$6.95

WINTER 2002

LANDSCOPE

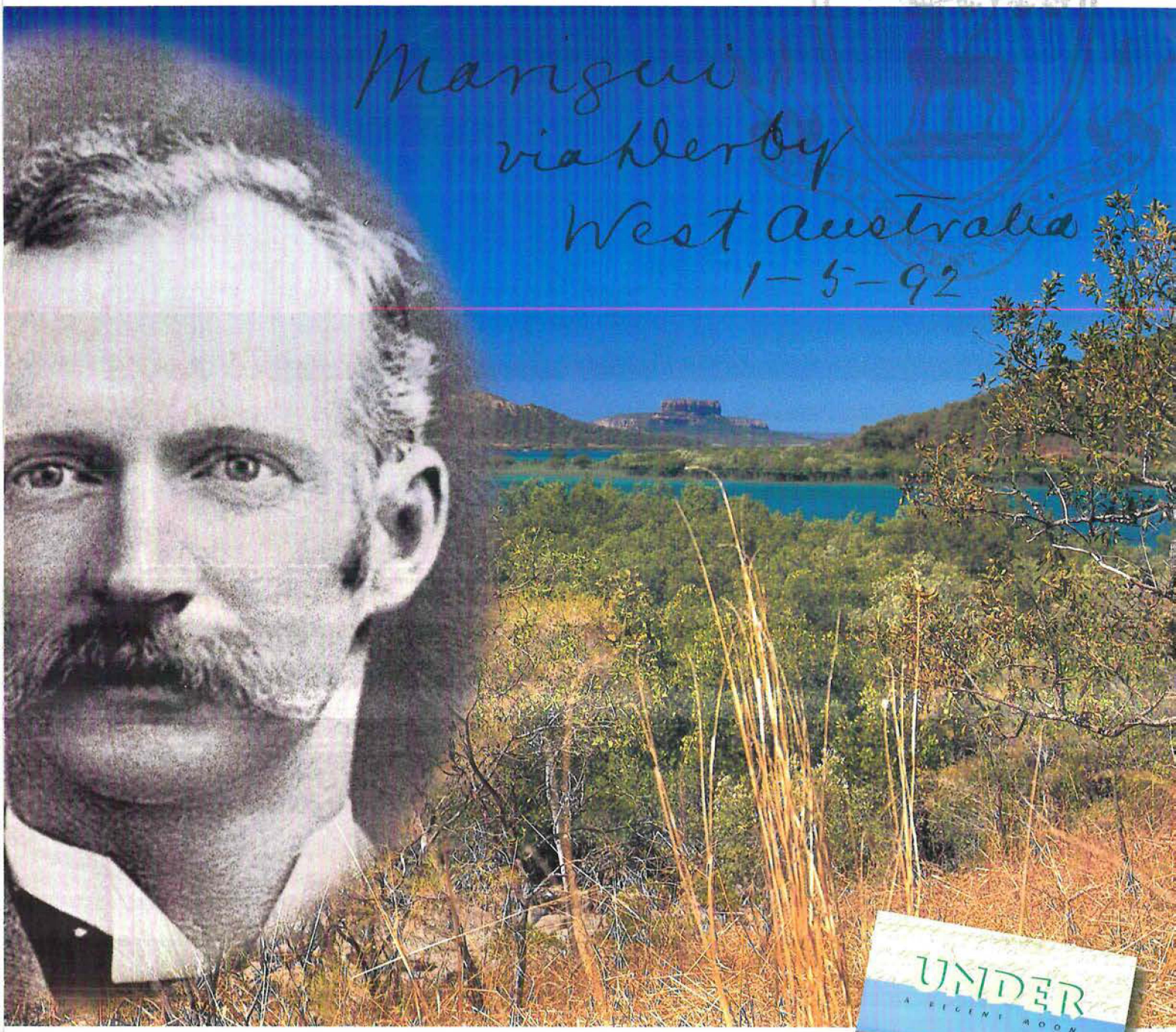
WA'S CONSERVATION, PARKS AND WILDLIFE MAGAZINE

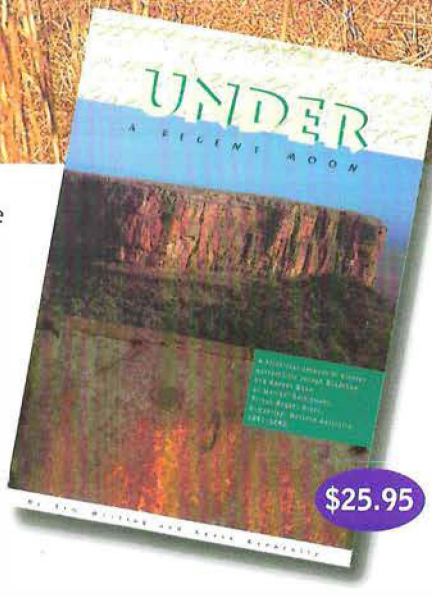
Forest hollows
wildlife homes

The guided experience
a new journey

Under a
regent moon

There's a new moon this season . . .





Under a Regent Moon provides a historical account of the Marigui Homestead on the remote Prince Regent River. Written by Kimberley researchers Tim Willing and Kevin Kenneally, the book is based on articles and diary entries written between 1891 and 1892 by pioneer pastoralist Aeneas Gunn.

Gunn and his cousin Joseph Bradshaw founded the Marigui Homestead in 1891. Gunn was later immortalised as 'The Maluka' in his wife Jeannie Gunn's Australian classic *We of the Never-Never.*

The endeavours of Gunn and Bradshaw have been beautifully captured in this 76-page book which includes colour and black and white photographs, maps and diary excerpts.

This book will appeal to a wide audience and is available for RRP $25.95 from good bookshops, newsagents and from the Department of Conservation and Land Management.

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GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT

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

LANDSCOPE

VOLUME SEVENTEEN, NUMBER 4, WINTER 2002

An exciting range of recreational opportunities are being offered in some national parks, creating employment for locals. See page 28.

Native animals need tree hollows and people need wood. How are these conflicting uses managed? See page 20.

The search to find out the cause of a new tree killer known as Mundulla Yellows. See page 41.

Declining water levels threaten a remarkable community of cave-dwellers in Yanchep National Park. Turn to page 34.

Re-discovering the long-forgotten memoirs of a Kimberely pioneer. See page 48.

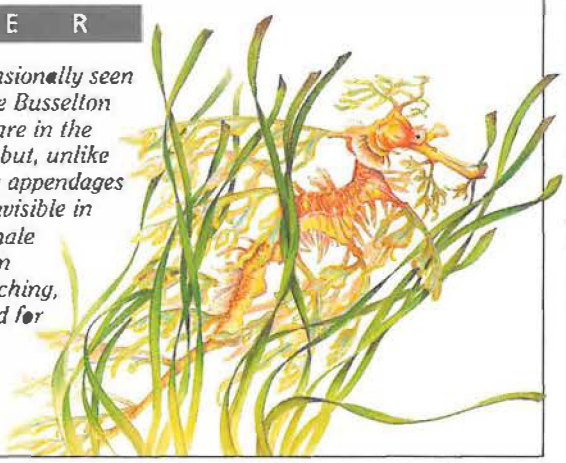
FEATURES

REGULARS

COVER

Leafy seadragons are occasionally seen in the seagrass around the Busselton Jetty (see page 10). They are in the same family as seahorses but, unlike seahorses, they have leafy appendages that make them almost invisible in their surroundings. The male carries the eggs in the skin beneath his tail. After hatching, the young swim off to fend for themselves.

Cover illustration by Philippa Nikulinksy



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Subscription enquiries: ☎ (08) 9334 0481 or (08) 9334 0437.
Colour separation by Colourbox Digital.
Printed in Western Australia by Lamb Print.

Please do not send unsolicited material to *LANDSCOPE*, but feel free to telephone the editors.

Visit NatureBase at www.naturebase.net

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

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

NATURE'S INTERPRETERS

"Human kind cannot bear very much reality," wrote T.S. Eliot. I think what he meant was that when myths and mysteries have filled our minds for so long, they become an investment that is most easily protected by buying more of the same.

For many people, living in big cities on our coastal fringe, nature has been, for so long, an impenetrable mystery and the doses of reality have been small and infrequent. The question this raises for a conservation agency is that if the wider community does not understand and appreciate the natural environment, how can it be an active participant in protecting and using it wisely?

Interpretation of the environment, history and culture of an area is one significant way to enrich peoples' experiences, appreciation and support for management. In debunking the myths with a participatory role for everyone, and in an atmosphere of guided discovery, interpretive programs in our parks educate visitors about park values and natural ecosystem processes, and are an integral part of the park experience.

The Department of Conservation and Land Management has 29 locations throughout Western Australia where guided activities are offered by staff and others. In this issue of LANDSCOPE, *Senior Interpretation Officer Gil Field reports on how the guided experience is at the core of nature-based tourism in the State. In "The Guided Experience: A New Journey", Gil documents the importance of the craft of designing and providing enriching experiences for others in this State, and offers a vision for its continued growth.*

In "Beneath the Busselton Jetty", regular LANDSCOPE *contributor and underwater photographer Ann Storrie explores the wonders of the underwater landscape and the remarkable inhabitants beneath the longest timber jetty in the southern hemisphere. For the non-diver or non-snorkeller, her photography and her word pictures are the next best thing to being there. She writes: "Imagine wandering through a forest, where thousands of flowering plants grow on every tree, and large flocks of birds fly in and around the branches ...." I can.*

Tree hollows in our forests provide animals with a secure and comfortable place to nest and rear their young. There are 42 species of birds, mammals and reptiles that use hollows in standing trees in Western Australian forests. Seven mostly use hollows on the ground. Adaptive management of our forests is contributing to a promising outlook for these hollow-dependent species and, in "Forest Hollows: Wildlife Homes", Kim Whitford examines the expanding base of scientific knowledge that is underpinning this management.

From high in our forests, we take you beneath the Earth's surface, to the caves of Yanchep National Park. Within these caves is a system of shallow streams that are home to an amazing community of night fish, gilgies, leeches, beetles, mites, microscopic worms, snails and crustaceans. In "Threatened Wildlife of the Yanchep Caves", John Blyth, Edyta Jasinska, Lyndon Mutter, Val English and Paul Tholen write about the threat that declining water levels is posing for this critically endangered community, and the actions being taken to save it.

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

Ron Kawalilak

Ron Kawalilak
Executive Editor

TOOLIBIN LAKE WINS NATIONAL SALINITY PRIZE

An integrated engineering approach to conserving an important wetland area in the Western Australian Wheatbelt has been recognised with a National Salinity Prize for innovation in engineering.

The Toolibin Lake Recovery Team and Technical Advisory Group received the $30,000 prize, sponsored by the Institution of Engineers Australia, for innovative development of new technologies and practical solutions that address the problem of salinity in rural and urban Australia.

(Left to right) Richard George (Department of Agriculture), Audrey Bird (farmer) and Ken Wallace (Department of Conservation and Land Management) with the National Salinity Prize.

Photo – Adam McLean/Canberra Times

The Toolibin Lake Catchment covers an area of 48,000 hectares in the headwaters of the Blackwood River in the Wheatbelt. Forty-two waterbird species have been recorded at Toolibin Lake, making it one of the most important wetland systems in the area.

The system is one of six natural diversity recovery catchments in WA under the State Government's Salinity Strategy.

In 1995, a structure to divert low volume, high saline surface runoff water from Toolibin Lake into a nearby saline lake was constructed. Since then, around 4000 tonnes of salt have been diverted from the lake. Since 1997, twelve groundwater pumps have been installed at the lake that remove around 750,000 litres of saline groundwater every day.

Thousands of deep-rooting oil mallees and biodiversity seedlings have also been planted across the catchment, to help consume excess water. In addition to combating salinity, the oil mallees provide a potential economic return to local farmers.

The Toolibin Lake recovery project is managed by the Department of Conservation and Land Management and is dependent on the support of local Landowners and government agencies. The Toolibin Lake Catchment Group, Edith Cowan University, Department of Conservation and Land Management, Department of Agriculture and Water and Rivers Commission are represented on one or both recovery groups.

While there is no one definitive solution to Australia's salinity problem, innovative developments such as those found in this project help restore nature's balance and overcome the effects of salinity.

The $30,000 prize will be reinvested into the Toolibin Lake Salinity System and will provide the Recovery Team with the opportunity to develop new facilities and programs in the area.

SURVEY WILL HELP DUGONG CONSERVATION

The first comprehensive survey of dugong abundance and distribution to be carried out during the summer months on the Western Australian coast was recently undertaken in the Shark Bay World Heritage Area. All earlier surveys had been done in winter.

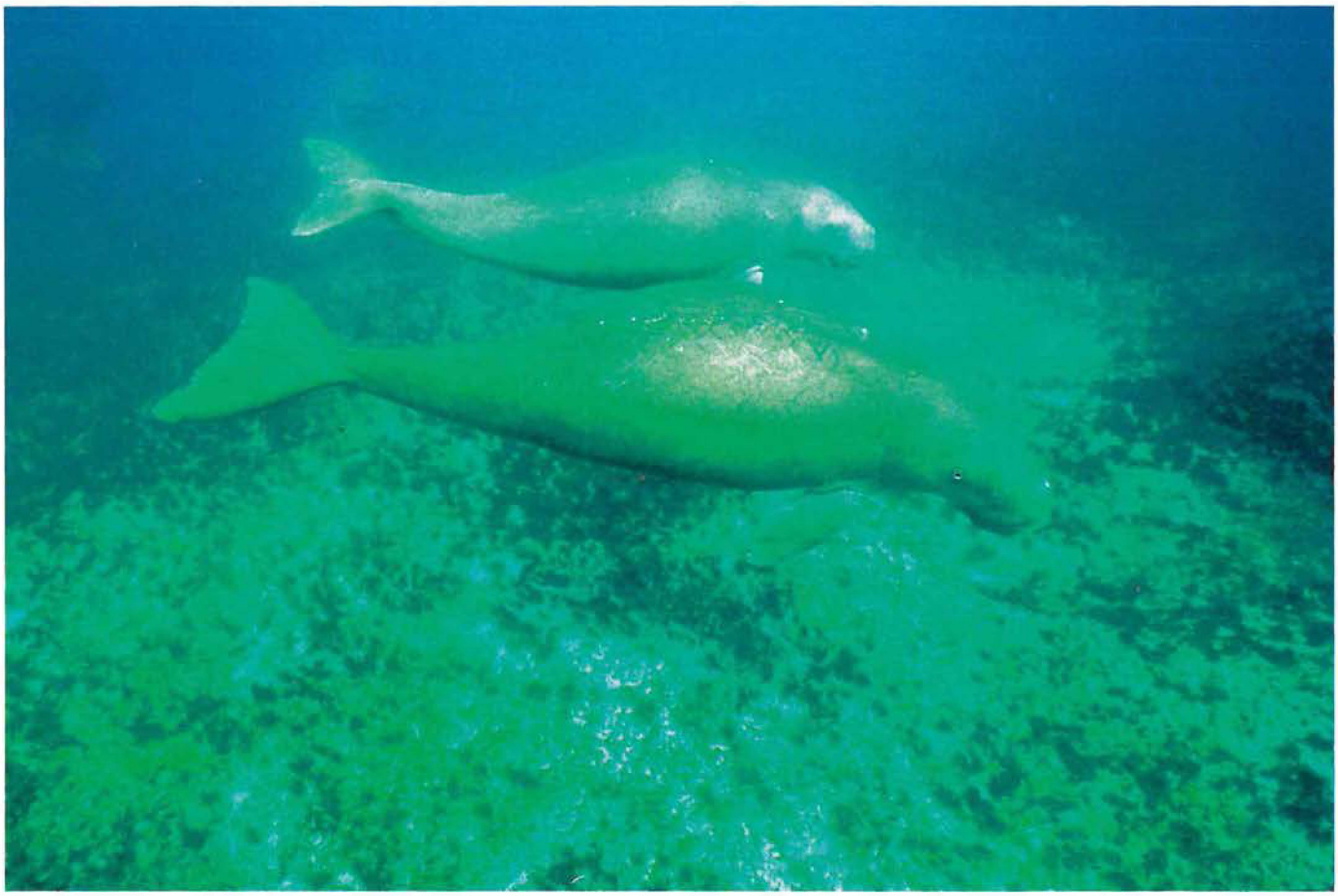
The aerial survey aimed to provide important information on dugong distribution patterns and habitats. Dugong distribution was known to be affected by water temperature and the availability of food (seagrass). However, the complete range of factors affecting seasonal movements of dugongs were not well understood. This survey should enable scientists to gain a clearer insight into the movements of the animals and the relationships between their movements and their habitats.

Team members carried out the survey in a twin-engined aircraft, from which they recorded the number of adult and juvenile dugongs, and the weather and sea conditions under which they were found.

Australian regional populations of dugongs, including those in the Shark Bay World Heritage Area, form the largest and most secure populations of the species in the world. The survey recorded an estimated 12,000 dugongs in the Bay, representing more than 10 per cent of the Australian population. This is the highest density per square kilometre known anywhere in the world where such surveys have been conducted.

The Western Australian Department of Conservation and Land Management is now better able to plan the future conservation of the species, balancing the needs of the dugongs against other demands on the area, such as aquaculture, nature-based tourism, fishing and any other activities that could disturb dugongs or their habitats. The survey was a collaboration between the department and James Cook University in Townsville, Queensland, and was partially financed by the Commonwealth World Heritage Fund.

Dugongs are found in tropical and subtropical waters through coastal parts of the Indian and western Pacific oceans, where, in some areas, they have become perilously closer to extinction.



A mother dugong and her calf at Shark Bay.

Photo – Doug Perrine/Innerspace Visions

NEW PARK FACILITIES AND UPGRADES

During the first six months of the 2002 International Year of Ecotourism, more than $2 million is being spent on developing and upgrading facilities in new and existing national parks in the south-west. These capital works, when completed, will enhance local visitors' and tourists' experiences of the unique environments found in national parks and forests. They are also expected to provide long-term benefits for a sustainable nature-based tourism industry, and employment opportunities for local communities.

The $2,050,000 is the 2001–2002 component of the four-year provision of $25.686 million allocated to the Department of Conservation and Land Management by the State Government as part of its commitment to establish 30 new parks in the south-west of WA, in line with its Protecting Our Old-growth Forests policy.

Some areas that are being upgraded or developed are around Manjimup, Pemberton, Northcliffe, Walpole, and in Wellington National Park near Collie.

In the proposed Greater Beedelup National Park, a day-use area and interpretation facilities are being developed in the former Giblett forest block, and the Cleave Road campground is being upgraded.

A walktrail is being developed in the proposed Greater Hawke National Park, while in the proposed Tone-Perup National Park environmental education and interpretation facilities at the Perup Forest Ecology Centre will be further developed. An observation deck, interpretation facilities and a day-use area are being constructed in the proposed Lake Muir National Park.

At D'Entrecasteaux National Park, a walk trail, lookout and associated visitor facilities will be established, Salmon Beach Road is to be upgraded, and a walktrail, lookout and associated visitor facilities at Mt Chudalup will be completed.

In Warren National Park, new visitor facilities will be completed as part of the Karri Forest Explorer Drive, which links to new and existing national parks. In the proposed Boorara-Gardner National Park, an upgrade to visitor and interpretation facilities at the Lane Poole Falls and the Boorara Tree will be completed.

In the Walpole-Nornalup National Park, visitor facilities at Coalmine Beach, the Knolls and other sites, visitors' picnic facilities at the Valley of the Giants, the Valley of the Giants Road and Knoll Drive are all being upgraded.

Within the Walpole Wilderness Area, day-use facilities are being upgraded and visitor safety improvements are being made at Circular Pool, Hilltop and other sites. Beardmore Road is being resurfaced between the South West Highway and Fernhook Falls, visitor facilities are being upgraded and visitor safety improvements made at the Falls, and the Nuyts Wilderness trailhead to Mt Clare is to be relocated.

The department has employed a number of former timber industry workers who will be trained in a range of skills, including park facility development and fire management.

Top left: Collie River, adjacent to Lennard Drive.

Photo – Gordon Roberts

Above left: Wellington National Park. Lower Collie valley. Big Rock Day School group activities.

Left: An international school group at Honeymoon Pool canoe and camping area.

Photos – Leon Price

NEW PARK FACILITIES AND UPGRADES

Above left: Wellington Forest, adjacent to Wellington Dam.

Photo – Chris Garnett

Above: Car park and picnic area at Wellington Dam.

Below: Picnic and camping area at Wellington Forest.

Photos – Gordon Roberts

WELLINGTON NATIONAL PARK

An additional 14,500 hectares are being added to reserves around Wellington Dam, bringing the total area of the park to more than 17,500 hectares. The capital works program includes new facilities, as well as upgrading several key roads to provide better and safer access to several spots along the Collie River.

A major project is the stabilisation of the eroded riverbank at Honeymoon Pool by erecting a retaining wall. New decking at the same site will provide safe access to the water for swimmers, canoeists and people with disabilities.

At the popular Wellington Dam, toilets are being upgraded. New facilities will be constructed and new equipment will be made available at the Wellington Discovery Forest EcoEducation Centre, to cater for the increasing numbers of school students and teachers participating in environmental EcoEducation activities. Just around the corner, the King Tree site is also receiving a much-needed revamp.

Major roadworks include upgrading River Road South and Lennard Drive to provide safer and better access to popular spots such as Honeymoon Pool, Longpool, Little Rock, Rapids, Big Rock and the dam wall. Safety upgrades are also planned for River Road North, Falcon Road and further sections of the Pile-Mungalup Road.

The capital works program is being carried out by the department's own staff, through a partnership with the Shire of Dardanup, and in some cases through tenders for major constructions.

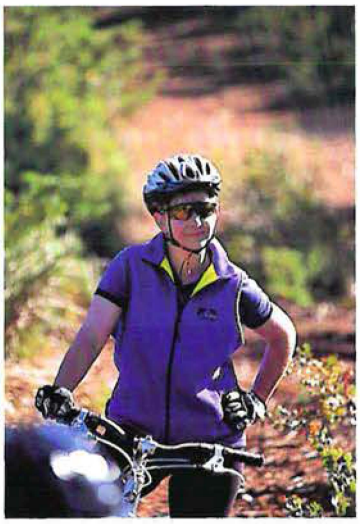
Further work to bring older sites up to standard is expected to begin in about mid-winter. Meanwhile, community consultation is well under way to prepare a management plan for the park.

MUNDA BIDDI MOUNTAIN BIKE TRAIL

Work on the new Munda Biddi Mountain Bike Trail—destined to be one of the world's greatest mountain bike trails—has begun, with the first section of Stage One (from Mundaring to Dwellingup) expected to be finished by September this year.

The trail is being built in three stages over the next two-and-a-half years: Stage One, Mundaring to Collie; Stage Two, Collie to Pemberton; and Stage Three, Pemberton to Albany.

Munda Biddi means 'path through the forest' in the Aboriginal Nyoongar language, and the trail when finished will cover nearly 900 kilometres between Mundaring and Albany. It will cater for recreational as well as more athletically inclined cyclists, with families and social clubs also expected to take advantage of this novel and healthy way of experiencing the bush and its wildlife.



Left: Pausing to take in the scenery.

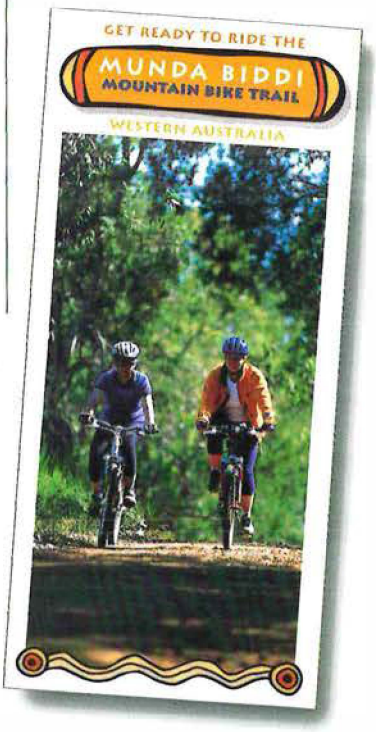
Photo – Geoff Logue/Wilderness Cycling Club

The Department of Conservation and Land Management's Munda Biddi Trail Coordinator, Therese Jones, said the trail would follow an existing network of forest roads and old rail lines, in order to reduce the impact on the natural environment.

"The trail will pass through towns and rural communities, taking in the most beautiful sites in the south-west, and traversing national parks and conservation reserves," Therese said.

Establishing and maintaining the Bike Trail is an ongoing cooperative effort between the department, industry and the community. The partners include Alcoa Australia, the WA Lotteries Commission, The Munda Biddi Trail Foundation, the Western Australian Mountain Bike Association, the Department of Sport and Recreation, the Great Southern Development Commission, the Department for Planning and Infrastructure, the Water and Rivers Commission, and the Water Corporation.

For further information, please telephone the Munda Biddi Trail Coordinator on 9334 0265. Alternatively, phone the Munda Biddi Trail Foundation's mobile phone number 0422 112 229, or email (biketrail.vol@calm.wa.gov.au).



Left: Topping up on fluids.

Photo – Geoff Logue/Wilderness Cycling Club

SANDALWOOD HISTORY RETURNS TO THE GOLDFIELDS

A slice of Goldfields heritage has been returned to Kalgoorlie. It is a 1927 Chevrolet truck used by sandalwood 'puller' and Goldfields identity, the late Bill Savage.

The Department of Conservation and Land Management bought the vehicle from Mr Savage's estate in 1995, and donated it earlier this year to the Western Australian Museum Kalgoorlie-Boulder (Museum of the Goldfields). The vehicle will be used as an educational tool displaying the valuable part it played in the State's historic sandalwood industry.

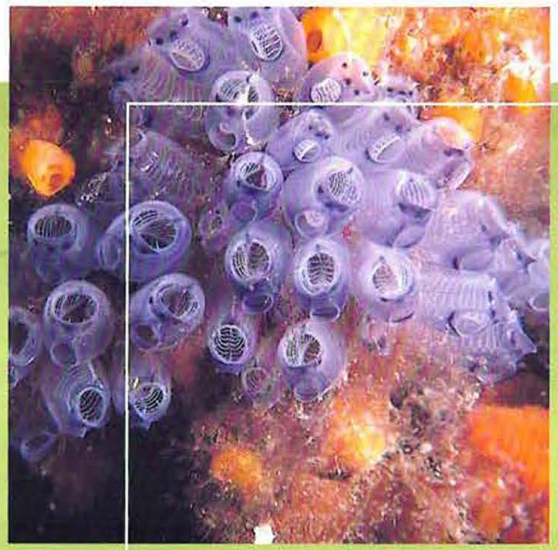
Bill Savage—who passed away aged 89 in June 1994—was typical of many of the rugged individuals who made up the sandalwood industry. He prospected and pulled sandalwood for most of his life around Laverton and east of Kalgoorlie near Karonie. Even in 1989, at the age of 84, he spent weeks at a time at his rustic bush-pole tent camp, 140 kilometres east of Kalgoorlie, pulling his annual quota of 50 tonnes of dead sandalwood. Bill was regarded by many as a classic 'bush mechanic' and his almost magical work with a length of 'number 8' fencing wire was legendary.

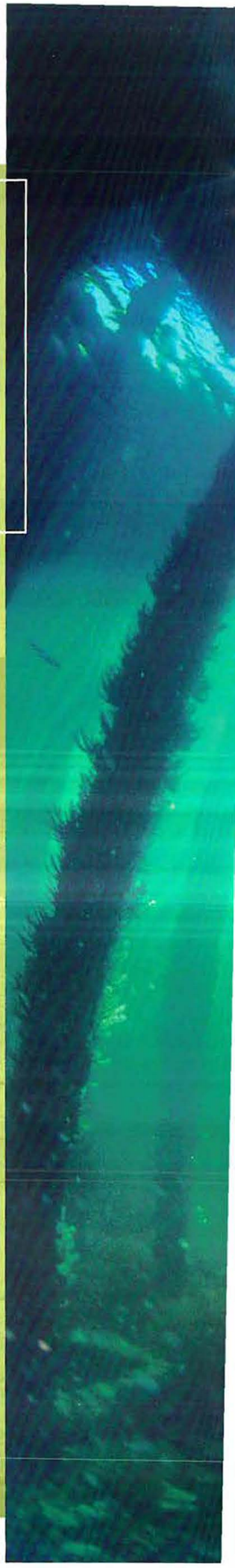
The truck was operating as a working vehicle into the early '90s, and was acquired by the department because of its unique status, its link to the history of the sandalwood industry and its important role in the development of WA and the outback.

The vehicle is in the same condition as it was when the department bought it, and, had it not been placed in the museum (and appropriately so in this Year of the Outback), a tank of petrol and a battery could have seen it back in the bush doing what it had done for 50 years.

Bill Savage's 1927 Chevrolet sandalwood truck.

Photo – Darren Graham





An underwater observatory, to be built at the end of the Busselton Jetty, will help people who have never dived or snorkelled to appreciate the wonders of the underwater landscape and its remarkable inhabitants

BENEATH THE BUSSELTON JETTY

by Ann Storrie

Busselton nestles between the picturesque shores of Geographe Bay and the Vasse River, 220 kilometres south of Perth. The area was first settled in 1834 when whaling was flourishing off the south-west coast and many ships used Geographe Bay as a safe anchorage. Lighters (flat-bottomed boats) were used for loading and unloading goods. In 1853, official sanction for the erection of a jetty in Geographe Bay was given, although work did not commence until 1865. The local timber industry provided the jarrah hardwoods used to construct the 158.4-metre-long jetty. Sailing ships were soon docking at the jetty and horsedrawn carts were used to carry goods to and from the town.

ADDING ON

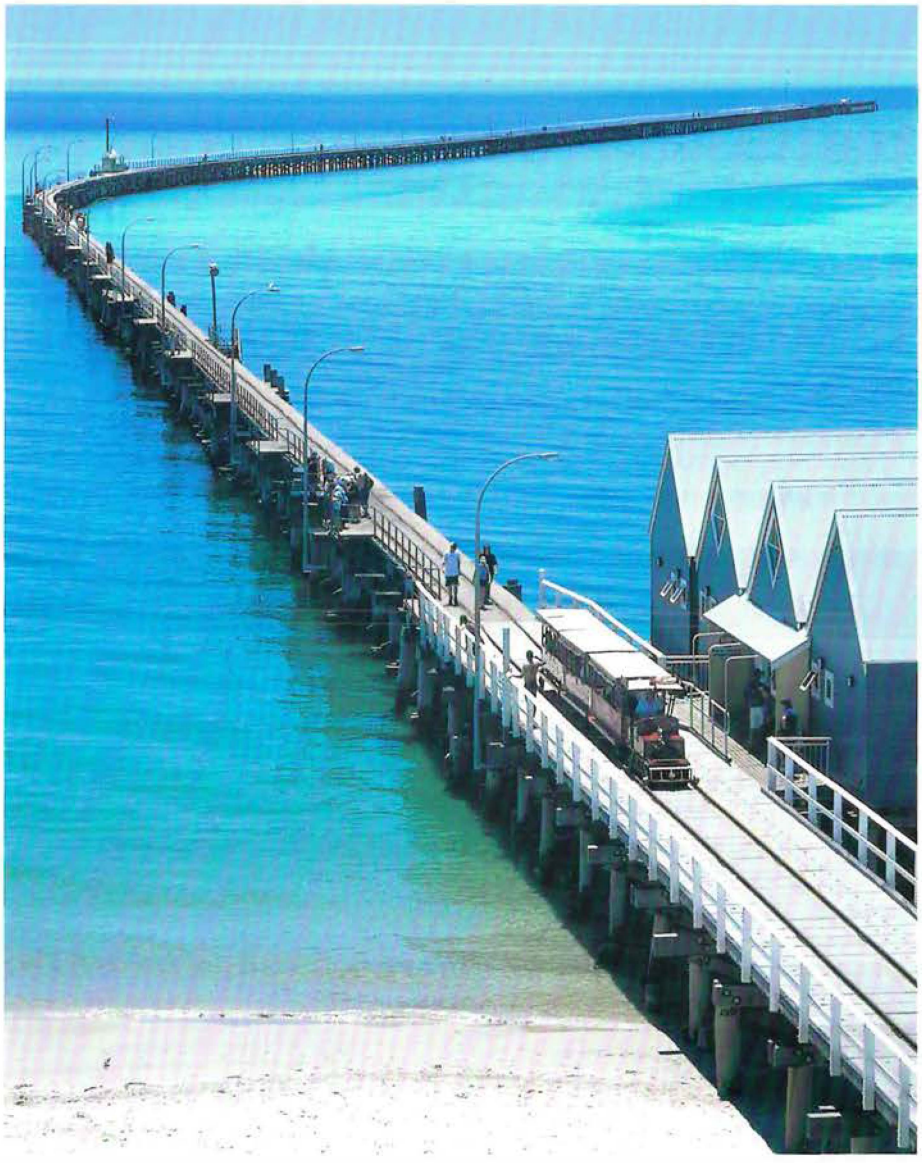
Over the next ten years, drift sand built up under the jetty until it was almost unusable. Another 129 metres were added on to what is now known as the number one head. Drift sand continued to be a problem, and further extensions were carried out five more times between 1884 and 1896.

Trains replaced the horsedrawn carts in 1911. Steam engines were used for the next 50 years to haul timber, potatoes and other produce to and from the ships. Diesel engines were introduced in the 1960s. More extensions were made to the jetty's length in the 1900s. The final extension, completed in 1960, brought the jetty's length to 1,841 metres (nearly two kilometres), making it the longest timber jetty in the southern hemisphere.

During the 1960s, State Ships ceased to use Busselton as a port of call. As a consequence, the Port of Busselton was officially closed to shipping in 1973. Maintenance was discontinued, and the jetty timbers began to deteriorate from wood borers, rot and the occasional fire. In 1978, Cyclone Alby destroyed a large section of the shore end of the jetty. Townspeople banded together to try to save the jetty, and eventually persuaded the State Government and the Shire Council to provide funds for repair.

In 1987, the Jetty Preservation Society was formed to provide a community-based fundraising campaign. Admission fees to the jetty were introduced and many donations were received. Despite a devastating fire in December 1999 that wiped out 65 metres of decking, 200 metres from the end, government bodies and the general public have rallied to provide finance, not only for repair, but for many new and innovative changes to the old structure. A passenger train now takes visitors and divers close to the end of the jetty. It leaves on the hour from an interpretive centre at the start of the jetty. The interpretive centre contains information on the surrounding areas, souvenirs, comprehensive details of the jetty's history and stunning photographs of the marine life that thrives beneath it.

As well as providing a wonderful venue for fishing, crabbing, walking and sightseeing, the Busselton Jetty is



Previous page
Main: Under the Busselton Jetty.
Insets from left: The elusive leafy seadragon has been sighted a number of times at the Busselton Jetty.
Blue-throated ascidian.
Photos – Ann Storrie
Background: Fishing from the jetty—a popular pastime.
Photo – Sue Morrison

Left: A train takes visitors close to the end of the jetty.
Photo – Sue Morrison

Right: Busselton Jetty circa 1870.
Photo – Courtesy of Busselton Historical Society.

Below right: Diving under the jetty.
Photo – Gerhardt Saueracker/Lochman Transparencies

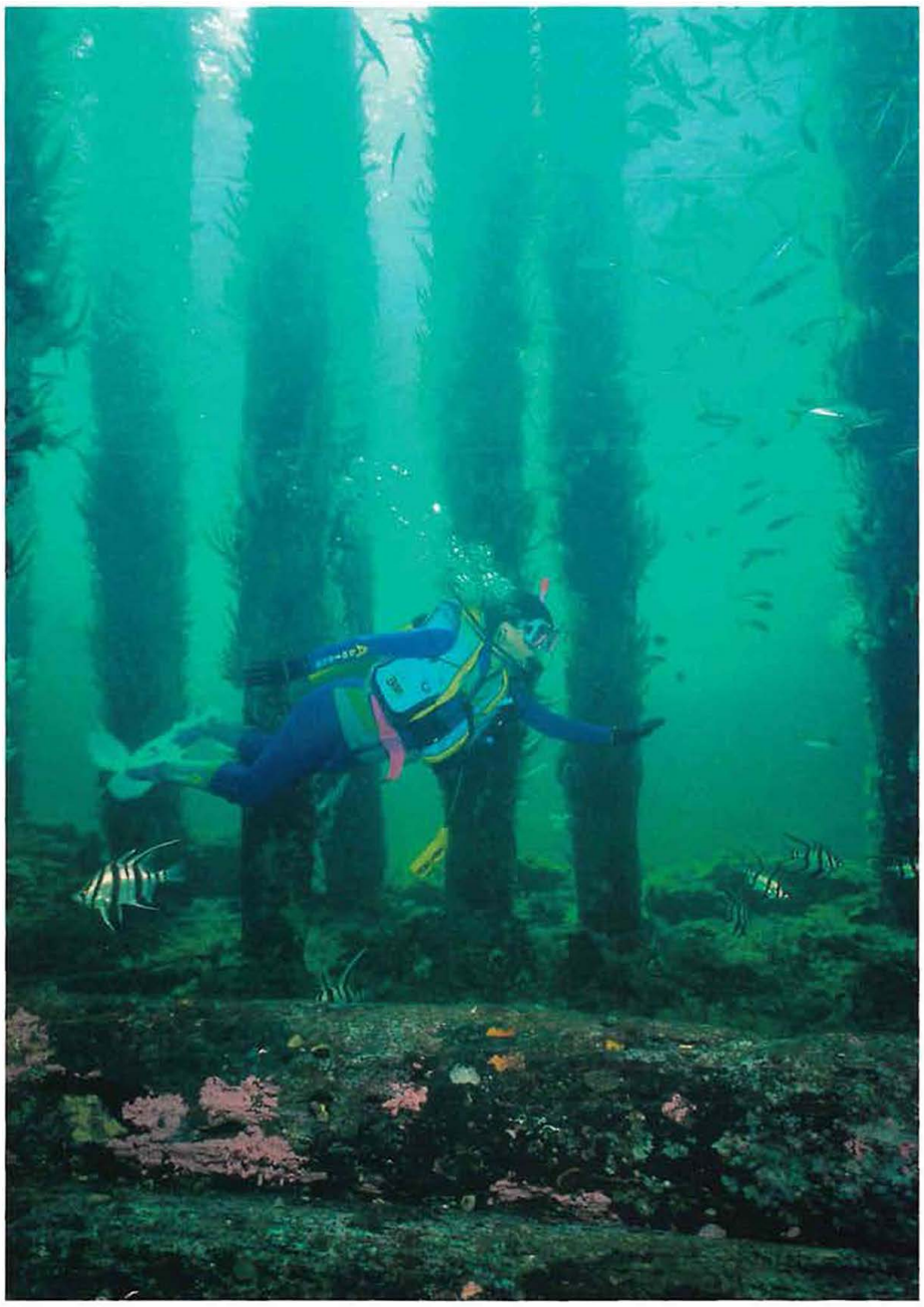
one of the easiest and prettiest dives in the world. Thousands of invertebrates have built up around the piles, creating a bevy of colours and forms. Many species commonly seen beneath the jetty are normally only found in deeper waters or under reef ledges, but exist here because the jetty protects them from the direct rays of the sun.

UNDERWATER OBSERVATORY

Imagine wandering through a forest, where thousands of flowering plants grow on every tree, and large flocks of birds fly in and around the branches. Tiny colourful animals hide among the flowers and the birds fly so close that their wings almost touch you as they soar past. Divers and snorkellers experience something akin to this when they swim near the end of the Busselton Jetty. Thousands of coral polyps that resemble tiny flowers radiate out from every pile. Like flocks of birds, enormous schools of fish swirl though the piles, streaks of sunlight glinting on their silvery bodies.

The scene is difficult to describe to the non-diver or non-snorkeller, but that problem is about to be solved. Several years ago, an underwater observatory was proposed for the end of the jetty. After much hard work from the Busselton Jetty Environment and Conservation Association, and with many generous donations, income from jetty admissions and government backing, the underwater observatory project is under way. It is expected to open to the public in March 2003.

Around 200,000 people visit the Busselton Jetty every year. This number is expected to increase, especially after the construction of the observatory. The underwater section of the observatory is being constructed in Bunbury and will be sunk at the Busselton Jetty before the top section is completed. It will be positioned about



Above and left: Artist's impressions of the future underwater observatory. The above-ground feature still requires funding.
Illustrations – Spowers Architects

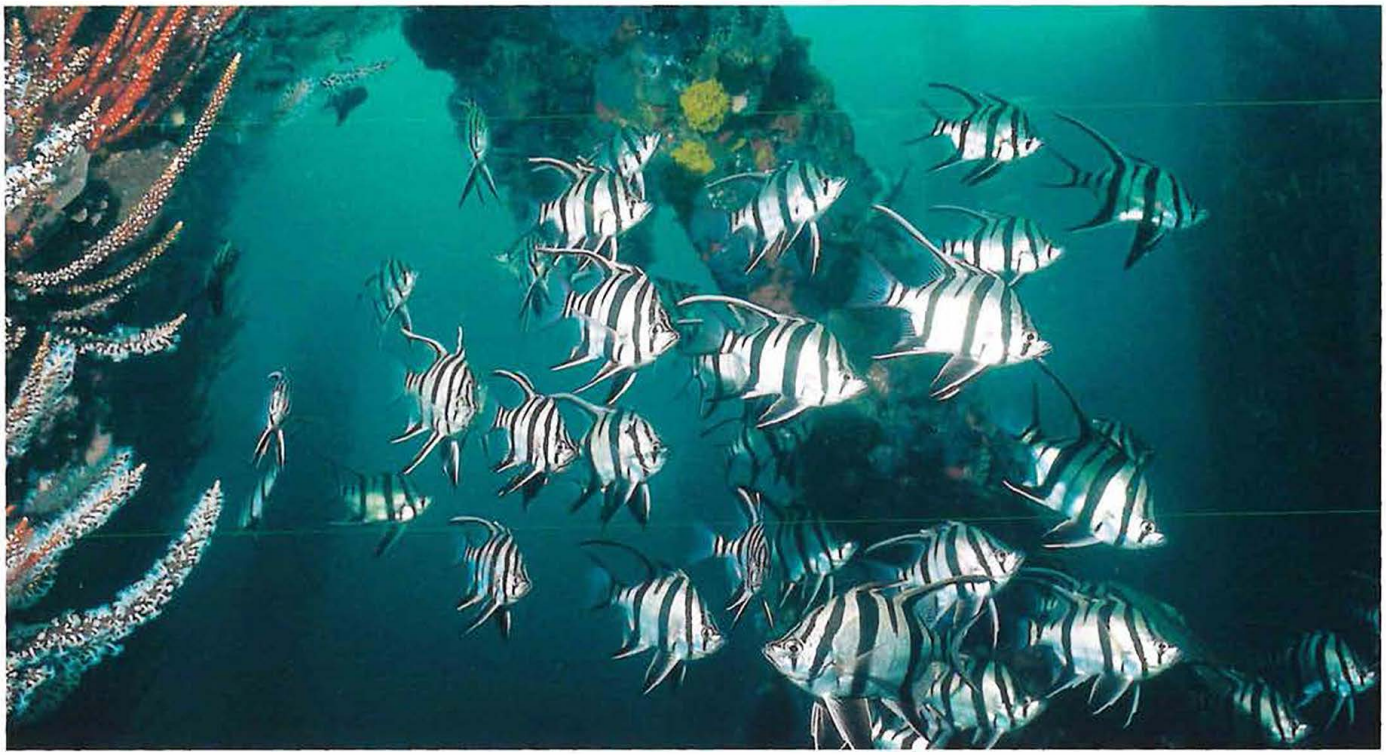
Centre left: Yellowtail scads (*Atule mate*) form enormous schools.

Below left: Red-striped cardinalfish (*Apogon margaritophorus*).
Photos – Ann Storrie

150 metres from the end of the jetty (just seaward of the burnt out section), where maximum benefit will be obtained for viewing the marine life. A set of stairs will also be constructed close to the observatory. They will run from the top of the jetty to a landing at water level to allow divers safe access to the water. The stairs will also continue to just below water level for easy entry and exit.

Animals such as sponges, sea squirts, corals and bryozoans grow on concrete quicker than on wood. In a matter of months, the outside of the observatory will become a colourful mass of the invertebrates that live on the piles. Not only will visitors within the observatory be viewing the underwater world around them, but divers will be photographing and looking at the growth of animals on the observatory walls. Divers will be employed to keep the viewing windows clean of animals and algae that will also quickly grow on glass.

The observatory will consist of a deck-level entrance, foyer, circular staircase and an observation chamber. The observation chamber will sit approximately one metre above the seabed, supported on a piled foundation. It will be nine metres in diameter, with one metre windows in



the outer wall. The circular stairwell leading to the chamber will have one metre diameter viewing windows that follow the stairwell. There will be three landings on the stairwell that will allow people to observe the different animals that live from the top to the bottom of the jetty piles and the schools of fish that swim at varying depths under the jetty. A passenger lift will enable people with limited mobility to gain access to the chamber. Forty visitors will be allowed in at any one time.

THE FISH

So what will people see from the underwater observatory? When divers first descend the eight to nine metres below the jetty, they are often overwhelmed by the big picture. Enormous schools of yellowtail scad, long-finned seapike, herring, whiting, old wives, trevally and trumpeters are just some of the fish that school around. As divers swim slowly past the piles, the fish barely move, and the number of fish making up each school is breathtaking.

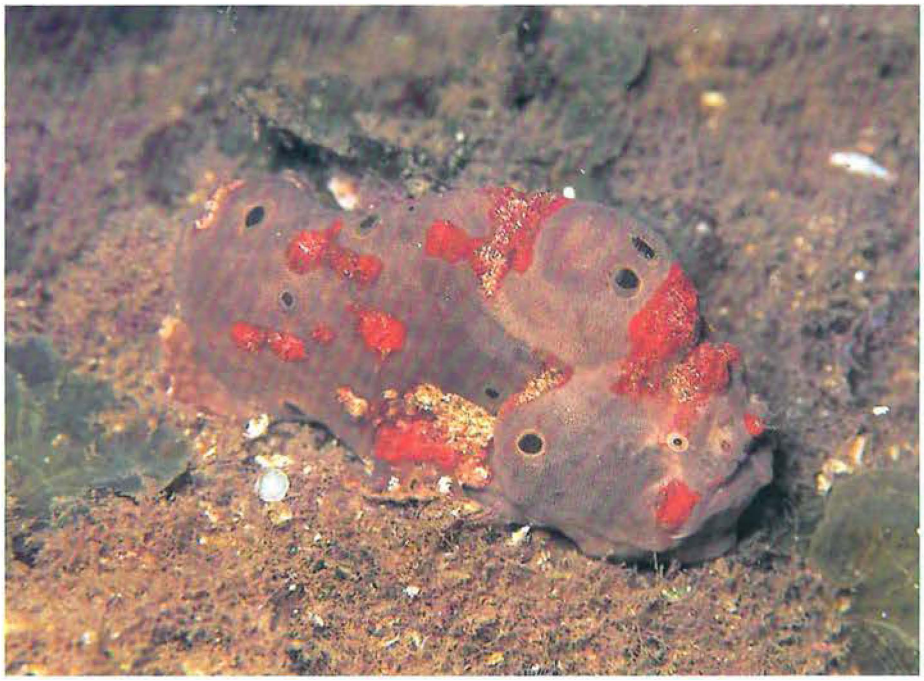
Divers who sit quietly on the bottom, taking in this extravaganza, may experience one of their most memorable moments beneath the water. It will also be memorable for visitors to the observatory. Smaller schools of bullseyes, cardinalfish, gobbleguts, wrasse and black-headed pullers swim close to the piles. Pairs of talma (truncate coralfish), and many species of leatherjackets, are often seen selecting food from the large number of small animals that grow and live on the piles.

Other fish prefer to feed or even live on the bottom. Gurnard perch—large, colourful scorpionfish that rely on camouflage as they sit among the rubble—wait for a meal to swim within range. Banded sea perch and harlequinfish rest on the bottom watching for a passing fish, while goatfish forage among the sand for small invertebrates.

One of the most interesting fish that lives on the bottom is the anglerfish. Several individuals live under the Busselton Jetty. They are masters of camouflage and look exactly like the surrounding sponges. They may be pink, yellow, orange or black, with skin

Above: Old wives (*Enplosus armatus*) school around the jetty piles.
Photo – Sue Morrison

Right: Juvenile western red scorpioncod (*Scorpaena sumptuosa*).
Photo – Ann Storrie



textures and bodies pitted just like a sponge. The anglerfish's fins are modified to form tiny 'feet' upon which a coating of algae aids camouflage. Although the anglerfish can move by either walking on its pelvic fins, or 'crutching' by rocking back and forth on its fins, these fish do not usually move far. Despite this, they are the fastest vertebrate predators on Earth. Their first dorsal spine is modified to form a lure, or esca, which has a small piece of tissue (the bait) at the tip. They wave this to attract other fish that, when within range, can be sucked into the anglerfish's mouth.

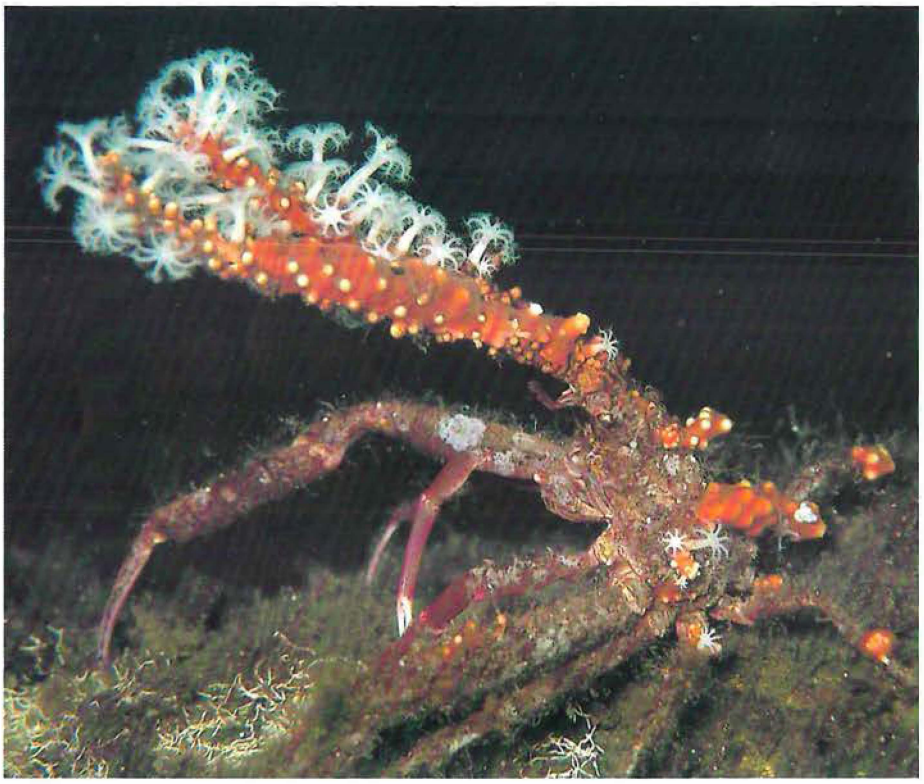
PILES OF LIFE

The jetty piles are covered with colourful soft corals, sponges, sea squirts, bryozoans and other animals that grow on, or encrust, the structures. Space is at a premium, and there is very little bare timber on most of the older piles of the jetty. The colours are amazing, although a torch is needed to show them in their true brilliance, as colours are absorbed by water. For this reason, artificial lighting is planned for intermittent use around the observatory.

The dominant coral that grows on the piles at the end of the jetty is a telesto soft coral. Its beautiful white polyps protrude from a matrix that looks like branches of trees sprouting from the timbers. These 'branches' are often bright red or orange, due to an encrusting sponge that grows over the pale-coloured matrix. The telesto corals also provide habitat for many other animals. The telesto nudibranch is a sea slug whose red or orange body matches the sponge-coated matrix of the telesto, and it has cerata, or outgrowths on its body, that are white and fluffy like the polyps. Decorator crabs also camouflage themselves among the corals. They pick the polyps and plant them on their backs. The coral grows happily on the crab as it now has a mobile existence.

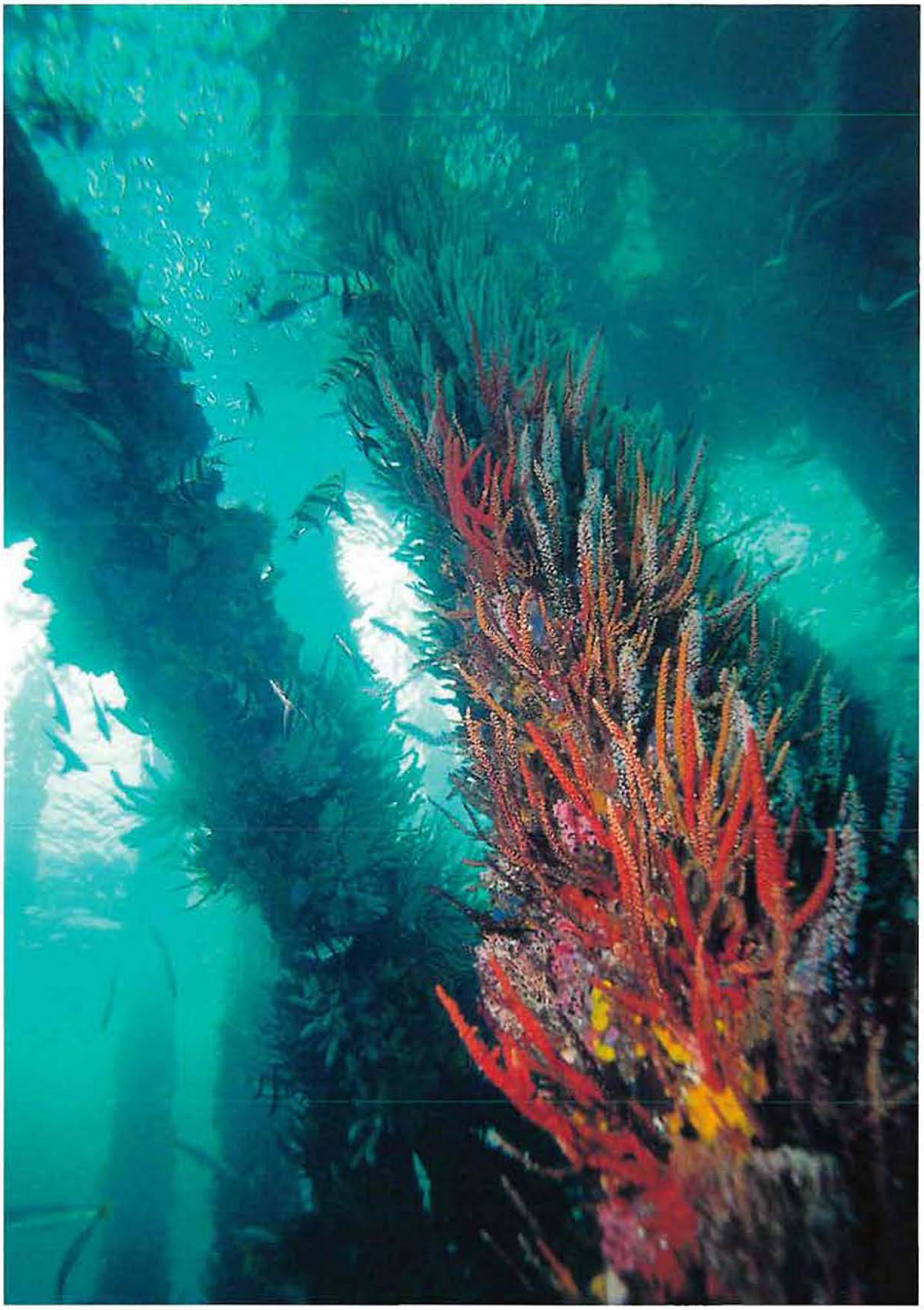
Many other nudibranchs (see also 'Slugs of the sea', *LANDSCOPE*, Spring 1996), such as the short-tailed nudibranch, are common on the piles and among the rubble on the bottom. These colourful orange creatures are often observed mating, and they are so common here that they are often referred to as 'Busselton Jetty nudibranchs'. Another beautiful example is a bright purple aeolid with long, sausage-like protrusions (cerata) on its body. It is an uncommon nudibranch, but has been seen many times under the Busselton Jetty.

Brightly-coloured sponges, such as the rose sponge, are often eaten by nudibranchs whose colours and textures are very similar to the sponge. Other molluscs, crabs, shrimps, worms and starfish and their relatives also feed on the plentiful supply of sponges and other invertebrates on the piles. Tiny fish live among these animals. Colourful little tripplefins dart around



Above left: Several well camouflaged anglerfish (*Allenichthys glauerti*) live under the Busselton Jetty.

Left: Decorator crab (*Naxia* sp.) 'decorated' with telesto coral.
Photos – Ann Storrie



Right: Colourful telesto coral (*Carijoa* sp.) and old wives.
Photo – Peter & Margy Nicholas/Lochman Transparencies

Below right: The short-tailed nudibranch (*Ceratosoma brevicaudatum*) is found in astonishing numbers under the Busselton Jetty.
Photo – Sue Morrison

the piles, the males bobbing the bright red blotches under their chins to attract females. The false Tasmanian blenny has a wide mouth, two fluffy bright yellow antennae, known as cirri, and large, bulging eyes that can swivel in different directions. It loves to make its home in crevices in the old timber or in empty mollusc shells. It is often seen at the top of the jetty piles and, most commonly, around the piles close to the beach.

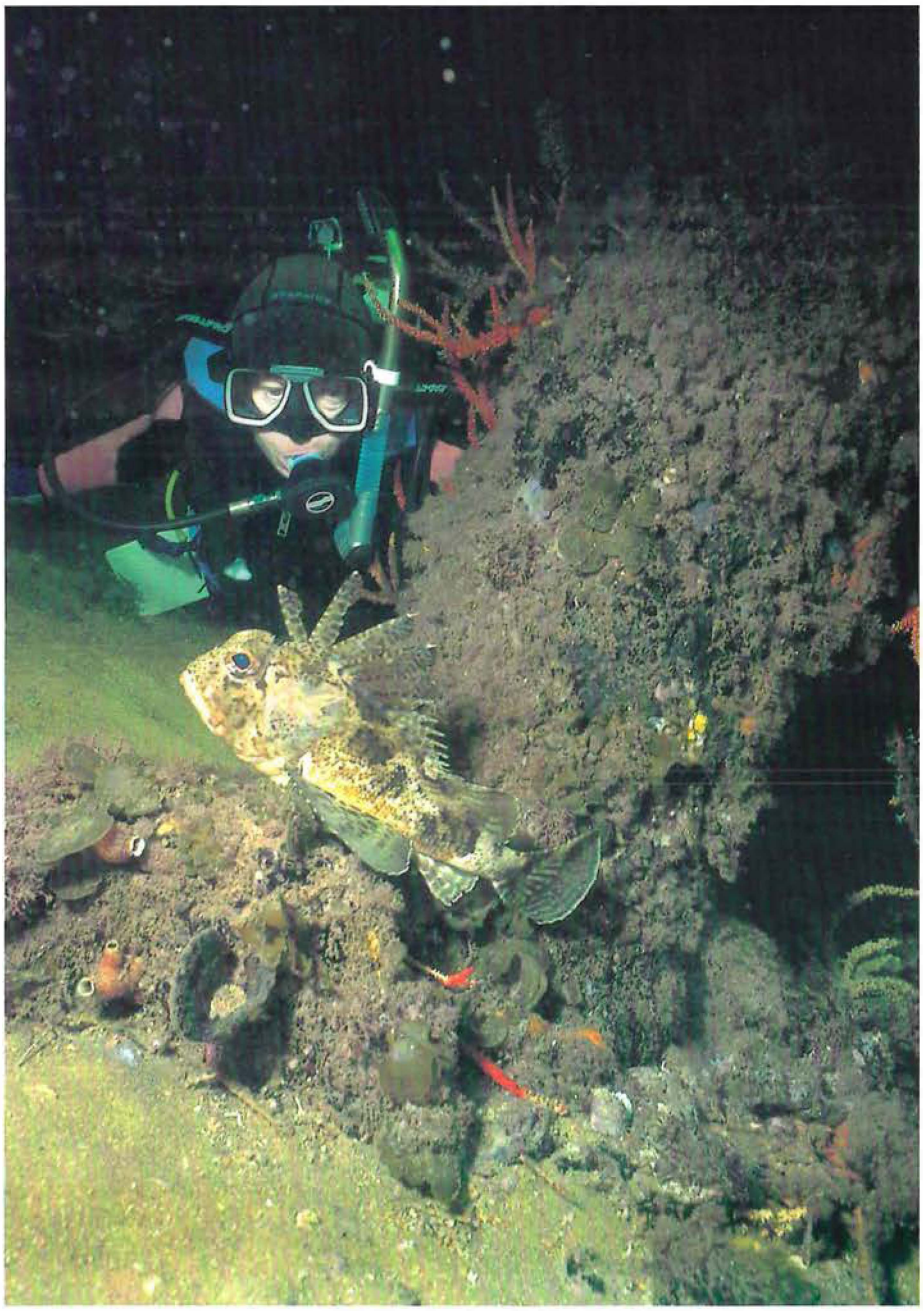
Fallen timbers, rubble, sand and silt on the bottom under the decking also provide shelter and food for many invertebrates, such as cuttlefish and octopuses. The giant cuttlefish sometimes hides under the fallen timber and, although cuttlefish do not usually inhabit permanent lairs, some have been observed for several months under the same timbers of the jetty. Octopuses make permanent lairs under the rubble or in hollows in the wood. They disguise their lairs by piling debris, rocks or shells in front of the entrances.

RESERVATION

To help preserve the magnificent environment under the jetty, the area is included in a proposed Geographe Bay marine conservation reserve, to be managed by the Department of Conservation and Land Management. Public consultation on the reserve proposal will be undertaken this year.

Many studies are being carried out on the water quality in Geographe Bay, the rich seagrass beds that surround the jetty, and the numbers and distribution of marine life in the area. Marine biological surveys carried out on the HMAS *Swan*, after its sinking near Dunsborough, showed a dramatic increase in fish life. Species increased from almost zero on that site to more

Left: The cuttlefish (*Sepia* sp.) can instantly change the colour and texture of its skin.
Photo – Sue Morrison



Below left: A diver with a gurnard perch (*Neosebastes pandus*).
Photo – Ann Storrie

than 80 within a couple of years. The *Swan* dive site has already proved to be one of the biggest attractions to divers in this State.

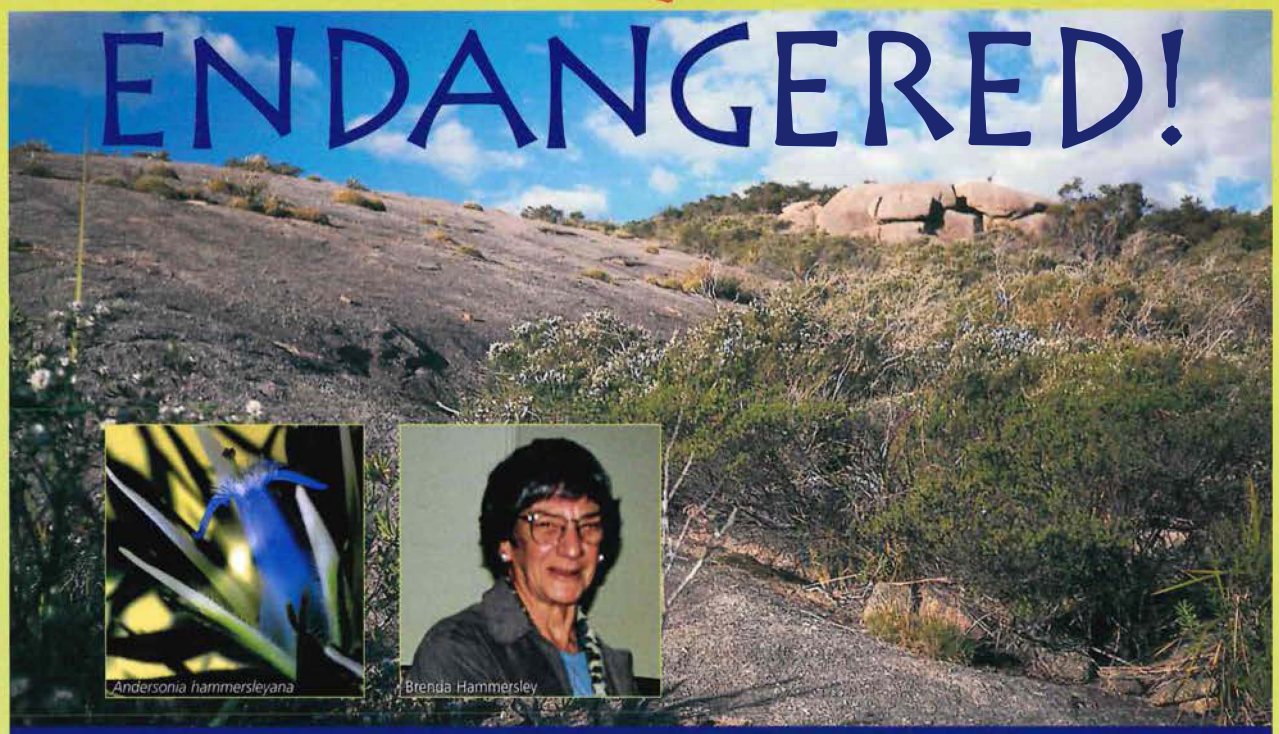
Fishing from the Busselton Jetty is a major recreational activity. However, application has been made to create a fishing free zone from the end to 258 metres shoreward. Since the fire in December 1999, people have not been able to reach the end of the jetty except by boat. The fish life in this area has increased dramatically during this time. John Dory and samsonfish that were occasionally seen out from the jetty now regularly swim through the piles. The schools of yellowtail scad and long-finned pike have dramatically increased, and the amount of rubbish—such as bait bags, fishing lines, sinkers, hooks, cool drink cans, plastic bags, fast food containers and thongs—under the end of the jetty has reduced.

The Busselton Jetty is a unique structure that already attracts thousands of people to this area. The construction of the underwater observatory and the proposed marine conservation reserve are exciting initiatives that will enhance the region, help to conserve the environment, and encourage people to observe the beauty around them.

Ann Storrie is a freelance writer and underwater photographer. She has co-authored two full-colour books (*The Marine Life of Ningaloo Marine Park* and *Wonders of Western Waters: the Marine Life of South-Western Australia*) that also feature many of her photographs. Ann can be contacted on (08) 9385 9355.

A book on the marine life of the Busselton Jetty by Sue Morrison, Peter Morrison and Ann Storrie will be published by the Department of Conservation and Land Management by the end of this year.

ENDANGERED!



Mt Lindesay-Little Lindesay Vegetation Complex

The impressive granite massifs of Mt Lindesay and Little Lindesay, near Denmark, host rare and endemic plant species and provide a last refuge for biodiversity eliminated from more altered lowland landscapes.

The 'Mt Lindesay-Little Lindesay Vegetation Complex' is listed as a threatened ecological community in the Endangered category. The complex is distinct from the plant communities of other similar mountain ecosystems near the southern coast, such as the Critically Endangered 'Montane Thicket of the Eastern Stirling Range'.

Jarrah shrub-mallee and heath predominate on the shallow to skeletal soils of the upper slopes and summit area, with mixed jarrah-marri-bullich low woodland in gullies. The middle slopes comprise relatively bare granite rock slabs and support a unique plant assemblage of scrub and open herbs. Four plants are endemic to Mt Lindesay: *Andersonia hammersleyana* ms, *Cryptandra congesta*, *Grevillea fuscolutea* and *Laxmannia grandiflora* subsp. *brendae*. Some other species are endemic to the immediate area, having their main populations on Mt Lindesay, as well as one or two populations close by. These include *Borya longiscapa*, *Andersonia virolens* ms, *Eucalyptus virgineae* ms, *Calothamnus* sp. Mt Lindesay and *Lasiopetalum cordifolium* subsp. *acuminatum* ms.

Other Rare and Priority plants that occur in the complex include Two Peoples Bay moss (*Pleurophascum occidentalis*), dwarf hammer orchid (*Drakaea micrantha*), James' paper lily (*Laxmannia jamesii*), two paper heaths (*Sphenotoma parviflorum* and *Sphenotoma* sp. Stirling Range), *Verticordia endlicheriana* var. *angustfolia*, showy flame pea (*Chorizema reticulatum*), *Gonocarpus trichostachyus*, *Sphaerolobium benetectum*, *S. pubescens*, *S. rostratum* and *Sollya drummondii*.

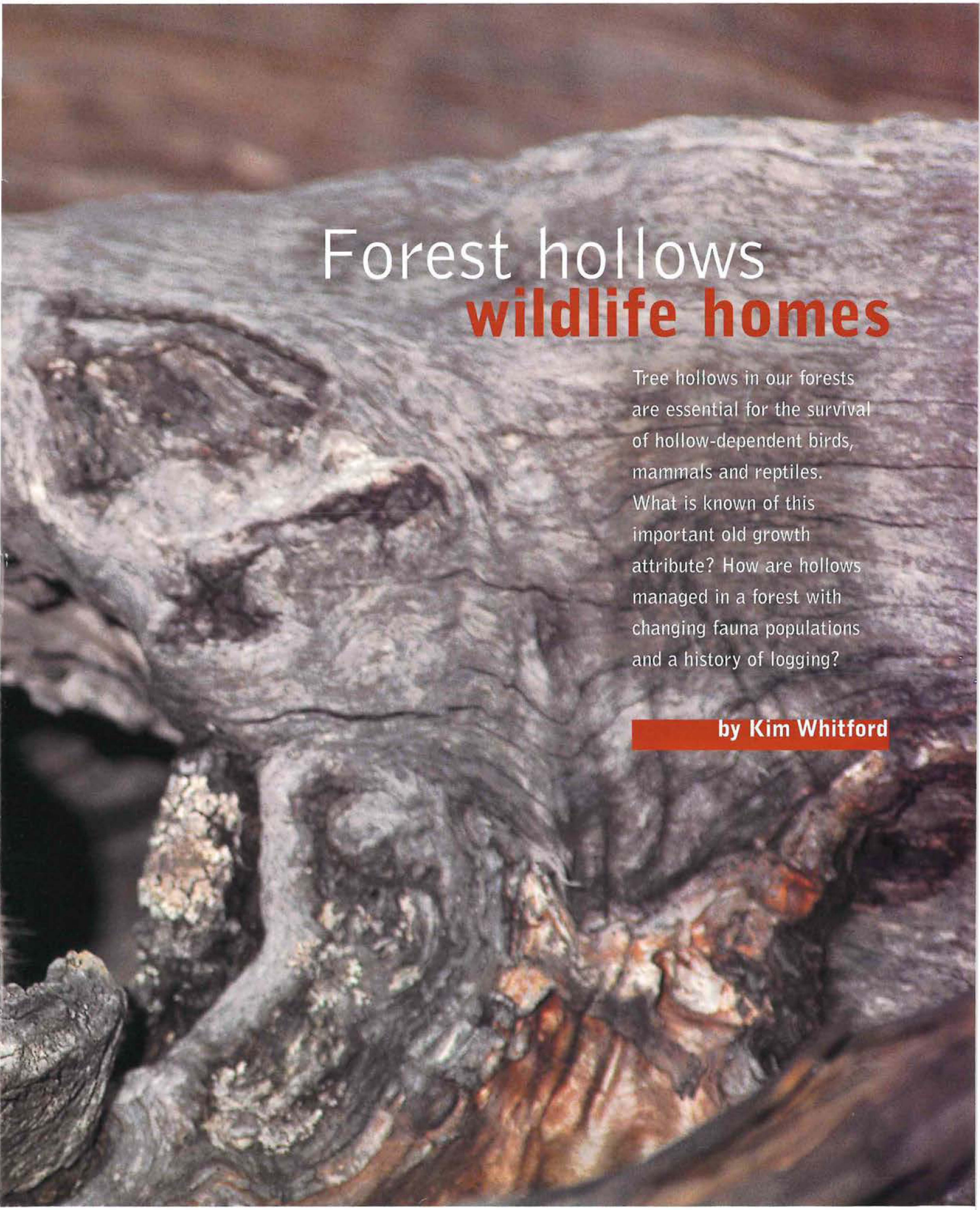
Volunteers, such as amateur botanist Brenda Hammersley, have added to our knowledge of this area by documenting flora and locating previously unrecorded rare and endemic plants. Two of the endemic plants located by Brenda are currently being described. These are the *Laxmannia* and the *Andersonia*—both being named after Brenda.

The Mt Lindesay-Little Lindesay Vegetation Complex is restricted to approximately 1900 hectares, all of which is located within an area of State forest that is a proposed conservation reserve. This ecological community is threatened by dieback caused by infection by the pathogen *Phytophthora cinnamomi*. While pockets of dieback-free vegetation still exist, dieback is widespread and has had a severe impact on large sections of the upper slopes. Other potential threats to the complex are frequent fire, feral animals and impacts of recreational activities.

The department's Warren region has put aside funds to map the current extent of dieback using aerial photography and ground survey. The photography and map will provide the necessary baseline information for future management actions. Immediate action will involve extensive *Phytophthora* control by applying phosphite using backpack misters. Volunteers and community groups will assist departmental staff in this work.

by Sally Black

photos by Sarah Barrett, Roger Hearn & Kath White



Forest hollows **wildlife homes**

Tree hollows in our forests are essential for the survival of hollow-dependent birds, mammals and reptiles. What is known of this important old growth attribute? How are hollows managed in a forest with changing fauna populations and a history of logging?

by Kim Whitford

In Western Australia, fox baiting and the reintroduction of threatened mammals, together with recent increases in forest reservation, have greatly improved the outlook for forest wildlife. As fox baiting restores native species to large areas of our forests (see 'Western Shield', *LANDSCOPE*, Winter 1996 and 'The Return of the Woylie' *LANDSCOPE*, Autumn 1996), greater demand is placed on the tree hollows in which animals breed.

As trees grow and decay, hollows form. The heartwood used to build houses, floors and furniture is dead tissue, and a tree can lose a large proportion of its internal heartwood and develop extensive hollowing, yet still maintain most of its structural strength. A 130-year-old tree has experienced storms, fires and persistent weathering that damage and tear off branches, exposing the heartwood to rain and sun. These cumulative events cause crowns to decline as trees get older. Wounds develop when branches are burnt or torn from the tree. Fungi, termites and other organisms attack, enlarge and extend these wounds, eating away the non-living heartwood. Eventually, hollows develop. Where these are open to the outside world, they are found and used by birds, reptiles and mammals.

HOLLOW USERS

In Western Australian forests, 42 species of birds, mammals and reptiles use hollows in standing trees. Seven of these mostly use hollow logs on the ground. Since European settlement, logging has deposited innumerable tree limbs and log ends on the ground. Combined with natural tree fall, these provide abundant hollow logs for

Previous page
Numbats, like chuditch and mardo, make use of the abundant supply of hollow logs on the forest floor.
Photo – Jiri Lochman

Above: Termites, along with fire, fungi and micro-organisms, contribute to hollow formation and development.
Photo – Jiri Lochman

Below: A boobook owl (*Ninox novaeseelandiae*) returning to its hollow in a broken limb.
Photo – Hans and Judy Beste/Lochman Transparencies

ground-dwelling species such as the numbat (*Myrmecobius fasciatus*), chuditch (*Dasyurus geoffroii*) and mardo (*Antechinus favipes*). This aspect of logging has probably benefited ground-dwelling forest animals by increasing the number of hollows on the ground. At the same time, logging has reduced the number of hollows available in large, standing trees. Consequently, species that use the hollows in standing trees are those most likely to be impacted by historic and recent logging.

Hollows provide animals with a secure and comfortable place to nest and rear their young. Small entrances provide protection from larger predators. Hollows reduce air movement and exposure, protect animals from rain, provide shade and insulation from summer heat, and limit the loss of heat in winter. These functions reduce extremes of temperature variation inside the hollow. And this helps animals maintain their body temperature and reduces their energy needs, leaving them with more energy to hunt or gather food, and to reproduce. For birds, hollows assist incubation by limiting the movement of eggs. All of these factors contribute to greater breeding success.

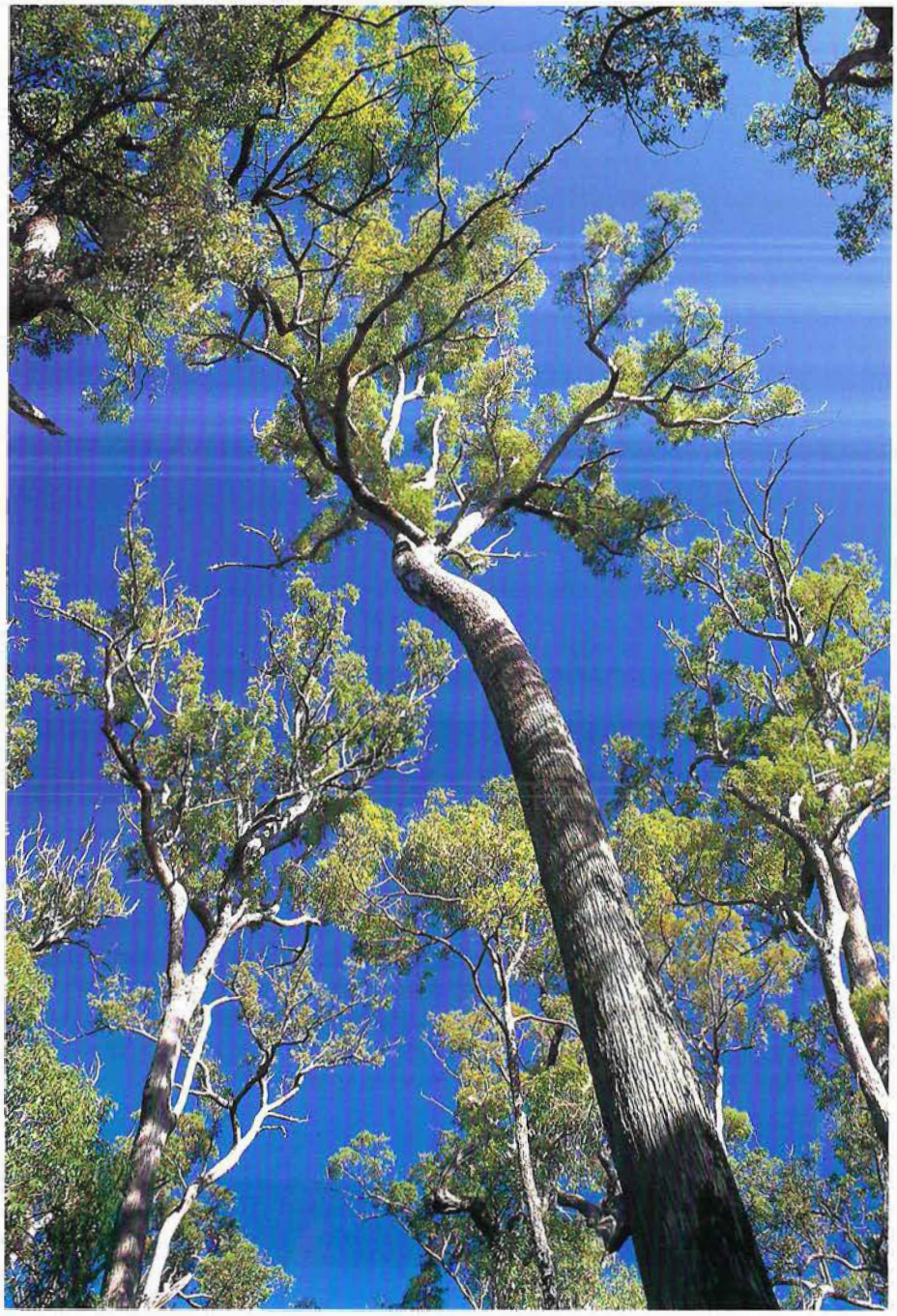
HOLLOW SIZE AND BODY SIZE

Researchers from CSIRO, the Agricultural Protection Board, the WA Museum, the Department of Conservation and Land Management, and Murdoch University have collected information on the size of hollows used by native animals. Hollows were found by radio tracking animals and by searching standing or fallen trees, and the dimensions of these hollows were measured. The size of hollows used by a species is related to its body size, with the largest species requiring the largest hollows, and conversely the smallest species using the smallest hollows. By studying the distribution of hollow sizes in the forest, and relating this to the sizes of hollows used by native species, general conclusions can be reached about how many hollows there are in the forest, and the availability of hollows potentially suited to these species.

Forest animals use all types of cavities in trees, but each species selects hollows from only a particular size range. Bats and lizards use small cracks and places where bark has lifted. Tree martins (*Cecropis nigricans*) and striated pardalotes (*Pardalotus striatus*) use small hollows about the size of a 600-millilitre water bottle. Phascogales (*Phascogale* spp.) and parrots nest in slightly larger hollows, whereas owls and cockatoos breed in the large hollows that form in the main branches and trunks of trees. Red-tailed black-cockatoo (*Calyptorhynchus banksii*) hollows can extend deep into the trunks of marri trees and be seven metres deep and half-a-metre wide. Entries to hollows are often surprisingly small, as most hollow-using animals will enter an opening that is big enough through which to squeeze their head. A brushtail possum (*Trichosurus vulpecula*), for example, is about the size of a large domestic cat, yet it can enter a hollow through an opening only six centimetres in diameter.

A brushtail possum emerging from a well-worn hollow entrance.
Photo – Wade Hughes/Lochman Transparencies

These studies show that only a small proportion of all hollows found in the forest are large enough to be used by tree-dwelling creatures. There are many more small hollows than large ones. No usable hollows occur in branches smaller than about 10 centimetres in diameter, and hollows found in branches close to this size are suited only to relatively small species,



such as striated pardalotes, rufous treecreepers (*Climacteris rufa*) and mardos. Larger mammals and birds need larger branches to carry hollows. Most hollows occur in the tree's crown, rather than in the trunk. Sixty-five per cent of all usable hollows in jarrah and marri are found in the dead wood, with 35 per cent in live wood.

WHERE ARE HOLLOWS?

Hollows are difficult, even impossible, to see from the ground. The entrances are often very small and hidden behind clumps of leaves. They are dark and hard to see in shaded parts of the tree crown. Even when they are visible from the ground, it is almost impossible to distinguish an entry into a hollow from the burnt-out stump of a limb that has been blackened by fire and goes nowhere. Because hollows are hard to see, the size of the tree and the condition of the crown help tree markers select trees to keep for wildlife in logged areas. These 'habitat trees' are selected because they are large and have specific types of crown damage associated with hollow development.

Hollows are most common in the largest and oldest trees. These typically have large crowns with many branches, much decay and more places for hollows to form. Although decay creates hollows, as it progresses it causes trees to lose limbs, leaving very senescent trees (those that are old and in decline) with only a few large limbs and reducing the number of hollows. Consequently, both highly senescent trees and those with little or no crown decline tend to have few hollows. The decline of the crown also changes the size of hollows found in the tree. Tree crowns that are largely intact have few or no hollows. Some decay leads to the formation of small hollows, and further decay leads to the formation of larger hollows. The largest hollows usually form in the trunk or in primary branches in the crown that have been

Above left: The hollows that form in these karri crowns provide nesting and roosting sites for a variety of native birds.
Photo – Len Stewart/Lochman Transparencies

Left: Although less majestic than karri, the jarrah forest is home to a greater number of tree-dwelling mammals.
Photo – Rob Olver

Right: An Australian owlet-nightjar (*Aegotheles cristatus*) peers from the entrance to a hollow.

Below: A phascogale and its young shelter in a nest of leaves, sticks and grass at the base of a hollow.
Photos – Jiri Lochman

broken off. So the size of the tree, the form of the tree crown and the type of crown decay all indicate what types of hollows may occur in that tree.

Although the largest trees have the most hollows, trees greater than a metre in diameter (measured 1.3 metres above the ground) make up less than two per cent of trees in the forest, while trees with diameters greater than 50 centimetres make up approximately 20 per cent of all trees. Even though smaller trees individually bear relatively low numbers of hollows, collectively they provide many of the hollows in the forest. This is typical in both regrowth and old growth forests, and conforms with population distributions in nature, as the number of small trees competing to become veterans of the forests is many times larger than the number of trees that actually become veterans.

PROTECTING HABITAT

The primary strategy to protect hollow-dependent wildlife is reservation, and this is applied at a range of scales. It includes the formal reservation of extensive tracts of land in national parks and nature reserves, through to smaller-scale informal reservation of areas alongside roads, streams and other uncut forest areas, down to the retention of groups of individual trees within logged areas. Trees are left across jarrah logging coupes—typically about 40 per cent of a jarrah coupe consists of uncut areas of various types. A very much larger proportion of the karri forest is in reserves of some type. To provide diverse and ongoing habitat, these various reserves, retained trees and stands of trees are spread across the landscape

Left: Geckos and skinks, like this Napoleon's skink (*Egernia napoleonis*), shelter in fissures in dead wood and under lifted bark.
Photo – Jiri Lochman

HOLLOW USERS IN WESTERN AUSTRALIAN FORESTS

Of the 42 forest-dwelling species that use hollows in logs and standing trees, 29—such as the red-capped parrot and phascogale—are highly dependent on hollows for breeding, whereas others—like the carpet python and pygmy possum—make only occasional use of hollows.

There are 12 large hollow-using birds: four owls (boobook, barking, masked and barn owls), four cockatoos (the red-tailed, Baudin's and Carnaby's black-cockatoos, and the long-billed corella), the peregrine falcon, and three large waterbirds (the mountain duck, black duck and grey teal). Medium-sized birds include the red-capped and ringneck parrots, western rosella and purple-crowned lorikeet. A mixed group of medium to small birds (the sacred kingfisher, owlet night-jar, rufous treecreeper, tree martin and striated pardalote) also use hollows.

Bats, such as this Gould's wattled bat (*Chalinolobus gouldii*), shelter under lifted bark, fissures in tree trunks, and open cavities often unsuited to other hollow users.
Photo – Jiri Lochman

There are three large mammals (chuditch, common brushtail possum and western ringtail possum), two medium-sized mammals (the numbat and phascogale), nine small bat species, and the small mardo and western pygmy possum. Surprisingly, five reptiles use hollows (carpet python, Stimson's python, marbled gecko, reticulated velvet gecko and Napoleon's skink).

Many hollow-using birds are well known. The black-cockatoos, parrots and corellas are brightly coloured and have distinctive calls. Most of the mammals are more cryptic. They spend the daylight hours secreted inside tree hollows, where they are sheltered from the elements and protected from predators. The brushtail possum is probably the best known. It uses large hollows, and its den trees can often be readily distinguished by the obvious parallel tracks worn into the bark on the uppermost side of the tree. The timid western ringtail possum has a restricted distribution and is most common in the peppermint forests of the coastal plain. Here, it uses hollows in tuart trees, but also builds platforms of branches and leaves (called dreys) in peppermint trees. In the jarrah forest, ringtail possums nest in the skirts of grasstrees, as well as using hollows.

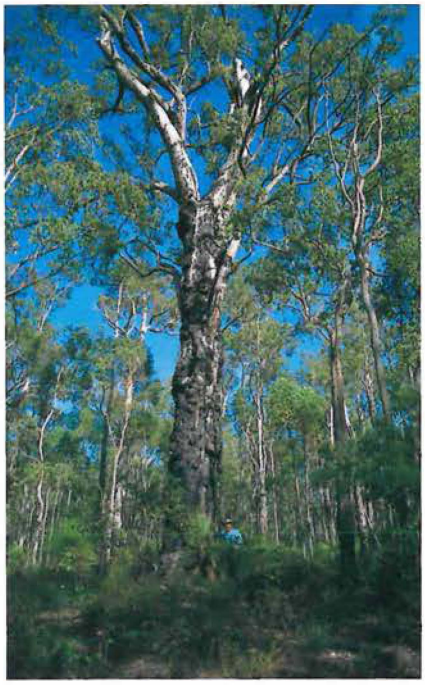
and logging disturbance is dispersed across the forest and through the years.

A variety of restrictions are placed on jarrah and karri logging activities that reduce the impact of logging by preserving habitat trees for animals to use. As already mentioned, some large trees are retained to provide habitat for hollow-dependent wildlife. These retained trees (called 'habitat' and 'potential habitat' trees and marked with a large white 'H') are the most visible hollow-conservation strategy in the harvested forest. However, the dispersion of logging over time and across the landscape, as well as the creation of reserves, are the most important and effective means of conserving habitat.

ASSESSING RISK

So how well protected are hollow-using species in our forests? The reserve network is extensive and substantial, and provides a secure foundation for conservation. However, the only way to fully answer this question is to monitor forest wildlife or to target research at those species most at risk.

The impact of disturbance and the capacity to adjust to it varies with each species. Some species are hardly affected by the loss of hollows. Other species do not have the flexibility in their behaviour or requirements to cope with this change. For example, species that are totally dependent on hollows for breeding are affected more than species that breed in both hollows and other types of shelter. Similarly, hollow-using species with small home ranges have fewer trees available in which to locate a hollow than species with large home ranges. In addition, large animals need large hollows (which are relatively rare when compared with the number of small hollows) and so they are more likely to be impacted upon than species that use small hollows. Combining and ranking these attributes helps to identify the species most at risk. Those species that are large, are totally dependent on hollows for breeding and have relatively small home ranges will be more affected by the loss of hollow-



Above: This large jarrah tree shows the ravages of age. Wind damage and fire scars allow water, fungi and micro-organisms to enter the tree, advancing the decay process.
Photo – Neville Passmore

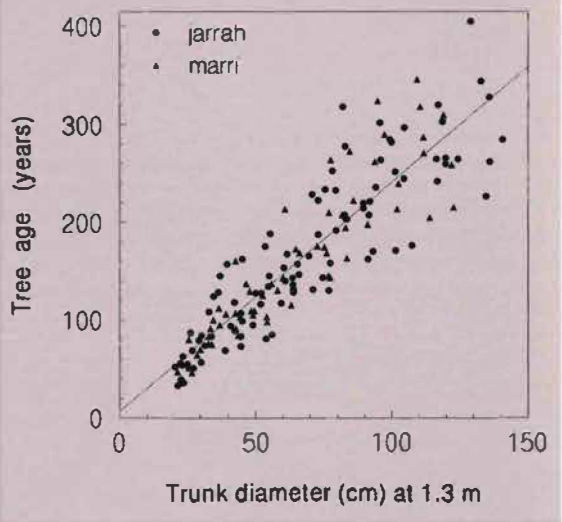
bearing trees than small species that nest in a variety of situations and have large home ranges.

To identify the species likely to suffer the greatest impact from the removal of hollow-bearing trees, Department of Conservation and Land Management scientist Ian Abbott and I assembled information from publications and sought expert advice from wildlife scientists. Of the 42 hollow-using species found in jarrah and karri forests, 29 are highly reliant on hollows in standing trees. Seventeen of these species are totally dependent on hollows for breeding and use relatively uncommon hollows. Of these seventeen, a group of eight species have small or medium-sized home ranges. These species—the rufous treecreeper, brushtail possum, sacred kingfisher (*Halcyon sancta*), phascogale, western rosella (*Platycercus icterotis*), red-capped parrot (*Purpureicephalus spurius*), Baudin's black-cockatoo (*Calyptorhynchus baudinii*) and red-tailed black-cockatoo—are most likely to be impacted by any shortage of hollows. Consequently, these species provide a focus for identifying the impacts of disturbance and determining the success of management practices.

AGE OF TREES WITH HOLLOWS

As trees grow, seasonal variations in wood growth create annual growth rings that can be counted to determine the tree's age (see 'The Age of Jarrah', *LANDSCOPE*, Autumn 1995). Growth rings on 162 jarrah and marri trees that had been felled for saw logs were counted. These trees were between 35 and 405 years old. The relationship between tree diameter and tree age can be used to estimate the age of trees with hollows. The smallest tree found with a usable hollow was 45 centimetres in diameter, and its growth rings showed that it was 163 years old. This tree had a single hollow big enough to be used by a striated pardalote. The youngest tree with a usable hollow was 48 centimetres in diameter, and its growth rings indicated it was 130 years old. This tree contained one hollow big enough for a phascogale or a red-capped parrot. A 405-year-old jarrah tree with a diameter of 129 centimetres had five hollows big enough to be used by the common brushtail possum, western ringtail possum, phascogale, Australian ringneck, western rosella, red-capped parrot and striated pardalote. In contrast, a similar-sized jarrah (135 centimetres in diameter) had a growth ring count of 227 years, but no hollows big enough to be used.

For all but the largest hollow users (red-tailed black-cockatoos and female brushtail possums), usable hollows are typically found in trees larger than about 45 to 50 centimetres in diameter, although phascogales and possums have been found using trees 40 centimetres in diameter. It's not unusual to find usable hollows in trees of this diameter range, which corresponds to ages of 112 to 124 years. Hollows in younger trees are generally suited to smaller species such as mardos, pygmy possums and striated pardalotes. The youngest tree observed with a hollow suited to red-tailed black-cockatoos was 130 years old.



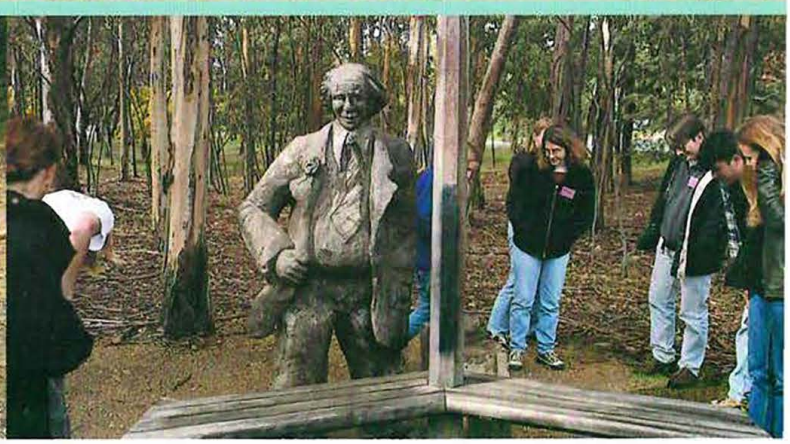
THE FUTURE

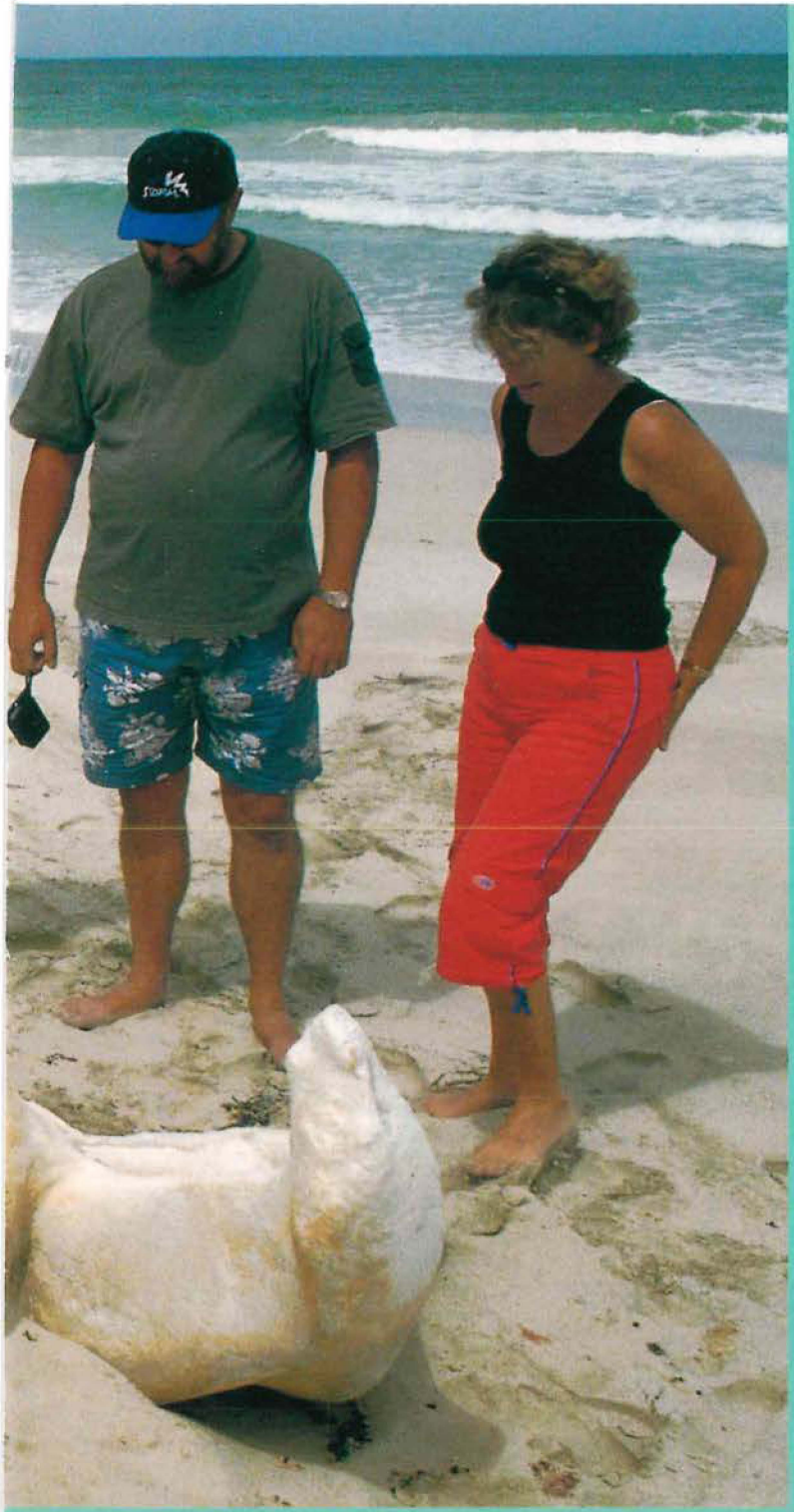
There are sound reasons to be optimistic about the future for hollow-using species in the south-west forests. The forests available for timber production, together with forest reserves and national parks, form a large, continuous and extensive forest mosaic through which species can disperse. The 1.9 million hectares of forests grow on relatively flat terrain, with few major rivers or other barriers to limit movement of ground-based species. Most hollow-using species are birds and bats, which can fly freely through the forest over relatively large distances and readily access hollows in the canopy. There are only three large, hollow-dependent, tree-dwelling mammals (compared with nine species in the forests of south-eastern Australia) and only three major types of tall forest. All of these factors simplify the task of managing the forests for hollow-dependent species in WA.

Forest management strategies are developed from an established and expanding basis of scientific knowledge of wildlife habitat requirements. Research—such as examining specific stand attributes that are related to the use of hollows by wildlife—is ongoing, and management practices are regularly adapted in the light of changing circumstances and improved knowledge. Fox baiting, recent increases in reservation and an ongoing commitment to adaptive management provide a promising outlook for hollow-dependent species in Western Australian forests.

Kim Whitford, from the department's Science Division in Dwellingup, researches the impacts of logging in the south-west forests. He can be contacted on (08) 9538 0021 or by email (kimwh@calm.wa.gov.au).

This article is based on studies described in scientific papers by Kim Whitford, Matthew Williams and Ian Abbott.





The guided experience

A new journey

A quiet revolution is occurring. The days of driving into a national park to snap a few photos are disappearing. Increasingly, visitors are coming to expect a guided experience as the cost effective and time efficient way to enrich their overall experience of Western Australia's natural attractions. And local communities are reaping the benefits, as they begin to enjoy increased employment as tour guides.

by Gil Field

Nature-based tourism is a core attraction of the tourism industry in Western Australia. The Department of Conservation and Land Management licenses more than 400 tour operators to bring visitors to national parks and marine parks in Western Australia. Most of these operations include travel, accommodation and meals, with an added guided experience component. Most of the tour operators' clients are interstate and overseas visitors.

However, fewer than 20 per cent of our visitors are from interstate or overseas. In other words, more than 80 per cent are Western Australians who are exploring their vast State, and most of them are self-drive 'free and independent travellers'. So it would be fair to say that the future of tourism in Western Australia lies more in our domestic market. Purchasing guided experiences is where we, as travellers, can make a difference to our experience and help to employ people in the nature-based tourism industry.

PARK EXPERIENCES

The department has 29 sites throughout Western Australia where guided activities are offered by staff and others. Access to these site-based activities is mostly by self-drive clients.

Daily attractions, such as the Monkey Mia Dolphin Experience and the Yanchep National Park Koala Experience, as well as more seasonal daily attractions, such as penguin viewing at The Penguin Experience Island Discovery Centre (from November to April, outside the penguin breeding season), provide short but enriching encounters for visitors to those sites.

There is a range of regular and varied activities, such as the 'Go Bush!' program at The Hills Forest in Mundaring and the Cave Tour at Yanchep National Park, north of Perth.

Seasonal activities programs are also conducted. These include the 'dry season' guided activities at Mirima National Park in the east Kimberley, Geikie Gorge Boat Tour in the west Kimberley and the spring, summer and autumn activities at the Valley of the Giants in Walpole-Nornalup National Park.

Above: A memorable moment at Monkey Mia, where the park guide improves the quality of experience for both people and dolphins.
Photo – Gil Field

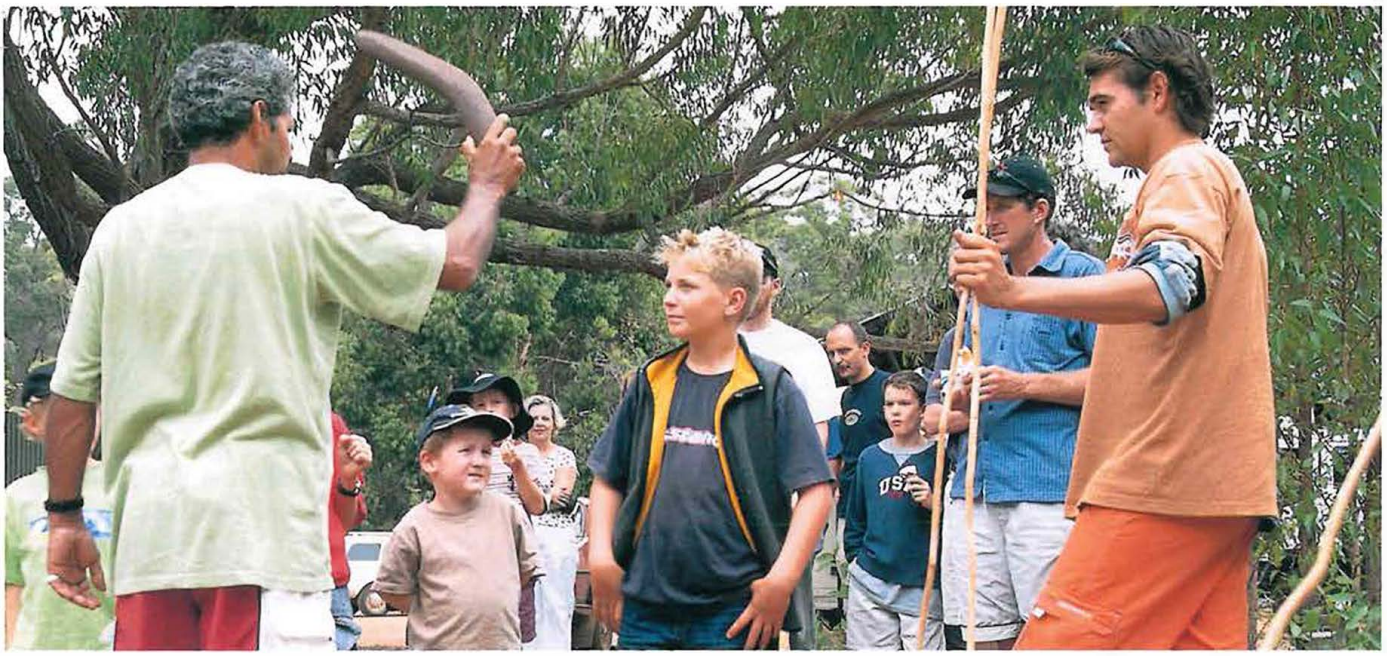
LANDSCOPE Expeditions offer people the chance to join scientists and regional staff from the department, often in remote areas of the State, and participate in scientific research and monitoring of wildlife and ecological events. They have enjoyed a strong support base over the past 10 years.

Special events, such as The Big Bush Heritage Celebration on Easter Saturday at Wharncliffe EcoDiscovery Centre in Margaret River, provide interpretive opportunities through guided activities at popular holiday times.

Customised activity programs and events for groups, such as the Australiana Day for Japanese visitors to The Hills Forest Discovery Centre, can also be provided.

Previous page
Main: A Park EcoGuide reveals the story behind this whale bone on Contos Beach in Leeuwin-Naturaliste National Park.
Photo – Gil Field
Insets (from left): Spear throwing with local Nyoongar guides.
Photo – Tony Nathan
Trainee EcoGuides at Mundaring Sculpture Park in the Perth hills.
Photo – Gil Field
Ready to go on a guided mountain biking adventure.
A close encounter of the furred kind.
Photos – Tony Nathan

Left: A Park EcoGuide helps youngsters get in touch with life on the edge at Contos Beach.
Photo – David Gough



Above and right: Sharing Aboriginal culture is an interactive experience at Wharncliffe EcoDiscovery Centre, in Margaret River.
Photos – Tony Nathan

TRAINING AND DEVELOPMENT

Currently, tourism courses at university and TAFE colleges are rivalling the interest in environmental management courses, yet many environment graduates struggle to find employment. Something needs to be done to stimulate the local market for nature-based tourism products so that tourism graduates don't go the same way.

During the past 16 years, the Visitor Interpretation Section within the department has put considerable effort into the training and professional development of members of the nature-based tourism industry. A four-day Designing Interpretive Ecotour Activities workshop has been conducted some 20 times, and is now at least an annual event attended by students from the University of Notre Dame Australia, in Fremantle, staff from other conservation agencies and interested individuals. This workshop looks at the planning, design, implementation and evaluation of guided activity programs, nature-based tours and special events.

Two books produced by the department—*Best Recipes for Interpreting Our Heritage* and *Developing Ecotours and Other Interpretive Activity Programs*—are making a significant contribution to the quality of nature-based tourism in Western Australia and elsewhere, by providing a benchmark for planning and designing activities, programs and tours in natural areas.

The department, in conjunction with the Western Australian Tourism Commission and the Kimberley Tourism Association, produced the highly successful *Kimberley Tourism Manual*. It was a response to requests from tour operators in the north-west seeking informed knowledge about the Kimberley environment and the places they were visiting. Now, the WA Government Old Growth Forest Policy and New Parks Strategy is funding a follow-up publication. The *South-West Tourism Manual* is currently in preparation and aims to benchmark the knowledge required for participants in the tourism industry in the south-west.

NEW INITIATIVES

In 2001, the department initiated a pilot Park EcoGuide Program in Purnululu National Park in the Kimberley. The program used volunteer guides and park rangers. The aim was to see how many campers would purchase a guided activity experience in addition to paying park visitor and camping fees. Around a third of the park's visitors participated in a guided activity, and, while this provided enough funding to pay a wage, due to the park's remote location, it didn't cover the travel costs involved in running the program. Nevertheless, visitor response was most encouraging.

In the summer of 2001–2002, a trial EcoGuide Program was implemented in Leeuwin-Naturaliste National Park at

Contos Campground, between Prevelly and Hamelin Bay, and at Wharncliffe EcoDiscovery Centre (the old Wharncliffe Mill) in Margaret River. Unfortunately, less than 10 per cent of campers at Contos attended the guided activities—an erratic and mostly disappointing response, but not wholly surprising since there were many more activities competing for visitors' time at this popular holiday destination.

In Easter 2002, The Big Bush Heritage Celebration at the Wharncliffe EcoDiscovery Centre was launched as a special event, using contract ecoguides, park rangers and other staff. There were displays by community groups (State Emergency Service, Margaret River-Augusta Historical Association), government agencies (Agriculture WA, CoastCare) and local businesses (the Celtic band Beltane Fire, a wood sculptor, local photographer, and Aboriginal craft and performance groups). This was an alternative approach to that trialed a few months earlier. The intent was to attract local community involvement, as well as resident and visitor participation, in guided activities that celebrated our natural and cultural heritage values.

There were more than 300 participants, and this was seen as a good start to an annual event. It demonstrated the department's position in embracing the community in partnership with community groups, individuals, businesses, residents and visitors, and in generating local employment.

The Big Bush Heritage Celebration was part of the south-west Park Activities Programs held over Easter and the autumn school holidays. Guided activities were again offered in Leeuwin-Naturaliste National Park at

Top left: The Penguin Experience Island Discovery Centre.
Photo – Michael James

Centre left: Trainee EcoGuides consider bush survival as a problem-solving activity at The Hills Forest Discovery Centre near Mundaring.
Photo – Gil Field

Left: Birdwatching—always one of the most popular of the guided wildlife observation activities on *LANDSCOPE* Expeditions.
Photo – Kevin Coate

Contos, Hamelin Bay and Ellensbrook; in Pemberton at the Gloucester Tree and D'Entrecasteaux National Park; and at Walpole in the Walpole-Nornalup National Park and The Valley of the Giants. Existing and past programs were given new impetus with the employment of local guides to assist park rangers and others.

It is expected that maintaining these programs will build the park 'ecoguiding' business through word of mouth and return visits to the sites. The Valley of the Giants has developed and maintained an interpretive activities program over the past five years, promoting on-site guided activities as well as activities at other sites led by independent tour operators and guides in the Walpole area.

CREATING A MARKET

The challenge ahead is to promote guided experiences to campers, other visitors and residents, and provide quality experiences. In this way, ecoguiding can become a profession, rather than just a casual seasonal employment opportunity.

Interpretation of the environment, history and culture through nature-based tourism enriches visitors' experiences, appreciation and support for management. Nature-based tourism also makes a financial contribution to local communities by stimulating the purchase of local products and providing local employment. Indirectly, through the use of environmental management programs and ecologically sustainable businesses, it minimises visitor impact by using water, energy and other resources wisely, and appropriately disposing of waste and rubbish where it cannot be reduced, reused or recycled.

The department's facilities and services are already making a significant contribution to local tourism businesses. The Tree Top Walk, in Walpole-Nornalup National Park's Valley of the Giants, has provided employment for locals as both ticketing staff and as guides. It is a major attraction to the area that has assisted other tourism businesses such as WOW Wilderness Adventures in Walpole, whose owner Gary Muir said, "Visitors to Walpole doubled and our family business trebled within one year of the Tree Top Walk opening".

For the ultimate guided experience, work with children and animals.
Photo – Tony Nathan

The construction of the Monkey Mia Visitor Centre complex, with a new ticketing office for tour operators, has seen business for local boat tour operators double and the creation of a business in artworks sold on site.

In Perth, the successful 'Perth Outdoors' and 'Go Bush!' activities programs are expanding to cover regional parks and bushlands across the metropolitan area. The news sheet *Perth Outdoors Guided Activities, Tours and Attractions* is cooperatively marketing and promoting a variety of guided activities and tours at a range of venues around Perth. It is evident that there is plenty to see and do with a guide if people will just give it a go.

THE FUTURE

Imagine arriving at your favourite campground and finding a range of low-cost activities available any day of the week—a Saturday evening meet and greet with a sausage sizzle, music and stories around the campfire and an open air slideshow highlighting local attractions; a Sunday morning beach walk where the kids could discover the intricacies of the fragile coastal environment in a fun and exciting way; and wildflower walks on weekdays with spotlighting tours at night. Such a range of activities could easily be provided by local guides.

As we see the benefits of placing guides at key sites throughout Western Australia to appeal to the self-drive market, we can expect more guides at key attractions (such as parks, historic and cultural sites, wildlife events and visitor centres) and accommodation centres (resorts, camping areas). Subsequently, casual seasonal employment should grow to make way for permanent, professional and accredited guides.

Site-based guides can also provide tour operators with high-quality, cost-effective and time-efficient packaged components that can be added to their tours. What's needed now is a concerted effort by agencies, industry and media to raise the profile of guiding, so it becomes a viable and professional business in its own right.

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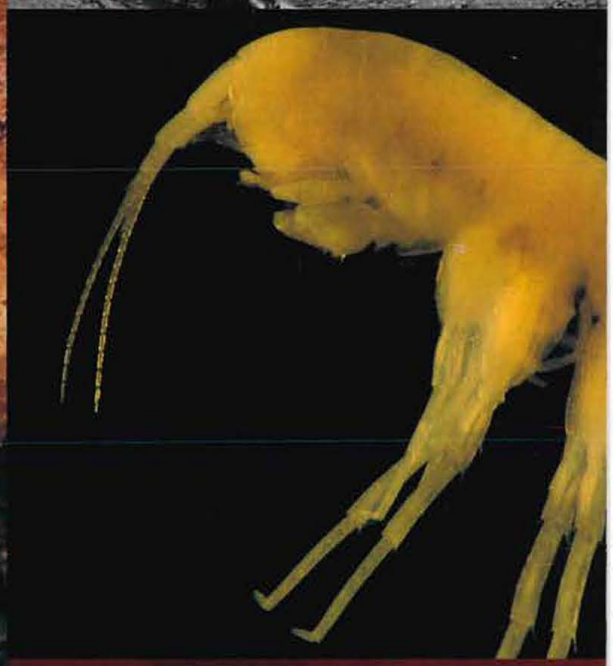
Threatened wildlife of the Yanchep caves



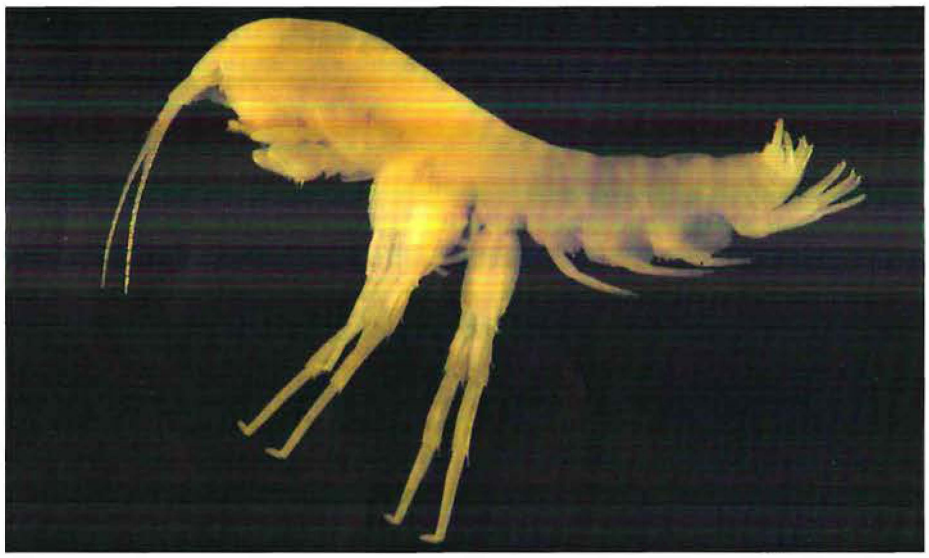
Beneath the Earth's surface, in the caves of Yanchep National Park, lives an amazing community of night fish, gilgies, leeches, beetles, mites, microscopic worms, snails and crustaceans. However, this unique underworld is seriously threatened by declining water levels caused by a range of factors. Can it be saved?

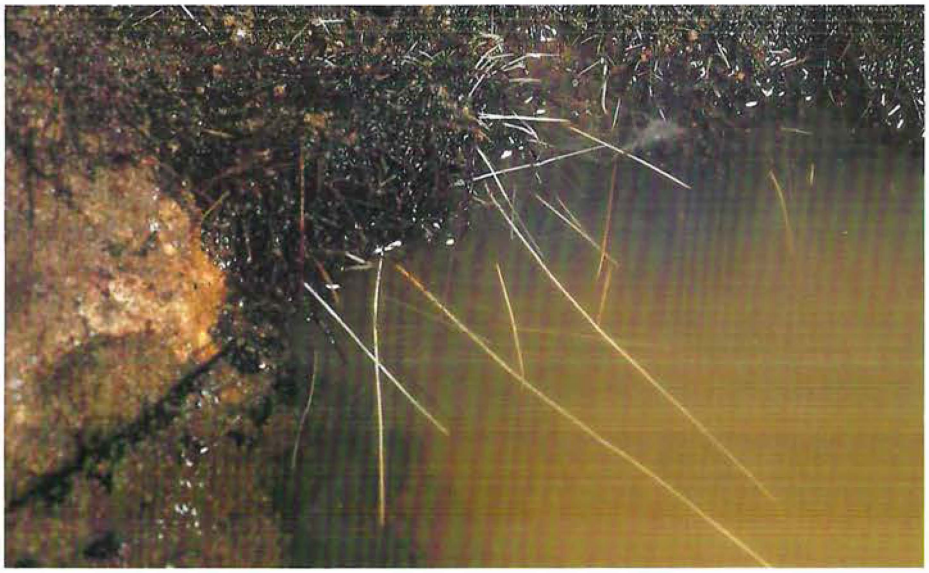
by John Blyth, Edyta Jasinska, Lyndon Mutter, Val English and Paul Tholen
Photographs by Michael James

Most dark zones of caves throughout the world are inhospitable places for animals to live in. This is mainly due to the lack of a reliable food source, because no plants will grow without light. Typically, all food must come from outside the caves in the form of washed-in debris, bat and cricket guano and dead animals. Known exceptions are caves in which bacteria use hydrogen sulphide as an energy source, and caves that contain tree roots.

In Western Australia, there are two areas (at Yanchep and on the Leeuwin-Naturaliste Ridge) that have relatively shallow caves containing mats of fine tree roots reaching down into streams and pools within the caves. These root-mats provide both food and shelter for numerous aquatic cave animals. Ancient species occur in the root-mats of both Yanchep and Leeuwin-Naturaliste cave waters (see 'Endangered', *LANDSCOPE*, Winter 1998). Edyta Jasinska and Brenton Knott, of The University of Western Australia (UWA), have studied these caves since the early 1980s.

The remarkable root-mat fauna consists mainly of invertebrates (animals without backbones), but night fish (*Bostockia porosa*) were also found in some of the Yanchep caves. A small number of ancient species are found only in a few (or just one!) of the Yanchep caves, and nowhere else. These caves are the only known location of at least six Gondwanan relicts—species whose ancestors existed when Australia was part of the supercontinent Gondwana, about 55–160 million years ago. None of these Gondwanan relicts would be able to survive the drying out of their habitat.





YANCHEP CAVE SYSTEM

The Yanchep caves occur at the junction of two ancient dune systems: the Tamala Limestone (Spearwood Dunes) and the silicon-rich sands of the Bassendean Dunes that underlie the Tamala Limestone in this area. The water in the caves comes from the Gnangara Mound—a shallow aquifer, held largely within the Bassendean dunes as if in a giant sponge (see key to landforms on page 37). In the area of Yanchep National Park, the water table coincides with the boundary between the surface limestone, five to 20 metres thick, and the underlying sands. This is also where an extensive development of caves occurs. The limestone and caves in the area formed between about 800,000 and 500,000 years ago.

Within the caves, the waters form a system of shallow streams, a number of them permanent and mostly only two centimetres deep. Channels up to 20 centimetres deep occur along the banks and in the narrowest sections of the streams. Being so shallow, these cave streams are extremely susceptible to changes in the level of the groundwater that feeds them, but 10 years ago groundwater levels varied very little. In fact, until the 1990s, all physical and chemical conditions of these cave stream waters were very stable, due to the substantial pressure and flow provided by the Gnangara Mound, with little direct contribution from rainfall. The freshness and low levels of ions in cave streams are typical of waters of the Gnangara Mound.

The fact that Gondwanan relicts occur in caves that were formed long after Gondwana broke up seems to be a paradox. However, it is believed that the animals, or their ancestors, lived in surface waters such as peatlands and springs on the ancient Darling Plateau.

Previous page
Main: Water Cave showing the current water level.
Inset: Close-up of the Crystal Cave crangonyctoid (*Hurleya* sp.).

Above left: The Crystal Cave crangonyctoid is critically endangered.
Photos – Edyta Jasinska

Left: Root-mat close up showing new growth (white shoots), Cabaret Cave.

During the last six million years, the permanently moist habitats of the Darling Plateau progressively dried and, about two million years ago, the Swan Coastal Plain emerged from the ocean. During later interglacial periods, the coastal climate was very wet and animals would have been flushed out of springs and wetlands down the Darling Scarp.

After the Yanchep caves began to form about 800,000 years ago, some of the animals would have been able to make their way to them through swamps and creeks. There, during the dry glacial periods, the animals would have moved into the caves seeking permanent water. They could have eventually come to live only in caves with permanent water and a reliable food source (the root-mats), having died out elsewhere as the permanent water on which they relied had virtually disappeared.

UNDERWORLD

The Western Australian Speleological Group has recorded more than 400 caves in Yanchep National Park, but only 10 to 15 contain permanent water, and only six of these are known to contain root-mats.

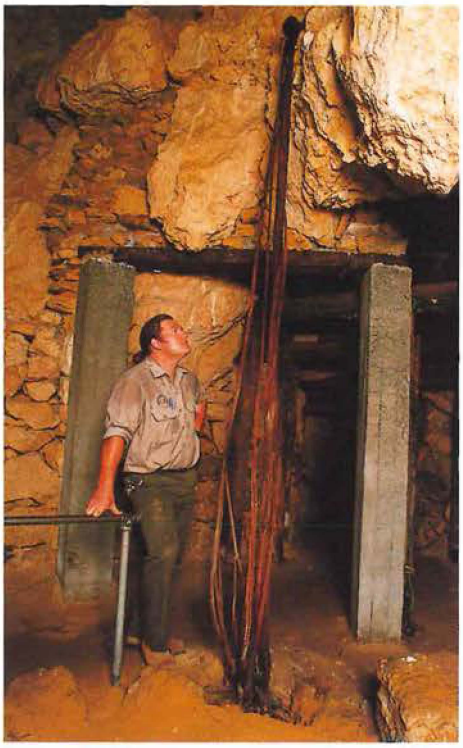
All of the roots that grow into the six caves at Yanchep belong to tuart trees (*Eucalyptus gomphocephala*). The root-mats in these caves provide a reliable food source, as well as shelter, and allow a complete and intricate miniature ecosystem to exist. The roots fringe the cave streams and form dense mats about 10 centimetres thick and 15 centimetres wide. A handful of the root-mats can contain about 500 animals. Microscopic fungi grow within the tissues of the fine roots and probably increase the nutritional value of the mats.

The cave fauna at Yanchep includes night fish, gilgies, leeches, beetles, mites, microscopic worms, snails and crustaceans. When first examined in detail, these six caves each contained 30 to 40 animal species. In total, about 100 species occur in the Yanchep caves. This is the greatest species richness known for aquatic cave habitat anywhere in the world (three to six species tends to be the norm for cave waters without root-mats). About a third of the 100 species are newly discovered, including the Gondwanan relicts.

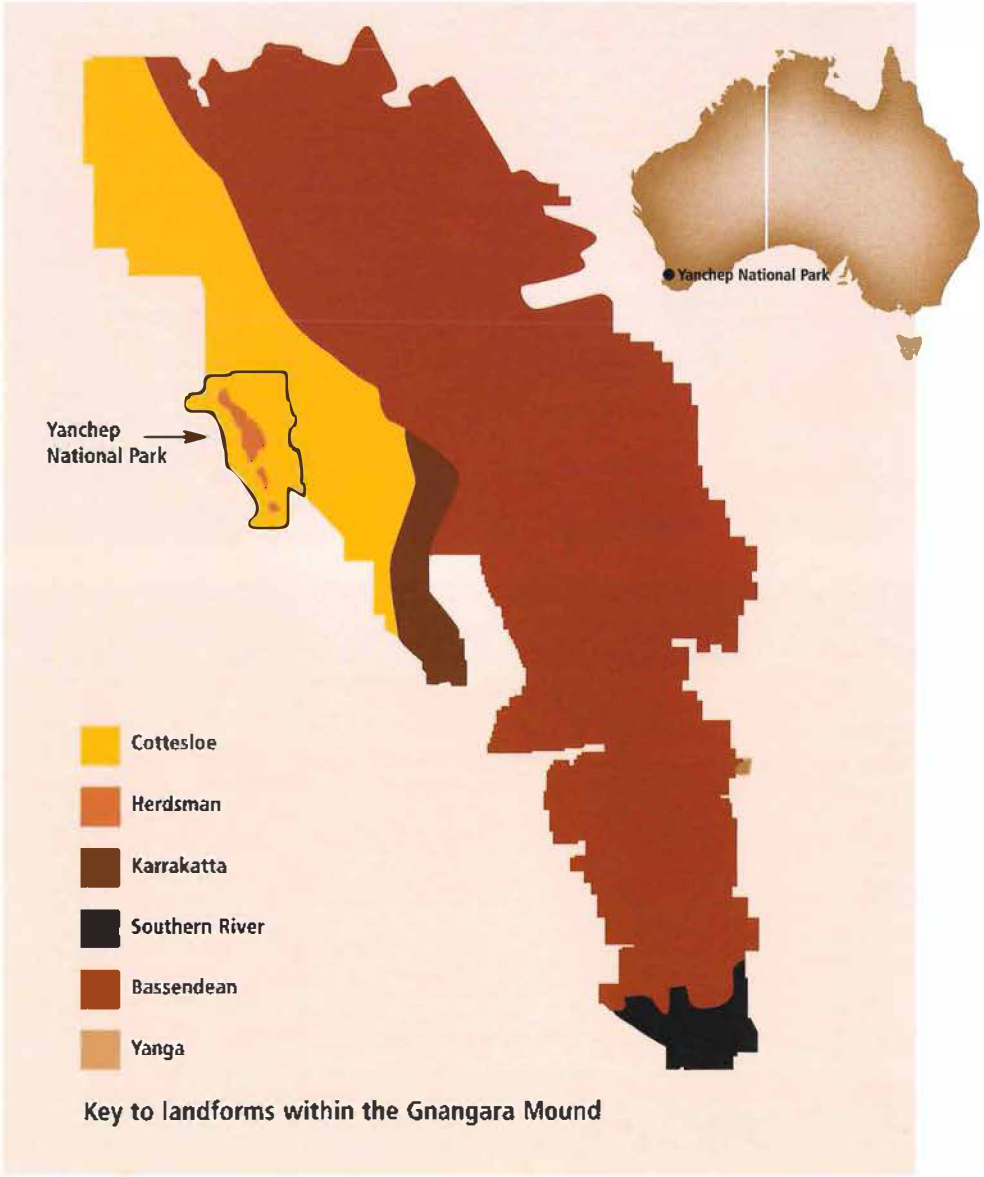
Even though the caves that contain the root-mat community are only separated by distances of 100 to 1500 metres, and are fed by the same water mound, they all contain at least one species that is found in no other cave. Little movement of animals between different caves is known, and some animals appear to be still evolving.

DECLINE OF WATER LEVELS

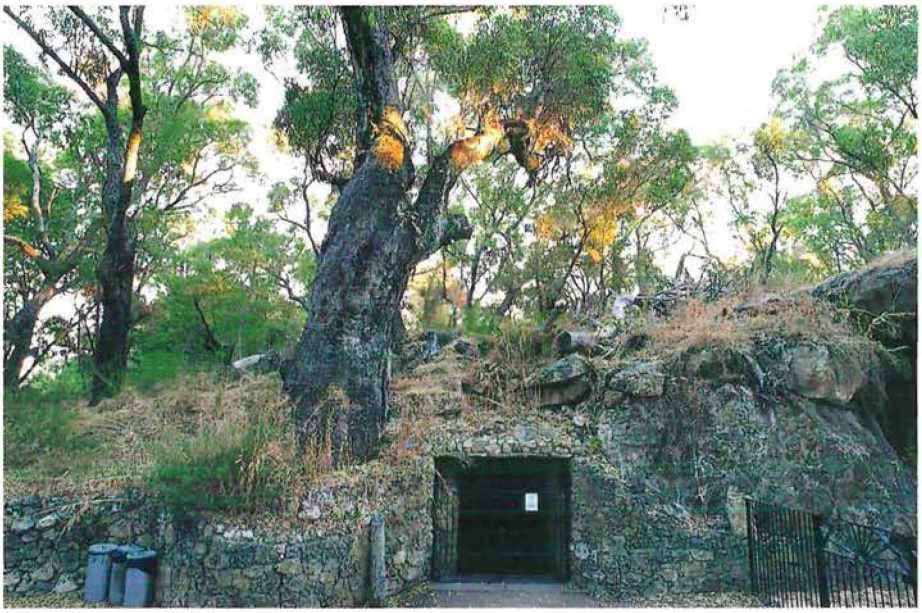
Since around 1976 the water level at the top of the Gnangara Mound has dropped by about five metres. Water and Rivers Commission analysis suggests that much of this decline has been caused by below-average rainfall between

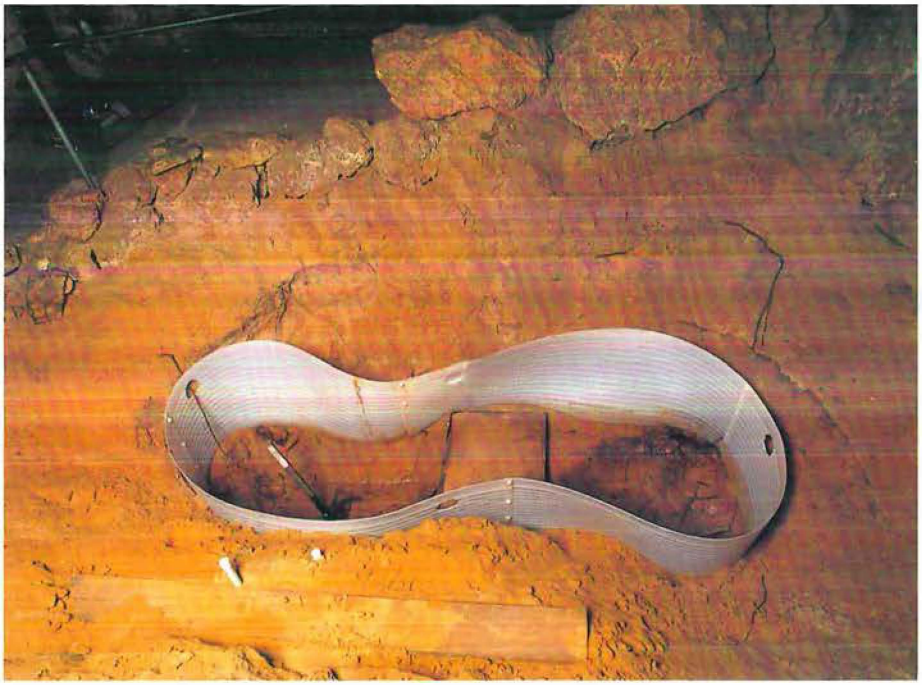


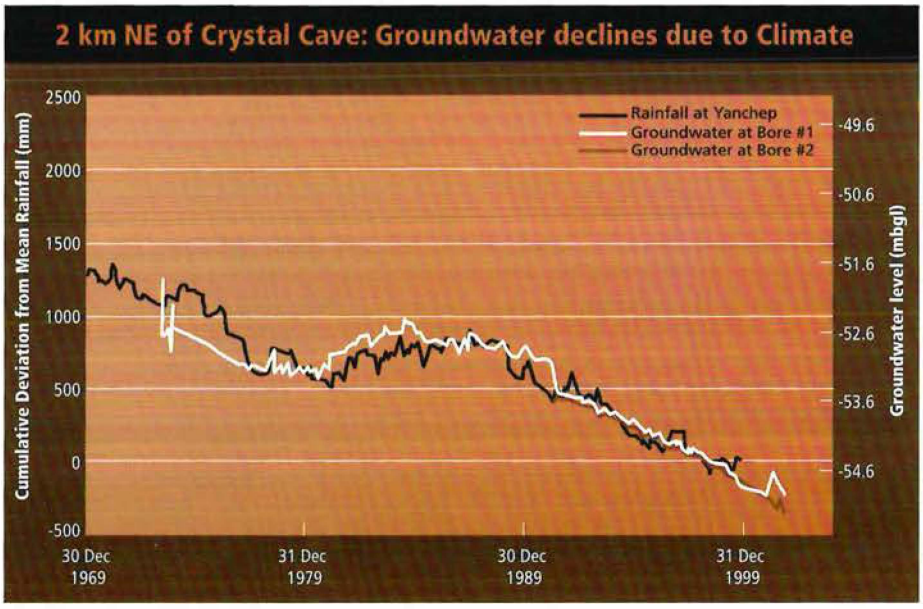
Right: Paul Tholen, Ranger (Nature Conservation) at Yanchep National Park, standing next to a tuart tap root in Crystal Cave.



Key to landforms within the Gnangara Mound







then and now (see graph on page 38).

However, zoologists familiar with the cave community believe that climate cannot be solely responsible for the loss of the permanent streams in the Yanchep caves. During the last glacial period (around 17,000 years ago) the climate was much drier than at present, yet the Gondwanan relicts persisted in the caves. They could not have done this if the cave streams had dried out. This suggests that it is the combination of lower rainfall and increased use of water, by public and private water abstraction and pine plantations, that has been critical in the recent drying of cave streams.

The hydraulic pressure head maintaining the Yanchep cave streams is no longer sufficient to keep the streams flowing in summer. Clarification of the contributions of the various factors to declining water levels is needed and studies are continuing.

The graph shows the close correlation between rainfall and water levels close to the Yanchep caves. An upward slope in the rainfall graph indicates rainfall above the long-term average, and a downward slope indicates below-average rainfall.

The volume and speed of water movement in cave streams has also fallen. The water level in Crystal Cave, which contains a threatened Gondwanan relict called the Crystal Cave crangonyctoid (an amphipod crustacean) but has no root-mat community, dropped by 25 centimetres between 1987 and 1997. This cave is very close to two of the root-mat caves.

The stream in Gilgie Cave (originally one of six root-mat caves at Yanchep) dried out completely in 1996, for the

Top left: Cabaret Cave area showing the tuart forest surrounding limestone caves.

Centre left: This pond containing Crystal Cave crangonyctoids is regularly excavated to follow the declining groundwater table. The plastic surround holds back the sandy stream bed to minimise the chance of collapse

Left: Rainfall (black) and groundwater levels (white and brown) at Yanchep from 1969 to 2000 (from Yesertener, C, 2002, with permission).

first time recorded, and recording of cave stream levels began in the early 1900s. When flow returned to Gilgie Cave in spring 1996, none of the larger animals, including the Gondwanan relicts, had returned to the cave stream three months after it began flowing again. So it appears that one out of the six occurrences of the root-mat community has been lost.

Water levels have continued to drop. From 1998 onwards, more cave streams containing root-mats have stopped running in summer, and extra water has been pumped into them to prevent them drying out completely.

RECOVERY ACTIONS

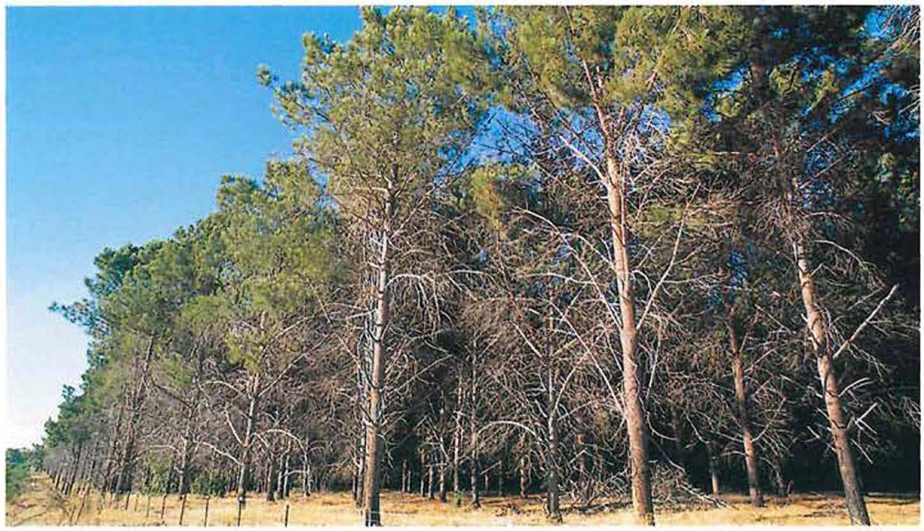
The community was listed as Critically Endangered, a Recovery Team was established and a draft interim recovery plan was developed by the end of 1997. The Recovery Team recommends both emergency actions and ongoing management to help improve water levels in the caves in the longer term.

Many organisations need to be involved in helping to conserve the root-mat community. The Department of Conservation and Land Management manages the caves and their animals, the Water and Rivers Commission monitors and maintains the levels and water quality of the Gnangara Mound and regulates its use, and the Forest Products Commission manages the pine plantations that use Gnangara Mound water. The Recovery Team includes representatives from each organisation, as well as scientists and other interest groups, such as the Water Corporation and the Western Australian Speleological Group.

A number of long-term measures have been implemented. The pine plantations in the catchment for the caves—about 15,000 hectares—are being thinned to a density that uses a similar amount of water to that used by the original vegetation. This target is likely to be reached by the agreed date, in late 2002. Monitoring of root-mat animals in the Yanchep caves is undertaken each year. Brenton Knott and Andrew Storey of UWA carry out this work, funded by the Water and Rivers Commission. The results of this, and of the water level monitoring, are reported to the Recovery Team. Monitoring, analysis and modelling of water levels to allow better understanding of what is needed to maintain levels that will conserve the root-mat community will continue. Monitoring wells were established in 1995 and 1996, both in the caves and upstream of them.

In addition to the long-term measures, Yanchep National Park staff have undertaken a number of emergency actions.

Four of the five caves with living root-mat assemblages now have watering systems to prevent the pools and root-mats from completely drying out. These are made up of lined pools with water pumped into them from soak-wells installed in the base of the caves. A float switch maintains water levels in the root-mat pools. Monitoring of the pumping systems requires an average of three visits per week, with a greater frequency over summer. Upgrading of liners, pumps and batteries has continued for the last three years. Water level probes have been



Above: Monitoring groundwater levels, Crystal Cave.

Above right: Paul Tholen with remedial water pumping and trickle feed set up on a section of root-mat to maintain water flow at Cabaret Cave.

Right: Pine plantation south of Yanchep National Park.

installed in the most dangerous caves, so as to limit the number of visits required.

The November 2000 results of fauna monitoring suggested that the watering systems were keeping the original animals in root-mat caves alive. However, groundwater levels have continued to fall—2001 was a very dry year—and some streams did not run even through the winter. Results of the spring–summer 2001 monitoring indicate that the condition of the root-mats, and the abundance and species diversity of animals, in the remaining five root-mat caves had declined, despite the watering systems having kept water in the pools.

In response to the recent monitoring report, and with advice from a consultant hydrogeologist, Yanchep staff have upgraded the watering systems to supply more water and get at least some water flowing through the root-mat pools.

In addition, the department has committed new resources to investigate and implement even more robust systems that can be easily monitored to determine the health of cave pools. This money will be spent on Crystal Cave, to protect the Crystal Cave crangonyctoid, on Cabaret Cave, which originally contained more species of animals than other root-mat caves, and on Water Cave, which still contains water. The methods developed can then be applied to other caves.

Left: A yabby in Water Cave. These introduced crustaceans threaten the rare root-mat creatures.

Below: Paul Tholen in Water Cave, looking at bands of limestone showing various water levels in previous seasons.

THE FUTURE

Other threats to the root-mat community include the potential death of tuart trees that provide the root-mats, vandalism, cave collapses and introduced animals such as yabbies (*Cherax destructor*). Nevertheless, if the current upgrading of water supply systems is able to maintain the root-mat community in the five caves in which it still occurs, and if there is an eventual change back to higher rainfall, the prospects for this remarkable assemblage of invertebrates would be good. However, the longer the dry conditions last, the lower the water levels will become, and the more difficult it will be to keep the root-mat community alive.

The pine trees on the Gnangara Mound are an important resource to the State and worth many millions of dollars, as is the water for public and private use. Nevertheless, reduction in the water used by these two factors is likely to benefit the root-mat community. The recovery team is looking at how further reductions might be achieved. For instance, the pine plantations are now being harvested, and will eventually be largely replaced with different vegetation that will use less water. Speeding up that process could contribute to the recovery of the Yanchep root-mat community.

The pattern and management of future land developments, particularly to the east of the caves, may determine whether or not the quality and level of the cave streams can be maintained. Sustainable management of Gnangara Mound water will be crucial in determining the future of the root-mat community.

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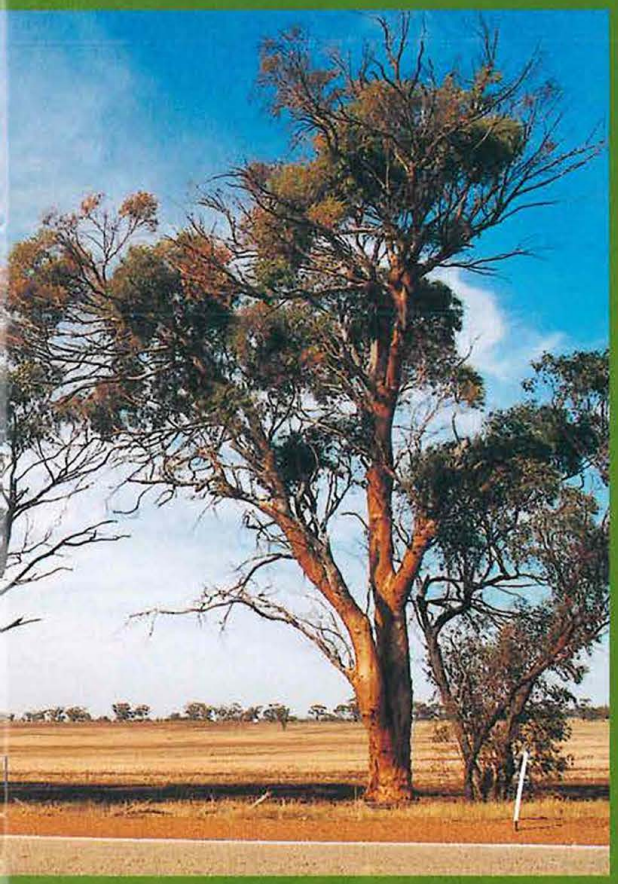
Mundulla Yellows — a new tree-dieback threat

A recently described tree-killing disease, Mundulla Yellows, has been found in Western Australia. It has the potential to seriously affect a number of our native plant species.
What is Mundulla Yellows and what can be done to combat the disease?



by Dagmar Hanold,
Mike Stukely and
John W Randles

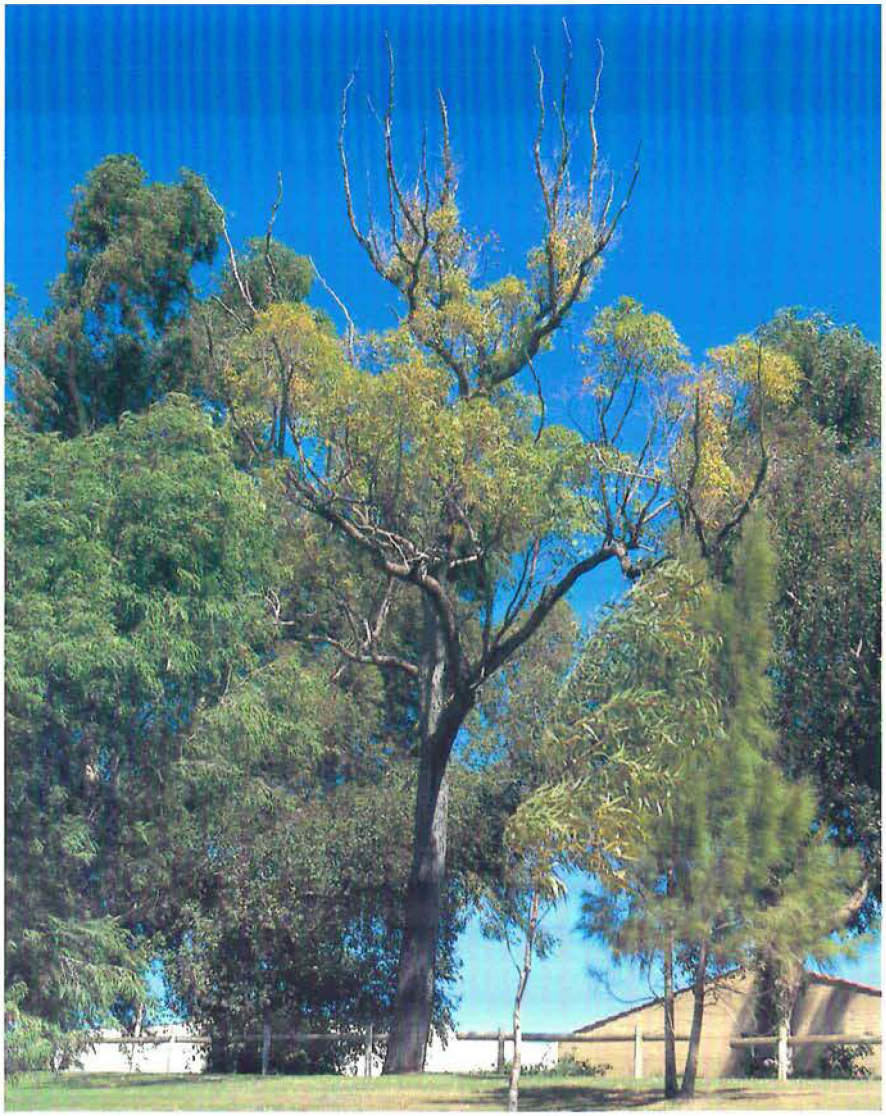
In Western Australia, the term 'dieback' generally refers to the devastating disease of many native plants, caused by the root-rotting slime mould *Phytophthora cinnamomi*. But there are other diseases of trees, caused by a variety of living organisms or environmental factors, that also cause tree crowns to die back. A little-known and only recently described disease, Mundulla Yellows, has the potential to seriously affect a number of our native plant species, as well as revegetation plantings on farms and possibly some eucalypt plantations. Mundulla Yellows is a progressive slow dieback and yellowing disease of many varieties of eucalypts, now suspected of being caused by a virus-like agent. It has been reported in trees of all ages. Once symptoms appear, the affected trees do not recover, and die within a few years.

Research is in progress to identify the cause of Mundulla Yellows, to develop a rapid diagnostic test, and to determine its distribution and how it is spread, so that strategies can be developed to manage the disease.

WHERE IS IT?

Mundulla Yellows was first reported in the late 1970s in the south-east of South Australia, by bee keeper Geoff Cotton. There is evidence that the disease also occurs in other States, including Western Australia, but typical Mundulla Yellows symptoms have not been reported outside Australia. In South Australia, Mundulla Yellows is present in scattered sites throughout an area estimated to exceed 25,000 square kilometres—and it is spreading! Many of the sites show high incidence of the disease.

Mundulla Yellows is named after the town of Mundulla in South Australia (see box). Its symptoms have been observed in a wide range of eucalypts growing in modified landscapes, as well as in remnant natural vegetation. Sheoaks (the *Allocasuarina* spp.), banksias (*Banksia* spp.) and wattles (*Acacia* spp.) show similar symptoms, which suggests that the disease may not be confined to eucalypts. Mundulla Yellows has so far been observed mainly in sites that have undergone significant disturbance, such as farmland, roadsides and urban parks. However, it has been seen occasionally in natural forest in eastern Australia.



Previous page
Main: A jarrah leaf showing interveinal yellowing—a sympton of Mundulla Yellows.
Photo – Mike Stukely
Inset: Salmon gum with medium stage Mundulla Yellows symptoms on a roadside in the WA Wheatbelt.
Photo – Allan Wills

Above: A jarrah (*Eucalyptus marginata*) showing medium to late stage Mundulla Yellows symptoms, in a Perth suburban park. Dead branches can be seen at the top, while the dense epicormic shoots that have sprouted lower down are clearly yellow. Only a small amount of green foliage remains. The other nearby eucalypts still appear healthy.
Photo – Mike Stukely

The first sightings of Mundulla Yellows in WA were made by Frank Podger (see box). Recent surveys by the Department of Conservation and Land Management in WA have located additional species with Mundulla Yellows symptoms. They include river redgum (*Eucalyptus camaldulensis*) and lemon-scented gum (*Corymbia citriodora*)—both of which are cultivated—as well as the WA natives salmon gum (*E. salmonophloia*) and York gum (*E. loxophleba*). Affected trees occur in a scattered distribution, and mostly in coastal areas, although Mundulla Yellows symptoms have been observed as far inland as York, Williams and Boyup Brook. In the Perth area, sheoaks also appear to be affected by Mundulla Yellows. The declines of wandoo (*E. wandoo*) and flooded gum (*E. rudis*) in the Wheatbelt and of tuart (*E. gomphocephala*) south of Perth do not, however, appear to be associated with Mundulla Yellows.

AN ENVIRONMENTAL CONCERN

The origin of Mundulla Yellows is unknown. Is Mundulla Yellows an exotic disease that has only recently

Right: Pricklybark (*Eucalyptus todtiana*) with Mundulla Yellows symptoms in a Perth suburban park. Dead limbs have been removed for safety reasons, but this treatment does not stop the disease, and clear yellowing is now spreading to other parts of the crown.
Photo – Mike Stukely

Centre right: Buckingham Old Coach Road, South Australia, showing healthy river redgums photographed during a flood in 1906.
Photo – Courtesy Mr Adrian Packer

Below right: The same site in 1999 with tree deaths due to Mundulla Yellows.
Photo – Courtesy The Border Chronicle

arrived in Australia? If so, where did it come from, and why is it already so widespread when its rate of spread appears slow? Alternatively, has the disease been present for a long time as a latent infection in some plants, causing little or no damage, and has its recent increase been caused by environmental changes favouring disease development or perhaps due to mutations in the pathogen(s)? Further investigation is needed.

Mundulla Yellows is now acknowledged as a threat of national significance to natural biodiversity and ecological sustainability. It causes the irreversible loss of natural vegetation, including ancient gum trees. Since a wide range of eucalypts and other species of native flora, which comprise natural Australian ecosystems, appear to be affected, it poses potential danger to natural wildlife habitats and, thus, the conservation of threatened plant and animal species. It has evoked considerable public concern, as well as much speculation as to its cause.

The potential of Mundulla Yellows to cause damage to our native flora may be exacerbated by climatic changes predicted for the coming decades. It is potentially detrimental to a number of industries and parties, including commercial tree growers, bee keepers, tourism, native cut flowers, public amenity, land and forest managers, and local government. It could jeopardise revegetation programs, salinity and groundwater level control, and input on the international carbon credits policy,

MUNDULLA YELLOWS: A SHORT HISTORY (BY FRANK PODGER)

In 1979, bee keepers and farmers Geoff Cotton, Bill Hunt and Sandy Mathison, from the Tatiara district of South Australia, noticed abnormal patches of bright yellow foliage in small numbers of large river redgums (*E. camaldulensis*) around Mundulla and in South Australian blue gum (*E. leucoxylon*) near Keith, close to the border with Victoria.

It is these magnificent old trees that lend an essential Australian character to the landscape, forever captured in the art of Hans Heysen. These ancient trees slowly declined and, over the next decade, died. Neighbouring trees also became affected, and discrete new centres of disease gradually appeared elsewhere in the landscape.

Despite Cotton's growing apprehension, most landholders took little notice of the problem until 1991, when Cotton first showed examples of Mundulla Yellows to David Paton of Adelaide University. In 1992, vital though modest research grants from the Honey Bee Research Council and from the Save the Bush Fund allowed Paton and his students to begin a disease monitoring program. Over the next five years, this work showed greater than expected rates of deterioration within affected trees, and further spread of the disease to healthy neighbours was much greater than expected.

The name 'Mundulla Yellows' was adopted in 1997 by Podger, Cotton, Choate and Randles, and is now in general use. The name refers to the small and lovely rural town of Mundulla (the name given by indigenous people)—the place where the disease was first recognised and where strong support for subsequent action originated—and the disease's distinctive and striking set of symptoms, particularly the early appearance of small clusters of bright yellow leaves in otherwise healthy crowns.

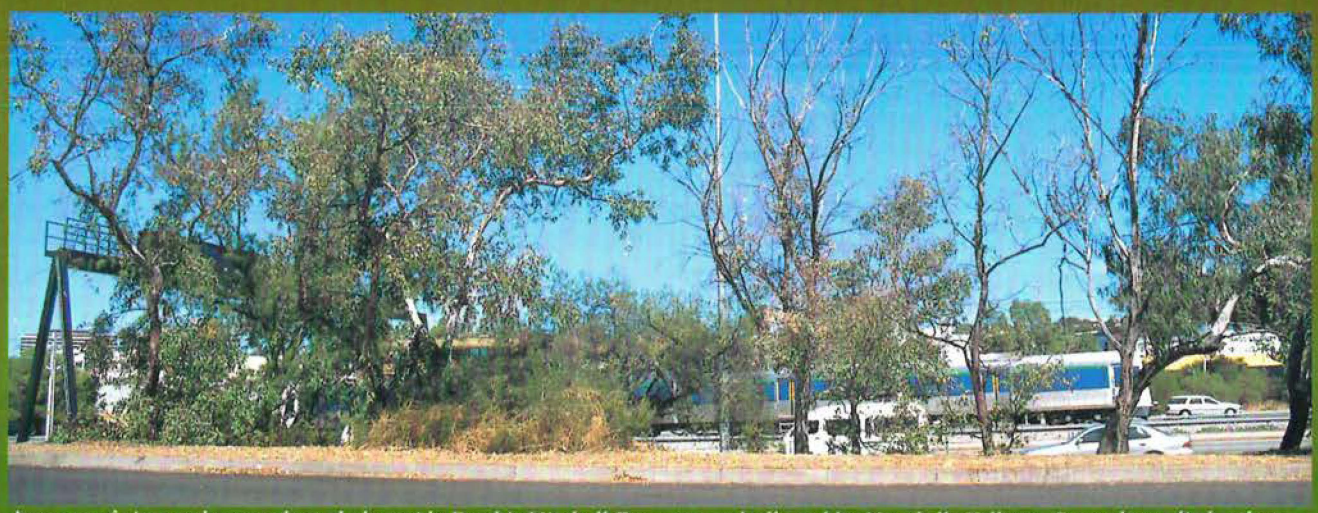
The connection with Western Australia first emerged soon after a conversation I had with Stan Bellgard in early 1993. He was then researching *Phytophthora megasperma* for the WA Department of Conservation and Land Management. He told me of a report from South Australia of the possible involvement of *P. megasperma* with widespread deaths of river redgum. To me, however, it seemed that several features of Mundulla Yellows, and of the climatic regime at Mundulla, did not fit the published requirements of *P. megasperma*. In August 1993 I visited the Tatiara district for the first time and was directed to Geoff Cotton. We took soil samples at five diseased sites around Mundulla, none of which yielded any species of *Phytophthora*. Most importantly, no evidence of rot in even the smallest secondarily thickened roots was observed in five excavated saplings of diseased river redgums.

Upon my return to Perth, I saw that Mundulla Yellows was widely established there. However, the degree of damage and the stages of symptom development seemed to indicate a later arrival in Perth than at Mundulla, perhaps by a decade or more. Soon afterwards, I encountered a report of work in Italy, which described somewhat similar symptoms in young eucalypts. The authors had attributed that disease to a phytoplasma. This led me to contact with Adelaide University's distinguished plant virologist John Randles at the Waite Institute. His subsequent interest has led to the first significant funding to support the assignment of Dagmar Hanold to research the possible role of phytoplasmas and viruses, and to the advances reported in this article.

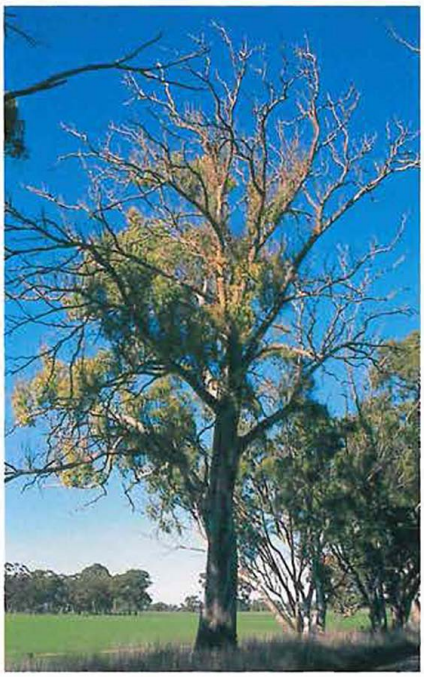
In the course of private surveys from 1993, over more than 20,000 kilometres, I have encountered Mundulla Yellows at many places across the length and breadth of Australia. The principal features of distribution of the disease, noted throughout these travels, are:

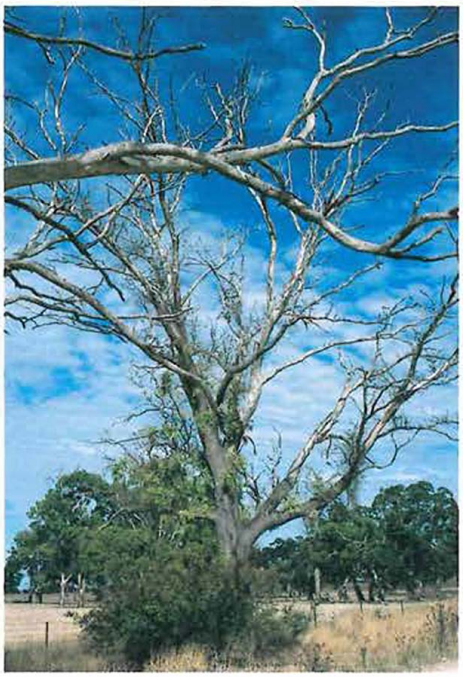
- it is rarely seen in essentially undisturbed natural vegetation, and then at the very margin with cleared land and roadways;
- in WA it occurs in a broken pattern that extends northward from Walpole in the far south-west to include infested sites in Bunbury, Perth, Geraldton, and on to the wet-dry tropics at Broome, Derby, Kununurra and, only in the last two years, Wyndham; and
- in country towns and cities, where it is most commonly encountered, it is most frequent in well-watered parks, road verge plantings subject to run-off, and well-cared-for home gardens. It is very uncommon at places where dry season moisture status is not ameliorated by some source of supplementary water.

Twenty-three eucalypt species native to Western Australia have been recorded as affected by Mundulla Yellows. Within Western Australia, these include tropical species such as long-fruited bloodwood (*Corymbia polycarpa*), woollybutt (*Eucalyptus miniata*) and Darwin stringybark (*E. tetrodonta*), which are highly susceptible, as are the southern temperate marri, red-flowering gum (*C. ficifolia*), jarrah, blackbutt (*E. patens*) and pricklybark (*E. todtiana*). Some other species natural to semi-arid areas of WA, and used in exotic plantings here and elsewhere, are also affected. A great many more eastern Australian native species are often severely damaged in exotic cultivation around Australia.



A group of river redgums planted alongside Perth's Mitchell Freeway, and affected by Mundulla Yellows. Some have died, others are near death, but some still appear healthy. Photo – Mike Stukely





and could impact on quarantine practices.

Mundulla Yellows has symptoms different from those of previously reported diseases of eucalypts. To define the problem—and to distinguish Mundulla Yellows from yellowing due to other factors—symptoms have been described in *A Field Guide to Mundulla Yellows* by D Hanold and J W Randles, published in 1999 by the University of Adelaide. The disease passes through three stages: early, medium and late.

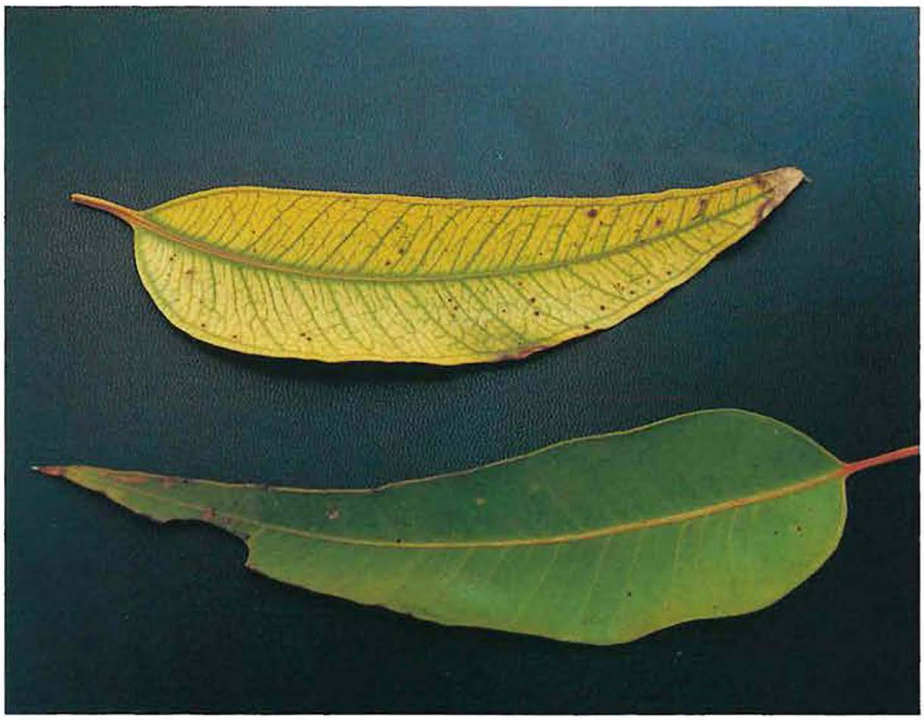
FINDING THE CAUSE

When investigations into the cause of Mundulla Yellows using molecular methods began, in January 2000, a living organism was thought to be the cause (see box on page 47). This was because affected trees occurred in mixed stands with, or immediately adjacent to, unaffected trees. If environmental factors—such as nutrient imbalances, herbicide spraying and high soil salinity—were the cause, they would be more likely to affect most trees in an area. Also, some disease symptoms had developed in previously healthy plants grafted with patches of bark taken from Mundulla Yellows-affected trees. This method is used widely by plant pathologists to see if a contagious agent is present.

Unlike *Phytophthora*-induced dieback, there was no evidence to suggest that disease-causing organisms such as fungi, bacteria or nematodes were associated with Mundulla Yellows. So researchers began to investigate the hypothesis that Mundulla Yellows was caused by a micro-organism that could not live or replicate outside the host cells (obligate intracellular pathogen).

Plant pathogens in this category can belong to the virus, viroid or phytoplasma groups. So far, more than 1000 viruses, 30 viroids and about 200

Top photos: Stages of Mundulla Yellows symptom development in river redgum.
Top left: Early stage. Uneven yellowing affects the outer parts of one limb or a segment of the crown. These zones comprise fully expanded leaves with interveinal yellowing (chlorosis).
Top centre: Medium stage. Dieback of affected shoots occurs with progression of yellowing inwards towards the centre of the crown. Flowering and seed production decline on the affected branches. Neighbouring limbs subsequently develop the same symptoms. Part of the crown is still unaffected.
Top right: Late stage. Yellow 'panic growth' (epicormic shoots) below the dying zones gives a denser appearance. Seed production ceases. Dieback progresses. Eventually the whole crown shows dieback and the tree dies.
Photos – Dagmar Hanold



Right: A jarrah leaf showing interveinal yellowing (top) compared with one that is healthy.
Photo – Mike Stukely

phytoplasmas are known to infect plants. Phytoplasmas and viroids do not vary much in their structure, but viruses can be very diverse. They can vary in the structure and biochemical properties of their genome (consisting of nucleic acids, i.e. DNA or RNA), and the composition, shape and size of their particles (consisting of proteins). Consequently, there is a vast range of potential candidates for this investigation.

Obligate intracellular plant pathogens cannot spread independently, but need either biological vectors or mechanical means of transmission. Sap-sucking insects, nematodes, fungi, pollen, seed and plant sap carried on tools are examples identified in the past as possible modes of spread.

BREAKTHROUGH

Thanks to advances in biotechnology, there is a range of methods available for testing whether such a pathogen is responsible for Mundulla Yellows. Tissue samples from normal eucalypts were compared with those affected by Mundulla Yellows using different means.

Karen Gibb and Nuredin Habili carried out tests that detected phytoplasmas in eucalypts; however, they were found with similar frequency in Mundulla Yellows-affected trees and healthy trees, so did not appear to be a cause of Mundulla Yellows. Virus-like particles could be observed occasionally in leaf tissue by means of electron microscopy, but their role as a cause could not be confirmed by this method.

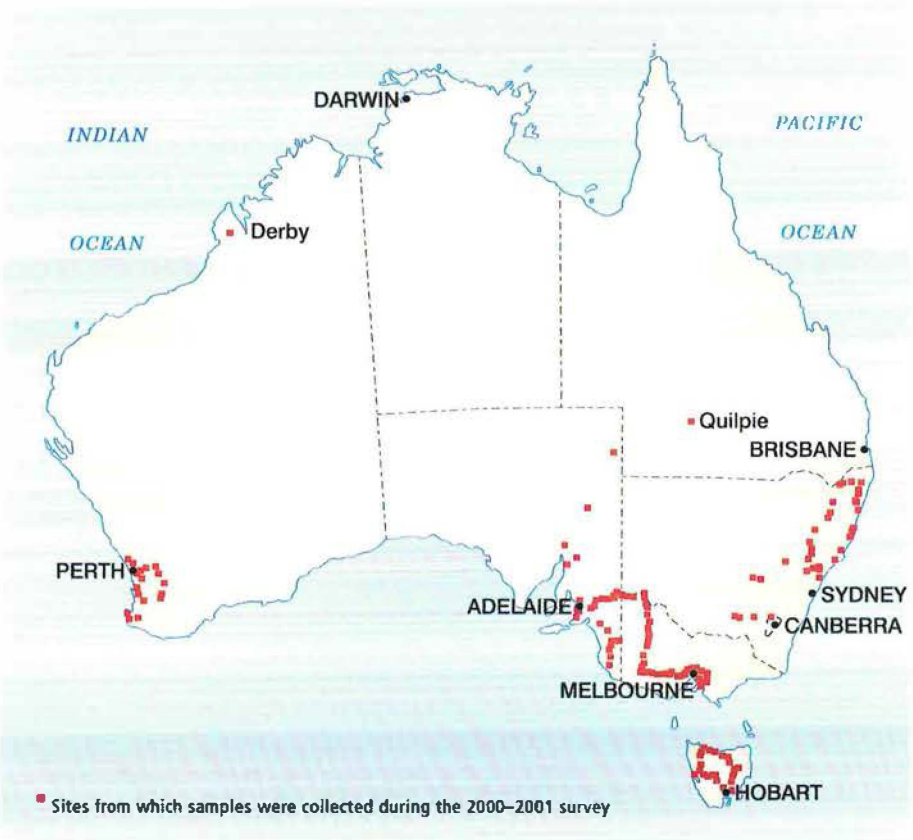
Left: **Dieback, leaf distortion and stunting symptoms in a river redgum seedling in the glasshouse after bark patch grafting, with normal seedlings behind.**
Photo – Dagmar Hanold

As no viruses or viroids of eucalypts had previously been characterised, a molecular test for virus-like agents in eucalypt tissue first had to be developed to test Mundulla Yellows-affected trees. Purified leaf extracts would be expected to comprise both general 'background' components from the host plant's cells and additional unusual components from pathogens if they were present. A breakthrough was made with this approach. Unusual nucleic acids (MY-RNAs) were found in Mundulla Yellows-affected river redgums (*E. camaldulensis*) in the south-east of South Australia. Indications from the size and biochemical characteristics of these nucleic acids pointed to a possible association with a virus or viroid.

MY-RNAs were detected in the leaf tissue of affected trees in South Australia before symptoms developed. This suggests that MY-RNAs are more likely to be associated with a cause rather than an effect of the disease. It also indicates that there may be a significant lag period between infection and appearance of disease symptoms. MY-RNAs have been detected in trees within revegetation sites and plantations less than a year after they were planted into areas previously without Mundulla Yellows. They have also been found in nursery-grown seedlings in the glasshouse. This suggests that the widely used practice of raising seedlings in one area for planting elsewhere may carry a risk of spreading Mundulla Yellows.

SURVEY

A survey conducted in the southern Australian states in 2000–2001 detected MY-RNAs in more than 30 species of eucalypts, as well as in sheoaks and bottlebrushes (*Callistemon* spp.), at a number of locations. However, it appears that symptoms may vary, perhaps due to environmental or host factors, or possibly variations in the MY-RNAs. In samples taken from trees with Mundulla Yellows symptoms in Western



Australia, MY-RNAs have so far been detected in marri (*Corymbia calophylla*), salmon gum, York gum and cultivated river redgum in the south-west, as well as in Darwin box (*E. tectifica*) from the tropical north.

There is preliminary evidence that insects may spread Mundulla Yellows. Field sites are being monitored for the development of symptoms and spread of MY-RNAs. Since symptoms take time to develop, and the spread of the disease appears to be slow, samples need to be collected regularly over at least five years.

With the above evidence, we are now investigating the hypothesis that Mundulla Yellows is caused by a virus-like agent. MY-RNAs now need to be characterised to test their association with a potential virus-like pathogen. A sensitive, specific and fast routine test suitable for screening large numbers of samples from a wide range of plant species needs to be developed. This will be essential for testing nursery material and planting stock for infected material, and to identify possible sources of genetic disease resistance for use in breeding programs. It will also be essential for investigating mechanisms of disease expression, modes of spread (such as different insect species) and other features of the disease cycle.

THE FUTURE

In the case of *Phytophthora* dieback in WA, it took more than 40 years from the first records of symptoms to the discovery of the cause—and, by then, huge areas of vegetation had been devastated. Groundbreaking advances in Mundulla Yellows research during the past two years have opened the way towards identifying the cause of this disease. Only when the disease cycle is known can specific strategies be designed to disrupt it and thus control the spread of the disease. Until more specific knowledge is available, general plant hygiene practices will help to minimise the risk through human activity of spreading diseases, including Mundulla Yellows, from plant to plant and, most importantly, into new areas. An integrated research program towards nationwide control of Mundulla Yellows has been devised, but funding still needs to be secured.

FINDING THE CAUSE OF A NEW PLANT DISEASE

Finding the cause of a new disease is rather like detective work. Evidence must be critically examined and possible suspects eliminated by means of specialised investigation methods. The approach we have used successfully in the past includes the following steps:

1. *Define the disease* and provide a range of descriptors to differentiate it from other diseases or disorders.
2. *Separate facts from fiction*. Usually a mixture of opinions and valid observations exists when starting to investigate a disease of unknown cause. It is necessary to critically assess this mixture to determine what facts are available to build on.
3. *Formulate a working hypothesis* on the most likely cause. The disease may be due to living organisms or environmental factors.
4. *Test this hypothesis* by designing experiments to establish whether it is true or false.
5. *Identify the cause of the disease* by proving or disproving the hypothesis. A set of rules established by the early microbiologist R Koch (Koch's Postulates) is used to verify whether the cause has been found. If the first hypothesis turns out to be wrong, a different one may have to be established and tested.
6. *Investigate the disease*, if the cause is a living organism, by: a) characterising its causal organism(s); b) determining the host range and the events leading to the disease's appearance and spread, i.e. the disease cycle; and c) examining the effects of environmental factors on disease expression.
7. *Design control or management strategies*. Once the disease cycle is known, strategies can be designed to disrupt it. This could involve controlling vector insects or preventing transmission by other means; identifying genetic resistance for use in breeding programs to establish resistant lines for replanting; or, in the case of some viruses, designing mild strains to inoculate host trees and thus prevent infection by virulent ones.

Depending on the nature of the pathogen and the host plants under investigation, this complete process could take many years. However, it prepares a sound base of scientific knowledge on which to build strategies to deal with a disease problem. In the long term, it saves resources from being wasted on unsuccessful trial-and-error approaches, and it may provide wider benefits by increasing our knowledge of plant pathogens. We are applying this approach to investigate the cause of Mundulla Yellows.

by Dagmar Hanold and John W Randles

Dagmar Hanold is a molecular biologist specialising in plant viruses and viroids of trees. She has been developing molecular diagnostic methods for new diseases and has conducted extensive disease surveys on palms in the Pacific area.

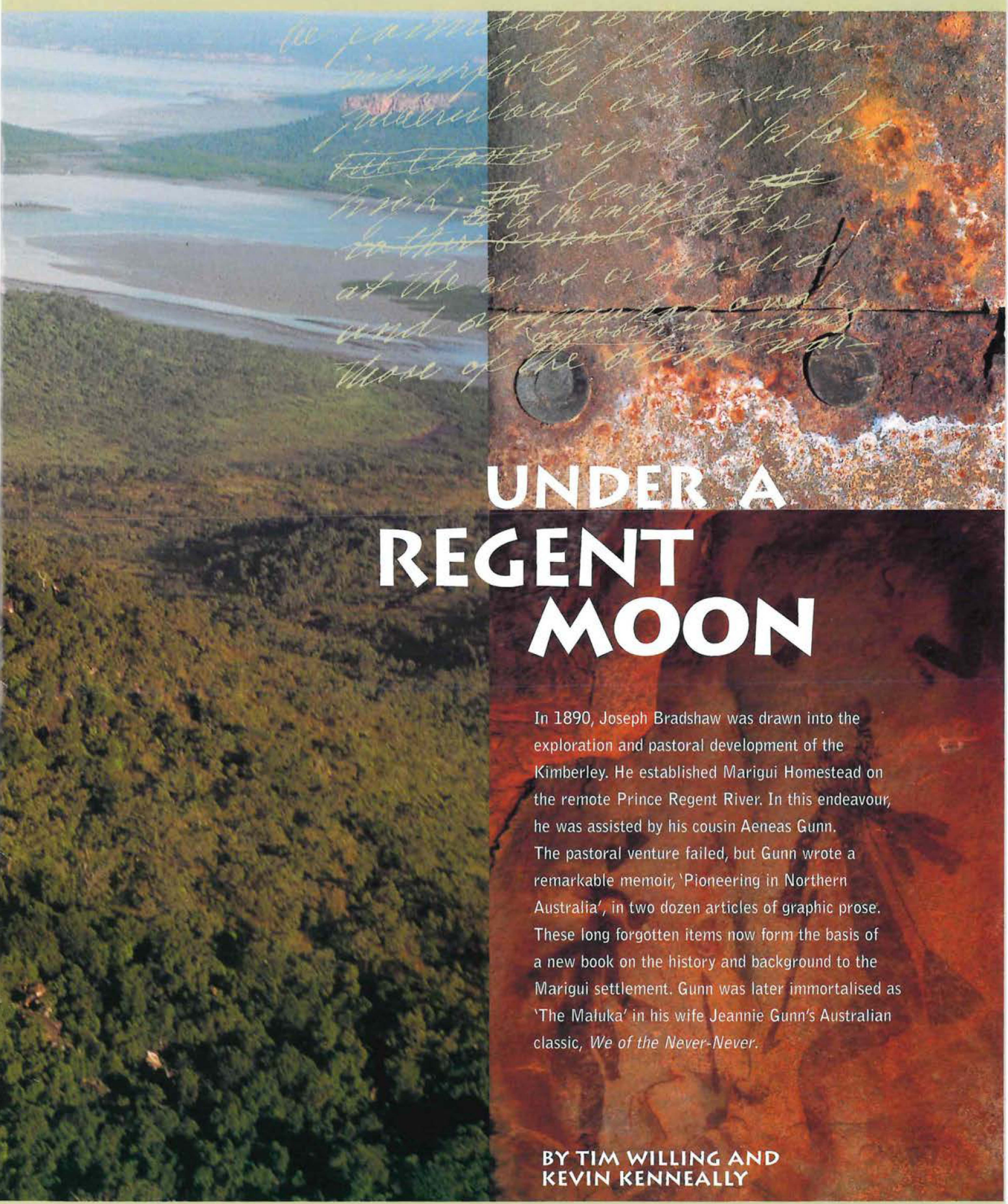
John W Randles is a plant virologist with a special interest in viroids and the characterisation and epidemiology of plant viruses. He has identified the viral causes of a number of new diseases in a range of plant species.

Both work at the Waite Institute (University of Adelaide), Department of Applied and Molecular Ecology, Glen Osmond, SA 5064. They can be contacted on (08) 8303 7307 or by email (dagmar.hanold@adelaide.edu.au).

Mike Stukely is a Research Scientist with the Department of Conservation and Land Management, based at Kensington. Mike can be contacted on (08) 9334 0299 or by email (mikes@calm.wa.gov.au).

Frank Podger has worked for almost 50 years on diseases of native vegetation in Australia, particularly in WA, where in 1967 he determined the cause of the devastating disease then called jarrah dieback. He later helped to develop strategies and policies for its management. He has had a keen interest in Mundulla Yellows from almost ten years ago, and maintains it in retirement. Frank can be contacted by email (frankpod@tpg.com.au).

Diseases and Pathogens of Eucalypts, published by CSIRO and edited by Keane, Kile, Podger and Brown, provides excellent further reading.



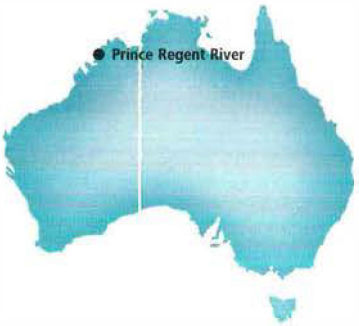
UNDER A REGENT MOON

In 1890, Joseph Bradshaw was drawn into the exploration and pastoral development of the Kimberley. He established Marigui Homestead on the remote Prince Regent River. In this endeavour, he was assisted by his cousin Aeneas Gunn. The pastoral venture failed, but Gunn wrote a remarkable memoir, 'Pioneering in Northern Australia', in two dozen articles of graphic prose. These long forgotten items now form the basis of a new book on the history and background to the Marigui settlement. Gunn was later immortalised as 'The Maluka' in his wife Jeannie Gunn's Australian classic, *We of the Never-Never*.

BY TIM WILLING AND KEVIN KENNEALLY

The Prince Regent River, in the far north-west Kimberley, remains one of Australia's most remote wilderness areas. No roads penetrate its rugged sandstone ranges, and a tide-race with formidable whirlpools restricts access from the sea. Upstream, from the veritable inland sea of St George Basin, the Prince Regent River runs straight as an arrow into the heart of the Kimberley Plateau, following an ancient fault line. The Prince Regent Nature Reserve, created in 1964, covers some 633,825 hectares and protects almost the entire river catchment. The reserve was nominated as an UNESCO World Biosphere Reserve in 1978, in recognition of its outstanding, intact wildlife and pristine values.

Previous page
Clockwise from left: View of St George Basin from Mt Trafalgar; a segment of botanist Ferdinand Mueller's manuscript description of a new plant he provisionally named *Bradshawia macrosiphonia*, based on specimens collected from the Prince Regent River in 1891 by Joseph Bradshaw. In 1891, the species was formally published and named by Mueller, *Ramphicarpa macrosiphonia*. It is now known as *Lindernia macrosiphonia* (see photo on page 51); riveted galvanised sheeting from the Marigui site and Bradshaw (Gwion Gwion) figurative rock art.
Photos – Tim Willing and Michael Cusack



NAMES AND LEGENDS

The first-known Europeans to gaze on this 'Regent' scene were the botanist, Allan Cunningham, and ship's surgeon, James Hunter, in September 1820 on the survey vessel HMC (His Majesty's Cutter) *Mermaid*, under the command of Lieutenant Phillip Parker King. While the ship was undergoing emergency hull repairs at Careening Bay, the pair had climbed a prominent hill, which they named Mount Knight. From this peak, their eyes were drawn to a glimmering inland tidal basin, as well as to a skyline dominated by a spectacular tilted mesa (an isolated, flat-topped hill bounded on at least one side by a steep cliff and having an extensive summit area).

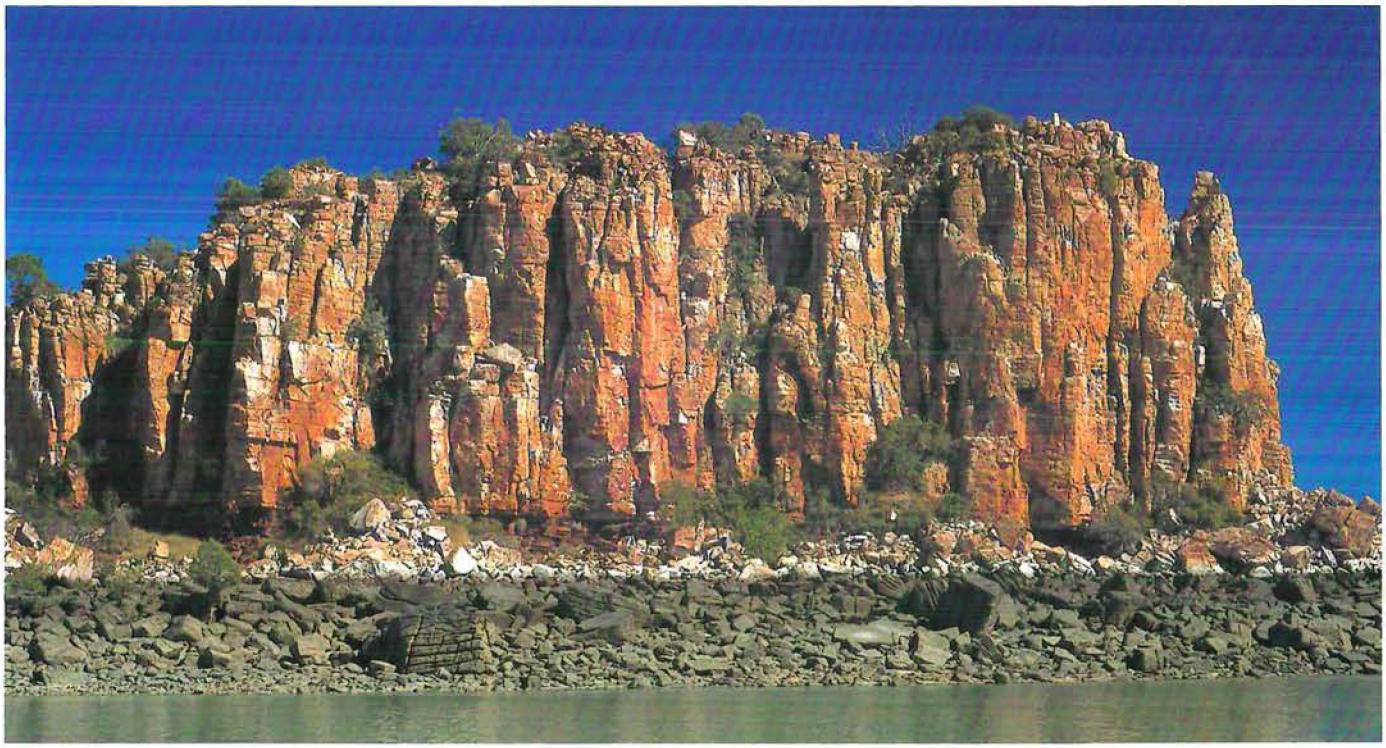
In the oral traditions of the Wororra, the local Aboriginal people, this mighty mesa, Ngayangkarnanya, had been carried in the Dreaming from the north by a vast shoal of fish, sharks and crabs. The colossal weight of the load not only exhausted them, it squashed many flat—creating in the process both rays and shovel-nosed sharks.

Unaware of these ancient legends, Phillip Parker King and the crew of the *Mermaid* ventured in to explore the basins and navigable lower river, bestowing British names with patriotic zeal. The Prince Regent River was named for the Hanoverian prince who would shortly succeed his incapacitated father, George III, and reign in his own right as King George IV. The 391-metre-high mesa was named Mount Trafalgar by Phillip Parker King, in honour of Nelson's great naval victory of 1805. An adjacent lesser peak was named Mount Waterloo, after the Belgian village that witnessed the decisive defeat of Napoleon by the Duke of Wellington's army.

MARIGUI

Seventy years later, another sailing ship, gliding in on the flood tide, ghosted into St George Basin in sweltering November heat. On the deck of the ketch, *The Twins*, three months out from Melbourne, stood hen coops, dog kennels, a pair of goats and a dozen expectant humans. Leading the party was Joseph Bradshaw, a Collins Street

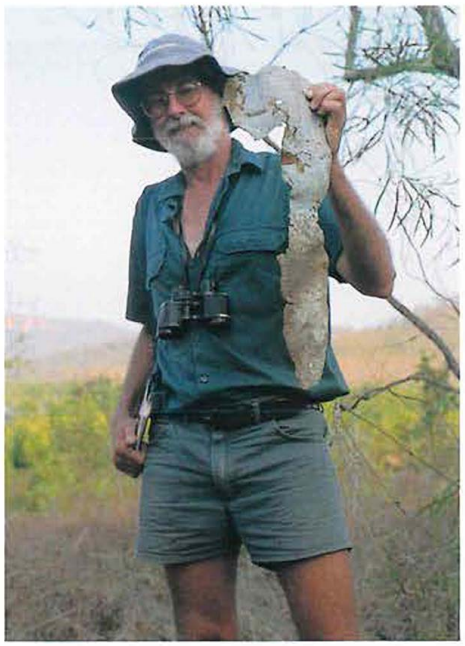
Below: One of Gunn's 'huge scowling cliffs' along the Kimberley coast.
Photo – Kevin Kenneally



investor, who one year earlier had secured a one-million-acre pastoral lease over the entire Prince Regent basin from the Western Australian Government. Also aboard were Mary Jane Bradshaw, Joseph's musically-gifted wife, her maid, a Chinese cook, a Scottish sea captain and several sailors, hailing from Mediterranean ports.

Bradshaw named their settlement 'Marigui', based on information contained in Phillip Parker King's published journals. King had visited Kupang (Timor) in 1818, and was advised by one of the fishing fleet leaders that large numbers of Indonesian vessels made annual visits south to fish for bêche-de-mer (also called trepang), a delicacy in Asia. King recorded that the name they used for the northern Australian coast was 'Marega'. However, it has now been established that the name Marega was more accurately applied to Arnhem Land and the Gulf of Carpentaria. The name given by the Indonesians to the Kimberley coast was 'Kaju Jawa' or 'Kai Jawa', a name apparently derived from a type of mangrove tree, the bark of which gives the bêche-de-mer a distinctive red colour.

A search for water by Bradshaw's party ensued, leading to the discovery of a spring trickling to the mangrove-fringed shore below Mount Waterloo. Tents were duly pitched under boab trees, but Bradshaw's failure to include mosquito nets caused the party much discomfort. Bradshaw supervised the construction of a timber and iron



Top: Bradshaw and Gunn's landing area cut into the mangroves in St George Basin.

Above left: Lindernia macrosiphonia, first collected from the Prince Regent River by Joseph Bradshaw and named by botanist Ferdinand Mueller.

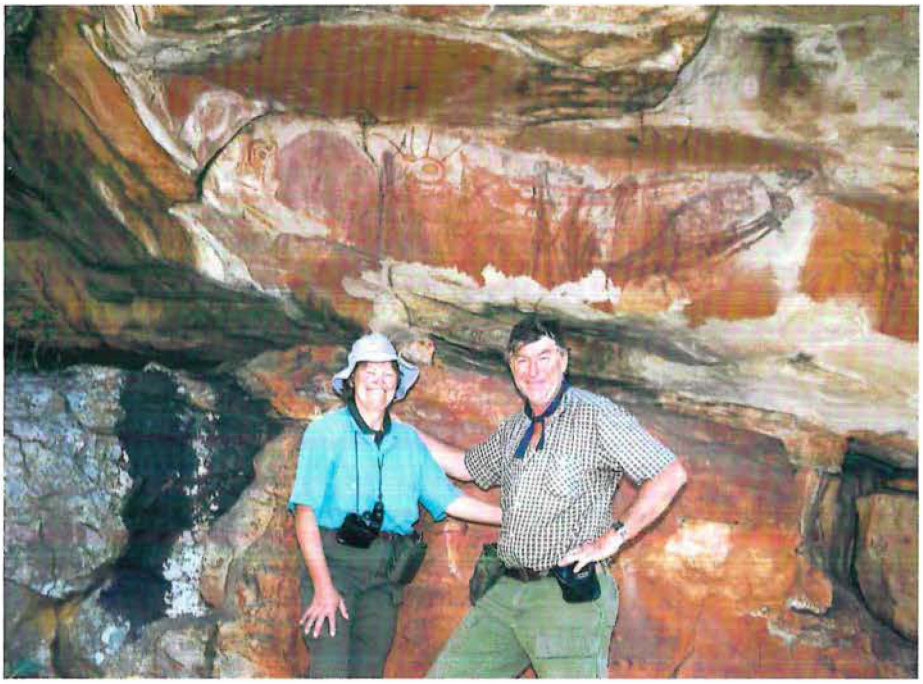
Above: Tim Willing at the Marigui site with a piece of lead solder.
Photos – Tim Willing

homestead, and laid plans to stock the run with sheep. Observing the scene with a discerning eye for detail, a poet's soul and a larrikin wit was Aeneas Gunn, Joseph's 29-year-old cousin. When the Marigui venture failed, Bradshaw—remaining undeterred—began yet another pastoral empire on the Victoria River in the Northern Territory.

SCOWLING CLIFFS

In Melbourne, some eight years later, Gunn converted into newspaper prose his vivid recollections of the party's hair-raising northern voyages, philosophical musings and tragicomic debacles in the service of his hero, Joseph Bradshaw. The modern voyager to the Kimberley coast, aboard a luxury charter vessel, can simply record highlights of the passing scenery on video. This contrasts strikingly with Gunn's era, when a deft literary touch was needed to convey such imagery. Gunn recalled from the deck of *The Twins*:

> "The run thence [from Cape Londonderry] to the Prince Regent River was along a coast, the scenery of



which is to the voyager a long panorama of wild grandeur. Huge scowling cliffs and bluffs of sandstone frown with red-hot angry faces on intruding ship and encroaching sea. The faces are scarred, gashed and wrinkled by the eternal onslaught of the elements. Centuries of ceaseless change have contorted the mountain masses into wild fantastic shapes, or built them into semblances of ruined towered cities, battered fortresses or crumbling amphitheatres. The pushing tides have gnawed deep bays, long reaches, and wide harbours out of their stern adamantine walls or wrenched from them masses of rugged rocky islands.

Day by day we sped past towering islands, clad with rich folds of tropical vegetation from rocky base to flat-topped summit, past tall commanding promontories with rounded basalt bases, down narrow channels fretted through wild lines of ragged rocks, and through noble straits dotted with islands and indented by secret coves and broad bays. At night the schooner, like a tired bird, would fold its wings and rest in some quiet haven hewn out of rocky hills or lie rolling to her anchor..."

FOOTNOTES

Retrieved from obscurity, and presented consecutively for the first time since publication in 1899, Gunn's 24 articles were originally headlined 'Pioneering in Northern Australia'. Comprising the heart of the new book, *Under A Regent Moon*, they will prove a revelation to all Australians, detailing a forgotten chapter in the history of the Kimberley frontier. Gunn's perspective is without parallel and, at times, frankly controversial in depicting the hostile relationship that soon developed between the would-be settlers and the Wororra warriors, defending their country. Besides editing Gunn's erudite memoirs with extensive footnotes, and locating Gunn's sketches in Sydney's Mitchell Library, the authors have

Top left: Wendy and Michael Cusack at Bradshaw's 'cave of paintings'.
Photo – Michael Cusack

Centre left: Boab tree at Marigui used by Bradshaw's party for target practice.

Left: The Prince Regent River runs straight as an arrow into the Kimberley Plateau.
Photos – Tim Willing

A view from the summit of Mt Bradshaw. Photo – Michael Cusack

delved deeply into the Western Australian State archives. They uncovered Bradshaw's forgotten maps and original correspondence, as well as his pressed plant collections preserved in the Herbarium of the Royal Botanic Gardens in Melbourne.

In 1988, staff from the Department of Conservation and Land Management rediscovered the ruins of the Marigui settlement, while investigating sites for a possible field research station in the Prince Regent Nature Reserve. Encouraged by Chris Done, who manages the department's Kimberley region, a *LANDSCOPE* Expedition returned to investigate the area in July 1997. Walking through the dry grassland at the base of Mount Trafalgar, expedition members found a boab tree with the inscription 'A J GUNN' carved into the trunk.

Bradshaw's name has continued to echo through the Kimberley to the present day, through his connection with Aboriginal rock art. Before his marriage and the Marigui fiasco, Bradshaw led an overland expedition from Wyndham across the central Kimberley watershed to a point we now know was in Prince Frederick Harbour. Believing himself to be on the Prince Regent River, when he was actually well north on the Roe River, Bradshaw sketched striking tassel-adorned ochre figures, which he had observed in some caves. The sketches were later published in his expedition report, making him the first European to document this art style, unique to the north Kimberley region. Incredibly, it was only in 1997 that Bradshaw's 'cave of paintings' was successfully relocated by Kimberley Society members Michael and Wendy Cusack. The name Bradshaw is now synonymous with this much-celebrated style of rock art, although some prefer to use its Aboriginal name, Gwion-Gwion.

By a strange twist of fate, Aeneas Gunn became a familiar figure to generations of Australians as the station boss known as 'The Maluka', in his wife's best-selling memoir *We of the Never-Never*, published in 1908. After a stint as Librarian in Prahran, Victoria, Gunn married Jeannie Taylor, a Melbourne teacher, in 1901. The couple swiftly relocated to the Northern Territory, after Aeneas accepted a position as manager of Elsey Station. Malarial dysentery sent him to an early grave in 1903, at the age of 41. Jeannie returned to Melbourne and did not remarry, achieving international acclaim as a writer.

It remains a poignant irony that Gunn's own writing has been allowed to languish in obscurity for more than a century—until now.

Under a Regent Moon—A historical account of pioneer pastoralists Joseph Bradshaw and Aeneas Gunn at Marigui settlement, Prince Regent River, Kimberley, Western Australia, 1891–1892 is published by the Department of Conservation and Land Management and is available from large bookshops for $25.95.

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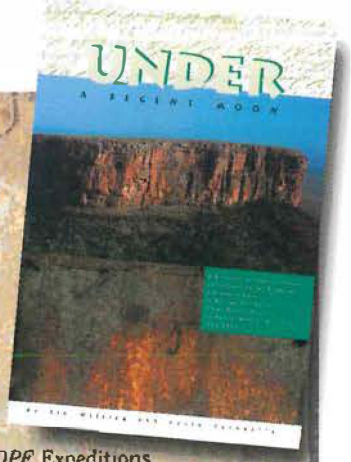
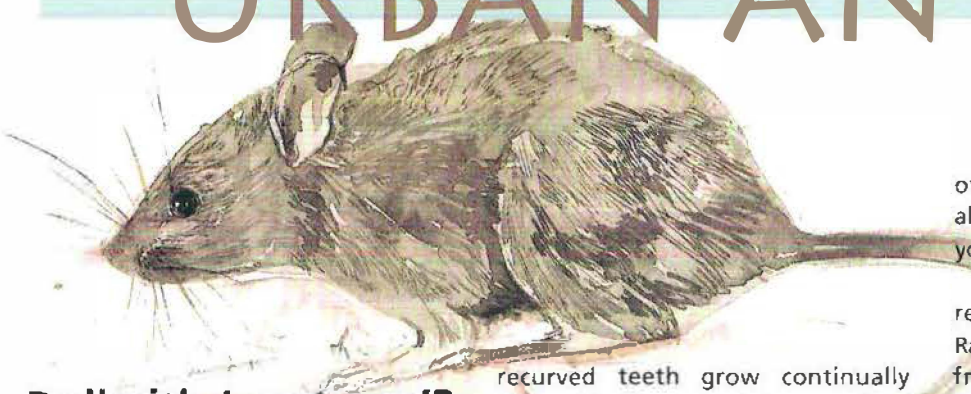


URBAN ANTICS



Dalkeith 'possums'?

WANTED

A gregarious exterminator, preferably with European ancestry and historical experience, plays a flute, clarinet or penny-whistle, and will rid the western suburbs of their current rat problem.

Ever since the Great Plagues of Europe (carried by rat fleas) in the late 1600s, that wiped out around 16 per cent the population of London alone, rats have been the objects of widespread fear and revulsion, but our native rodents are frequently tarred with the same brush.

The Order Rodentia includes the familiar introduced rats and mice, as well as many other rodent species, including the squirrels, guinea pigs, beavers and porcupines that are often depicted as favourite characters in cartoons and comics. Altogether, they comprise more than 2000 described species and make up nearly half of all mammal species on Earth.

There are many species of Australian native rodents, all in the Family Muridae. They are found throughout the country and generally live in their respective niches away from human dwellings. Most of this group came as 'late invaders' among the Australian mammal fauna, when they crossed from eastern Indonesia up to 15 million years ago. Most native rodents are not considered to be pests. They occupy terrestrial, arboreal and amphibious habitats on the continent and comprise about a fifth of our indigenous terrestrial mammal species (62 species of a total of 305 species).

Rodents are characterised by having only one pair of upper and one pair of lower incisors. These long and recurved teeth grow continually during life (in some cases as much as 12 centimetres per year). Because of a hard enamelled front surface and soft rear, they become chisel-edged when continually worn away by the animal's persistent need to gnaw. Rodents do not have canines, and most species also lack premolars.

While our native rodents are as much a part of our heritage as marsupials, it was with the coming of Europeans that the house mouse and two species of rat were introduced to become feral intruders and community-wide pests.

The brown, wharf, sewer or Norway rat *(Rattus norvegicus)* and the black, tree, ship or roof rat *(Rattus rattus)* are, like the cockroach, extremely successful and resilient pests in human habitation. Here, the rats not only spread disease, but also cause food poisoning with their faeces, urine and hair, and economic loss due to property damage. The black rat has also established in many bush areas.

Brown rats, which are larger-bodied with small ears and eyes, generally build their nests at or under ground level, while smaller-bodied black rats with large ears and eyes prefer vegetation, wall cavities and ceiling spaces. While the black rat and most native rats are timid creatures, a cornered 'brown' will repeatedly launch itself, even at humans.

Rats eat almost anything, including their own dead and dying.

Their peak breeding periods are in autumn and spring and, depending on the availability of food, they have up to nine litters, weaning up to 50 young a year. Theoretically, a pair and its increasing number of offspring can produce 15,000 rats a year, but the evolutionary process has produced mechanisms that prevent overpopulation (for example, the abortion of foetuses and eating of young).

The domestic rat problem is the responsibility of the whole community. Rats derive their life support systems from our waste-management systems, food-processing places, storage areas and general junked-up and overgrown backyards. All are found in households, public facilities, restaurants, food stores and factories.

It is no good baiting and trapping these pests if we don't also attend to and secure our bin-lids, wood heaps, fruit trees, vegie patches, fruiting vines and open compost heaps. We must take away the availability of the life supports or another rat will just move in to the territory. After your prized passion fruit have disappeared overnight, it'll be too late then to 'give a rats . . . !'

BY JOHN HUNTER

DID YOU KNOW?

- *As well as being able to tread water for up to three days and swim up to a kilometre, rats can walk along the inside of a sewer pipe and swim up through the 'S' bend water seal (ouch!).*
- *Rats can gnaw through lead, wood, aluminium and fibro sheeting and leave marks on glass and steel. A rule of thumb is, if you don't see any rats, there are probably five nearby. If you see one, there are probably 15.*
- *Australian native rodents have gained a poor reputation by being compared with the introduced species. Using Aboriginal names rather than 'rat' or 'mouse' is one way of improving their image (see 'Dinkum Aussie rats' in* LANDSCOPE, *Spring 1996).*

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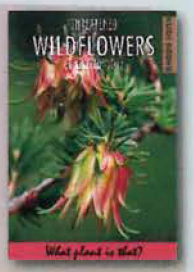

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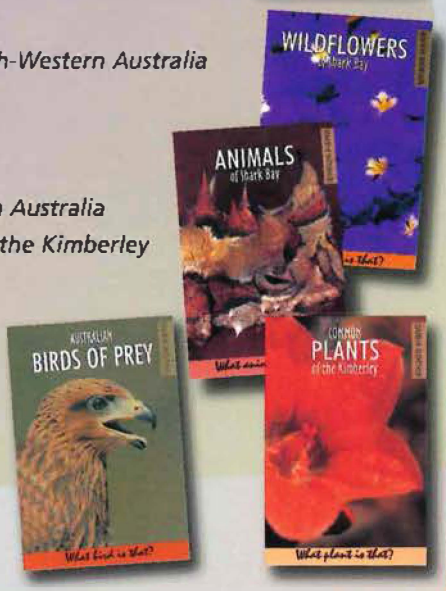
Birds of the Kimberley
Australian Birds of Prey
Threatened and Rare Birds of Western Australia



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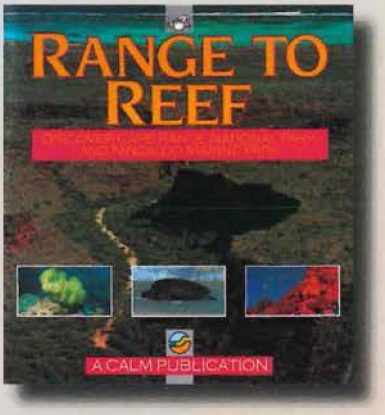

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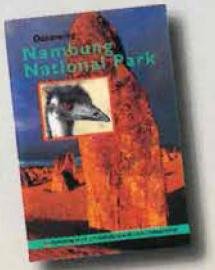

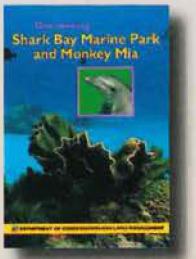

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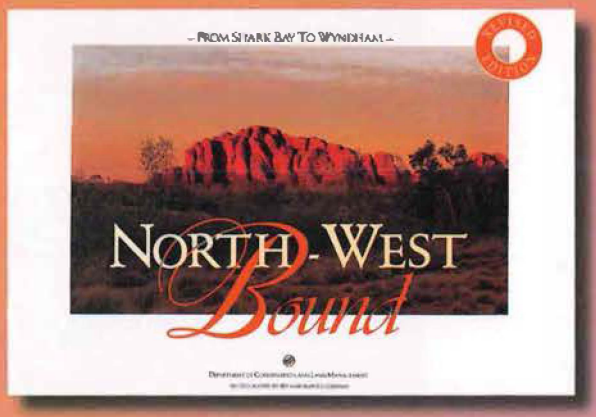

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ISSN 0815-4465

9 770815 446041

PRINT POST APPROVED PP665002/00004