerable | An ecological community that has been adequately surveyed and found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. |
| Presumed destroyed | An ecological community which has been adequately searched for but for which no representative occurrences have been located. The community has been totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. |

supporting efforts to conserve threatened ecological communities in various parts of the State means there is hope for the future of our environment.

If you think you know of a piece of remnant vegetation and/or bushland that may be unique to your area, please contact the authors.

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URBAN ANTICS

SNAKE TREK

Spring . . . the recurring frontier. This is a story of urban enterprise. A mission, when creatures with an urge to explore strange new worlds, to seek out new life and new parameters boldly go where people have already gone before.

It is the time of year when all living things in the suburbs of the State's south-west are now doing what they've been dreaming about all winter—breeding, eating, sunning, growing and generally seeking to expand territorial boundaries. The march of the bobtail skinks now commences, along with the movements of many other lizards accompanied, of course, by the usual 'warning' about snakes.

Snakes and lizards are closely related. Together they comprise the Squamata, by far the largest of living orders of reptiles on the planet. It seems a shame, however, that in contrast to lizards, snakes are often feared and abhorred when most of the 2,800 species are inoffensive.

It is important for us to realise that our local pythons are harmless and, because of habitat destruction and 'bad press', may have dwindled from their virtual obscurity, into abject rarity.

The urban areas of our south-western coastal towns and cities lie within the natural distribution of only one constrictor, the carpet python (*Morelia spilota imbricata*). Here, where there is suitable shelter and food such as birds and small mammals, they silently wait in complete camouflage to carry on their cryptic habits.

One lucky Albany person, however, has been rewarded with some of the best urban antics through his willingness to share his backyard with a group of local carpet pythons.

It started some 12 years ago when a swarm of bees commandeered his woodshed. To deter the invaders, he lightly smoked the interior with a small grate fire and stayed to watch them exit. While the swarm headed en masse for the window, the neat piles of chopped wood started to dislodge and, in the gloom, large tongue-flicking heads suddenly arose. In an action reminiscent of the movie 'Indiana Jones', he was out of there, followed by several irritated serpents that headed straight through the wire fence and hissed off into the bush. Thankfully, after a few days of fresh air, they returned to their lodgings, each bringing a mate with them, and have since set up the 'Python Hotel'.

On the same property, a large python, which must have been living in the house roof, developed a tasssstey habit. 'Monty', as shown in the picture in 'Bush Telegraph' (page 5) was sssneaking from his quarters to catch wild rosellas that rested on the gutter. After parrot number four was conssssumed, the python was caught and placed in the woodshed with his cousins. Before long he was back and, after parrot number five succumbed, he was taken about two kilometres away and

released in the bush. Five weeks later, 'Monty' was back, ssssnacking on number six.

Although the snake now resides in a nearby national park, the woodshed is still sanctuary to nine other pythons. Snogging and resting in the sun under translucent roof panels between trips into the bush is an ongoing ritual. And the parrots are back.

At this time of the year, adult male pythons go wandering in search of curvaceous mates. Please watch out for them on the roads, as they are worthy neighbours, yet a diminishing heritage.

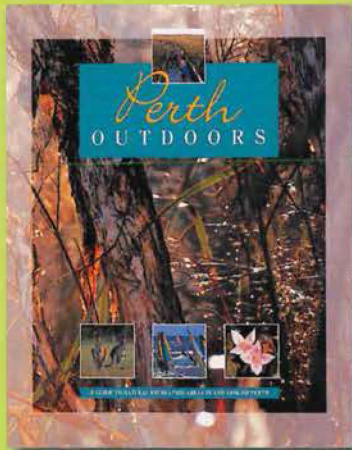
BY JOHN HUNTER

DID YOU KNOW?

- *Pythons belong to an ancient group that evolved from lizards between 100 and 65 million years ago. They still carry the remnants of their ancestors' hind legs in two tiny pelvic spurs.*
- *WA has nine species of pythons; two species and two subspecies are endemic to the State.*
- *For more information, check out the article 'Pythons—masters of the waiting game' in LANDSCOPE, Summer 1994–95, and 'Bush Telegraph' in this issue.*

Discovering Perth's outdoors

Perth and surrounding areas have a range of outdoor recreation sites that are perfect for visitors and locals alike. Here are publications packed with ideas for a great day out.



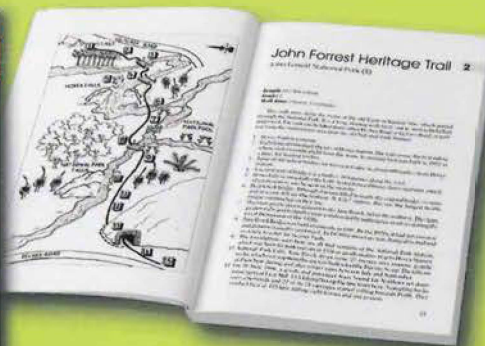
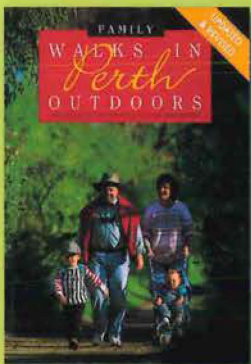
PERTH OUTDOORS \$21.95

Perth Outdoors contains information on almost 300 nature-based recreation spots. Each is described in detail, with information about what to do there, facilities, travelling time, and the best time to visit. Full colour photographs, features and maps make it an essential guide for planning weekend or holiday outings.



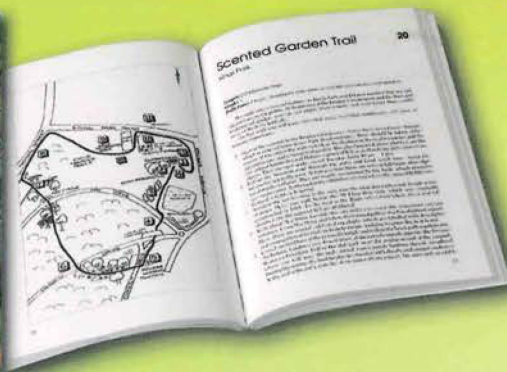
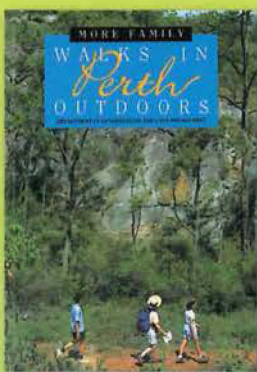
POCKET SIZE GUIDES \$6.50 each

Each pocket guide is 64 pages, full colour and packed with information and spectacular photographs.



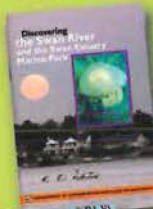
FAMILY WALKS IN PERTH OUTDOORS \$16.45

Few capital cities have such a variety of natural areas right on their doorstep. This book sets out 50 walks to explore Perth's forests, woodlands, wetlands and coastal environments, ranging from a few hundred metres to 20 kilometres. Each walk is described stage-by-stage and illustrated with a mud map to keep you on track.



MORE FAMILY WALKS IN PERTH OUTDOORS \$16.45

More Family Walks follows in the footsteps of the bestselling Family Walks. It contains maps and descriptions of another 52 walks, as well as features on some of the plants and animals you might see while out walking, and a list of common birds of the Perth area.



Discovering the Swan River



Discovering Yanchep National Park



Discovering Penguin Island



Birds in the backyard



Bugs in the backyard

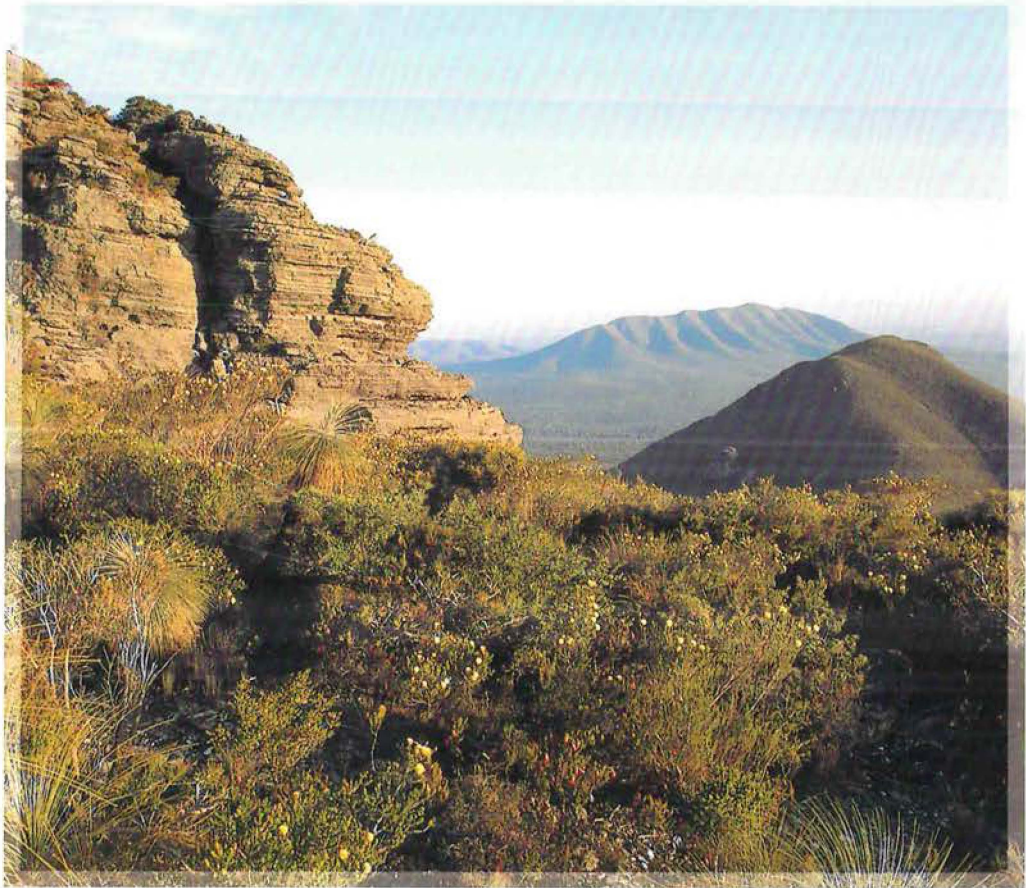


Beachcombers guide

Available from good bookshops, newsagents and Department of Conservation and Land Management offices, or by mail order from the Department at the address below (postal charges apply).

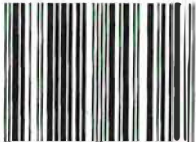
Locked Bag 29, Bentley Delivery Centre, Western Australia 6983

Tel: (08) 9334 0333, Fax: (08) 9334 0498 TTY (hearing impaired) facility available (08) 9334 0546



Stirling Range National Park.
Numbats have been returned to this ancient landscape.
Photo – Marie Lochman

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