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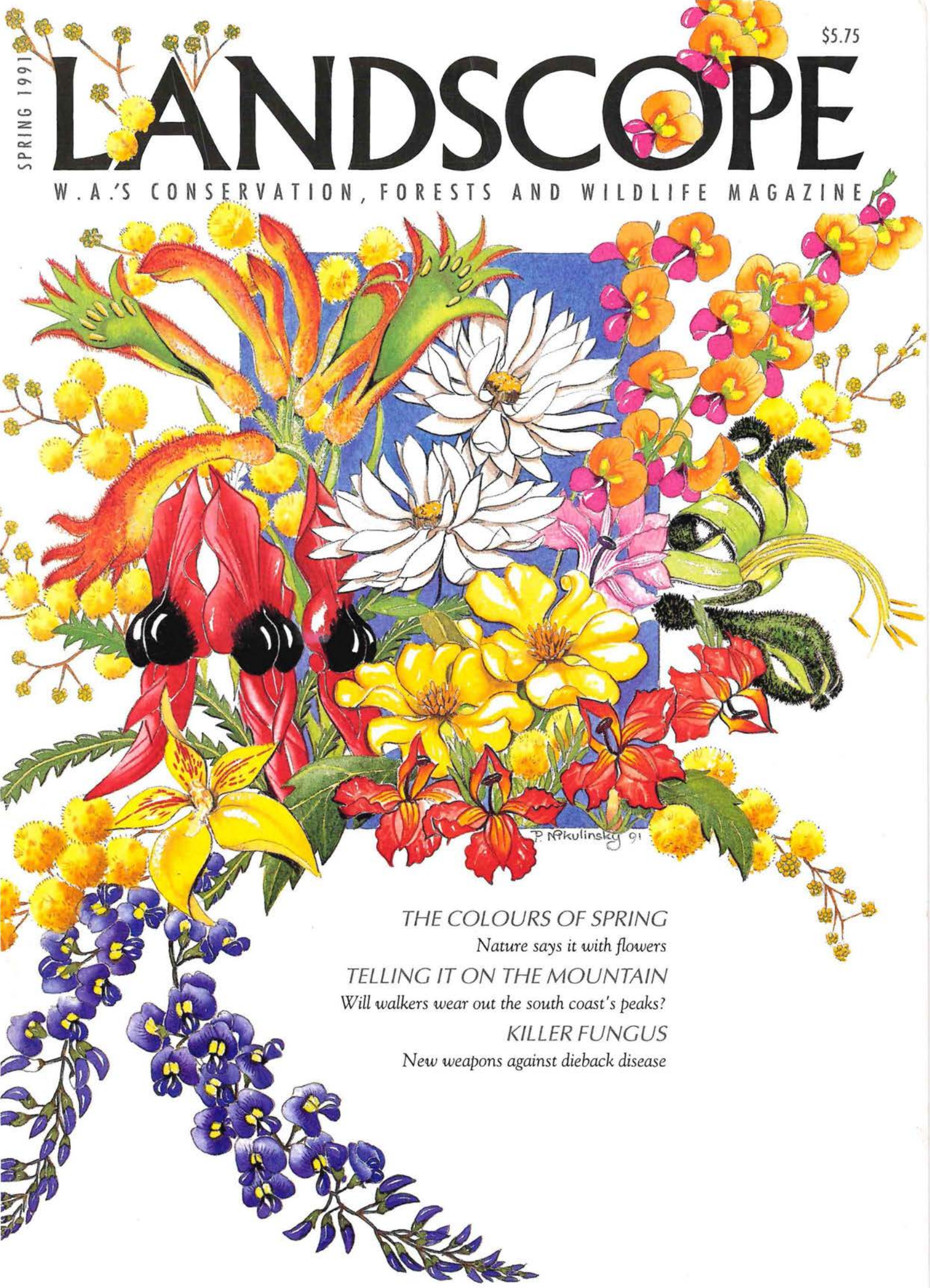
LANDSCOPE

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



THE COLOURS OF SPRING

Nature says it with flowers

TELLING IT ON THE MOUNTAIN

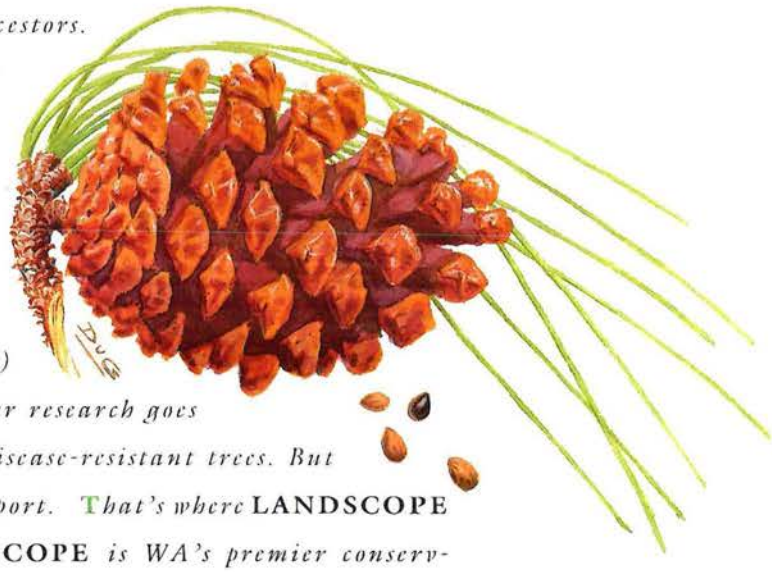
Will walkers wear out the south coast's peaks?

KILLER FUNGUS

New weapons against dieback disease

TALL VIGOROUS AND WELL-BRED

If you go down to the bush today you're sure of a big surprise. In parts of the south-west of Western Australia there are plantations of tall, vigorous and well-bred pine trees that are the result of years of painstaking research. Pines now grow faster and straighter than did their ancestors. The timber yield from these commercially grown trees has been increased by over 30 per cent and further improvements are expected as scientists from the Department of Conservation and Land Management (CALM) continue their research. Other research goes on into breeding salt- and disease-resistant trees. But someone needs to watch and report. That's where **LANDSCOPE** *magazine comes in.* **LANDSCOPE** *is WA's premier conservation quarterly. Our stories on wildlife, forests, reserves, and national and marine parks are well informed and scientifically researched. We pack each issue with facts, problems, solutions and achievements, and we care about the future of our planet. We think you do, too. That's why we want your continued support. If you'd like to subscribe to* **LANDSCOPE**, *for yourself or a friend, please write or telephone.*



LANDSCOPE
window on the west

Department of Conservation and Land Management
50 Hayman Road COMO Western Australia 6152
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A wave of colour is spreading from Shark Bay to Jurien and inland to Meekatharra. Our story on page 10 takes you into Wildflower Country.

LANDSCOPE

VOLUME SEVEN NO. 1 SPRING EDITION 1991

The WA Museum is 100 years old. It houses a staggering four million specimens of insects, marine animals, fish, birds, reptiles and frogs. Page 22.

Seven species of microscopic dieback-disease fungi are attacking WA's unique wildflowers. See page 28.

The rugged Pilbara landscape has some hidden delights. On page 16, go up hill to Hamersley Range, then down Dales and other spectacular gorges.

How does WA's conservation heritage look to the people who look after it? Turn to page 26 for some great photographs from a recent competition run for CALM staff.

F E A T U R E S

R E G U L A R S

S P E C I A L S

C O V E R

Out now! Wildflowers are blooming in the vast tracts of country north of Perth, especially in the northern sandplains and Murchison, which is experiencing a bumper wildflower season following heavy winter rains. Philippa Nikulinsky's illustration shows some of the wildflowers for which WA is justly famous: the splendid everlasting, buttercup, red leschenaultia, Sturt's desert pea, catspaw, wattle, native wisteria, black kangaroo paw, flame pea, and scaevola - all covered in the newly released book, Wildflower Country. *See page 10.*

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TROIKA

Environmental problems can be put into a troika of categories.

Some are ideologically inspired, with little technical basis. In Australia, for example, millions of dollars have chased phantom forest conservation problems when the real problem is political. Then there are the real environmental problems, which can be solved if there are resources. In other issues of LANDSCOPE *we have described the exciting idea of reintroducing native mammals to the arid inland; now we report the launching of "Desert Dreaming", a project sponsored by WAPET to reintroduce mammals into the Gibson Desert from Barrow Island - an oilfield abounding with mammals that are rare or extinct on the mainland.*

Finally, there are some environmental problems that are truly frightening because of their sheer magnitude. In this issue of LANDSCOPE *we tell of a genuine environmental tragedy - the attack by* Phytophthora *species on our unique flora. "Wildflower dieback" could cause the extinction of hundreds of species, including some of our spectacular wildflowers. The worst environmental problems to solve are those based on ideology. They also consume most resources.*

If LANDSCOPE*'s analyses of environmental problems cause funds to be redirected to solving real problems, which we can beat through scientific management, that alone would justify its existence.*

The Publisher

A BOUQUET FOR OUR STORY ...

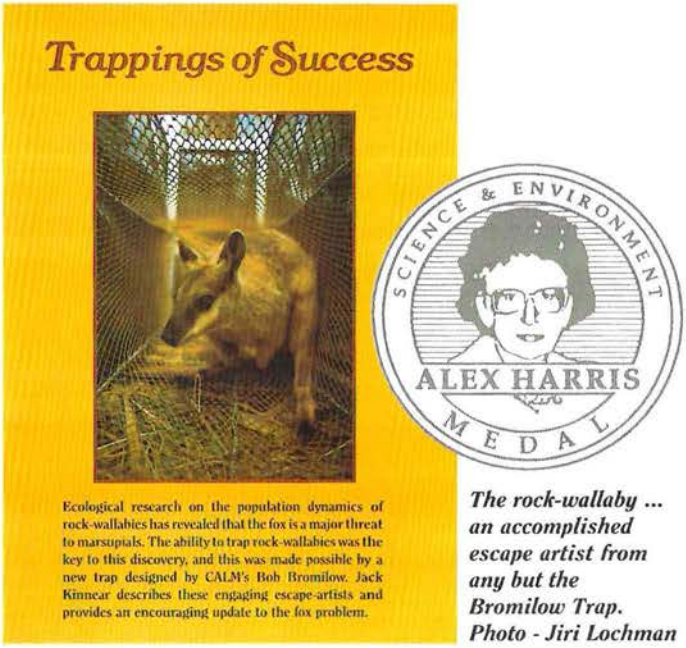
In 1978 in the central Wheatbelt, Technical Officer Mike Onus and I commenced a survey of the last surviving population of rock-wallabies in the South West. We systematically inspected almost every nook and cranny for signs of rock wallabies. We failed to find any traces of one population, another was nearly extinct, and the remainder had suffered a massive population decline.

We had no idea what was wrong ...

So began Jack Kinnear's engaging article on the vulnerability of rock-wallabies to foxes and the invention of a new trap that was the key to this discovery. The article, entitled 'Trappings of Success', was published in the Autumn 1990 edition of *LANDSCOPE* and is part of a series Jack is authoring for this magazine on the fox as a threat to marsupials and what is being done about it.

Everyone connected with *LANDSCOPE* was therefore delighted to learn recently that Jack was the inaugural winner, for 'Trappings of Success', of the Alex Harris Medal for excellence in science and environmental writing. The medal honours the late Alex Harris, who worked for *The West Australian* for nearly 30 years and was an important link between the scientific community of WA and the general public because of her ability to simplify complex scientific and environmental issues without trivialising them. Mrs. Harris died of cancer last year.

Jack, a Principal Research Scientist with CALM, won the award because the judges felt 'Trappings of Success' displayed many of the attributes Mrs. Harris displayed in her own work: writing that is clear and accessible, that provides good information on important research being carried out in Western Australia, and that combines human interest and flashes of humour. Jack's winning article also exemplifies what we are trying to do with *LANDSCOPE:* to not only inform but to enrich and to delight you.



The rock-wallaby ... an accomplished escape artist from any but the Bromilow Trap. Photo - Jiri Lochman

The Alex Harris Medal will be awarded annually and is open to any writer of a major news or feature report on an environmental or scientific WA topic published or broadcast in WA. It is co-sponsored by the Australian and New Zealand Association for the Advancement of Science (WA Division), the CSIRO, and *The West Australian.*

... AND A BOUQUET OF STORIES

The success of *LANDSCOPE* is due largely to the talent of our photographers and authors - most of whom, like Jack, are members of CALM. Their commitment to conservation and land management provides us with many fascinating stories.

In this edition Carolyn Thompson, Steve Hopper, Greg Keighery and Penny Hussey take us through the flora-rich country north of Perth in 'Wildflower Country' (p. 10). This area is one of the most diverse wildflower areas in the world.

In 'Up Hill, Down Dales' (p. 17), Allan Padgett and Stephan Fritz explore some of the less accessible gorges of Hamersley Range, in Karijini National Park.

Bryan Shearer, Ray Wills and Mike Stukely are all CALM scientists. In 'Wildflower Killers' (p. 28), they provide insight and hope concerning the threat our unique wildflowers face from dieback disease.

This is but a sampling of what's in store for you in the following pages. Read and enjoy!

RON KAWALILAK
MANAGING EDITOR

Your letters are welcome. Please address any correspondence to *LANDSCOPE* Editor, CALM, 50 Hayman Road, Como WA 6152

DESERT DREAMING

A WA oil company, West Australian Petroleum (WAPET), will sponsor an ambitious project to reintroduce mammals extinct on most of the Australian mainland.

The three-year *Desert Dreaming* experimental project will investigate the dramatic decline in desert mammals by reintroducing endangered boodies (burrowing bettongs) and golden bandicoots to the Gibson Desert Nature Reserve. Without WAPET's support the project would not be viable, because of the cost of working in such an isolated area.

Scientists from the Department of Conservation and Land Management (CALM) plan to release up to 40 of each species in the Gibson Desert Nature Reserve in May next year. CALM researcher Per Christensen said the study would help to determine why 15 mammal species have declined significantly or become extinct in Australia's deserts, and help CALM to control feral animals in remote desert reserves.

"Over 90 per cent of mammal species with an adult body weight between 35 and 5500 grams have disappeared from Australia's arid zone in the last three decades - over a third of all the original mammal species of the desert," Per Christensen said.

"The fact that so many mammals have disappeared from our deserts is a conservation tragedy of enormous dimensions."

The boodies and bandicoots will be taken from healthy populations on Barrow Island, from which WAPET has been extracting petroleum products in an environmentally sensitive manner for many years, and airlifted to the Desert.

The released animals will be placed in fenced compounds and supplement-fed for about two weeks, to give them time to adapt to their new environment. When they appear to be acclimatised, holes will be made in the fences to allow them to disperse and they will be fitted with radio collars and tracked almost continuously. Radio-tracking will provide valuable information about their behaviour and their ability to adapt to and breed in their new environment.

It is thought that the mammals disappeared from Australia's deserts because of fox and cat predation, changed burning patterns after Aboriginals left the land and competition from feral herbivores such as rabbits.

Before the animals are reintroduced, CALM will remove feral animals from the release area by baiting and complete patch burning to provide a choice of habitat for the mammals.

The tracking of the animals will help to determine whether the mammals favour burnt or unburnt habitat.

CALM scientists visited the Gibson Desert in August and September to continue preparation work for the release. Pit traps have been placed in the bait area and a control area to determine the impact that baiting feral animals will have on local mammals and reptiles.

The Gibson Desert Nature Reserve, where endangered species will be reintroduced next year.
Photo - Ray Smith

The wongai ningaui, one of the small mammals that still persist in the desert.
Photo - Ray Smith

RARE EUCALYPT REDISCOVERED

Giles' mallee *(Eucalyptus rameliana)*, a rare eucalypt that has eluded botanists for 115 years, has been rediscovered.

The find, by wildflower picker Nick Foote, has solved one of Australia's great mysteries of desert biology. The mallee was the only eucalypt thought to have become extinct.

Mr Foote was searching for a well on the old rabbit-proof fence 100 km south-east of Newman, in the Pilbara region of Western Australia. He drove over a sand dune and, in his words, "Bang, there it was."

The rare mallee was first collected in 1876 by Ernest Giles, whose original specimen is housed in the National Herbarium, in Melbourne.

Baron F. von Mueller, who sponsored Giles' expeditions, named the species and noted that it was collected "beyond the Alfred and Marie Range". These small hills are about 180 km north-north-west of Warburton.

Since 1983, several fruitless expeditions have been made to the area in search of the elusive tree.

In May this year, South Australians Dean and Bob Nicholle walked 80 kilometres westwards over four days along Giles' 1876 path from the north end of the range. They found some smooth-fruited plants in a population of Kingsmill's mallee *(E. kingsmilli)*, and believed they had found Giles' mallee.

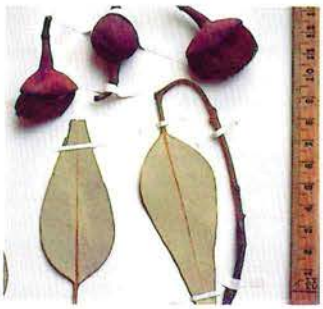
A further expedition was mounted, but, although thousands of Kingsmill's mallees were found, no plants matched Giles' single-flowered specimens.

A relatively smooth-fruited variant of Kingsmill's mallee was found, but its fruit was arranged in clusters of three. Although Dean's collection did not match Giles' mallee, it is probably the first time a rare hybrid of Kingsmill's mallee and Tammin mallee *(E. leptopoda)* has been collected.

Exactly three months after Dean Nicholle's collection, Nick Foote found the elusive tree 500 km beyond the Alfred and Marie Range.

After scrutinising Giles' book, CALM research scientist Steve Hopper believed that the explorer probably collected the mallee close to where Nick Foote found his specimens. Perhaps Giles had forgotten exactly where he picked up the specimen, or Mueller had not recorded the location accurately, only remembering that it was "beyond" the Alfred and Marie Range.

Either way, it appears that the recent expeditions had been looking in the wrong place and that Giles' mallee is a native of the Little Sandy Desert, not the Gibson Desert.



The rare Giles' mallee, collected recently by wildflower picker Nick Foote.
Photo - David Gough

Giles' original collection is housed in the National Herbarium, in Melbourne.
Photo - Steve Hopper

SOUTH COAST SEALS MAKE EXCELLENT PROGRESS

New Zealand fur seal colonies affected by the *Sanko Harvest* oil spill were given a clean bill of health after a further monitoring trip to the Esperance islands (see *LANDSCOPE*, Winter 1991).

Department of Conservation and Land Management (CALM) officers flew to Seal Rock and Hood Island by helicopter to catch, measure and weigh tagged animals that had been small pups several months before.

The animals were extremely difficult to locate and catch, and the wetsuit-clad CALM staff had to crawl under rock crevices and into rock-covered streams to find them. Harnesses were attached to two officers who clambered down over difficult rock inlets to find the seals. It was a comforting sight to see big, healthy animals on both islands.

Fur seals were hunted almost to extinction on the south coast of Western Australia in the 18th and early 19th centuries. They are now fully protected and are making a strong recovery. New colonies were discovered by the CALM staff in the wake of the *Sanko Harvest* spill, and the species is now abundant on many islands near Esperance.

CALM officers will return for follow-up inspections during the next fur seal breeding season.

New Zealand fur seals huddled between rocks on Hood Island.
Photo - Tanyia Maxted

FROGS, FROGS, FROGS

The chance to see some of Australia's rarest frogs will be the highlight of a "frogging weekend" at Ludlow Forest in October.

"Frogs, Frogs, Frogs", a course offered by the University of Western Australia's extension program, will examine recent developments in the frog world, including reports of a worldwide decline in their numbers.

Course participants will also participate in spotlighting, trapping and censusing programs and study practical programs designed to conserve two of Australia's rarest frogs.

This is the first time this course has been offered in the beautiful setting of the Ludlow tuart forest. The Friends of the Tuart Forest will provide tea, damper and hot soup.

Senior Research Scientist Grant Wardell-Johnson, who has been studying the frogs of the area for several years, will take the course. People wishing to attend the weekend on October 25 to 27 should telephone Jean Collins at the University of Western Australia on 380 2579.

Banjo frogs (Lymnodynastes dorsalis) *are common near Ludlow.*
Photos - Grant Wardell-Johnson

The green and gold tree frog (Litoria moorei) *may be seen in its native habitat at Ludlow.*

LEARNING ABOUT LOGGERHEADS

A number of baby loggerhead turtles found recently on beaches from Perth to Bunbury have added to knowledge about the rarely seen reptiles.

It's unusual for such a large number of the species - normally only found in the warm waters of the North West - to be found so far south, and it's probably the first time that such a large raft of hatchlings has been seen in the Perth area since 1964.

At least 30 loggerheads were taken in to the Department of Conservation and Land Management (CALM) by people who found them on the coast. They are probably around six months old.

CALM turtle expert Bob Prince said the turtles were hatchlings born last summer at nesting sites near Shark Bay and off the North West Cape.

"They would have swum out to sea after hatching and have since drifted south in the warm Leeuwin Current," he said.

Young loggerhead turtle typical of those found recently near Perth.
Photo - Dean Lee

"Strong westerly fronts off the WA coast blew them out of the current and on to southern beaches."

Although CALM has been carrying out a marine turtle research program for the past five seasons, studying six species of turtle found off the WA coast, Bob said not much was known about west coast loggerheads.

Loggerheads grow to a shell length of 1.2 metres and weigh 140 kilograms, whereas the baby turtles brought in to CALM have a shell length ranging from 60 to 80 mm.

"Like other marine turtles, they spend most of their lives at sea, only coming to shore to nest when they reach adulthood at about 25 to 30 years of age," he said.

"The adults range widely. One turtle tagged and released at Exmouth in February 1988 was caught 15 months later in the Northern Territory.

"Only about 300 to 500 adult female loggerheads are thought to nest in WA each year, each laying about five or six clutches of around 100 eggs. The survival rate of hatchlings is extremely low."

Bob said a recorded decline in the loggerhead turtle population on Australia's east coast had led to further concern about WA's population.

Information gleaned from any sightings or finds would help CALM understand the current status of WA's loggerhead turtle populations.

The turtles that were washed up are being cared for at Underwater World until they can be returned to northern waters. Biologists there have been assisting in rehabilitating stranded or injured marine animals for the past few years.

"The turtles should ideally be kept in a warm 22 to 23 degree seawater aquarium, fed fish and kept until they are at least three years old before being released into the wild," Bob said.

NEW VISITOR CENTRE AT MILLSTREAM

The old homestead at Millstream-Chichester National Park, which was once the focal point of a sheep and cattle station, has had a face-lift and will reopen as a visitor centre.

The homestead has been reroofed and repainted and will introduce visitors to the natural and cultural value of Millstream, which is about two hours' drive from Karratha in the Pilbara.

Millstream was an important place for Aborigines for many centuries.

The first pastoral lease on Millstream was granted in 1866 for sheep grazing. Wool was transported by camel train to the port at Cossack until the turn of the century.

The present homestead was built in 1914 after a cyclone destroyed the original building in 1908.

The newly refurbished Millstream Homestead. Photo - Richard Hammond

The State Government bought the station in 1982, and in 1986 the homestead lease was purchased by the Department of Conservation and Land Management.

Among the displays in the new centre is a room devoted to the Yinjibarndi Aborigines, the traditional custodians of the Millstream area.

The room displays local artefacts. There is a recording of a traditional song about the Millstream wetlands by Yinjibarndi elder Yilbie Warrie and a reproduced rock engraving of Nyngara the Rock Man, a magic man who once terrorised the people. Also included is a full-size replica paperbark hut, built by Ranger Bruce Woodley and friends.

The Settlers' Room houses a reconstructed station hands' hut, and a recording of Doug Gordon - whose family were associated with Millstream Station from 1914 to 1964 - telling his story.

Other displays inform visitors of the park's attractions and some of the experiences to be had, and help them to interpret the geology of the region, the arid lands, and the remarkable wetlands oasis at Millstream.

Much of the artwork for Millstream Homestead Visitor Centre was prepared by Sally Watson, whose work can also be seen at Milyering Visitor Centre in Cape Range National Park.

EXOTIC PALMS INVADE

Far left - exotic palms have taken over at Millstream, choking out the native vegetation and creating a fire hazard.
Date palms regenerating after a fire.
Photos - Peter Kendrick

Exotic date palms have taken over parts of the wetland habitats in the Millstream-Chichester National Park.

The palms were introduced late last century by pastoralists and Afghan camel drivers as both ornamental trees and a food crop. They are fast-growing and prolific seeders, and have spread from where they were originally planted into the delta streams and the bed of the Fortescue River.

Accumulations of dead fronds have provided fuel for intense wildfires in the wetlands, and while the date palms recover quickly, native trees such as the large cajeputs and river gums have been killed by repeated intense fire.

Another impact of the palms has been to deny light to the understorey plants and constrict stream channels with invading root mats: the end result is a thick, pure date palm stand on bare, saline soil.

The Department of Conservation and Land Management is trying to protect the wetlands by reducing the exotic palms to manageable levels and re-establishing native species.

A grove of several hundred mature palms will be retained around the Homestead area to provide a contrast to the natural wetlands nearby, and to remind visitors of the historical significance of the palms to the pastoral history of the Pilbara, but in the remainder of the area the wetland vegetation will be protected and regulated.

NUTTY WOYLIE

A youngster of one of Western Australia's rare nocturnal mammals - the woylie - is being handraised on the south coast at an Albany wildlife shelter.

The tiny woylie was found on the side of the road where its mother had been killed by a car near Lake Muir Nature Reserve, south-east of Manjimup.

Following a telephone call to Department of Conservation and Land Management (CALM) wildlife officer Peter Collins, the month-old woylie was taken to the shelter, where it has developed a liking for walnuts, cauliflower, mushrooms and apples. Shelter owner Eunice Daubert named the woylie Thumbelina.

Woylies were once widespread in WA, but are now largely confined to South West forests and woodlands. Like many other small mammals their principal enemy is the introduced European fox. A Woylie Recovery Plan is currently being developed. It is hoped to bring the species back from the brink of extinction over a five-year period.

Recovery plans are also being written for the tammar, rock-wallaby, Shark Bay mouse, chuditch, two species of frog and four species of rare flora.

CALM has received a grant from the Australian National Parks and Wildlife Service to write the plans.

In Collie, an extensive fauna trapping program being carried out by CALM is showing that woylies are prevalent in an area of State forest into which they were translocated from the Perup Forest several years ago.

As well as woylies, the program has located populations of chuditches and possums in the State forest.

Thumbelina, the orphan woylie from near Lake Muir, is being cared for at Albany.
Photo - Tanyia Maxted

Wildflower Country

Kangaroo paws, everlastings, featherflowers, orchids and banksias - many of them unique to WA - are just a few of the many wildflowers that draw tourists and wildflower enthusiasts to the country north of Perth.

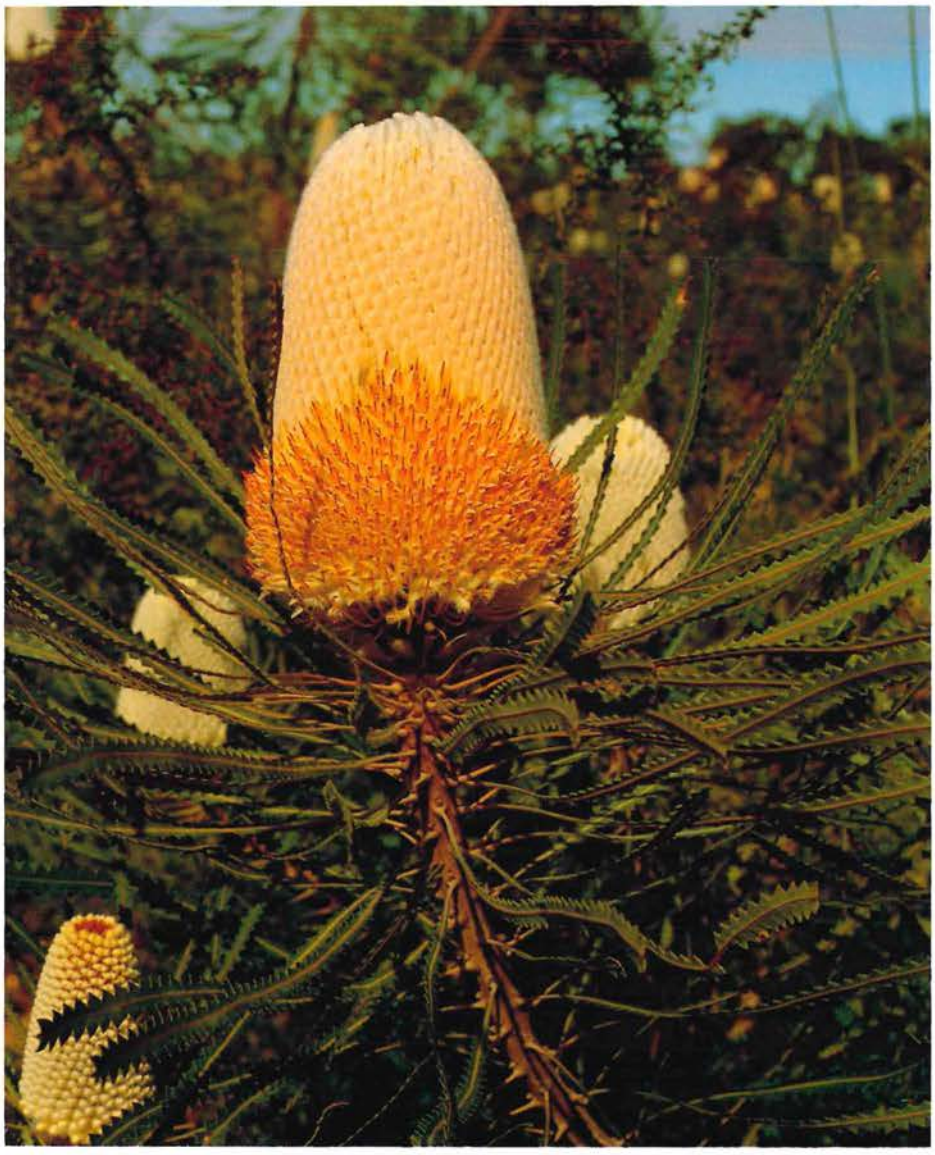
A new book, *Wildflower Country*, explores this flora-rich area from Jurien to Shark Bay and inland to Meekatharra.

by Carolyn Thomson, Steve Hopper, Greg Keighery & Penny Hussey

Wildflower Country covers an area with over 3 000 species of flowering plants. It is one of the most diverse wildflower areas in the world, with a great burst of flowers during spring. The book encompasses the kwongan (shrublands) of the northern sandplains, the woodlands and shrublands of the northern Wheatbelt, the desert regions of the Murchison Goldfields and the arid peninsulas of Shark Bay.

Previous page:
Parakeelya. Photo - Jiri Lochman
Honey possum on Hooker's banksia. Photo - Jiri Lochman
Cowslip orchid. Photo - Andrew Brown
Purple starflower. Photo - Tony Tapper

Hooker's banksia, confined to the Eneabba area, is favoured by the wildflower trade.
Photo - Jiri Lochman



The northern sandplains and Batavia Coast is one of two parts of southern Western Australia where species-rich heathlands are best developed. Flowering is at its peak in August and September, depending on rains.

The plants of the northern kwongan are the typical Australians: the banksia family, the eucalypt family, the boronia family, the southern heaths and the peas. These five families dominate the vegetation types of the region, and provide more than half of the area's species.

NORTHERN SANDPLAINS

The sandy or lateritic soil of the northern sandplains supports mostly heath or kwongan, but there are also large areas of mallee shrublands and swamps or woodlands in valley floors or depressions.

Low heath dominated by blackboys is common on the lateritic uplands. This plant community is conspicuous around the Badgingarra and Mount Lesueur area. Another striking plant is the zamia, seen growing over two metres tall along the banks of Coomallo Creek, near the Jurien Bay turn-off on the Brand Highway.

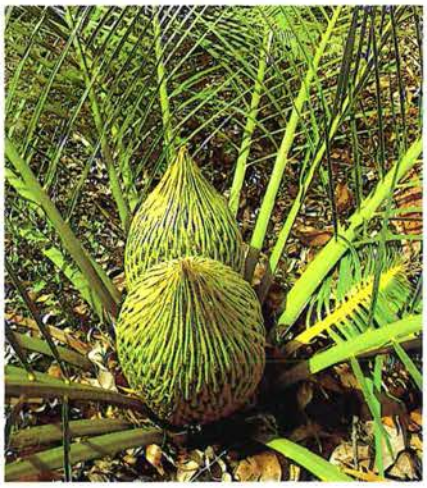
In spring, colour is provided *en masse* by perennial herbs and shrubs, especially the wattles, smokebushes, banksias, grevilleas, bottlebrushes, numerous species of pea, coneflowers, starflowers and leschenaultias. This colour continues into spring with copper cups and feather-flowers, the famed *Verticordia* species. One of the most striking verticordias is orange morrison, which flowers in early summer and can be seen in profusion at Moore River National Park.

The yellow kangaroo paw, which has many flowers borne on tall stems, is one of the showiest plants of the sandplains, flowering from December to January. The region's abundant orchids include sun orchids, such as the Queen of Sheba and its spectacular relative Cleopatra's needles, and spider orchids.

Common banksias of the heaths include candle banksia, which can be recognised by its long, yellow flower spikes, and the firewood banksia, which has red, white and yellow flower spikes. Both species grow all the way to Kalbarri and at least one of them is usually in flower at some time of the year. Hooker's banksia, confined to the Eneabba area, is favoured by the wildflower trade because of its rich orange and white flower spikes.

Inland, kwongan grows on sedimentary sands mostly comprised of quartz. The heath is interspersed with small lakes, swamps and occasional woodlands. The heath contains eucalypts, chiefly pricklybark, or banksias. Hooker's banksia and sandplain woody pear are common on the deep sandy soils. Spectacular examples of heath communities can be seen in Badgingarra, Alexander Morrison, Watheroo and Tathra National Parks and Mount Lesueur.

In many of these places, a bewildering variety of different plants coexist in a small area. The region is especially rich in dryandras and there



This one-sided bottlebrush grows at Badgingarra National Park and Mount Lesueur.
Photo - Tony Tapper ▲◀◀

Zamia fruits were used by the Aborigines for food, after first treating them to remove the poisons.
Photo - Jiri Lochman ◀▲

Candle banksia is used by many birds and insects. Honeyeaters drink the nectar and they and other birds pluck insects off the flower-spikes.
Photo - Gerhardt Saueracker ▲

This tall grevillea is known as "old socks" because of its unpleasant smell.
Photo - Jiri Lochman ◀

are numerous pea plants. Daviesias, with their crowded stems of red-brown flowers, are noticeable, as they flower in winter. The staghorn bush, a daviesia with flattened stems and large nodding scarlet flowers, also grows here.

BATAVIA COAST

The Batavia Coast has a similar character to the northern sandplains. The tall sandheaths between Dongara and Kalbarri support 12 types of banksia, including sceptre banksia and the uncommon Burma Road banksia, which has globular, rather than cylindrical, flowerheads. There are about 10 other species with similar flower spikes, most of which are found in the northern sandplains. The presence of large numbers of similar species within the same group is a typical feature of the region's rich flora.

Parrotbush, an upright shrub with prickly-toothed leaves, grows on limestone outcrops amid a distinctive heath vegetation. Its cream flowers, which appear from late autumn to late spring, are used extensively by beekeepers. Isolated clumps of illyarrie grow best on the limestone hills between Cervantes and Dongara and north to the Zuytdorp Cliffs. This small white-barked tree stands out with its scarlet bud caps and bright yellow flowers. The spoon-leaved wattle flowers in August, turning the area golden yellow. North of Dongara, low wind-pruned heath covers the tall coastal cliffs, and succulent herbs become increasingly common towards Shark Bay.

There are many different hakeas, including the spectacular red pokers, and there are avenues of a tall grevillea with cream flowers, known as 'old socks' because of its pungent smell. Beneath the taller plants are a wealth of smaller ones, including many delicate orchids, and the tiny stars of yellow logania and the felted bellflower.

Kalbarri National Park is also rich in plant species. Several species are unique to the area, including the Kalbarri spider orchid, which can only be seen at Kalbarri National Park and adjacent areas. Sandstone species grow along the gorge and at Red Bluff, while the heavier redder soils at the eastern end of the park support mallee and wattle scrub and small pockets of eucalypt woodland. Low coastal heaths and banksia heaths and thickets grow on the sandplains which dominate the park.

NORTHERN WHEATBELT

The woodlands and shrublands of the Wheatbelt merge into the heathlands on their eastern margin. This region is drier, and the soils are less sandy. The loamy soils of the broad valleys are covered with woodlands of salmon gum, York gum or wandoo. Sandy soils usually support thickets of sheoaks, wattles or melaleucas. Granite outcrops are scattered throughout the area.

The granites are among the oldest rocks in the world. They are islands in a sea of woodlands or wheatfields and they contain many diverse habitats within a small area. Many plants are confined to them. Lichens are the only plants able to gain a foothold on the bare rock. Depressions that fill with water in winter

support primitive fern-like quillworts and tiny annual mud-mats. Pincushions - which dry out and appear to be dead in summer but rapidly rehydrate and turn green after rain - are found in the shallow soils that fringe the rocks. Sun orchids and spider orchids are often scattered amongst the pincushions. Larger shrubs, such as hop-bushes and blind grass, and wattles, such as jam, grow in adjacent deeper soil.

The salt lakes that are found in depressions throughout the area are typically covered in heath of samphires, which are low and spreading salt-tolerant plants. A few species of these fleshy plants, such as the large-articled samphire, are rare and confined to the northern Wheatbelt. The slightly elevated sandy rises fringing the salt lakes are home to several unusual orchids. Perhaps the most bizarre species in the northern Wheatbelt is the hinged dragon orchid, which is pollinated by male wasps. The orchid has inconspicuous flowers that mimic flightless females.

The thickets can be colourful in spring. Within the woodlands the first carpets of brightly coloured annuals are found, which reach the apex of their development in the Murchison Goldfields.

Pigface growing at the edge of Lake Moore near Paynes Find.
Photo - Marie Lochman ◄▼

Bright podolepis forms part of the floral carpets that form in the Murchison during August and September if there are good rains.
Photo - Marie Lochman ◄▼▼

The spotted bowerbird is fairly common in the Murchison, where it builds bowers in the undergrowth.
Photo - Jiri Lochman

MURCHISON GOLDFIELDS

The Murchison Goldfields is a transitional area, rich in plants, that links the central deserts and northern Wheatbelt. This is a region of red sand, salt lakes, low ironstone hills, red-brown loams and granite rocks. Woodlands, mallee over spinifex, and acacia shrublands or woodlands, especially mulga, grow here.

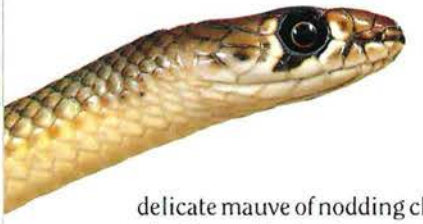
If rain arrives in winter, the shrublands or woodlands are carpeted with annual flowers in spring. The area has the highest concentration of such annual short-lived species in Western Australia. There are many different species of everlastings - plants in the daisy family with papery flower parts that, if dried carefully, will keep their colour and form beautiful, long-lasting flower arrangements. They have a breathtaking array of different forms and colours. There are pom-pom everlastings, pink cluster everlastings,

poached egg everlastings (with yellow and white flowers), sticky everlastings (pink), charming sunrays (bright yellow) and, with the largest flowers of all, the splendid everlastings (cream flowers with a yellow centre).

Some of the daisies in the floral carpet are not strictly everlasting, as they do not have papery flower parts. They include the mauve or white-flowered Swan River daisy, golden longheads, bright podolepis and billy button sunray (all yellow). Some of the most delightful daisies are the tiny ground-hugging plants in odd shapes, like the committee plant, which looks as though the designer could not decide what it was supposed to be. Tiny plants from other families include the pink trumpet stylewort, which is related to the trigger plant. On drying claypans and river banks, look for the trailing stems and bright blue flowers of peplidiums.

Two species in the Leschenaultia family contribute substantially to the colour carpet, especially on the edge of the Wheatbelt. Pink velleia is prominent at Jibberding, while swathes of the large, delicate yellow flowers of cut-leaf goodenia form drifts under the shade of wattles between Yalgoo and Morawa.

All of these are temporary plants, and they survive the dry season as seeds. However, there are some plants which regrow each year from bulbs or tubers. They include the upright pale lilac spikes of Murchison Nancy and the



delicate mauve of nodding chocolate lily, which smells, in the evening, of milk chocolate.

As you go further north and east into the drier areas, the composition of the ground flora changes, and everlastings give way to mulla-mullas, which have pink, mauve or green hairy flowers, and to peas such as swainsonas, which have deep purple flowers.

The sandalwood tree grows throughout the Murchison and can also be seen in some areas of Shark Bay and the northern sandplains. It has irregular spreading branches, grey-green fleshy leaves and red fruits. The small tree's aromatic wood provided vital export income in the early days of the Swan River Colony and is still a valuable export today. Sandalwood is a semi-parasite that uses a range of host species.

The Shark Bay daisy is a creeper that grows over shrubs and covers them in daisies.
Photo - Jiri Lochman

Yellow-faced whipsnake.
Photo - Jiri Lochman

DESERT COAST

A unique mix of southwestern species and desert plants grow on the arid prongs of Shark Bay. The southern heaths end on Edel Land, and over 20 unique plant species are found only here. The aromatic Tamala rose is one of the region's most well-known and showy species. The spectacular sceptre banksia flowers in summer and provides nectar for honeyeaters and insects. At 30 centimetres, its cone of flowers is unusually long.

The red sandplain country traversed by the Useless Loop Road extends well southwards. It is home to many plants found nowhere else. Among them are Royce's gum, Rogerson's grevillea and a golden lambstail, a shrub that grows to two metres tall, covered in golden felt-like hairs.

Peron Peninsula is much more arid, with sandhills, limestone, and shallow saline lakes known as birridas. The scenery is spectacular but the vegetation is low and wind-pruned and dominated by wattle shrubland or spinifex grasslands. Annuals, such as the Shark Bay daisy, are only common around saline depressions.

Whether your interests are wildflowers, or enjoying some of the spectacular landscape of this part of the world, *Wildflower Country* has something for everyone. It includes a seven-page wildflower calendar that features over 150 species. The calendar will help people identify wildflowers by their colour, the locality in which they are found, and the season in which they flower. There are also comprehensive wildflower indexes of scientific and common names and a locality index to the area's many attractions. The region it covers is about to burst into masses of spring flowers, so grab the book and take a walk on the wild side. ▣

Carolyn Thomson, a Communications Officer with CALM, is the editor of *Wildflower Country*. Botanists Steve Hopper, Greg Keighery and Penny Hussey also work for CALM and contributed extensively to the book. *Wildflower Country* is a sequel to the successful series of guides to WA's natural areas that include *North-West Bound; Wild Places, Quiet Places; and Beating About the Bush.* It is available from CALM offices and all good bookshops and newsagents for $19.95.

ENDANGERED!

QUENDA

In many areas fringing Perth, bandicoots are the last remaining native mammal except for bats. It is common to see them late in the afternoon - pointy-nosed, grey-brown mammals the size of a rabbit - feeding in open land or scurrying into nearby dense vegetation.

This is the southern brown bandicoot (*Isoodon obesulus*) known locally by the Nyungah name quenda. It also occurs in South Australia, Victoria, Tasmania and on the eastern seaboard, where it is called the short-nosed bandicoot to avoid confusion with *Perameles nasuta*, an eastern bandicoot with an even longer nose.

Quendas inhabit dense vegetation around wetlands on the coastal plain, and along water-courses in the Darling Range and southern forests. They feed on adult and larval insects as well as earthworms and tubers, making small conical excavations while foraging. Most feeding is done within easy reach of cover.

Quenda young are born between July and April. The gestation period is less than 15 days, and a single female can produce as many as three litters in one season. Litter size varies from one to six, but only large females can successfully rear more than two young at once. The juveniles are weaned at 50-60 days, when they leave their mother's home range to search for suitable available habitat.

Individuals in low-density populations are territorial, but where quendas live at high density, considerable overlap in home range occurs, with individuals apparently avoiding each other. Large males increase their area of movement during the extended breeding season, and subordinate males appear to move less widely.

Quendas were once quite widespread in the south-west. They still occur in the jarrah and karri forests, and as recently as 1971 there were populations at Dryandra Forest near Narrogin and at Tutanning Nature Reserve east of Pingelly. The most inland records were at Wyalcatchem in 1963 and Hyden in 1965. Today there are none in drier inland locations: quendas are restricted to south-west forests and to their prime habitat, the coastal margin from Yanchep to Cape Le Grand.

Unfortunately, their preference for low-lying coastal areas brings them into conflict with humans, as land development spreads along that strip and into semi-rural land around the urban areas.

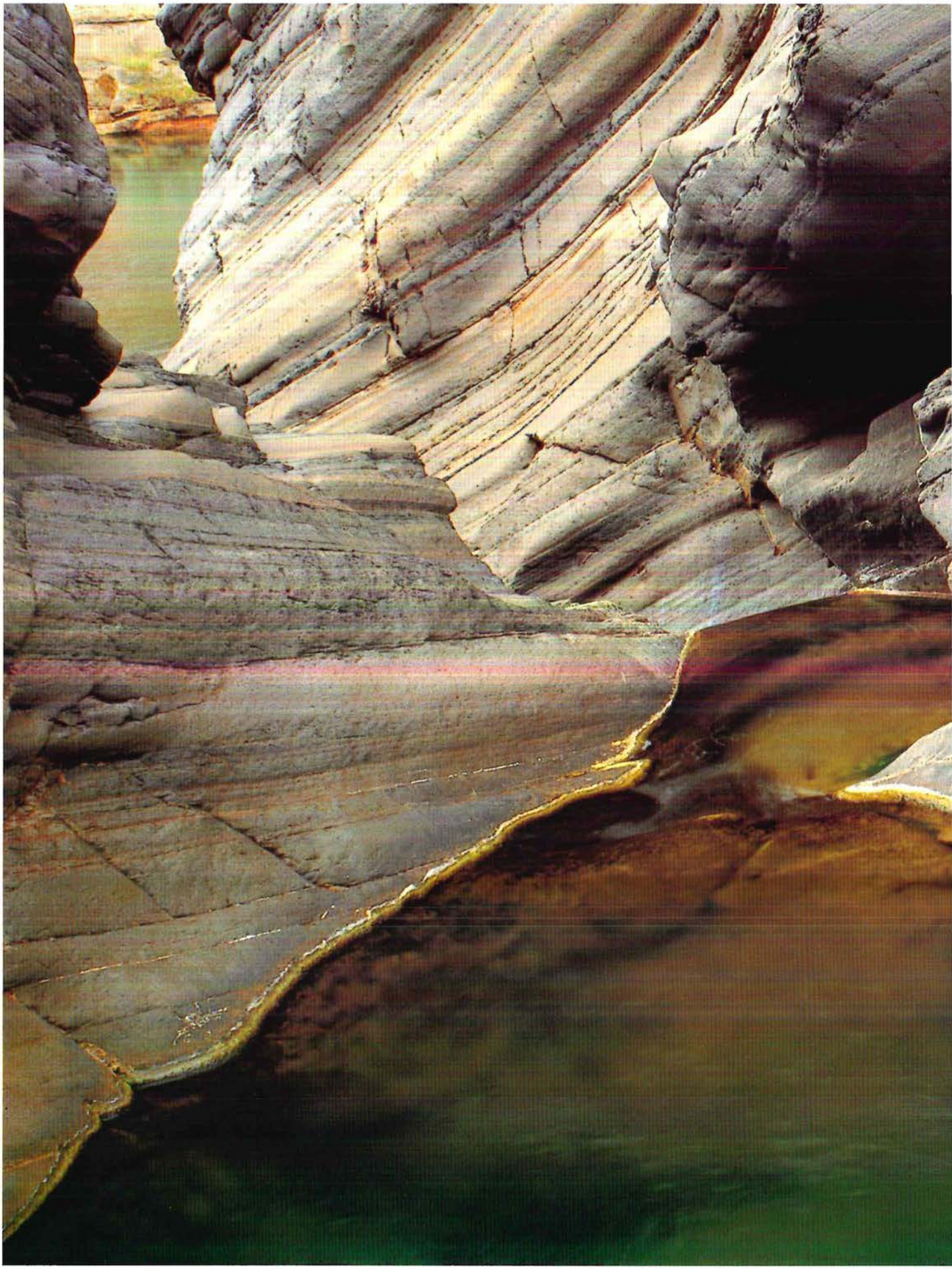
Quendas are remarkably resilient to change in their environment. By living in thick vegetation, and reproducing at such a high rate, they cope with predation by cats and foxes better than many other native animals.

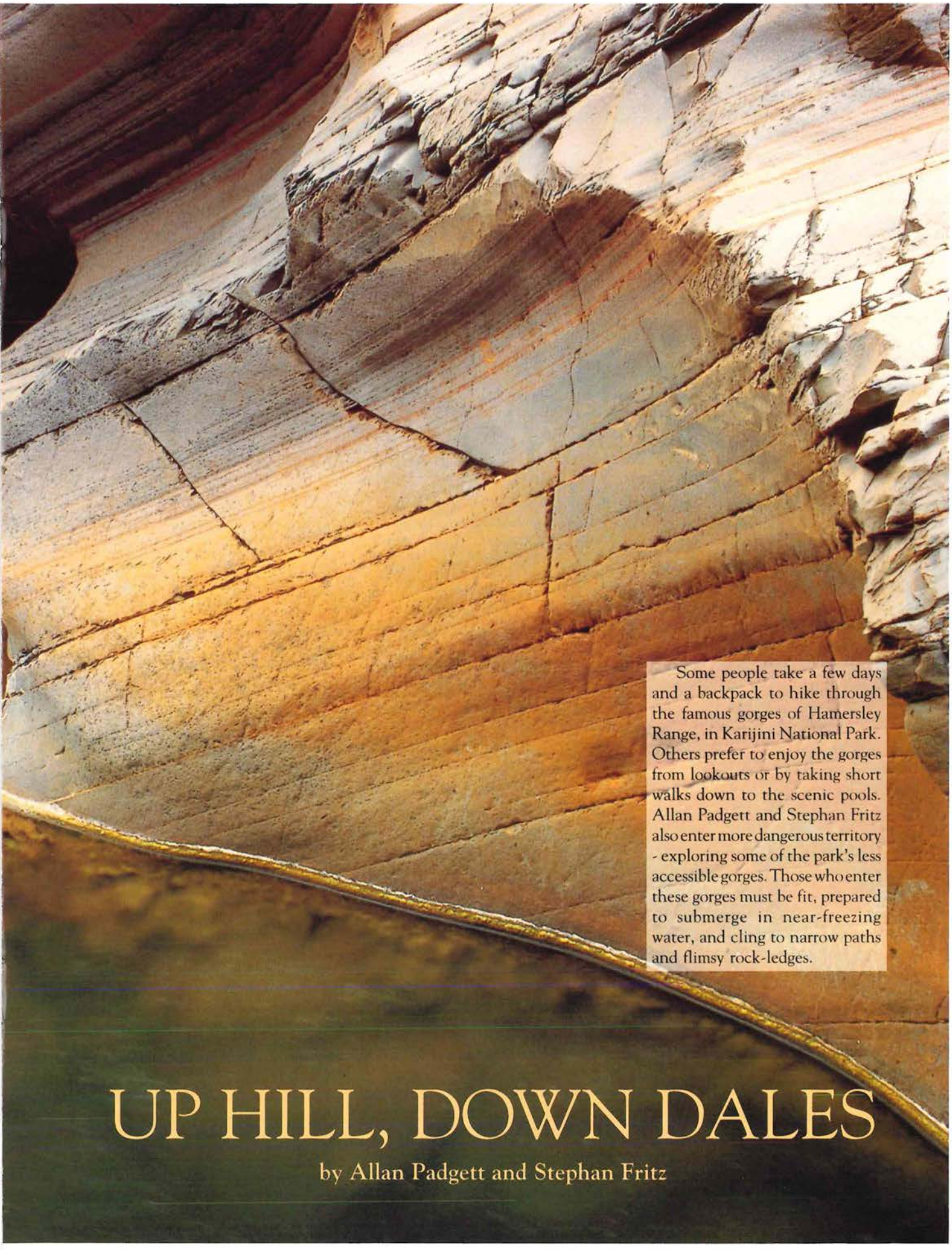
Each year, however, more and more of the quenda's prime real estate is disappearing, or coming under pressure from nearby residential developments that bring cats, dogs and bushland degradation.

Unless substantial areas of good habitat on the coastal plain are reserved and managed, the quenda may be lost from that part of its range. If habitat loss continues, it might eventually join those less resilient Western Australian marsupials that survive only in small remnant populations.

Photos - Jiri Lochman

TONY FRIEND





UP HILL, DOWN DALES

by Allan Padgett and Stephan Fritz

Some people take a few days and a backpack to hike through the famous gorges of Hamersley Range, in Karijini National Park. Others prefer to enjoy the gorges from lookouts or by taking short walks down to the scenic pools. Allan Padgett and Stephan Fritz also enter more dangerous territory - exploring some of the park's less accessible gorges. Those who enter these gorges must be fit, prepared to submerge in near-freezing water, and cling to narrow paths and flimsy rock-ledges.

The approach to the Hamersley Range from the Fortescue River gives no indication of the massive gorges inside Karijini National Park. From this northern perspective the escarpment, built from fine sediments deposited in the sea over 2.5 billion years ago, rears to about 250 metres above the surrounding plains.

Within the park, towards the ranger station, is a crossroads with signposts announcing destinations which have become well-known to visitors to the Pilbara. Circular Pool, Dales Gorge and Fortescue Falls lie to the east of this junction. To the west are Kalamina, Knox, Joffre, Red, Hancock and Weano Gorges. Nothing quite prepares the traveller who, in passing over some insignificant creek, discovers after a little more driving that the creek has become a massive incision, probing 100 metres into the earth.

Emerging from small creeks lined with the brilliant white trunks of coolibah (*Eucalyptus coolibah*) and surrounded by countless clumps of spinifex springing from dusty red gravels, each gorge offers a unique experience. All plunge deeply through a parade of geological history (see **Geology of the Gorges**).

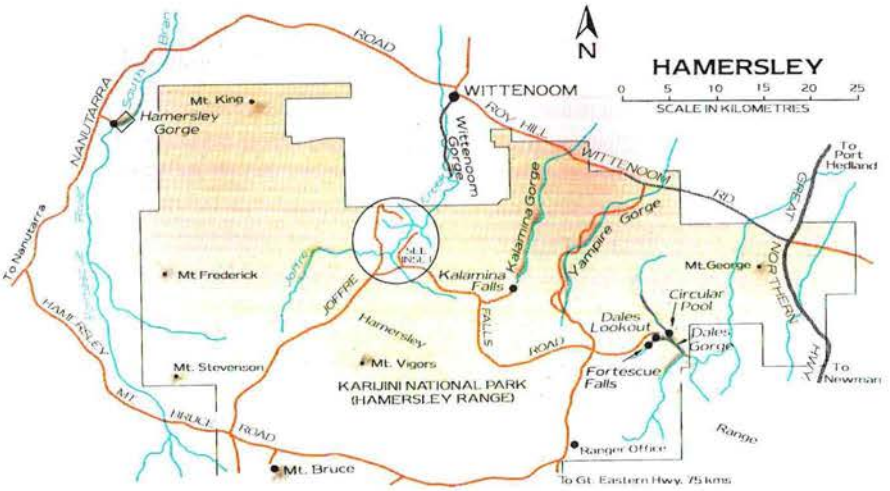
Kalamina Gorge is readily accessible, with an easy path from the carpark to the gorge. From the top, the essential character of the gorges is evident. The steep, rich red, iron-saturated rock walls shelter tranquil pools. A curved waterfall denotes the start, where permanent water trickles over ledges holding clumps of fern. The rim of the gorge is defined by clumps of spinifex and the twisted white trunks of snappy gum (*Eucalyptus leucophloia*).

The caustic vine (*Sarcostemma australe*) clambers from its tenuous hold on the rockface, bereft of foliage but with photosynthetic green stems. Without leaves, the plant has less surface area exposed to long months of high temperatures, an adaptation that conserves precious water.

The smooth rock platforms on the floor of the gorge alternate with pebbles; for most of the year, the creek forms a series of pools. Clumps of fringing reeds shadow the cool, clear pools, where fish are busy foraging; tall, flaky-soft trunks of cajeput (*Melaleuca leucadendra*) rear from the margins. The cajeput has a shallow root system spread over a large area, and its specialist tissue allows oxygen to penetrate. This gives it the ability to withstand waterlogged conditions for extended periods. The microclimate at this level is far removed from the hotter, drier conditions on the rim. The walk within Kalamina Gorge is a good introduction to the gorge system, as it is relatively easy to climb into and negotiate.

Dales Gorge is only a short drive east to the Fortescue recreation area. A stroll of 100 metres allows visitors to view Circular Pool, deep within the gorge. The weather-beaten landscape of Dales Gorge has been gouged by millions of years of rain and flood, revealing the banded iron formations of the walls.

Most visitors are content to view Circular Pool and the remainder of Dales Gorge from the rim walk. Those with a greater sense of adventure and more agility venture down the precipitous track that tumbles into the depths of the gorge. Unlike Kalamina, this entry is not for most people. For those able enough, the effort is repaid many times over. Rock platforms step upwards, in shades of grey, pink, orange and buff; while sheets of water fall off and cascade down. Species of sedge, grass and rush cling to the edges of deeper pools, and emerge from those which are shallower. Numerous saplings of river gum (*Eucalyptus camaldulensis*) and cajeput have successfully established themselves and resisted torrents of seasonal rain. The highwater mark is shown by a stain on the gorge walls, and by long-dead branches wedged among rocks and piled against tree trunks.



Previous page:
Rock pool in Hamersley Gorge.
Photo - Chris Garnett

Opposite:
Huge cajeputs rooted to thousands of layers of sedimentary rock at Dales Gorge.
Photo - Chris Garnett ▶

Stephan Fritz, John Parker and Russell Bone were part of a team that conducted a safety audit of the gorges.
Photo - Allan Padgett ▶▼

One of a series of permanent waterfalls in Dales Gorge below Fortescue Falls.
Photo - Allen Padgett ▶▶▼

Native fig trees grow in seemingly impossible positions on the rock face of the gorges.
Photo - Chris Garnett ▶▶▶▼

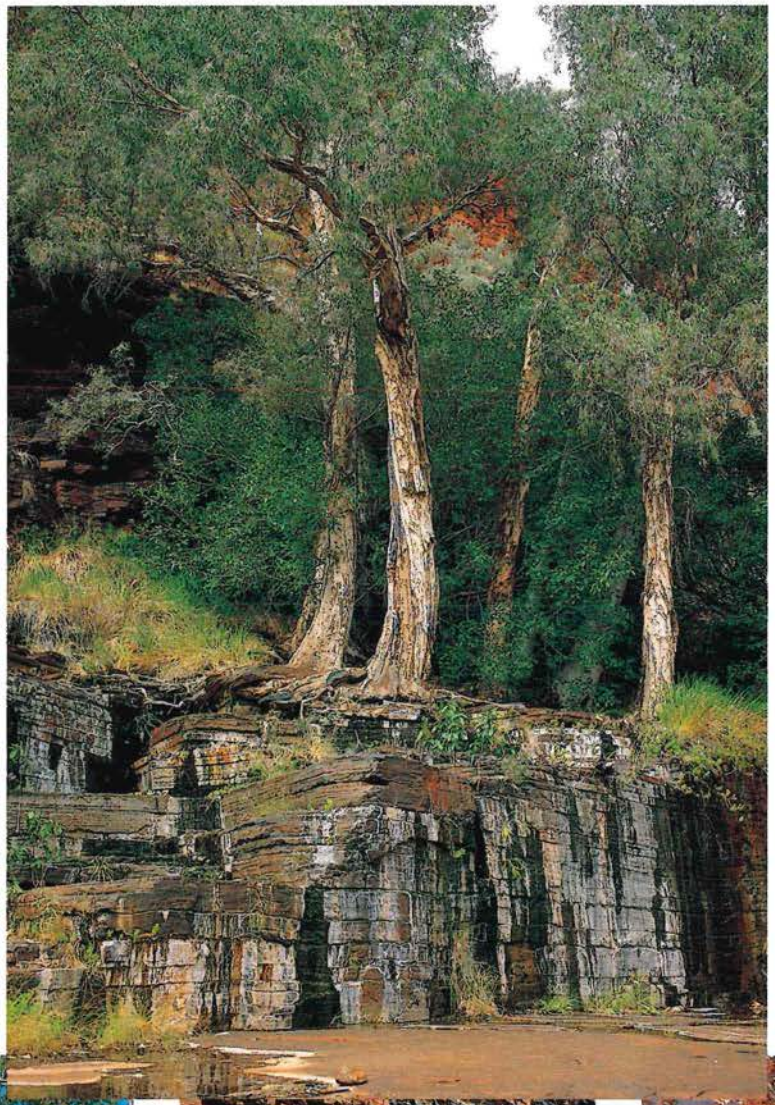
Circular Pool nestles at the base of steep walls from which water drips and seeps, providing a continuously moist environment. Numerous ferns sprout vigorously from ledges slippery with algae and, for most of the year, the pool is deep and inviting.

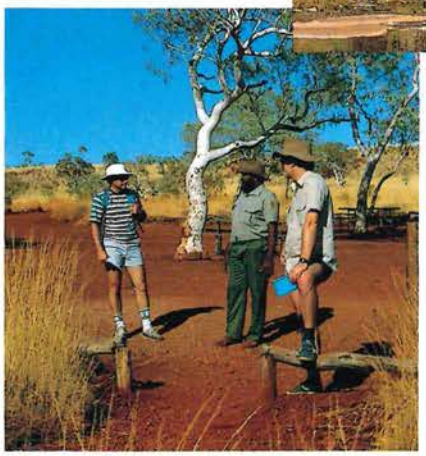
The walk through Dales Gorge toward Fortescue Falls, away from Circular Pool, passes through tall thickets of grasses and cajeput. The sedimentary nature of the gorge walls is obvious at every step; at one point a fig emerges from a vertical face, and many of its exposed roots indicate its penetration into unseen water sources deep within the striated and compressed layers of rock. Birds that eat the fleshy fruits of this species deposit the undigested seeds on rock ledges. After the seeds germinate in small pockets of soil, the fig's roots grow downwards, and can sometimes be traced entering permanent water 10 metres below.

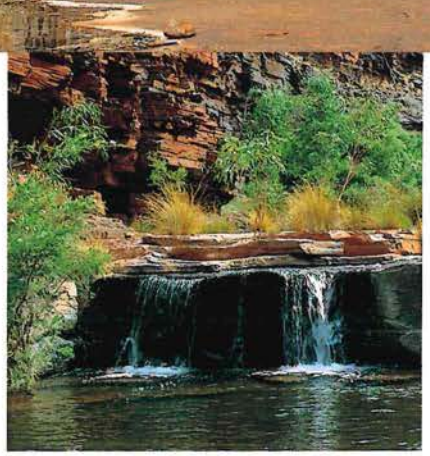
Close to Fortescue Falls a number of broad pools appear, similar to those close to Circular Pool but larger, and with greater volumes of water spilling over. The landscape at one such pool is dominated by a white-barked gum, rearing in contrast to the adjacent red cliff and the background of spinifex, with shallow water in front reflecting the sky. The falls are a must on most travellers' itineraries; a track allows visitors access from the car park above. Emerging from the cliff face above the Falls is a small population of white cypress (*Callitris columellaris*), surviving in this protected position because of the absence of fire.

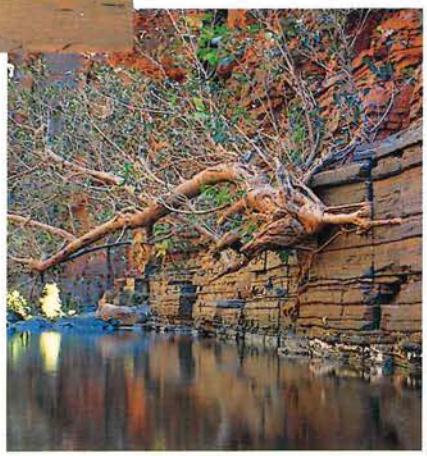
Leaving Dales Gorge and travelling 50 kilometres westward, then strolling a short distance from the carpark, a view of Knox Gorge spreads into the distance. The gorge is deep and has a rich range of colours. Plants cling to precipitous rock walls, and far below are the white trunks of cajeputs and eucalypts. The track into this gorge is steep and hazardous; again, most visitors stay on the lookout points and have no desire to venture into the belly of the gorge.

Visitors intending to walk through Knox Gorge need to be properly informed of the dangers of proceeding through to Red Gorge. A ranger must be advised and close attention paid to signs at the carpark about visitor safety. For the few who venture further, the greatest surprise is in discovering that the broad reaches of Knox Gorge narrow imperceptibly to a dark fissure that is impossibly slippery, forcing crab-like progress. The gorge narrows further, bringing to mind images of the gorge in flood and thoughts of escape. Going on becomes even less attractive when it appears that a five-metre leap into a pool from a steeply sloping, and wet, rock ledge is the next step. At this stage the warning which visitors receive from rangers that this trail is only for the experienced becomes real. The jump is taken with heart in mouth, the ice-cold water is deep enough to absorb the impact, and a minute or so









GEOLOGY OF THE GORGES

by Alan Thorne, Geological Survey of Western Australia

The rugged beauty of Karijini National Park results from a unique combination of geology, climate and natural vegetation. Of these, geology has probably had the greatest influence in shaping the landscape.

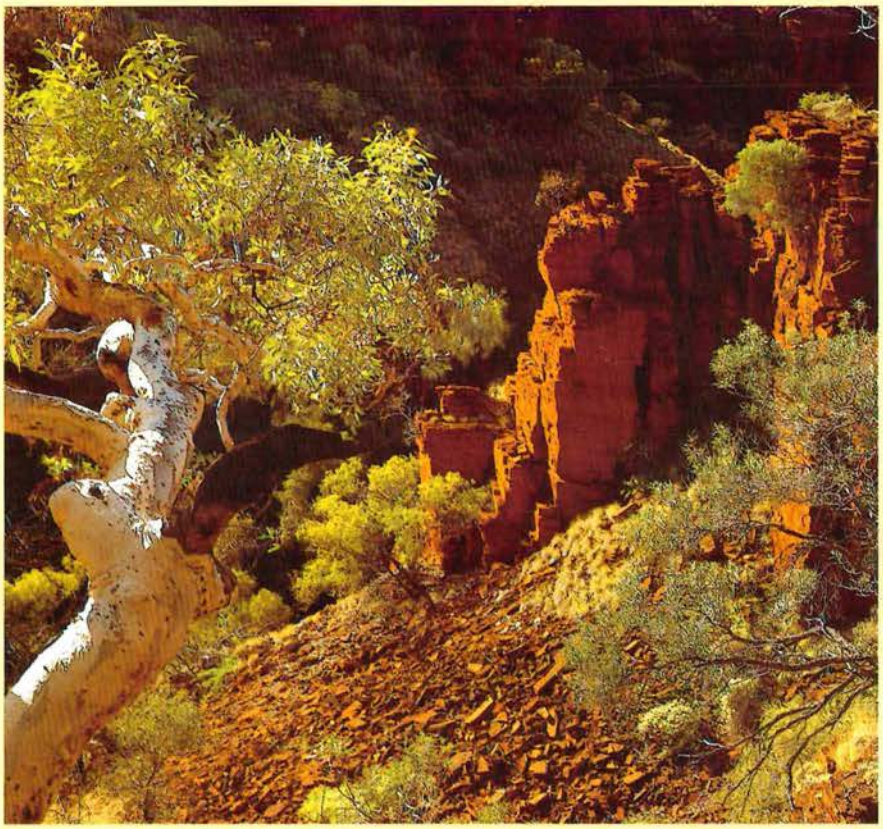
Rocks exposed in and around the gorges originated as fine-grained sediment which accumulated on the sea-floor 2 500 million years ago. Many of these sediments laid down in the oceans were unusually rich in iron and silica. Conditions on earth were quite different to the present day. The atmosphere contained much less oxygen, and the only forms of life were simple bacteria and algae.

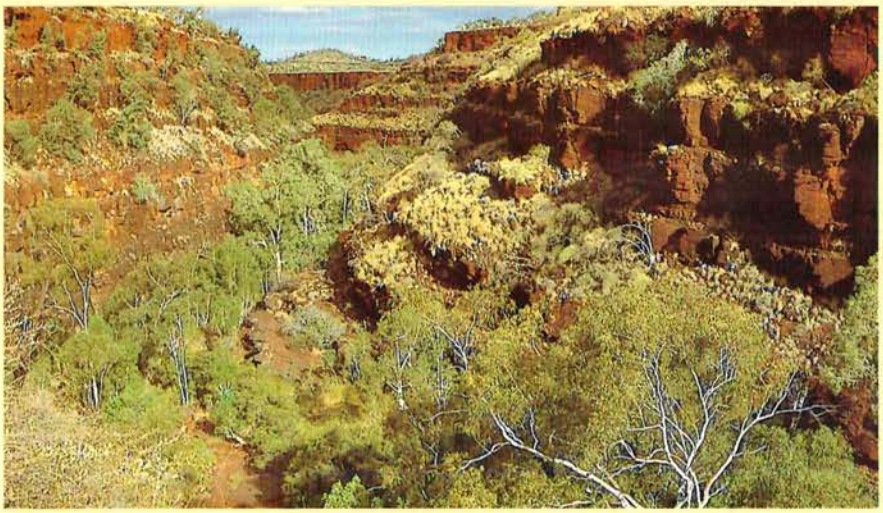
Blue-green bacteria were the first organisms to possess chlorophyll, which captured and converted energy from the sun into sugars, by absorbing carbon dioxide and water. Oxygen, released through photosynthesis, combined with soluble iron in the ancient seawater to form iron-rich compounds. Over eons, these sediments fell to the ocean floor to form banded, iron-rich deposits which were transformed by the pressure of further sediments laid down over them. Trapped water within the sediments was driven out and they gradually turned into tough, well-bedded rock.

Later, horizontal compression caused the rocks to buckle and develop numerous vertical cracks (joints), before being lifted to the surface to form dry land. Erosion over millions of years finally sculptured the rocks into the present day landscape.

Many creeks have exploited joints and other fractures cutting across the rocks. These water courses are characteristically straight and often parallel to neighbouring valleys. Angular creek junctions occur in areas where two or more directions of jointing are present. Soft, easily eroded shale and dolomite, occurring beneath the main iron formation layers, has enabled the creeks to cut back rapidly into the Range. Spectacular gorges and waterfalls are the result. Plunge pools occur at the foot of many of the falls, such as Circular Pool and Joffre Falls.

The slope and step appearance of many valley sides results from the alternation of weak and resistant rock types. Shale and dolomite generally form the gentler slopes, while iron formation outcrops are marked by notches and steep cliffs.

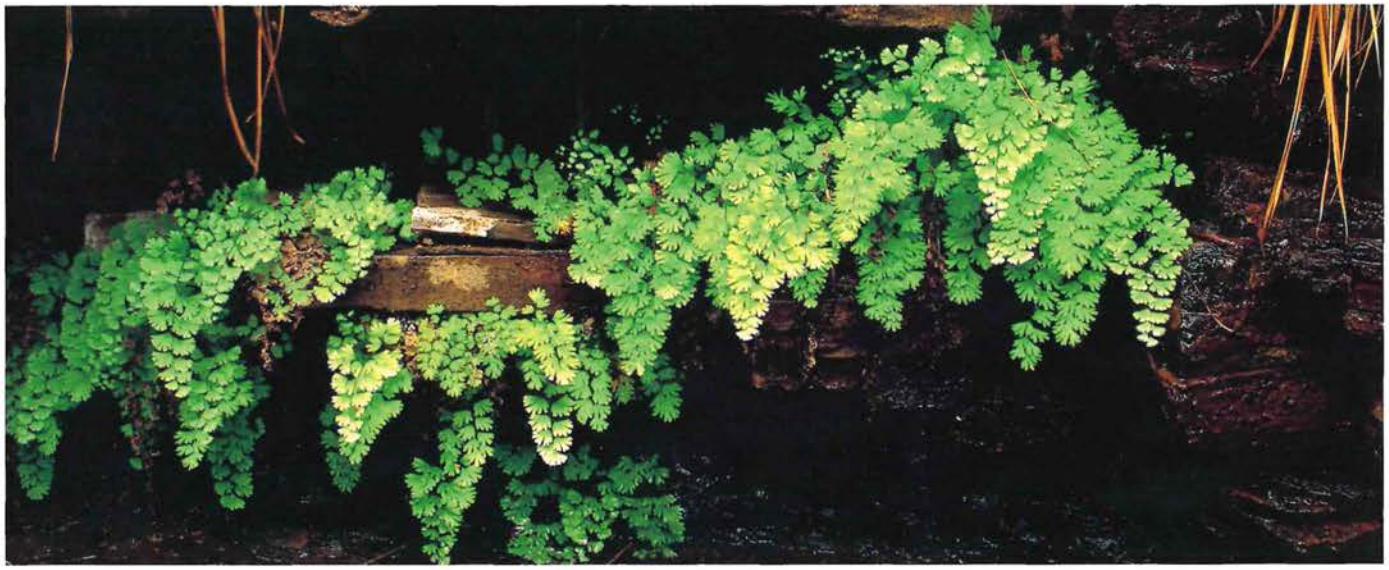




The sedimentary strata have collapsed onto the floor of Knox Gorge, because of erosion.
Photo - Chris Garnett ▲▲

The stepped walls of Knox Gorge result from the alternation of weak and resistant rock types.
Photo - Allan Padgett ▲

The slippery, well-worn surface of Hancock Gorge.
Photo - Chris Garnett ◄



Luxuriant ferns thrive on the moist rock ledges at Circular Pool.
Photo - Chris Garnett

later, paddling on an inner tube across what appears to be the entrance to Red Gorge, the fear has gone and been replaced by a sense of satisfaction. For the moment ...

From this pool a ledge, looking deceptively narrow and harmless, leads on to another jump! But this time there is greater uncertainty about the depth of the pool another five metres below. Still, the choices are not all that broad; to retreat up the previous waterfall would be virtually impossible without the right skills and equipment. So the adventurers go over again, with the first jumper calling out encouraging comments to the reluctant forces assembled above. Final egress into the junction of Knox, Red and Wittenoom Gorges made the effort worthwhile. Vertical red walls soar 100 metres from the sandy bed of the gorges, hot and silent in the midday sun.

The walk - and paddle - upstream through Red Gorge winds along the base of towering cliffs to Junction Pool, where Red, Joffre, Weano and Hancock Gorges meet. This must become a cauldron when cyclones pass and flood waters crash together at this point, shown by the huge boulders that were strewn there by raging water. From here, leaving the gorge may well call for more fortitude than that required to negotiate the waterfalls of Knox Gorge. Options include climbing out on the wet and slippery, highly polished rocks of Hancock Gorge, or paddling through pools of cold water and scaling boulders and cliff faces along the six kilometres of Joffre Gorge.

At the upper margins of the gorges there are safe views, as long as care is taken toward the edges, where scree slopes can make movement hazardous. Platforms have been built at some particularly good viewing points, including Joffre Falls, Knox Gorge and Circular Pool. The well-known natural rock platform of Oxer's Lookout serves the many thousands of visitors who travel vast distances to admire the conjunction of the four gorges far below. The views from lookouts into Red Gorge and Joffre Gorge are particularly inspiring: the former is magnificently coloured and very deep; the latter forms a natural amphitheatre with water cascading over steep rocky steps after heavy rainfall.

The carpark above Weano Gorge is close to the gravelly walk which dips and winds into the gorge, passing the familiar white and gnarled trunks of snappy gum. As the gorge narrows in its deeper sections, the walls towering above close in around Handrail Pool, which is accessible along a moderately steep, but slippery, path. A metal handrail allows the agile visitor to clamber onto shaded rocks surrounding the cool waters of the pool. Sitting silently in this tranquil place, deep within Weano Gorge, the visitor is again encouraged to reflect on the power of water in shaping this unique landscape, and on the immense passage of time over which such erosion occurred.

Venturing further west, the traveller reaches Hamersley Gorge. A series of pools connected by cascades is visible from the rim of this far smaller and shallower gorge. A safe, stepped pathway allows access for most visitors. The highly coloured layers of the walls of the gorge twist and contort, reflecting the geological forces which uplifted and bent this landscape millions of years ago. A short and easy walk takes the visitor past striking rock formations and on to a cool, clear pool shadowed by overhanging rock walls covered with ferns that flourish in the permanently moist atmosphere.

Whatever the motivation and physical ability of visitors, the park's gorges offer special recreational opportunities. Travelling through the arid Pilbara landscape, with its iron-capped hills and mesas and spinifex growing on stark red plains punctuated by brilliant white eucalypt trunks, is one thing. It is quite another thing to experience the gorges. They are not only ruggedly beautiful, but provide the chance to explore 2 500 million years of geological activity. ▣

CALM Planning Officer Allan Padgett (phone 364 0777) is coordinating a management plan for Karijini National Park. Stephan Fritz is Operations Officer for CALM's Pilbara Region (phone 091-868 288).

COLLECTIONS OF A Century

by Paddy Berry

Founded in September, 1891, the Western Australian Museum this year celebrates its first century of collecting and research.
What is the value to conservation of such collections?
Paddy Berry, Head of the Museum's Division of Natural Science, explains - using as an example the fauna collection, just one of the Museum's collections of a century.

Before we can conserve our fauna, we need to know which animal species exist now and which existed in the recent past. We also need to know the extent of their distributions and whether those of living animals are increasing or decreasing. This requires hard evidence such as that provided by museum collections. This type of evidence is superior to anecdotal recordings and sightings, as one can return to and more fully scrutinise a collected specimen. Even photographs do not provide the same quality of information; they portray only one dimension, and they deteriorate.

Collections are the basis for studies that provide internationally recognised scientific names for animals - names that are needed for legislation, management and research. This research, leading to classification and naming of animals, is called taxonomy, and is one of the major activities of the Western Australian Museum.

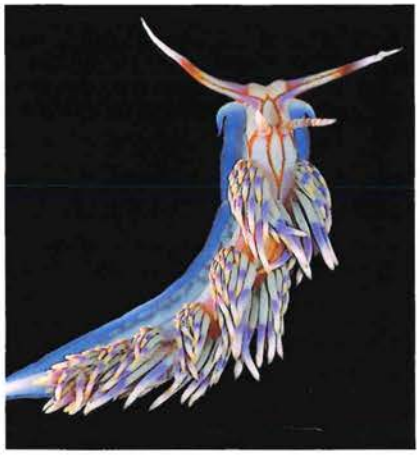
Taxonomy reached its zenith in Europe, the USA and early colonial countries in the late 18th and 19th centuries, so its arrival in Western Australia was rather late for this State to benefit from the boom. Other factors also made the task of collecting and naming rather formidable. The State, with an area of 2.6 million square kilometres, covers one third of the continent, runs along more than 12 500 km of coastline, and spreads across tropical, temperate and arid faunistic zones. As a result, WA's fauna is so inadequately recorded that many species are yet to be discovered. In the last decade alone 11 new species of mammal, 83 new reptiles and 20 new fish were described from WA - and these vertebrates are the best-known of the fauna groups.

However, we need information on all our fauna. The invertebrates, such as insects, corals and worms, are far more diverse than the vertebrates and ecologically just as important. Thousands of species undoubtedly remain undescribed (130 new marine species were discovered recently in two weeks at Rottnest Island!). Invertebrates are probably becoming extinct before we are even aware of their existence. Comprehensive documentation of invertebrates is probably unattainable, and in WA we have a long way to go even to adequately sample subsets of invertebrate diversity or specific groups.

One hundred years ago, in September 1891, the Western Australian Government established the 'Perth Museum' with Bernard Woodward as Curator, and a collection of geological specimens originating from the Geological Museum in Fremantle. In 1892, collections of the Swan River Mechanics Institute were added, including ethnological material and zoological specimens from interstate and overseas. The institution became known as the Perth Museum and Art Gallery. Two years later the first examples of Western Australian fauna were officially recorded in the leather-bound *Catalogue of the Museum, Perth, No. 1.* The first two entries written in Curator Woodward's copper-plate script were: *1894; 'Spined Echidna'; locality Toodyay; collector Otto Lipfert;* and *1894; 'Banded Ant-eater'; locality Coolgardie; collector Frank Reed.*

IRREPLACEABLE INFORMATION

The State's reference collections and associated data bank on its native fauna are now the responsibility of the Museum's Division of Natural Science. The Division ensures that representative examples of the native fauna, fossils, minerals and meteorites of WA, and from



Sea-slug (*Godiva quadricolor*), an example of a poorly known invertebrate group.
Photo - C. Bryce, WA Museum ▲◄

Rough leatherjacket (*Scobinichthys granulatus*) from the fish collection that comprises 37 000 specimen lots.
Photo - J. B. Hutchins, WA Museum ▲

Magnificent treefrog (*Litoria splendida*). Work is required to enable the tadpoles of WA frogs to be distinguished, as they have potential as indicators of habitat and water quality.
Photo - R. E. Johnstone, WA Museum ◄

Which is the common bush rat and which is the heath rat? Many small mammals cannot be identified from photographs; examination of a preserved specimen is essential.
Photos - Babs & Bert Wells ▲

The collections, stored in secure and environmentally controlled conditions.
Photo - D. Elford, WA Museum ◄

Pincushion starfish (*Culcita schmideliana*).
Photo - G. Bryce, WA Museum ▼

X-ray of scalpellid barnacle (*Litoscalpellum juddi*). Identification is by the numbers and arrangement of plates embedded in tissue.
Photo - D. Jones, WA Museum ►▼

elsewhere in the world, are preserved for reference, advancement of knowledge and enjoyment by succeeding generations.

Although young by world standards, the Division's collections are an irreplaceable source of information on our fauna. Even Woodward's second Western Australian specimen record (the 'Banded anteater') provides valuable evidence about the former distribution of our faunal emblem, the numbat, which is now extinct in the Goldfields. The collections include well over 4 million specimens or approximately 800 000 specimen lots (a group of more than two specimens collected from the same locality at the same time) and associated data. Their replacement value is conservatively estimated at $20 million.

The fossil specimens alone total a staggering 1.5 million. The collection includes insects (125 000 lots), terrestrial arthropods such as spiders and scorpions (120 000 lots), molluscs (190 000 lots), crustaceans (21 000 lots), worms (2 500 lots), corals, anemones and the like (10 200 lots), sponges (925 lots), echinoderms such as star-fishes and sea urchins (18 500 lots), other marine invertebrates (3 400 lots), fish (35 000 lots), and 36 000 mammal, 25 000 bird, 85 000 reptile, and 25 000 frog specimens.

Recently, the Division started a collection of soft tissue for modern genetic and bio-chemical studies. Stored at minus 80 Celsius, the frozen tissue collection currently contains samples from approximately 10 000 specimens.

Housed in the Francis Street building, Perth, in environmentally controlled conditions, all the collections are preserved as a reference and research resource in perpetuity. Type specimens, used as the basis for describing new species, have international status and are given special protection.

In many respects the collections are like a library. They are widely used by scientists from Australia and overseas, who either visit the Museum to work or have specimens lent to them. Each specimen is a miniature data bank, of an array of information that is not apparent from the exterior: for example, its unique genetic makeup, special food requirements and feeding habits, parasites and pathogens, reproductive information (breeding cycle, litter size, etc.), age and rate of growth, and levels of pesticides and pollutants. Scientists from many disciplines are making increasing use of the collections.

Caterpillar, probably of a boab hawkmoth.
Photo - T. Houston, WA Museum ◄

Gwardar (*Pseudonaja nuchalis*). The Museum answers over 12 500 enquiries each year, many of which are about potentially dangerous animals.
Photo - R. Johnstone, WA Museum ◄◄

Skull of 350-million-year-old fossil lungfish (*Latocamurus coulthardi*) from Gogo, Kimberley.
Photo - J. Long, WA Museum ▲

Efficient retrieval of individual specimens and/or data associated with them is very important. All vertebrate registers (except birds) and some invertebrate registers are now computerised. This allows researchers, wildlife managers, mining companies and environmental consultants to make rapid searches of species recorded within a specified area.

BUILDING A PICTURE

The collection continues to grow. Most specimens are acquired by Museum staff, but other government agencies such as the Department of Conservation and Land Management (CALM), universities and members of the public make substantial contributions to them. That dead possum lying on the road or the 'mouse' your cat brought in could provide valuable information and should be sent to the Museum. It is not just rare species that are important. Today's 'common' species could be on the decline (brushtail possums are a good example), and each record helps to create an overall picture of the distribution and status of the species that becomes more and more valuable with time.

A museum specimen can also directly benefit conservation. For example, in 1983, the Museum was given routine sample specimens of the common bush rat (*Rattus fuscipes*). The specimens were found during a fauna survey near Ravensthorpe by biological consultant Andrew Chapman (now an ecologist with CALM). In 1987, these specimens were examined by Museum research associate Alex Baynes and found to be the similar-looking heath rat (*Pseudomys shortridgei*), of which only three specimens were known from Western Australia. It had been last recorded in 1931 and was thought to be extinct in WA. This find helped establish that the heath rat survives near Ravensthorpe. Further searching has now established its presence in the Fitzgerald River National Park.

Some people are concerned about killing animals for collections. However, collecting is controlled by a scientific licence, issued by CALM, which limits numbers and distribution of specimens taken. This level of collecting, spread over a wide geographical area and period of time, has a negligible impact on survival of populations (compared with habitat destruction and competition and predation by alien species) and must be weighed against the benefits to conservation and knowledge derived from it. Museum staff also operate under the auspices of Murdoch University's Animal Welfare and Ethics Committee.

The Division of Natural Science has 16 curators and 10 supporting technicians, whose job is to maintain and expand the collections, conduct research on them and communicate the results to the community. The Museum's scientific journal *Records of the Western Australian Museum* documents much of this work.

This basic research has to be done before it is possible to produce authoritative books that allow non-specialists to recognise and identify WA animals. Over the past decade the Museum has averaged more than 50 scientific publications per year. During the same 10-year period, books on birds, lizards (skinks, dragons and monitors), frogs, snakes, sea-shells, sea-stingers and freshwater and marine fishes have all been published. Staff also received more than 12 500 direct inquiries each year on fauna, fossils, minerals and meteorites.

New displays on natural history, with particular emphasis on animal diversity, the environment and conservation, are being planned for the Museum's Perth complex. This will help make the collections and the information derived from them even more accessible to the public. ▣

NAMES DO MATTER

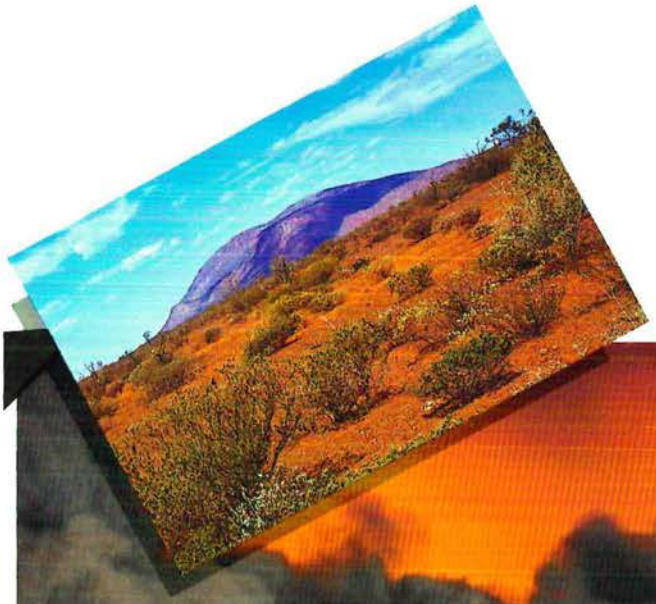
In 1962 Dr Ray George, then Curator of Crustacea at the Museum, recognised that the western rock lobster was a distinct species, confined to the west coast of Western Australia, and named it *Panulirus cygnus*.

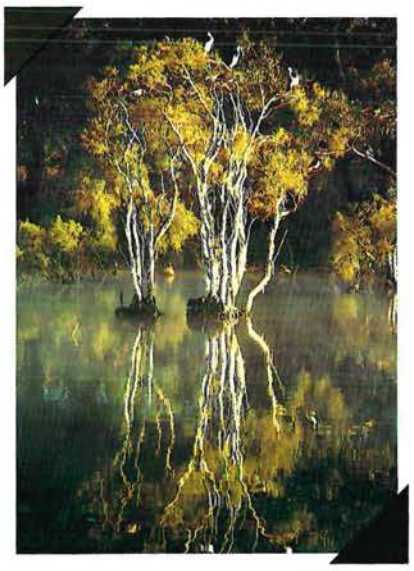
Before this, the western rock lobster was considered to be *Panulirus longipes*, a species widely distributed in the Indian and Pacific Oceans. Because of the great distributional capabilities of rock lobster larvae in ocean currents, it was uncertain whether the Western Australian adult rock lobster population originated from Australian larvae. It was also unclear whether or not management of the adult stock would necessarily benefit the local fishery.

Recognition that *Panulirus cygnus* was a distinct species, confined to Western Australia and hence solely the management responsibility of this State, was the catalyst for research, management and legislation that resulted in the most successfully managed rock lobster fishery in the world and the largest single-species fishery in Australia. The fishery for *Panulirus cygnus* was worth $200 million in 1989-90.

Paddy Berry is Head of the Museum's Division of Natural Science. He can be contacted on (09) 328 4411.

through CALM eyes





Top:
Mount Augustus
Beverley Koch - Herbarium

Above:
Winner
Energy to burn
Gerard van Didden - Fire Protection

Far right:
Ibis on paperbarks
Wally Edgecombe - Silviculture Branch

Right:
Bud to blossom
Ray Smith - Wildlife Branch

Close encounters
Doug Coughran - Wildlife Branch

Beautiful banksia bloom
Mike O'Donohue - Wildlife Branch

Below:
Reflections
Tony Tapper - Park Ranger

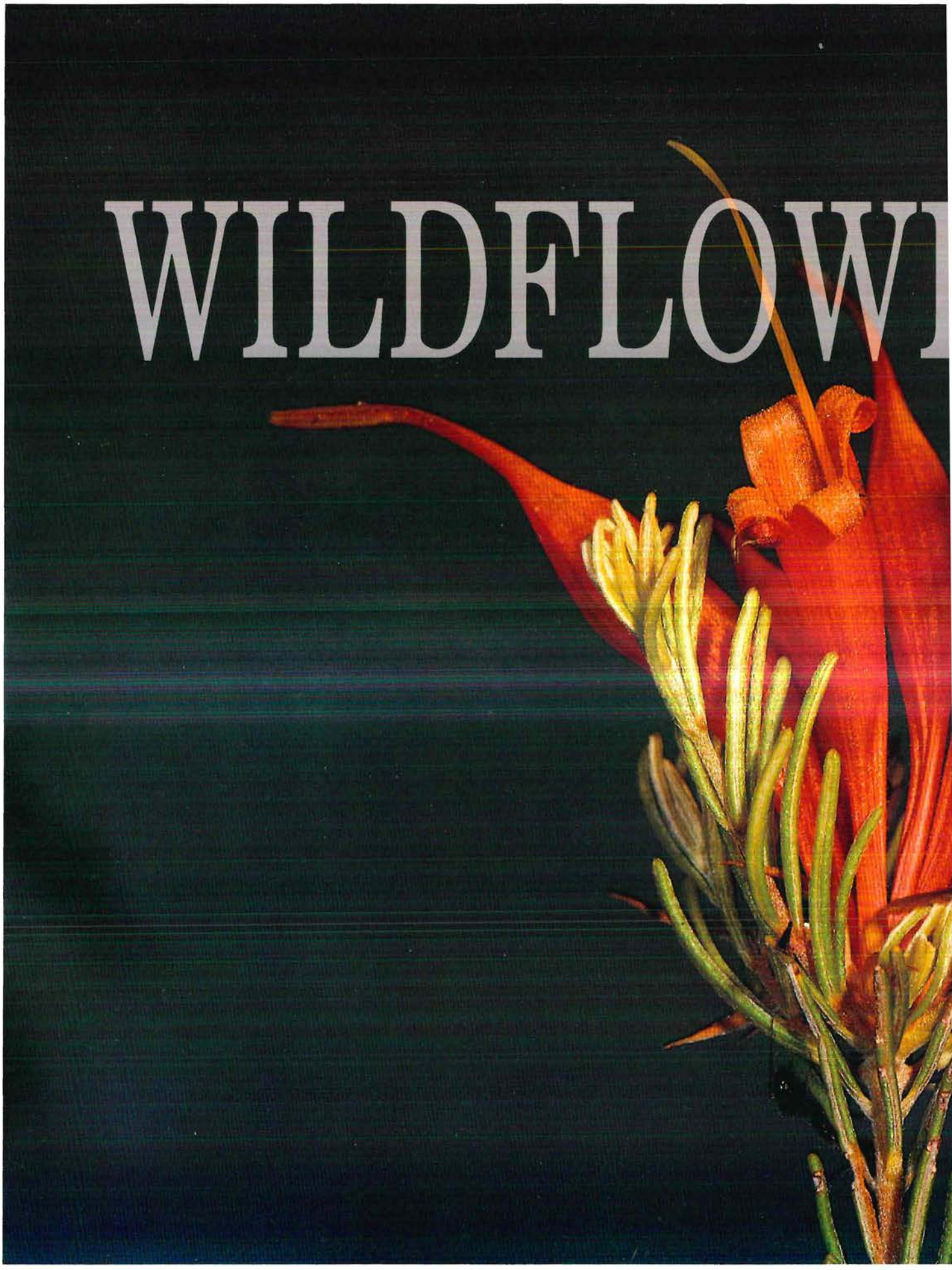
On these two pages are some of the pictures submitted as part of a staff photographic competition run by the Department of Conservation and Land Management. We thought you'd enjoy seeing them.

CALM is made up of a wide range of people in a myriad of different jobs - tree planters, park rangers and managers, foresters, wildlife officers, secretaries, research scientists, information and education officers, accountants, landscape architects, firefighters, mechanics, cartographers, computer programmers, recreational planners, and many more. Some are recent arrivals in Australia, some can trace their ancestry here for several generations, and others have a connection with the land, forests and wildlife of Western Australia that extends back for 40 000 years.

The images on these two pages show that in addition to sharing CALM's task in conserving the unique natural heritage and wildlife of WA for present and future generations, many of the people in CALM share an interest in capturing the land and its inhabitants on film. Photographs taken by CALM people have been an important part of this magazine since the first issue of LANDSCOPE was published in June 1985. And they will continue to be an important part of LANDSCOPE.

It doesn't take long to see why...

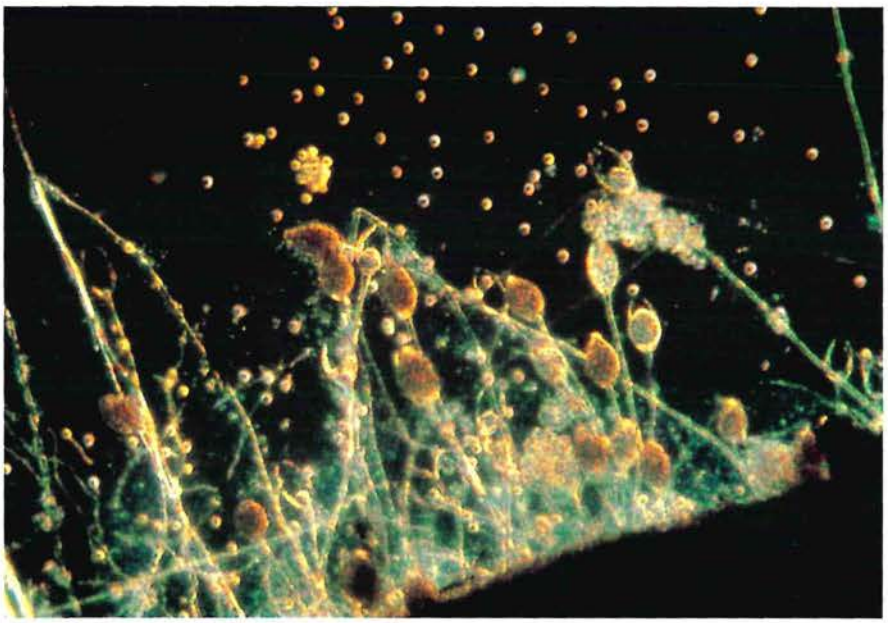
The dance
Allan Padgett - Planning Branch


WILDFLOWI

ER KILLERS

by Bryan Shearer, Ray Wills and Mike Stukely

Western Australia's unique wildflowers evolved in response to environmental stresses brought about by ice ages, earthquakes, flooding, fire and drought. Now they face one of the greatest threats to their existence, from seemingly insignificant, microscopic fungi belonging to a group called *Phytophthora* - the wildflower killers.



Previous page:
Wild honeysuckle (*Lambertia ericifolia*) and golden dryandra (*Dryandra nobilis*).
Photo - Jiri Lochman

Spore sacs of *P. cinnamomi* release zoospores that swim in free water and infect nearby roots.
Photo - B.L. Shearer

Dieback-stricken banksia woodland in Cape Arid National Park.
Photo - Jiri Lochman▲

For decades after foresters first noticed the deaths of jarrah trees in the early 1920s, the cause of 'jarrah dieback' escaped scientists. Only in the mid 1960s was the destroyer of jarrah finally identified by Dr Frank Podger as the soil-borne fungus, *Phytophthora cinnamomi* (see *LANDSCOPE*, Spring 1989). Dr Podger described the effects of the killer fungus in the jarrah forest, and in banksias and other wildflower communities throughout the South West. However, most of the attention and subsequent research focussed on the jarrah forest. This changed in 1985 when the departments of Forests, National Parks and Wildlife amalgamated to form the Department of Conservation and Land Management (CALM). Since then, a lot more attention has been given to the problem of infections in wildflower communities outside the forest.

We can now identify which wildflower communities are vulnerable to dieback disease, and use hygiene methods developed in the jarrah forest to help protect these communities. We also know that dieback disease is caused by seven species of soil-borne *Phytophthora*. *Phytophthora cinnamomi* is the most common and destructive, but *Phytophthora citricola*, *P. cryptogea*, *P. drechsleri*, *P. megasperma* var. *megasperma*, *P. megasperma* var. *sojae* and *P. nicotianae* also kill wildflowers.

FOREIGN INVADERS

The seven *Phytophthora* species attacking wildflower communities are not native to WA. They were probably introduced to the State with imported plants around 1900, before quarantine procedures were in place. *Phytophthora* species are now spread around the world, but the killer fungi probably originated in the sub-tropics.

During the 40 years before it was recognised that *P. cinnamomi* killed jarrah, the fungus was unwittingly spread throughout the South West by off-road vehicle activity and in infected gravel used in road construction. The fungi are also spread in soil clinging to the boots of bushwalkers, and on the feet of animals. They have also been widely distributed by people moving infected plants.

Within diseased areas, the fungi spread by growing in the root systems of infected plants, and can even spread uphill in this manner. Downhill spread is mainly by infectious spores carried by water; many of our soils contain a hard pan below the surface which causes water to pond and flow across it, carrying spores of the fungi with it. So, as well as being found in water running over the top of the soil, fungi spores may survive and spread up to five metres below the soil surface.

VULNERABLE COMMUNITIES

From the initial small dead patches of forest, dieback disease infected an estimated 280 000 ha of Crown land by 1977. Today, *Phytophthora cinnamomi* threatens diverse wildflower communities from Eneabba in the north, to the eastern edge of the jarrah forest and along the south coast to Cape Arid.

The killer fungus dramatically changes the wildflower-rich jarrah forest understorey. Wildflowers of the banksia, pea and heath families are commonly killed, causing an irreversible decline in the diversity of infected areas. Surviving trees in the forest often mask the full impact of the disease, but its effects can be as severe as those in shrubland and woodland on the coastal plain and south coast.

Dieback disease is destroying banksia communities on coastal sandplains around Perth and on the south coast. North of Perth, it is threatening the geographically restricted rose banksia (*Banksia laricina*) in the Moore River National Park. In banksia woodlands near Perth the dominant candle, holly leaf and firewood banksias (*B. attenuata*, *B. ilicifolia* and *B. menziesii*) are killed. In affected areas, no overstorey remains. Many understorey wildflower species are similarly affected: the number of species in 64-square-metre quadrats decreased from 56 in healthy woodland to 41 in diseased woodland.

On the south coast, the rare and dieback-susceptible feather-leaved banksia (*B. brownii*) is threatened with extinction; all of its few known locations are infected. The rich flora of the Stirling Range National Park is also under threat. The fungus was probably spread throughout the park by off-road vehicles and the construction of firebreaks and roads during the 1940s to 1960s. Walk trails are also infected. Grassy areas of low diversity replace wildflower-rich shrublands and woodlands in the infested areas of the park. Vegetation in Cape

Arid and Cape Le Grand National Parks is also suffering considerable damage.

The Fitzgerald National Park is one of the richest wildflower areas in WA, with 20 per cent of the State's described plant species. *Phytophthora cinnamomi* infects a narrow six-kilometre strip along Bell track, illegally built in 1971 in the northern-central part of the park. Bird's nest banksia (*B. baxteri*) and Lambertia thicket is being destroyed within the infected area. The spectacular royal hakea (*Hakea victoreae*) survives for a time in infected areas, but eventually dies. The protection of the healthy vegetation that still covers most of the park is a high priority.

The other wildflower killers are also causing concern. *Phytophthora citricola* is the most widespread, mainly killing individual plants in the area bordered by Kalbarri in the north, Boyagin Rock to the east and along the south coast to Cape Arid. *Phytophthora megasperma* kills banksia communities in seasonally waterlogged areas on the Northern Sandplains and south coast. *Phytophthora cryptogea* and *P. drechsleri* are associated with water bodies and *P. nicotianae* occasionally kills banksias.

Large areas of wildflower-rich shrublands are still disease-free, but vulnerable to infection. It is essential to prevent further losses by protecting healthy wildflower communities from disease.

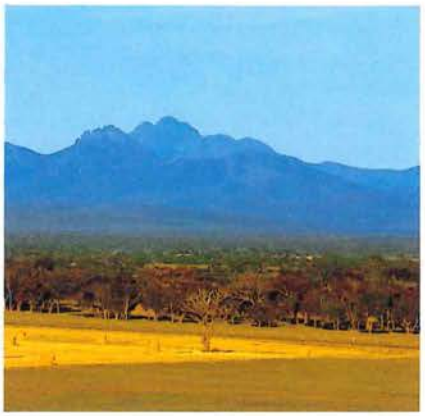
LOSSES TO THE COMMUNITY

In 1989, government and industry spent at least $3.5 million dollars on dieback disease detection, mapping, prevention and research. These costs will probably increase in the future as the fight against the disease intensifies.

The loss of wildflowers directly affects multi-million dollar industries such as tourism and honey production. The wildflower areas north of Perth and on the south coast are vulnerable to infection, while popular tourist areas such as the Stirling Range National Park and Two Peoples Bay Nature Reserve are severely affected.

The death of wildflowers also affects the species that depend on them for food and shelter. Wildflower communities are varied and complex. The firewood banksia and the woollybush (*Adenanthos cygnorum*), for instance, are keystone species in the banksia woodlands around Perth.

Firewood banksia flowers in winter and is an important source of pollen and nectar for many birds and insects, at a time when few other species flower. Insect larvae that use the flower heads are an important food for cockatoos, while in autumn the nutritious seed and seedlings are eaten by many animals. Woollybush flowers from spring to autumn, and complements firewood banksia as a nectar source for birds and insects. It also has special glands that provide nectar for ants, wasps and other insects all year round. Woollybush fruits provide



The rich flora of the Stirling Range National Park is threatened by dieback disease, especially along walktrails.
Photo - Cliff Winfield ▶

Royal hakea survives for a time in infected areas but eventually succumbs to dieback.
Photo - Marie Lochman ▼

food for birds, rodents and ants, while the leaves are eaten by a specialised moth, the larvae of which are preyed upon by a wasp. The death of just these two plants has great consequences for these dependent animals.

Similar interactions occur in many other wildflower communities. About 15 per cent of South West plant species are pollinated by birds and mammals. Banksias and related wildflowers have large flowers pollinated by nectar-eating animals such as the western pygmy possum and honey possum. Seed-eating parrots might also be affected by the loss of favoured seed-producing species such as banksias or hakeas.

Populations of bird or mammal pollinators may dwindle as the plants on which they depend are eliminated. If only a few plants remain, there may not be enough food to sustain the pollinators. If the pollinators disappear, the few remaining plants may never set seed, despite having survived the killer fungi. In this way, death of susceptible species may reduce the numbers of pollinators essential to the survival of more resistant plants such as the endangered rose mallee (*Eucalyptus rhodantha*), and can thus affect neighbouring communities as well. However, we still have to learn a lot more about the interactions within wildflower communities in order to determine the true cost of dieback disease.

WHY SO VULNERABLE?

The *Phytophthora* fungi can attack at least 1 000 plant species throughout the world. Because the killer fungi were only recently introduced to WA, the State's wildflowers have little resistance to infection. Our wildflowers have adapted to poor soils and drought by developing extensive specialised root systems for maximum intake of nutrients and water, but that is precisely what makes them vulnerable to the killer fungi.

Western Australian climate and soils provide many favourable environments for the fungi. *Phytophthora* species thrive in warm, moist conditions during autumn and spring. Rainy winters create wet conditions that allow infectious spores to survive and spread in moist soil picked up by vehicles and in flowing water. Moist conditions are created for most of the year above hard pans deep in the soil. Thus, even though the surface soil may be dry, millions of infectious spores may be produced and distributed deep in the soil. Warm temperatures in summer also favour rapid fungal growth along the root systems of infected plants and result in the infection of new hosts through root-to-root contact.

MANAGING THE DISEASE

Dieback disease is everybody's problem. Effective control depends on the combined efforts of the public, assorted industries, and federal, state and local government. The more people know about the disease, the more they can do to prevent its spread. Rotary International District 9460 and a newly formed Northern Sandplains Dieback Working Party are helping the government increase public awareness and training.

Mapping the extent of the disease is an essential first step in effective prevention. The dieback mapping system developed by CALM staff for the jarrah forest is one of the most effective disease detection techniques in the world. This system is based on the interpretation of colour aerial photographs and is now also used to map dieback distribution in wildflower communities.

Quarantine and hygiene procedures have been developed in areas managed by CALM. Roads and tracks in national parks, reserves and forest have been closed to stop the infection from being introduced into healthy areas with susceptible and endangered wildflowers. Everyone can apply their own quarantine by keeping to all-weather roads, especially during wet weather.

Clean work practices also help to prevent the movement of infected soil, plant material and water into healthy areas. A package of hygienic procedures is used to minimise the consequences

Above:
A CALM officer injects an acorn banksia (*B. prionotes*) with phosphorous acid.
Photo - Bryan Shearer

Far left (above):
Animal species such as honey possums that use susceptible plants for food are also affected by dieback.
Photo - Michael Morcombe

Far left (below):
The rare rose mallee is fairly resistant to the disease.
Photo - Jiri Lochman

Left (above):
Flowering understorey of the jarrah forest - honeybush dies out, leaving only the resistant wattle, prickly moses.
Photo - Marie Lochman

Left (below):
Fox banksia (*Banksia sphaerocarpa*) is susceptible.
Photo - Michael Morcombe

should any one procedure accidentally fail. These include cleaning machinery, vehicles and footwear; controlling the movement of soil and road-making materials; minimising activities when soils are wet and sticky; disinfecting water used from streams and dams; paying attention to drainage; and carrying out essential activities only.

These methods of disease management help protect large areas of healthy bush from dieback disease, but are regarded as a holding action until better methods of controlling the disease have been developed.

FUTURE OPTIONS

At the moment, dieback fungi are usually only detected after plants have died. Remote sensing, using special detectors that sense thermal and infra-red radiation, may give early warning of infection. Trials are under way to see if healthy wildflower communities growing on soils that favour the disease can be mapped and if infected plants can be identified before they die.

Scientists now know much about how *P. cinnamomi* survives and spreads under local conditions. We need to learn more about how the other six *Phytophthora* species reproduce and survive. Determining moisture and temperature conditions that affect the ability of the fungi to produce spores, survive and infect hosts will help scientists to assess the risk of infection, and to develop hygiene maps and effective methods of control.

There may also be great potential in a host's own resistance. While many populations of susceptible species are decimated by the killer fungi, a few individuals occasionally survive. Though they often escape by chance (perhaps some subtle barrier in the soil prevented infection), some plants may have developed a genetic variation that helps them resist the fungus. If resistant individuals can be found, there is hope of replacing susceptible populations with resistant varieties. Research on resistant jarrah has shown great promise. This work will be expanded to include other key groups of plants.

Where conserving plants in the wild is not possible, tissue culture can be used to propagate and store plants at risk. This may allow us to re-establish these plants after means of controlling the killer fungi have been fully developed. Longer-term research may allow genetic engineering of the plants to include genes for resistance found in other species.

Chemotherapy is another important measure. Phosphorous acid, a cheap, biodegradable fungicide not toxic to people or animals, may be a practical way to control infection in wildflower communities. The fungicide controls all the *Phytophthora* species except *P. megasperma*. It penetrates all parts of the plant, even roots metres below the soil surface. The fungicide has a double action; it directly attacks the fungi and also boosts the plants' natural defences. Phosphorous acid protects banksias from

Photo - Jiri Lochman

infection for at least four years after being applied, and banksias already infected by the fungi can heal themselves after treatment. The fungicide can be applied to plants by injecting it in their trunks, and by spraying onto the foliage for large areas. It is currently being used to protect the feather-leaved banksia from infection.

Biological research offers hope of turning the fungi on themselves. Genetic engineering may be able to exploit weaknesses in the make-up of the fungi in order to help control them. However, such options are expensive and will take time to develop.

In the meantime, the whole community must combine to fight the killer fungi. The cost of protecting healthy plant communities is small compared to the loss of conservation, plant resource and aesthetic values caused by the disease.

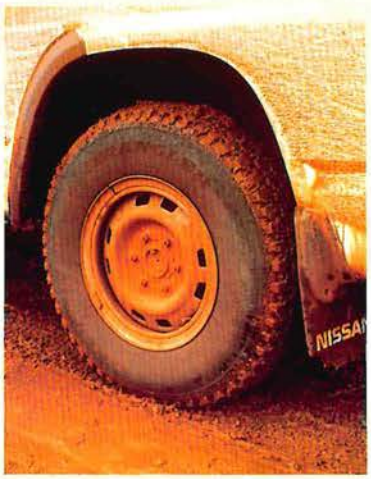
Although there is as yet no cure for dieback disease, human ingenuity always provides hope for the future. Meanwhile, considerable advances in research and hygiene procedures provide a holding action. Until the wildflower-killing fungi are beaten, the preservation of some of WA's unique plants and animals will hang in the balance. ⊡

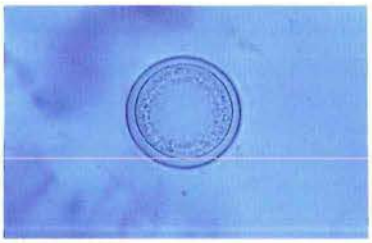
Bryan Shearer, Ray Wills, & Mike Stukely are all research scientists within CALM's plants disease program.

WHAT YOU CAN DO

The fight against wildflower dieback must involve the whole community. You can help if you:

- Find out about the biology of the killer fungi.
- Become aware of where wildflower dieback already occurs and the effects the disease is having on plant communities.
- Take an interest in protecting your local piece of bush.
- Support the efforts aimed at containing the spread of the fungi and at finding a cure.
- Stop the spread by keeping to well-formed, well-drained roads and observe "road closed" signs.
- Make sure you are not a fungus carrier if you have to go off road.





Thick-walled oospores of *P. citricola*.
Photo - Bryan Shearer

THE KILLING FUNGI

The seven soil-borne *Phytophthora* species that kill our wildflowers extract their food from plant tissues by a mass of microscopic threads, or **mycelium**, which forms the body of the fungi.

Given warm, moist conditions and interaction with soil microbes, the mycelium can bud off microscopic spore sacs which release millions of tiny infectious **zoospores**. This is the main way the *Phytophthora* species infect plants and reproduce. Once released, the zoospores swim over short distances or are passively moved in moist soil through human activity and in running water.

Active zoospore production occurs mainly in spring and autumn. In winter zoospores survive in moist soil but their production is limited by low temperatures. If the soil dries out in summer the fungi usually die, but can survive in infected roots or as more resistant spore types.

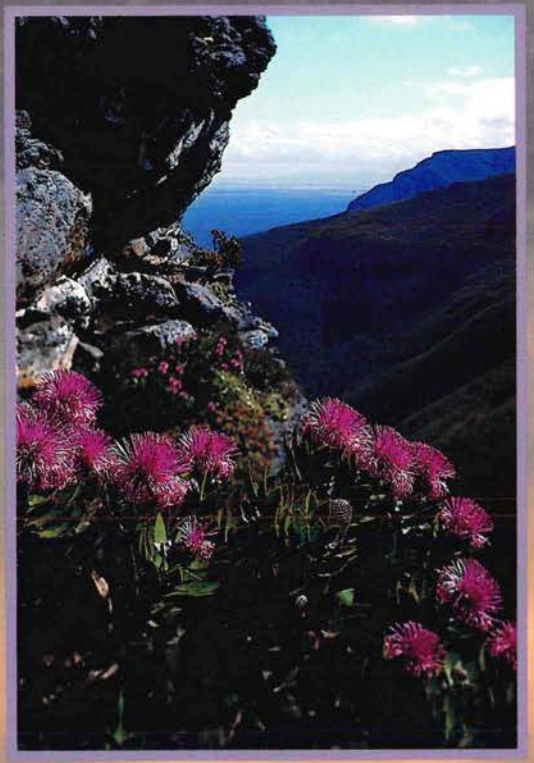
The mycelium may also bud-off **chlamydospores** which are larger than zoospores and can survive in soil and plant tissue for long periods, provided conditions do not become too dry. They cannot move on their own, but can be transferred in infected roots and soil particles. When conditions are favourable the chlamydospores germinate and produce mycelium and zoospores.

Thick-walled spores called **oospores** are also produced by the mycelium under certain conditions. Oospore production by *P. cinnamomi* is infrequent because two types of mycelium must grow together before they are formed. In comparison, *P. citricola* and *P. megasperma* readily produce oospores, as the fungi form the spores from the one type of mycelium. The thick-walled oospores can survive dry conditions and probably account for the wide distribution of *P. citricola* in south-western Australia.

After infection, the fungi invade root bark and form lesions of dead tissue. The fungi kill their hosts by destroying fine roots and girdling major roots or the base of the stem, depriving the plant of access to nutrients and water.

More than 80 per cent of species in the banksia family (banksias, grevilleas, dryandras, hakeas, and so on) may be killed by the fungi. The banksia family is often the most abundant group in many areas of the South West and so provides the fundamental elements of many plant communities.

# of mists and mountains



by John Watson

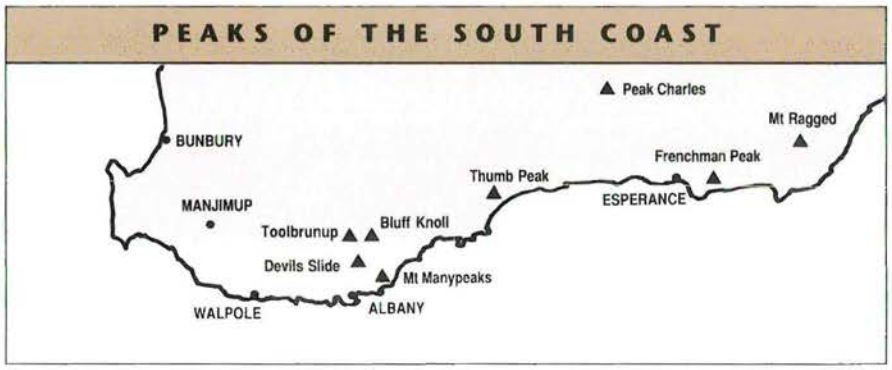
Compared with Mt Everest, the Matterhorn and the Himalaya, Western Australia's mountains are tiny. But they far outweigh the massive barren peaks of other lands in biodiversity and conservation value. Unfortunately, the human impact on them is much more telling...

John Watson takes us on a path into the mountain mists of the south coast, where every step we take is precious.

Mountains were once thought to house evil spirits who hurled rocks or avalanches of snow at anyone who dared venture near them. In the mountains of Scotland people still claim to see and hear the ghost of the Great Grey Man of Ben MacDhui, or Ferlas Mor, as he is called in Gaelic. Some Aboriginal legends also feature mountains, though not necessarily with evil spirits; the sleeping warrior in the Stirling Range is a good example.

In time, mountains inspired artists, poets, and eventually photographers. As people began to test human limitations, mountains became a new frontier in adventure, leading many climbers to their deaths. Today, mountains are considered a thing of beauty as well as an unpredictable environment demanding respect. People visit them to bushwalk, rock-climb, study nature, photograph the wilderness and even hang-glide.

The mountains of the South Coast region of Western Australia are essentially islands of remnant vegetation in a vast ocean of sandplains and heathlands, much of which has been cleared for agriculture. Moreover, these 'remnants' have unique floral associations because of their landform, climate and elevation gradients.



Previous page:
Misty sunrise on Bluff Knoll.
Photo - Robert Garvey

Inset:
Isopogon latifolius in the Stirling Range.
Photo - Michael Morcombe

The rolling contours of Mt Manypeaks (565 m) in the Waychinicup National Park near Albany.
Photo - Michael Morcombe

Being geologically old, Western Australia's small mountains are very rich in species, often much more so than the mountain giants of the world. For example, the Fitzgerald River National Park has more plant species in it than the whole of the British Isles, and a high proportion of species occur in the Barren Ranges, a small group of quartzite peaks near the park's southern coastline. The Stirling Range peaks have many plants found nowhere else, with a large proportion of declared rare species and species in need of special protection. Among the better-known genera are the mountain bells of the Darwinia, about eight species of which are endemic to the Stirling Range, some found only on specific peaks in the range.

Closer to the coast with its marine influence, the Waychinicup National Park, including Mt Manypeaks, has almost the same floral diversity as the Stirlings despite being only one-tenth the area and a little over half the vertical elevation range.

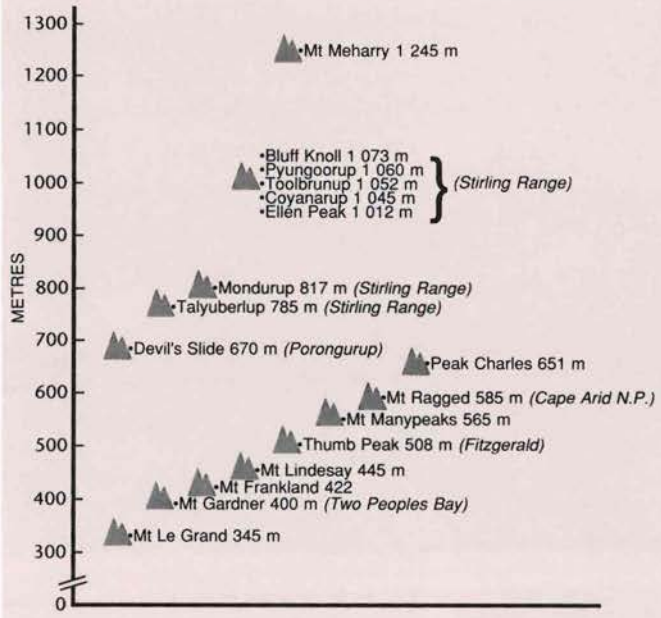
As well as a high degree of plant biodiversity, Western Australia's mountains contain populations of relic Gondwanaland fauna. There is a limited amount of research on invertebrates in mountainous regions, but already researchers such as Barbara York-Main have established Gondwanan links for one species of spider between the Stirling Range, Madagascar and Africa. (For information on other fauna of the Stirlings, see *LANDSCOPE*, Winter 1991.)

WALKING A FINE LINE

While mountains appear strong and timelessly resilient, they can be vulnerable. This is especially the case with the mountains of Western Australia's south coast.

Thousands of walkers visit these mountains each year. The most popular places are peaks in the Stirling and Porongurup Ranges, such as Bluff Knoll and the Devils Slide, with a steady trickle of visitors to lesser-known areas such as Mt Ragged, Peak Charles, Mt Manypeaks, and the Barren Ranges of Fitzgerald River National Park.

Human impact has affected these natural areas in several ways; the introduction of dieback disease (seven species of *Phytophthora*) and the



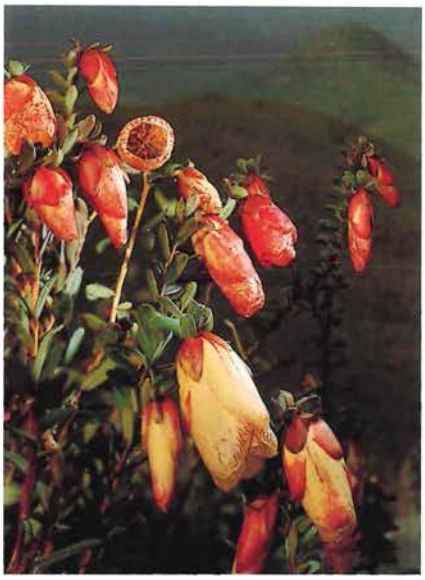
Western Australia's highest point is 1 245 m (4 085 ft) at Mt Meharry in the Hamersley Range (Karajini) National Park. However, it's in the south that some of the State's most spectacular and widespread mountain peaks occur. Here there are five mountains above 1 000 m (3 281 ft), all in the Stirling Range, and a further 33 peaks above 550 m (1 700 ft). These include Mt Ragged (585 m) and Peak Charles (651 m) in the Esperance District, Mt Manypeaks (565 m), about a dozen 'tops' in the Porongurup Range (Devils Slide summit 670 m), and an additional 20 or so lesser peaks in the Stirling Range. There are also a number of much smaller peaks around Esperance in Cape Le Grand National Park (Mt Le Grand 345 m), in the Fitzgerald River National Park (Thumb Peak 508 m), around Albany (e.g. Mt Gardner at Two Peoples Bay 400 m) and, further west, isolated granite peaks such as Mt Lindesay (445 m) and Mt Frankland (422 m).

erosion of popular paths are the main concerns.

It is now well documented that dieback disease can have a devastating effect upon whole genera of local flora, including many of the rare or specially protected species occurring on mountain peaks. Due to their elevation in the landscape and their relative remoteness, many peaks have escaped dieback infection so far. Some, however, especially those which have experienced a high level of recreational use, are now infected with the disease.

With dieback disease's potential spread downslope, the long-term ramifications of such infections are daunting. In the Fitzgerald River National Park an area in the central region of the Barren Ranges (Thumb Peak, Woolbernup Hill and Mid Mount Barren) has been closed to bush walkers to prevent further infection spread. Some parts of other high-value conservation areas such as the Stirling Range National Park may also need to be closed.

In many mountains on the south coast, mountain paths are quite literally wearing out. This is hardly surprising on paths such as that leading to Bluff Knoll in the Stirling Range, with pedestrian-counting machines registering about 20 000 pairs of feet a year. This problem is by no means confined to Western Australia - it is faced in most mountainous regions of the world.



Mondurup bells (*Darwinia macrostegia*) in the Stirling Range National Park.
Photo - Michael Morcombe ▲

Mountain bells (*Darwinia collina*) on Bluff Knoll. The plant is confined to the eastern parts of the Stirling Range.
Photo - Michael Morcombe ▶▲

Over the past decade the Department of Conservation and Land Management (CALM) has made contact with mountain managers throughout the world to share up-to-date knowledge and experience about path management and restoration. Paths are surveyed to identify and document specific problems, and restoration work is then undertaken. CALM is now actively seeking funds to implement further restoration of paths in south-coast mountains, with donation boxes installed near path beginnings at such areas as Frenchman Peak in Cape Le Grand National Park, Bluff Knoll in the Stirling Range, and the Gap and Natural Bridge in the Torndirrup National Park.

In the South West Tasmania World Heritage Area, an estimated $1 million is being spent annually on footpath work, and it was recently estimated that $15 million would be required to upgrade all paths in that area. CALM has conservatively put its first target figure for south-coast path restoration at $100 000 per annum. This work is

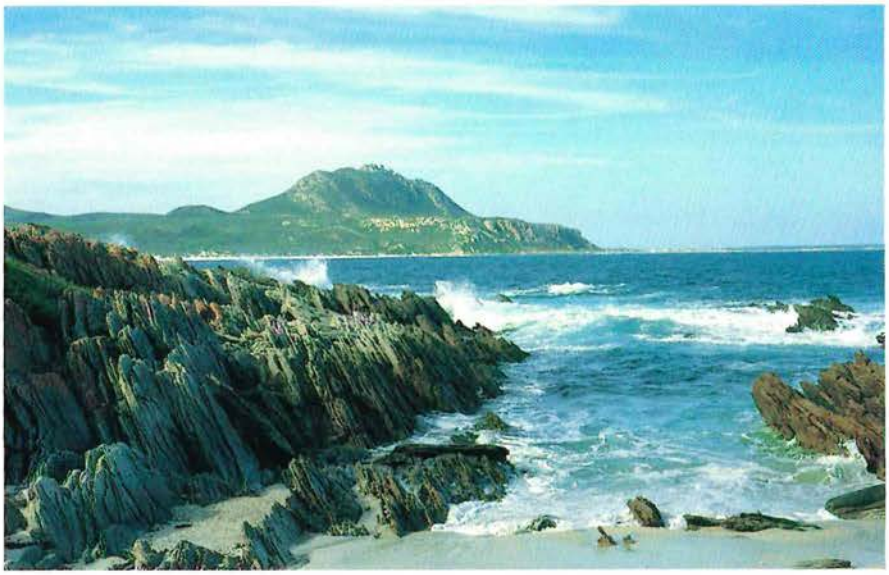
extremely labour-intensive; unlike road construction, where there is ready access to bulldozers, tip trucks, graders and bitumen tankers, workers on mountain paths have to use picks and shovels and Shanks's Pony.

SUPPORT YOUR LOCAL MOUNTAIN

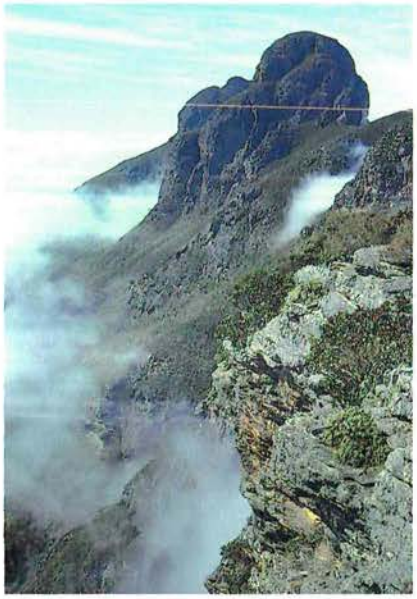
CALM's work towards dieback control and path repair in the south coastal mountains is increasingly being recognised at home and abroad. But CALM needs public support. Donations are always eagerly received; CALM offices in Albany and Esperance have established Path Restoration Funds for the purpose. And volunteers are warmly welcomed into 'busy bees' on mountain paths.

This work must be done. Mountains are special places, breathtaking and awe-inspiring. But they are vulnerable environments, and many of them are the last stronghold for old, rare flora and fauna.

John Watson is CALM's South Coast Regional Manager, based in Albany. He is an experienced rock climber and walker who has travelled and climbed in mountain areas throughout the world. He is attending an international conference on protected areas and mountain environments in Hawaii later this year, which is sponsored by the East-West Centre (Hawaii), the World Conservation Union (IUCN) and the US National Park Service.



East Mt Barren (299 m) in the Fitzgerald River National Park, clearly showing the old wave-cut platform.
Photo - John Watson



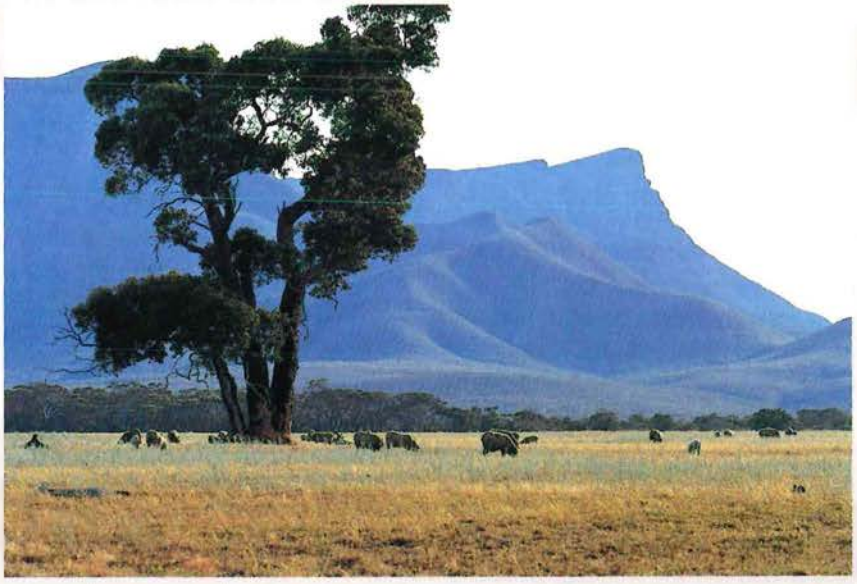
Early morning cloud on the Arrows, Stirling Range National Park. Pyungoorup (1060 m) is in the middle distance and Ellens Peak (1012 m) beyond.
Photo - John Watson

WHAT IS A MOUNTAIN?

The simple definition in the Concise Oxford Dictionary is 'a large or high and steep hill'. Of course the terms *large, high* and *steep* are not defined, and if you look up *hill* in the same dictionary it is defined as a small mountain!

In practice you really have to look at local definitions. In the Himalaya, for example, where the peaks rise to 8 848 m (29 028 ft), mountains are generally required to have summits above 6 100 m (20 000 ft) - anything less than that is a mere foothill!

However, as there are hardly any mountains elsewhere in the world higher than 6100 m ...



Bluff Knoll in profile - at 1073 m, this is the highest peak in south-western Australia.
Photo - Michael Morcombe

SPACE INVADERS

OF A WEEDY KIND!

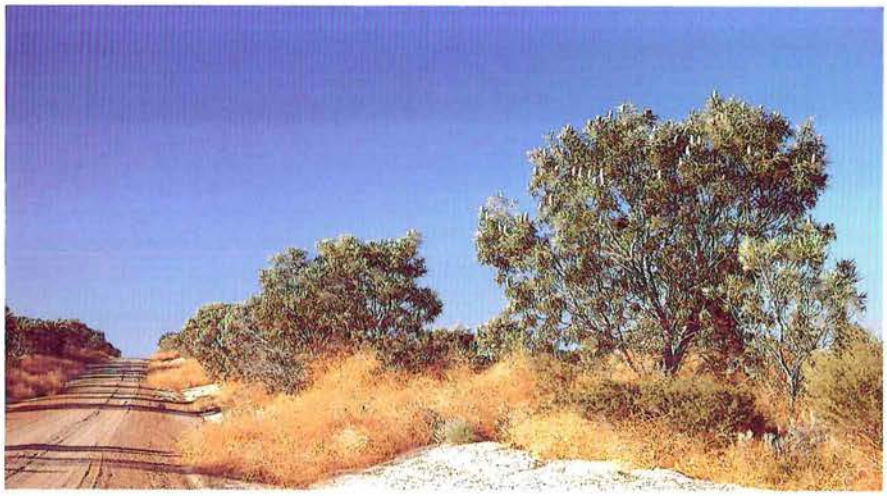
by Penny Hussey

Roads, railways, rights-of-way and other transport corridors are ideal for the spread of plant invaders. They are open, disturbed areas, cleared of their local inhabitants and just waiting for the arrival of an army of colonists. Aided and abetted by humans, the aliens take over and soon come to rule...

Any human construction - buildings, bridges, roads and railways - inevitably leads to soil disturbance and areas of bare ground. However, it will not lie waste for long. Plants capable of living in these harsh conditions will move in and establish a foothold on the ravaged soil. Ecologists call them 'disturbance opportunists', 'pioneers' or, as I have done here, 'space invaders'.

Wherever humankind moves around, creating a disturbance and laying waste, camp followers trail behind, invading the space created. One group of plants that are very successful at doing this we call 'weeds'.

Although there are disturbance opportunists and pioneers in nature, there are no weeds. Only when we come along to decide what should grow where, will we have plants that defy our edict and grow despite us. These are the weeds - plants growing where they are not wanted. To a farmer, anything that competes with the crop, or is unpalatable in the pasture, is a weed. Many farm weeds originated in northern Europe, growing on the bare soil left by the retreating glaciers, but they appreciated the bare soil of ploughed fields just as much and have travelled with Europeans all around the globe. North American Indians called ribwort plantain (*Plantago lanceolata*) 'White Man's Footprint' because it appeared as soon as Europeans started to use a trail. It can be found in Western Australia too, on better soils and in the higher rainfall areas; in fact it is now cosmopolitan. Many of the worst weeds in south-west Western Australia originated in South Africa, where the climate is very like ours.



Turnip from an adjoining paddock smothers a roadside in Dandaragan.
Photo - Penny Hussey

Previous page:
Natal redtop in the Helena Valley.
Photo - Penny Hussey

Apart from our farms and gardens, where we have definite plans for what we wish to grow, nature reserves and national parks are established to protect the native plants, so anything introduced becomes a weed. Plants that can be useful in their right place, such as tagasaste (*Cytisus proliferus*), an excellent fodder shrub, are a nuisance and have to be eliminated from nature reserves. In Western Australia, most people would prefer to see local trees, shrubs and wildflowers along rural roads and railways, so introduced plants, again, are weeds.

WHERE DO THE ALIENS COME FROM?

Records at CALM's Western Australian Herbarium show that about 10 per cent of the plants currently growing wild in Western Australia have been introduced to this continent by humans. In many cases the introduction has been deliberate. The plant may have been considered potentially useful for food or fodder - like doublegee (*Emex australis*, introduced as a salad vegetable) or tagasaste - or else as an ornament for our gardens, like watsonia (*Watsonia* spp.) and cape tulip (*Homeria* spp.). Other plants have been introduced accidentally, having hitched a ride on - or in - something we do consider useful.

We must also remember that our present feeling that only native plants should be growing in our bush has only recently become the prevailing view. Many people believed the bush should be livened up a bit and acclimatisation societies were formed in the early years of the colony. These mainly brought in animals, but several prominent people deliberately spread plants. In the early nineteen hundreds, a well-known horticulturalist considered banksia woodlands to be visually boring, so carried seed of the pink gladiolus (*Gladiolus caryophyllaceus*) in his pockets. As he rode around, he scattered handfuls of the seed. No wonder the plant is so widespread! It is attractive too, and now rare in its native South Africa.

Watsonias - weeds deliberately introduced from Europe as garden plants.
Photo - Penny Hussey

Capeweed is so well established in WA that it is often featured as a native wildflower. Here, in Mingenew, it covers the paddocks and forms an attractive border for the native lilac hibiscus.
Photo - Penny Hussey

Introduced plants will only survive unaided here if they find conditions to their liking. For example, a seed of bonduc (*Caesalpinia bonduc*) was found washed up on Penguin Island. It is an attractive shrub, widespread throughout the tropics; it might well have survived if it had landed in a suitable place in the Kimberley, but not in Perth. The South West of Western Australia has a Mediterranean climate of hot dry summers and cool wet winters and so it is not surprising that most of our weeds come from similar areas: South Africa and the Mediterranean itself.

Having arrived, if a plant is to become a weed it must have as many as possible of the following features:

- no special requirements for germination
- no predators in the native fauna
- rapid growth rate
- strong competitive ability
- efficiency at absorbing water and nutrients, and utilising energy
- very efficient dispersal mechanisms, and
- a good seed set, often facilitated by self-pollination.

African love grass (*Eragrostis curvula*) has all of these features. It produces huge numbers of small, light seeds which are easily blown along. It germinates wherever the seed lodges and grows very quickly, setting seed within four months. It forms a dense tussock with a mass of fibrous roots which out-compete surrounding seedlings. Most importantly, it grows during summer when most other plants are dormant and so has all the available water and nutrients for itself. As a C4 plant (see box), the wet summers of 1989 and 1990 were ideal for it, and many observers commented on its rapid spread, luxuriant growth and long flowering season in 1990.

Flower and fruit of a caltrop.
Photo - Jiri Lochman

ROADSIDES - SPACE FOR INVADERS

As the Indians noted in North America, weeds follow roads and tracks. The reasons for this are obvious - roads and railways are deliberately designed as transport corridors, carrying people, their goods and their weeds ever further into the wilderness. In addition, maintenance keeps the edges of the track clear and open, creating ideal landing beaches along the invasion route.

Roadsides have all the features necessary for successful weed establishment: disturbed soil; relatively high water and nutrient levels; an open

Stinking Roger - common weed of roadsides and waste places, from South Africa.
Photo - Jiri Lochman ▼

Bridle creeper is making a takeover bid for WA roadsides. Watch this plant! It could well be the greatest ecological winner of the next decade.
Photo - Penny Hussey ▼▼

and exposed character; and a continual source of weed seeds, carried by people, their stock or their vehicles.

Not all soils, however, are easy to colonise. Laterite (gravel), for example, is an inhospitable, nutrient-poor soil and without some help from humans (such as extra fertiliser or too frequent burning) it is quite difficult for weeds to get established. Undisturbed clay soil is sealed with a crust of lichens and algae which inhibits weed germination. On the other hand, sandy soil is easily disturbed and the loose sand particles move in the wind, preventing the re-establishment of all but the toughest plants - the weeds.

Road managers are beginning to appreciate that the best way to retain their roadside remnants of native vegetation is to minimise soil disturbance. Clearance should be kept to a minimum and gravel pits located away from the road reserve. A grader clearing out a table drain can push seeds, corms and whole plants along with it, and then, if care is not taken, heap them up on top of good bush. A plant with tough seeds such as Patterson's curse (*Echium plantagineum*) or caltrop (*Tribulus terrestris*) can easily be spread in this way, as can plants that reproduce vegetatively. Plants with corms, like watsonias or woodsorrels (*Oxalis* spp.), or grasses with rhizomes like couch grass (*Cynodon dactylon*), are ideal. One plant which is increasing rapidly along wetter South West roads is wavy gladiolus (*Gladiolus undulatus*), which every year forms up to 30 tiny cormels, each of which is capable of growing into a new plant.

But roads are not just used for transport. Power lines, telephone lines and pipelines may use the same corridor. They also cause disturbance during installation and maintenance, which the authorities in charge of them are taking steps to minimise. Thoughtless people also contribute to the roadside's woes, dumping garbage such as exotic plants, herbicides or sheep carcasses among otherwise well-conserved bush.

Fire is a major form of disturbance. In agricultural areas weed seeds are usually abundantly available along roadsides, and establish readily in the open areas left after a fire. The weeds often out-compete native plant seedlings and, if the fires are frequent, will come to dominate the ground layer to the exclusion of all else. Firebreaks, which may be installed on the roadside, are a major site for weed invasion. The weeds then become a much greater fire hazard than the original native bush. To minimise weed invasion, CALM's Roadside Conservation Committee recommends that firebreaks should only be permitted where the roadside strip is wider than 20 metres, and then only when the break is needed to protect the roadside vegetation.

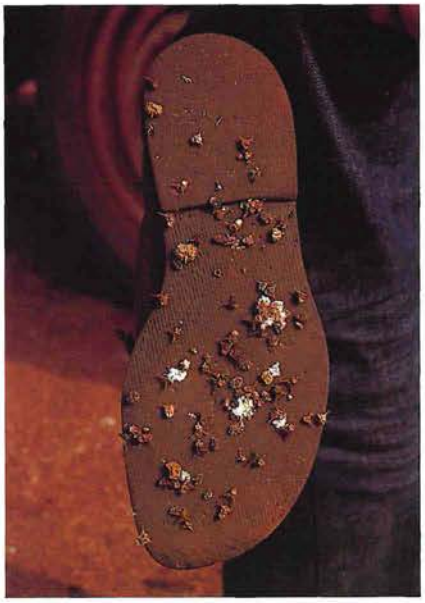
Arum lilies were introduced as garden plants from South Africa.
Photo - Jiri Lochman ▶

Kangaroo grass - in Chittering. These grasses are Australian natives, but they take over disturbed sites just as efficiently as any alien.
Photo - Penny Hussey

ROADS CAN BE WIND TUNNELS

Large vehicles moving at speed lift and carry light objects long distances. Many of the composite (daisy family) weeds that infest roadsides have seeds with a parachute of hairs especially designed for wind transport, and they produce many thousands of them. Occasionally in summer, people in Perth notice clouds of tiny parachutes floating across the city. They are the fruits of stinkweed (*Dittrichia graveolens*) and the various fleabanes (*Conyza* spp.). These, together with flatweed (*Hypochaeris glabra*), compass lettuce (*Lactuca serriola*), sow thistles (*Sonchus* spp.) and bushy starwort (*Aster subulatus*), are spreading rapidly along rural roads. Capeweed (*Arctotheca calendula*) is now so common that people are photographed among it to advertise wildflower tourism in WA!

Skeleton weed (*Chondrilla juncea*) is well known for its success in reaching WA by stowing away on trains from the East, but other plants can hitchhike too. In the past, docks were the places to look for vagrants like this (called 'adventives'



Foot transport - doublegees (and capeweed) encrust a shoe.
Photo - Penny Hussey ◄

Natal redtop was planted by a nurseryman as a 'filter' for flower bunches. Now it lines the roadsides and the nurseyman's widow fights the relentless battle among the roses.
Photo - Penny Hussey

by ecologists), but now chemical control of plants at docks and railway marshalling yards is so effective that they are rather barren places. Instead, you have to find a road junction where huge road trains judder to a halt, shaking off seeds onto the receptive roadside. You'll spot all sorts of odd things!

ROADSIDE WEED PROBLEMS

The roadside weeds in the South West fall into five main groups:

Woody weeds: These are trees and shrubs growing where the road manager doesn't want them, in the line of sight, for example. They are usually native plants, wattles, sheoaks or eucalypts. York gums (*Eucalyptus loxophleba*) are a prime offender, germinating prolifically in table drains after a wet summer.

Perennial grasses: These break up the shoulders, choke drains, degrade native bush and create a fire hazard. African love grass, perennial veldt grass (*Ehrharta calycina*), tambookie (*Hyparrhenia hirta*), fountain grass (*Pennisetum setaceum*) and Natal redtop (*Rhynchelytrum repens*) are but a few in this group.

Annual grasses: These invade the bush and create a fire hazard when they die down each summer. Wild oats (*Avena fatua*) is the most problematical, but bromes (*Bromus* spp.), canary grass (*Phalaris* spp.) and blowfly grass (*Briza maxima*) are also significant.

Broad-leaved annuals and perennials: These invade the native bush and inhibit the regeneration of native plant seedlings. They include capeweed, fleabanes and Paterson's curse, as well as turnip, lupins, caltrop and doublegee.

Annually renewed plants: These die down to a bulb, corm or tuber during summer, and include watsonias, cape tulip, Guildford grass (*Romulea rosea*), thread iris (*Gynandriris setifolia*), bridle creeper (*Asparagus asparagoides*), baboon flowers (*Babiana* spp.) and gladioli.

Specific control strategies have to be worked out for each type.

ROADSIDE WEED CONTROL

For the Main Roads Department, African love grass is 'Public Enemy Number One' in the South West. Not only is it unsightly, but it clogs table drains, impeding drainage, invades the native bush, creates a fire hazard, and more than doubles the cost of road shoulder maintenance. This is because when it is removed the dense root mass breaks up the shoulder formation, needing several passes of the grader to reform the shoulder. Also, the mass of weed debris has to be disposed of. Nobody loves love grass!

Weeds can be controlled in four ways:

- physically, by hand-pulling, mowing, slashing or grading
- biologically, by introducing a specific predator
- ecologically, by creating conditions that are unsuitable for weed establishment and growth, and
- chemically, using various types of herbicides.

On roadsides, grading is the most common method of weed control, but it has its disadvantages. Not only does it spread the weeds, but it creates an ideal seed-bed for weed re-establishment. Biological control was used very successfully to control prickly pear in Queensland, but the research needed to apply it is lengthy and expensive, and roadside weeds are unlikely to be economically significant enough to warrant it.

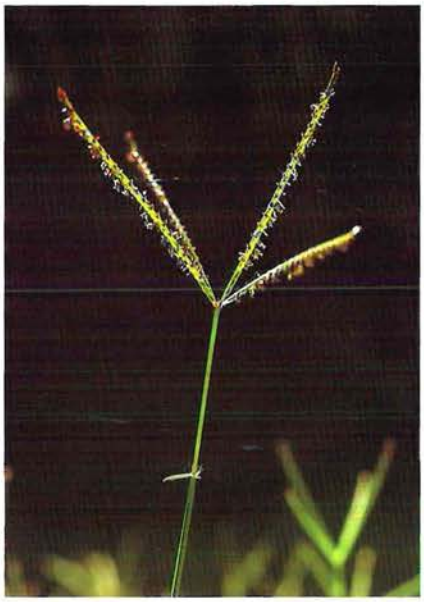
The best control is prevention of establishment through careful roadside management. If the soil is not disturbed, weeds will find it difficult to get a hold. If disturbance is inevitable - for example during road re-alignment - then the disturbed ground should be sown thickly with native species which will crowd out the weeds.

This has been done very sucessfully by the Main Roads Department in various parts of Western Australia. If the topsoil has a store of weed seeds and fertiliser, it is scalped off to a depth of 6 cm. The subsoil is then tilled lightly - if compacted it will have been ripped first. A native seed mix is sown directly onto the soil. With luck, if the weather co-operates, you will get a spectacular display which prevents erosion and helps to create a wildlife corridor.

Where weeds are already established, chemical control can be very effective. But care has to be taken to use exactly the right chemical, at the right time, and in the right place, or else desirable plants could also be killed. Regrettably, this has been the case with some mature trees, especially salmon gums (*Eucalyptus salmonophloia*) which have been killed by chemical applied over several years. Plants can also develop resistance to herbicide, and Westrail, which must keep the track clear for safety purposes, is having trouble with ryegrass (*Lolium perenne*), some populations of which have developed tolerance to certain herbicides. But there are some bright hopes. Newly developed selective herbicides are showing great promise for grass control without harming native plants.

In any weed control program, however, there must be a concurrent plan for filling the space vacated by the weeds with native species. Otherwise those space invaders will come right back! ⊡

Ribwort plantain.
Photo - Penny Hussey



Couch - grows well in higher rainfall areas and can tolerate shade.
Photo - Penny Hussey

Penny Hussey is a botanist currently employed by CALM to develop guidelines for the management of bush on private land. She is the executive officer for CALM's Roadside Conservation Committee and can be contacted on 367 0438.

Dew glistens on tambookie flowers. Photo - Penny Hussey

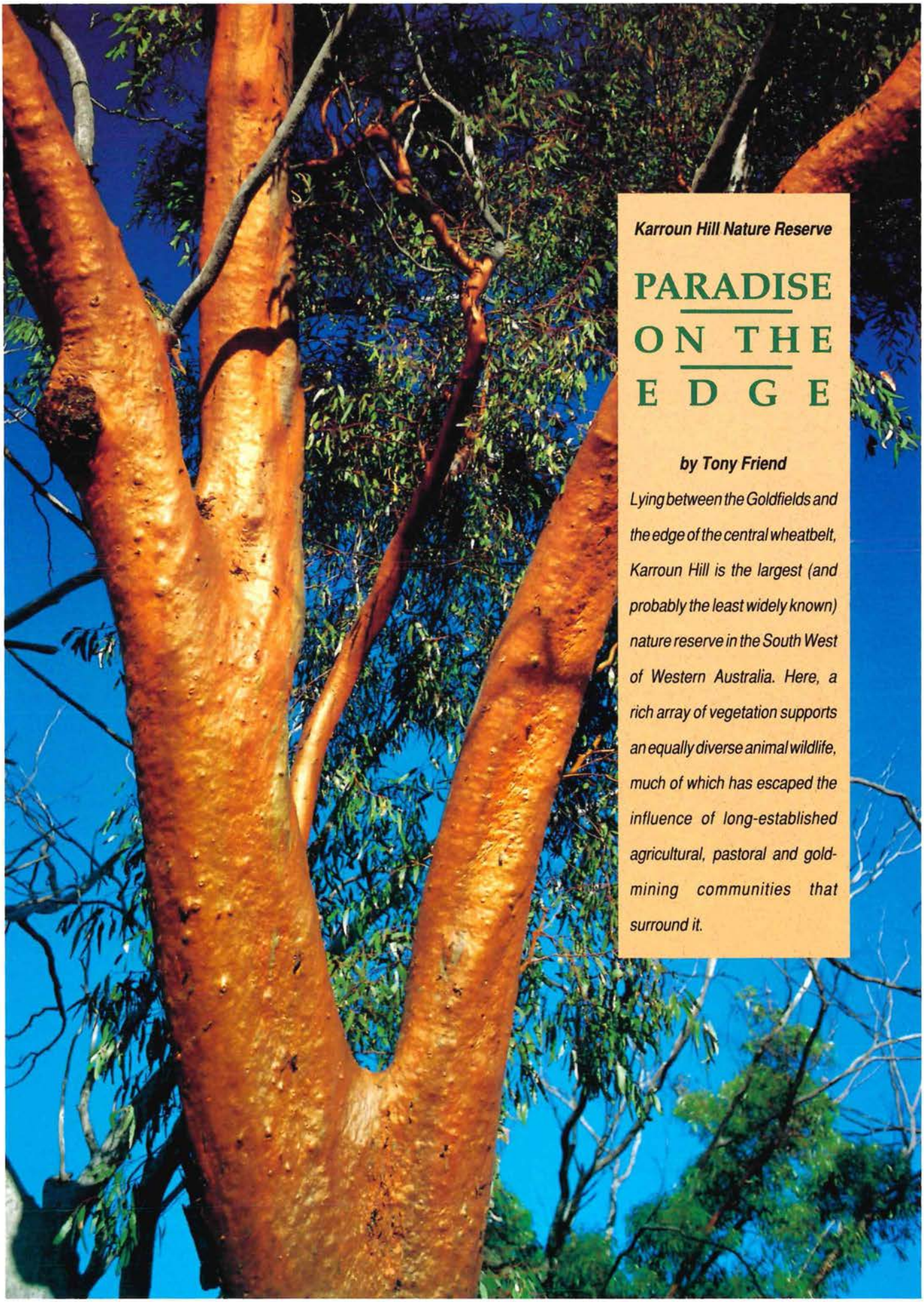
Feathertop forms large, quite attractive clumps. Photo - Penny Hussey

C_4 PLANTS

Plants manufacture food by photosynthesis. They take in carbon dioxide (CO_2) and water and, with the help of light energy, convert them into sugar which is then used for other purposes. Most plants start off this photosynthetic cycle by making carbon dioxide into a compound with three carbon atoms. They are C_3 plants.

Some tropical plants, of which sugar cane is the most well-known example, behave differently. They convert the CO_2 first into a four-carbon compound. This C_4 process is much more efficient than the C_3 one, and gives these plants a great competitive advantage.

African love grass, tambookie, Natal redtop, feathertop and paspalum are introduced examples of C_4 grasses, while silkyheads, matgrass and kangaroo grass are native examples.



Karroun Hill Nature Reserve

PARADISE ON THE EDGE

by Tony Friend

Lying between the Goldfields and the edge of the central wheatbelt, Karroun Hill is the largest (and probably the least widely known) nature reserve in the South West of Western Australia. Here, a rich array of vegetation supports an equally diverse animal wildlife, much of which has escaped the influence of long-established agricultural, pastoral and gold-mining communities that surround it.

A travel-weary Ernest Giles painted this rather exaggerated word-picture:

'The country between the cliff and Mount Churchman was filled to overflowing with the densest of scrubs: Nature seemed to have tried [to see] how much of it she could possibly jam into this region.'

He was describing the vegetation his party encountered east of Lake Moore on his first successful attempt to reach the west coast from South Australia in 1875. This area is now part of the largest nature reserve in the south-western part of Western Australia.

Karroun Hill Nature Reserve, in the Shire of Mount Marshall, sprawls between the emu-proof fence to the south and the rabbit-proof fence to the east, and lies along the Wheatbelt's north-eastern limit, beyond which the annual rainfall is considered too low for profitable agriculture. The eucalypt-mulga line passes through the reserve and is the boundary for two botanical regions, the wattle-dominated vegetation of the arid zone and the eucalypt-dominated bush of the South West. The reserve occupies 309 678 hectares - equivalent to one-sixth of the area of state forest in Western Australia.

The earliest use of the area by Europeans was probably for sandalwood cutting. Old wheelruts can be found far from the present tracks, and former campsites can be located by telltale rusted cans or old bottles. Near Karroun Hill itself, at Wattle Soak, are the decaying remains of a courageous cattle-grazing

Previous page:
The twisted trunks of *Eucalyptus salubris* inspired such common names as 'gimlet' and 'cable gum'.
Photo - Steve Kelly

Granite outcrops provide shelter for reptiles under loose slabs of rock and for euros in crevices between boulders.
Photo - Steve Kelly ▲

venture. Here, between 1928 and 1933, George Clamp, the owner of a butcher's shop in Mukinbudin, fenced at least 2 000 acres of the granite hill and nearby natural grasslands.

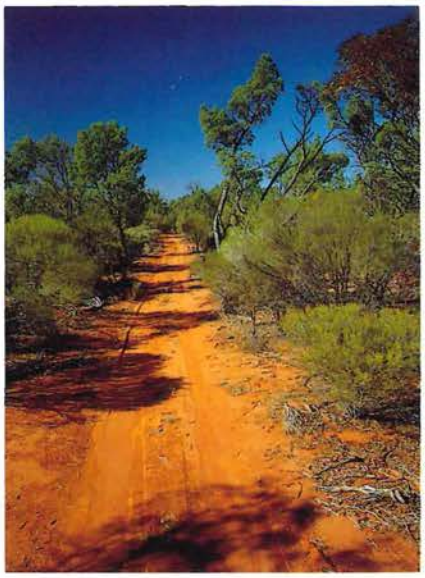
Today, the post and wire fence can be traced for most of its length around Karroun Hill. The old humpy at Wattle Soak has been largely demolished; and a corrugated iron tank, used to store water collected from the granite rock, stands bottomless nearby. The most obvious result of this episode in the history of the reserve is the establishment of capeweed and other introduced plants at Wattle Soak.

LANDSCAPE, FLORA AND FAUNA

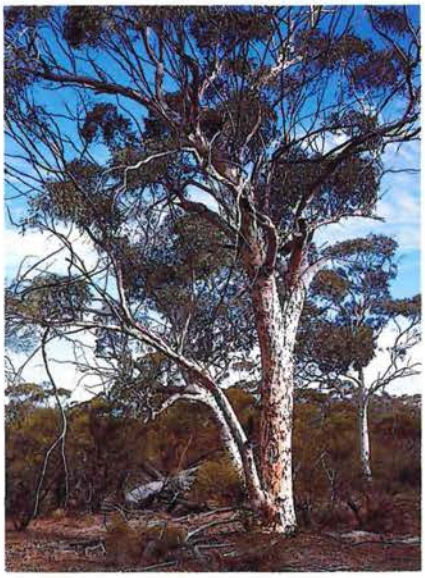
The landscape is very subdued, so the few low granite domes that protrude above ground level dominate the nearby country. Some of these, such as Mount Churchman (just outside the reserve) and Karroun Hill itself, were named by early white explorers and settlers, but most, including a spectacular high granite in the centre of the reserve, remain unnamed. Salt lakes at the western end of the reserve are an important feature as there are few in conservation areas in the region.

The lower land typically supports eucalypt woodland dominated either by York gum (*Eucalyptus loxophleba*) and the remarkable native conifer *Callitris columellaris*, or, in the broad drainage lines, by the tall and graceful salmon gum (*E. salmonophloia*). Gimlet (*E. salubris*) occurs on clay soils in narrow bands at the base of breakaways, or in extensive open stands on the flats. At the edges of the upland surface, the change in slope can be almost imperceptible, or it can take the form of a breakaway or cliff up to five metres in height. In upland sites, the vegetation often forms a mosaic dependent on soil type. The dense scrubs encountered by Giles are found here, the most impenetrable being tall shrubland of *Acacia* species near the plateau edge.

Known rare plants, mapped in 1989 by CALM botanists Steve Hopper and Andrew Brown, include the sandpaper wattle (*Acacia denticulosa*) and magnificent prostanthera (*Prostanthera magnifica*), which occur on granite rocks; jingymia mallee (*Eucalyptus synandra*) is found on pale yellow sands high in the landscape, while Southern Cross mallee (*Eucalyptus crucis*



Wandoo (*Eucalyptus wandoo*) is not common in Karroun Hill Nature Reserve but provides valuable nesting hollows for birds, bats and small marsupials.
Photo - Tony Friend ▶



The native conifer (*Callitris columellaris*) occurs in vast expanses of the open woodland shown here.
Photo - Steve Kelly ▶▶

Spectacular displays of everlasting daisies and other annuals transform woodland areas in August and September.
Photo - Tony Friend ▶▼

lanceolata) reaches its north-eastern limit on granite rocks, and the remote spider orchid (*Caladenia remota*), known only from two other localities, is also found in the reserve.

Dramatic biological events follow the annual weather cycle at Karroun Hill. Perhaps the most spectacular is the spring flowering of several species of everlasting daisy and other annuals, forming carpets of colour in the open York gum and acacia woodland. The profusion of everlastings varies from year to year, but always provides a memorable sight. As the ground dries with the arrival of hot weather in October, the everlastings fade and dry. At night and on overcast days, harvester termites (*Drepanotermes* sp.) swarm out of their underground nests through small holes in the ground, collecting the dried remains of the daisies.

Because of the lack of water, especially before the rains begin, late autumn can be the most stressful time of year. Many shrubs die, creating spectacular displays of autumn colours, sometimes rivalling those of the northern hemisphere. At this time, too, red kangaroos, euros and emus congregate around granite rocks where the last of the water is generally found.

Other significant events are related to the breaking of the annual drought. As the warm soil becomes moist, especially after summer thunderstorms, termite activity increases to fever pitch as some food sources become available for a short time. Wood-eating termites plaster the exterior of fallen branches with a mixture of faecal material and sand, creating galleries connected to their nests. These galleries have a moist environment that extends the termites' feeding time should the rain not continue. Litter-feeding termites plaster the litter and rapidly consume it. Later in winter, some termites build small towers from which their winged reproductive adults launch themselves into the air to leave the nest. As the rock-pools on the large granites fill up, the evening air comes alive with a chorus of frogs. Sediments in the larger ponds contain the dried eggs of a range of invertebrates. A swarm of life appears in the rock pools as copepods, ostracods and flatworms, as well as mosquitoes and midges, hatch soon after the pools fill. The shallow mud at the bottom of the pools turns green with the short spiky leaves of primitive quillworts, and of tiny-flowered mud mats.

MAMMALS AND MALLEE FOWL

It is clear that the mammal fauna of the area was much richer in pre-European times. In October 1836, the Surveyor General, John Septimus Roe, travelled through the present Mukinbudin-Mount Marshall district and wrote in his diary of seeing 'an increased number of kangaroos, rats, bandicoots and a burrowing animal which makes a large hole'. This last animal was without doubt the burrowing bettong, or boodie (*Bettongia lesueur*). In order to protect their crops, the early settlers in the area poisoned boodies, which were still present near the town of Mukinbudin in 1910.

Surveys by Ken Youngson and Norm McKenzie during the 1970s found 13 native mammal species in Karroun Hill Nature Reserve: three marsupials, two rodents, seven bats and the echidna. Subsequent research has shown that another marsupial, the grey kangaroo, occurs there. Fat-tailed dunnarts (*Sminthopsis crassicaudata*) are periodically found on nearby farmland, and are probably present in the reserve.

Numbats (*Myrmecobius fasciatus*) were known in the Mount Marshall and Mukinbudin Shires in the early part of

this century, and Alex Baynes found an old numbat femur just outside Karroun Hill Nature Reserve in 1975. Many overhanging breakaways preserve intact nests of stick-nest rats (*Leporillus* sp.), now extinct in the wild on mainland Australia.

The early explorers recorded the prevalence of mallee-fowl (*Leipoa ocellata*) and their large incubating mound-nests in the area. They found the eggs to be a welcome change from their expedition rations, and Giles noted that, during the laying season, these eggs were a principal dietary item of the local Aborigines. As Giles' party passed through the northern half of the present reserve they collected only 20 eggs in one day, a disappointing haul compared with their previous day's effort of 45 eggs. To achieve this last total they would have had to raid more than 10 nests. Today, while mallee-fowl are occasionally sighted, nests are not common. In more than 50 days' walking in the reserve since 1987, only one active mound has been seen.

Disappearance of mammals in arid and semi-arid zones has been linked with changing fire regimes, effects of rabbits and the effect of introduced predators like the fox and the cat. Fire in Karroun Hill Nature Reserve, however, is still mainly related to lightning strikes and does not carry through the woodland. Rabbits are certainly present throughout the reserve, as are cats and foxes, and the combined effects of these introduced species probably account for the losses of mammals. It is likely that predation by foxes, as shown by recent research in New South Wales, has caused the decline in the mallee-fowl population. The Australian bustard, still present in the reserve, nests on the ground and is also likely to be under threat from foxes.

The large size of Karroun Hill Nature Reserve makes it a suitable site for reintroducing native mammal species that still survive in other areas. Since 1987, a program has been under way to reintroduce numbats to this reserve. Fifty-seven numbats have been released there under a light regime of fox-baiting. All numbats recaptured for observation have been in good condition and breeding has been occurring at a surprisingly high rate. The third generation of reintroduced numbats has now been born there. Apparently, numbat habitat and food supplies (termites) have not deteriorated significantly, despite the changes that have occurred in the 200 years of European settlement.

Clearly, Karroun Hill Nature Reserve is an extremely valuable asset in Western Australia's conservation estate. As well as conserving a highly significant array of eastern Wheatbelt wildlife, it has the potential to provide a sufficiently large area in which to reconstruct the mammal fauna that has been lost from the region.

NATIVE MAMMALS OF KARROUN HILL NATURE RESERVE
(EXCLUDING BATS AND THE DINGO)

IN ORDER OF DECREASING BODY WEIGHT

PAST	PRESENT
Red kangaroo	Red kangaroo
Western grey kangaroo	Western grey kangaroo
Euro	Euro
Black-footed rock-wallaby	•
Crescent nailtail wallaby	0
Dalgyte	•
Rufous hare-wallaby	•
Boodie	•
Woylie	•
Chuditch	•
Pig-footed bandicoot	0
Numbat	(reintroduced)
Greater stick-nest rat	•
Red-tailed phascogale	•
Mitchell's hopping-mouse	Mitchell's hopping-mouse
Sminthopsis dolichura	*Sminthopsis dolichura*
Fat-tailed dunnart	Fat-tailed dunnart
Sandy inland mouse	Sandy inland mouse
Western pygmy possum	Western pygmy possum

• = population surviving elsewhere
0 = extinct species

Tony Friend is a Senior Research Scientist at CALM's Wildlife Research Centre at Woodvale. He can be contacted on 09 405 5100.

Numbats have been reintroduced by CALM to Karroun Hill Nature Reserve in a project supported by the World Wide Fund for Nature (Australia).
Photo - Jiri Lochman

Drawing the Line

Mapping plants along a transect

by Robert Powell

A group of students in metropolitan Perth have been stretching lines of coloured tape through areas of remnant vegetation. Why does this help them as budding ecologists?

Students from City Beach Primary School in Perth recently ventured into a nearby remnant of varied vegetation. They carefully laid out a line along a partially worn track, down a slope and across a larger track to a point halfway up a slope on the other side. They then placed markers at one-metre intervals along the line and began to sketch and note the positions of the trees, shrubs and other plants that lay along the line, or, to use its proper term, the transect.

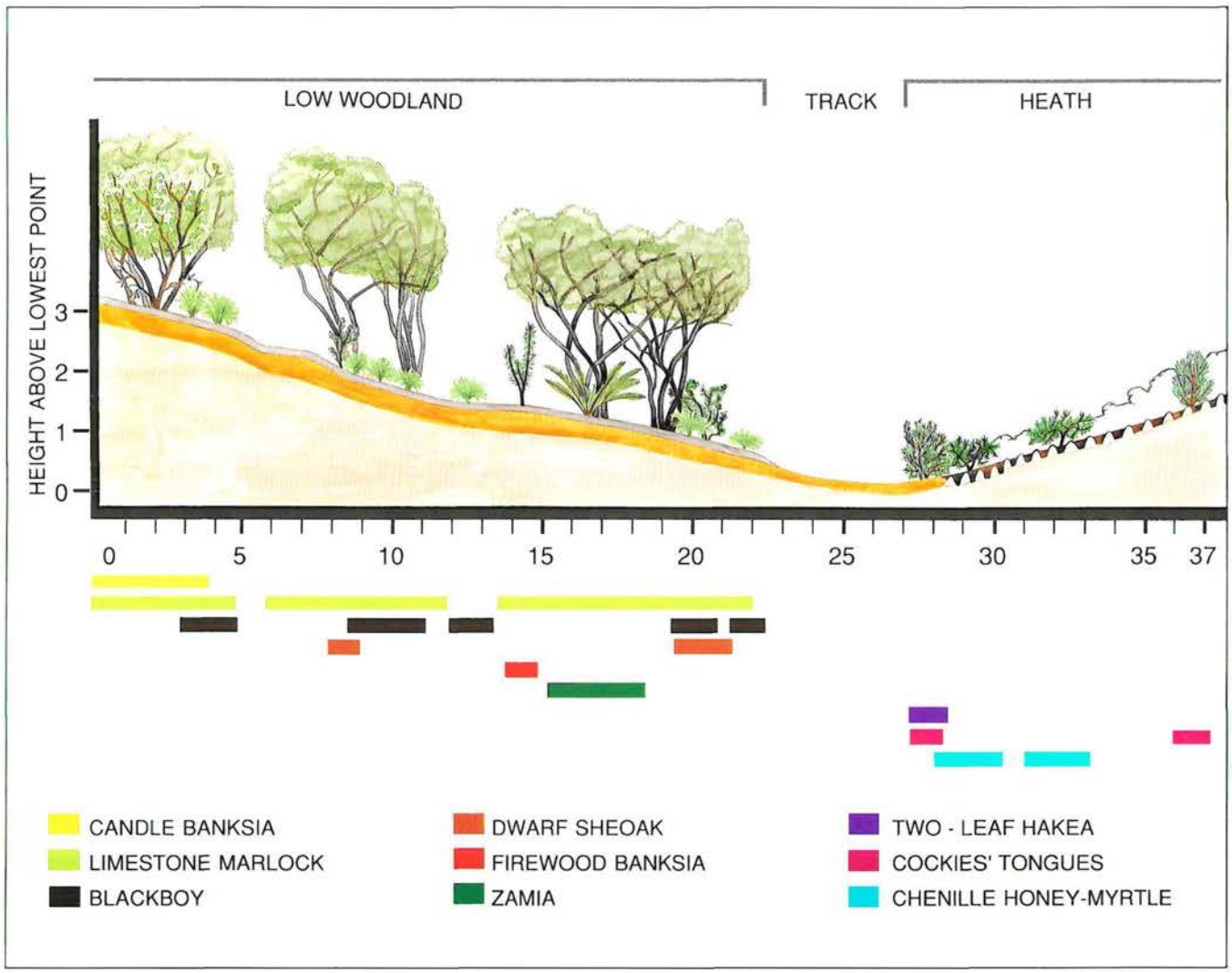
By mapping, measuring and sketching the plant species, noting such characteristics as outline, shape, structure, and distribution of foliage, the students acquired valuable knowledge and skills vital to any plant ecologist: skills in observation, drawing, graphing, and using basic surveying and mapping instruments. They were able to observe the general character of the vegetation and its variation along the transect, and learnt to recognise nine of the plant species. They graphed the canopies of these species and recorded the slope of the land and the type of soil as they moved along the transect. From these recordings and measurements the students were able to draw a profile of the land and vegetation, and they discovered how dramatically the vegetation changed, both in species and in structure, where sand gave way to limestone.

Such an example of the hands-on approach to conservation and environmental awareness shows an emphasis that was lacking in the education many of us received. It will surely help give today's young more opportunity to treat their natural environment with understanding and care.

The study of natural vegetation is one of the best ways to learn about nature. Vegetation is varied and fascinating in itself; it is vitally important as habitat for animals; and it closely reflects the

Students laid the tape along the track and placed markers at every metre.
Photo - David Gough

Previous page:
Flowering stems of cockies' tongues (enlarged).
Photo - Michael Morcombe
Inset:
Students sketching the cockies' tongues.
Photo - David Gough



Here, on the west side of Garden Island, the vegetation in the background changes from low heath to moonah forest as one heads inland. Such sites are ideal for transects.
Photo - Robert Powell ◄▲

An Abney level was used to map the rise and fall of the land.
Photo - David Gough ▲

physical environment in which it occurs. Changes in vegetation often indicate changes in the geology or soil. In this way vegetation helps us locate minerals, and in past decades it helped us decide which land to release for agriculture. Moreover, today's remnants of vegetation often show us clearly the impact humans have had on our natural surroundings.

Mapping plants along a transect is a useful exercise for students of almost any age. From direct experience, they learn not only about the types of vegetation encountered - how many layers they comprise, for example, and which species are commonest or dominant - but also about how the vegetation relates to aspects of the environment such as slope, soil, water-table, salt winds, fire, weeds and human disturbance.

These factors can best be studied if the transect is located where vegetation changes. For example, if we begin the transect near the ocean, say at the top of the beach, and head inland, the vegetation changes markedly over a short distance. Wetlands too are very suitable for transects; so are sites where the soil varies in type or depth, such as on the Darling Scarp or on the coastal limestone.

By recording the plant species (either all of them or just a selected few) and also some of the environmental factors listed above, a transect diagram can be drawn, showing how the vegetation reflects the physical environment. If the typical sizes of the different species are noted and simple sketches of them are made, the vegetation can be represented pictorially, providing a diagram that is especially meaningful and easy to interpret.

In preparing and conducting their field excursion, the students from City Beach Primary School made use of a Resource Note entitled *Mapping Plants along a Transect* (No. 22: February 1991), published by the Department of Conservation and Land Management (CALM). This explains in detail how to plan and carry out the activity. It includes several very useful references for identifying plant species and to help understand the many factors that determine our different types of vegetation. It also includes a page of graph paper for recording plants along the transect, and examples of other sorts of recording-sheets.

When planning a mapping exercise, permission should be sought, from the body that controls the land concerned, to conduct the excursion and to collect any plant specimens needed. For any specimens collected on public land, one also needs a licence from CALM.

Furthermore, plants should be treated with care. An untrained group can quickly degrade vegetation by inadvertently trampling through it, especially where the soils are sandy. However, such damage can be minimised by splitting the group into smaller groups, each of which is assigned to a different part of the transect.

Also, as in the case above, running the transect along an established path and keeping students to that path, as far as possible, will help to minimise damage. Repeated excursions to the same transect line should be avoided. When the survey is finished, all tapes and pegs must be collected and taken home.

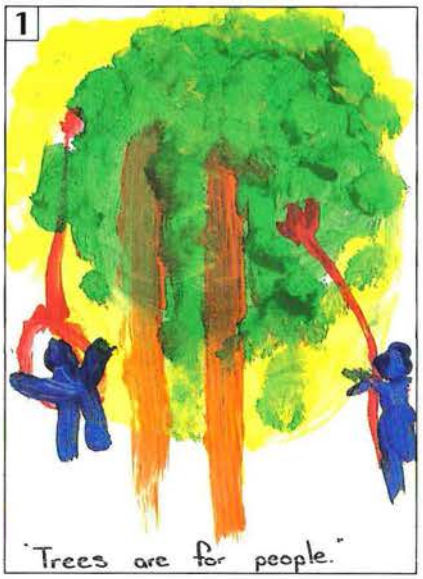
There are many long-term benefits from taking part in projects to map plants. By learning to recognise some of the natural plant species of an area, we begin to notice those species elsewhere and we get to know them. We learn where they occur, how they are affected by events in their natural environment (e.g. fire), and to what degree they are able to cope with changes imposed on their environment by human beings. Furthermore, having studied the vegetation of a particular site, we begin to observe things about other remnants of vegetation: their structure, their composition, and how they relate to their particular environment.

Perhaps the most important benefit for many of us is that our local vegetation will no longer be 'foreign' to us, but will become meaningful and interesting: we shall begin to develop a feel for it and a sense of belonging to it. ⊡

Robert Powell is the author of the book *Leaf and Branch*, the authoritative and comprehensive guide to Perth's trees and tall shrubs.

What trees

ARBOR DAY 1991 POSTER COMPETITION



What Trees Mean To Me was the theme of this year's Arbor Day Poster Competition, sponsored by *LANDSCOPE* magazine and Radio 6WF.

The competition attracted 6745 entries from primary school children in 153 schools around Western Australia, with two school entries from the Cocos Islands and Alice Springs.

Colourful and creative paintings, drawings and collages depicted scenes of happy hours spent outdoors with nature, of the way people and nature live side by side. Some showed how trees provide oxygen for all life on earth, while others showed the recreational use of trees - for playing in, and as shade for picnics with their families.

Many of the children urged people to 'Plant More Trees', showing the effect on the environment of having no trees on the environment - leading to land degradation caused by salt and erosion.

Some of the poster competition entries were displayed at CALM's Arbor Day celebration at Matilda Bay, where the Premier of Western Australia, Dr Carmen Lawrence, officially launched measures to protect native trees in natural areas.

Other entries were displayed at an interactive display on dieback and Arbor Day at the R&I tower in Perth.

Radio 6WF personality Ted Bull and CALM officers visited several schools to present prizes to winners of the competition, following the announcement by Environment Minister Bob Pearce and CALM Executive Director Dr Syd Shea of the winners on Ted's breakfast session on Arbor Day.

Every child who submitted an entry received a certificate of recognition.

As well as the individual winners (listed opposite), prizes were awarded to the following schools for the 'best class' entries:

- Geraldton Primary School, Geraldton (Year 1)
- St Joseph's School, Busselton (Year 3)
- Flinders Primary School, Albany (Year 5)

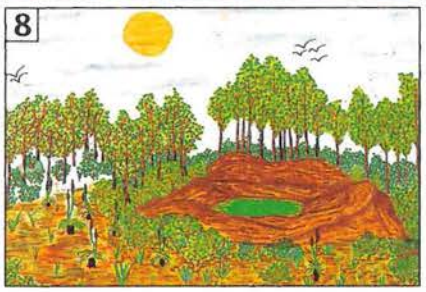
The youngest winner in the competition, five-year-old Tegan Sloan from Meekatharra School of the Air, received a flying visit from CALM.

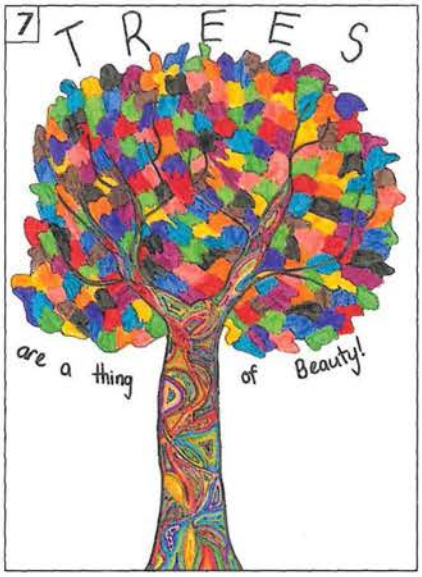
Skywest Airlines flew a CALM representative to Meekatharra to present Tegan with a eucalypt for the family station, an Arbor Day poster and a *LANDSCOPE* gift pack.

Tegan's schoolteacher was also on hand to receive a gift pack of CALM publications for the school. ⊡

The 'thank you' certificate awarded to each of our young contestants.

mean to kids





THE WINNERS

1 Tegan Sloan (Pre-Primary)
Meekatharra School of the Air

2 Danielle Anile (Year 1)
Good Shepherd School, Kelmscott

3 Anastasia Cartoni (Year 2)
Weld Square Primary, Morley

4 Adam Beeley (Year 3)
St Joseph's Primary, Busselton

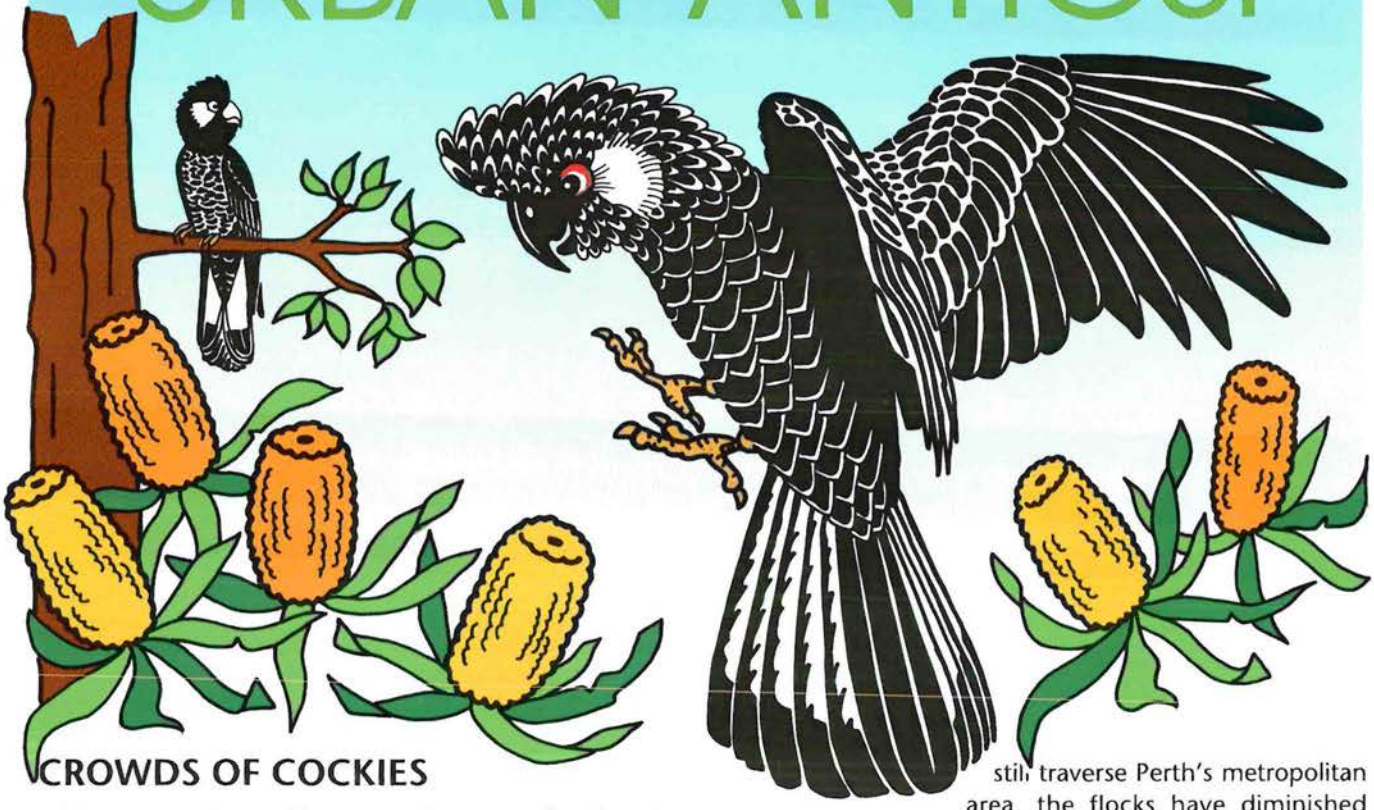
5 Carrie Retallack (Year 4)
Creaney Primary, Kingsley

6 Angela Phillips (Year 5)
Wanneroo Primary School

7 Rachel Cooper (Year 6)
North Kalgoorlie Primary

8 Karen Johnston (Year 7)
Busselton Primary School

URBAN ANTICS!



CROWDS OF COCKIES

'Here come the cockies, son - it's going to rain.'

My dad used to say that in the autumn and winter every year during the forties, as wave after wave of white-tailed black cockatoos darkened the skies over our house. It always did seem to rain too (even though there is no scientific truth in the statement), but as a little 'un I was eager to believe him.

Often the wails and screeches of a thousand birds penetrated the surrounding bush and asbestos walls of our tiny Scarborough dwelling, obliterating all other sound. Then, like a bomber squadron, the whole flock would land in nearby tuart and banksia trees, spreading to dryandra thickets while cursing and tearing at seed pods and foliage.

There are two species of white-tailed black cockatoos in the South West of Western Australia, Baudin's cockatoo (*Calyptorhynchus baudini*) and Carnaby's cockatoo (*Calyptorhynchus latirostris*). They are similar in appearance, but Baudin's cockatoo has a longer bill and prefers the southern eucalypt forests, where it feeds mainly on the seeds and nectar of marri and banksia. Carnaby's cockatoo frequents the drier woodlands and sandplain areas around Perth and to the north, mainly feeding on the small hard fruits of hakeas, grevilleas, banksias and dryandras.

In the metropolitan area from about January to June each year, flocks of this seemingly slow-flying, large, noisy bird forage for food in native vegetation and gardens. It is usually easy to see where a group has been by the mess of seedpods and foliage on the ground, especially under pines. At times gum nuts and pine cones rain down to damage vehicles or narrowly miss an observer's unprotected head.

Rain does seem to excite the birds, which probably look forward to a feed of fresh nectar and insect larvae under wet bark.

About July each year the cockatoos disperse to their usual breeding areas in the wandoo and salmon gum woodlands north and east of Perth. Here, each life-bonded pair raise one chick in a hollow-branch nest.

After 11 weeks of brooding, the fledgling and parents join other family groups and move to their coastal summer refuge. They congregate in flocks at plentiful food sources in and around the suburbs.

While white-tailed black cockatoos still traverse Perth's metropolitan area, the flocks have diminished drastically both in size and numbers. This is due primarily to the rapid and extensive clearing of the birds' food trees and nest trees in agricultural areas. Today, like the dryandras and banksias they eat from, the white-tailed black cockatoos are but a remnant of past populations. Those small, feathery black clouds on the horizon are perhaps a storm-warning for another species heading towards extinction. Only time will tell.

JOHN HUNTER

Did You Know

White-tailed black cockatoos lay two eggs. The second nestling usually dies within two days of birth.

A reliable food source near the nest is vital. Brooding adults usually feed in line-of-sight vegetation. If this is fragmented and isolated, time may run out for a hungry nestling.

The galah (Cacatua roseicapilla), an aggressive competitor for the cockatoos' nest sites, has increased in numbers. It breaks Carnaby's cockatoo eggs when the birds temporarily leave the nest.

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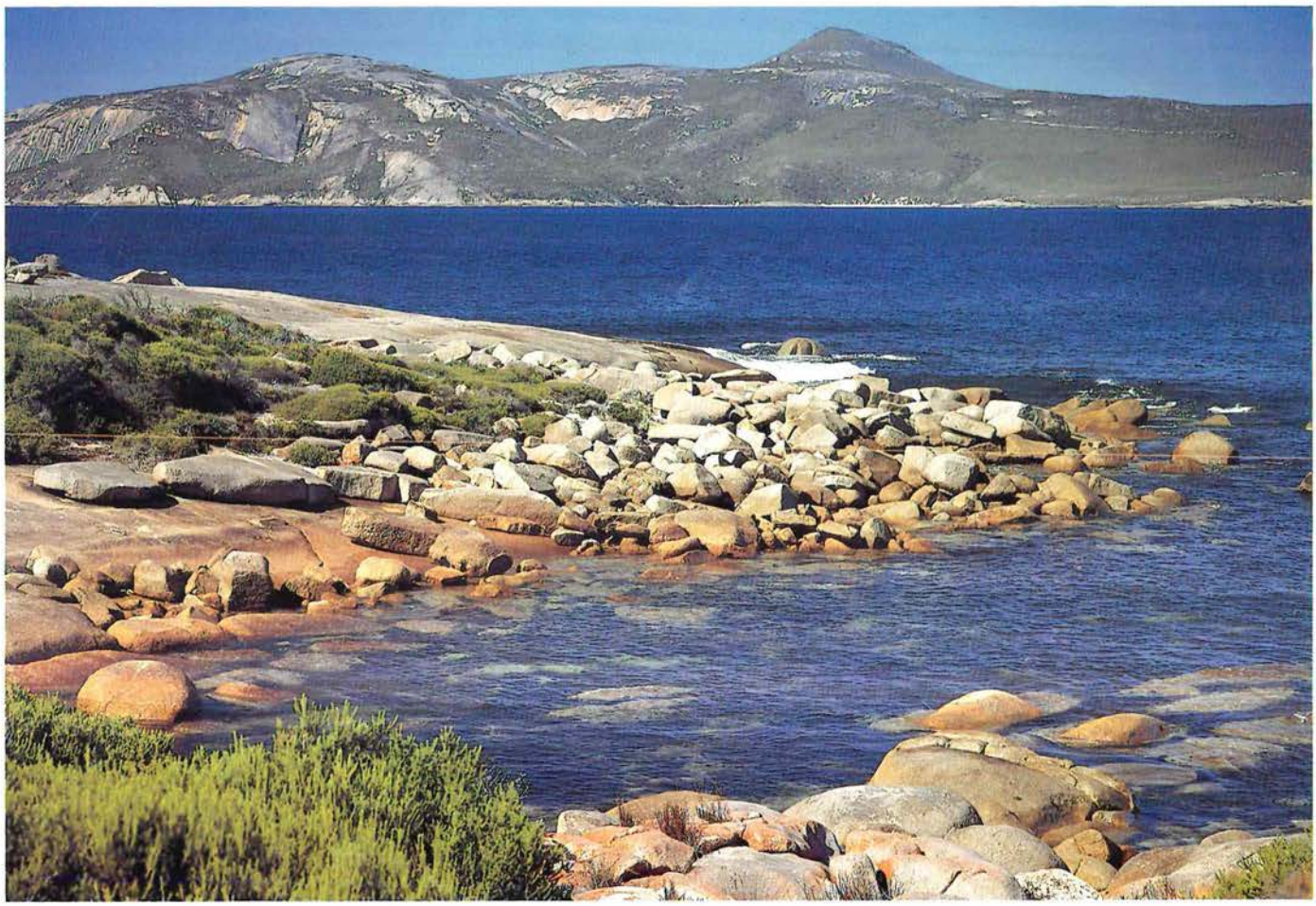
Conditions of entry: 1. Competition entry is achieved by returning the fully completed appropriate ANH gift or new subscription coupon (or copy) together with payment. 2. The competition is open to all Australian residents. 3. Entries close on the last mail Friday 13 December 1991. 4. Employees of the Australian Museum and TraveLearn, their families, suppliers and associate companies are not eligible to enter. 5. The names and addresses of each entrant will be placed in a barrel and the winning entry will be drawn on 18 December 1991. 6. The winner will be notified by mail and published in *The Australian* 21.12.91. 7. The prize must be taken as offered and is not redeemable for cash. 8. The trip must be taken either 30.8.92–5.9.92 or 6.9.92–12.9.92. 9. Entrants under 18 years of age must have their entry authorised by parent/guardian and be accompanied by an adult on the tour. 10. The trip includes TraveLearn's 7-day Whale Watching/Fraser Island tour ex Brisbane (twin-share accommodation, all meals, lectures, two whale watch cruises, coach transfer from Brisbane and return, tours of the island and information book). NSW CHIEF SECRETARY'S DEPARTMENT PERMIT NUMBER TC91/1418

TWO PEOPLES BAY



The rocky coast of the *baie des deux peuples* (bay of two nations) near Albany - named to commemorate a meeting of French and American sailors in 1803.
Two Peoples Bay is now a nature reserve.

Photo - Michael Morcombe