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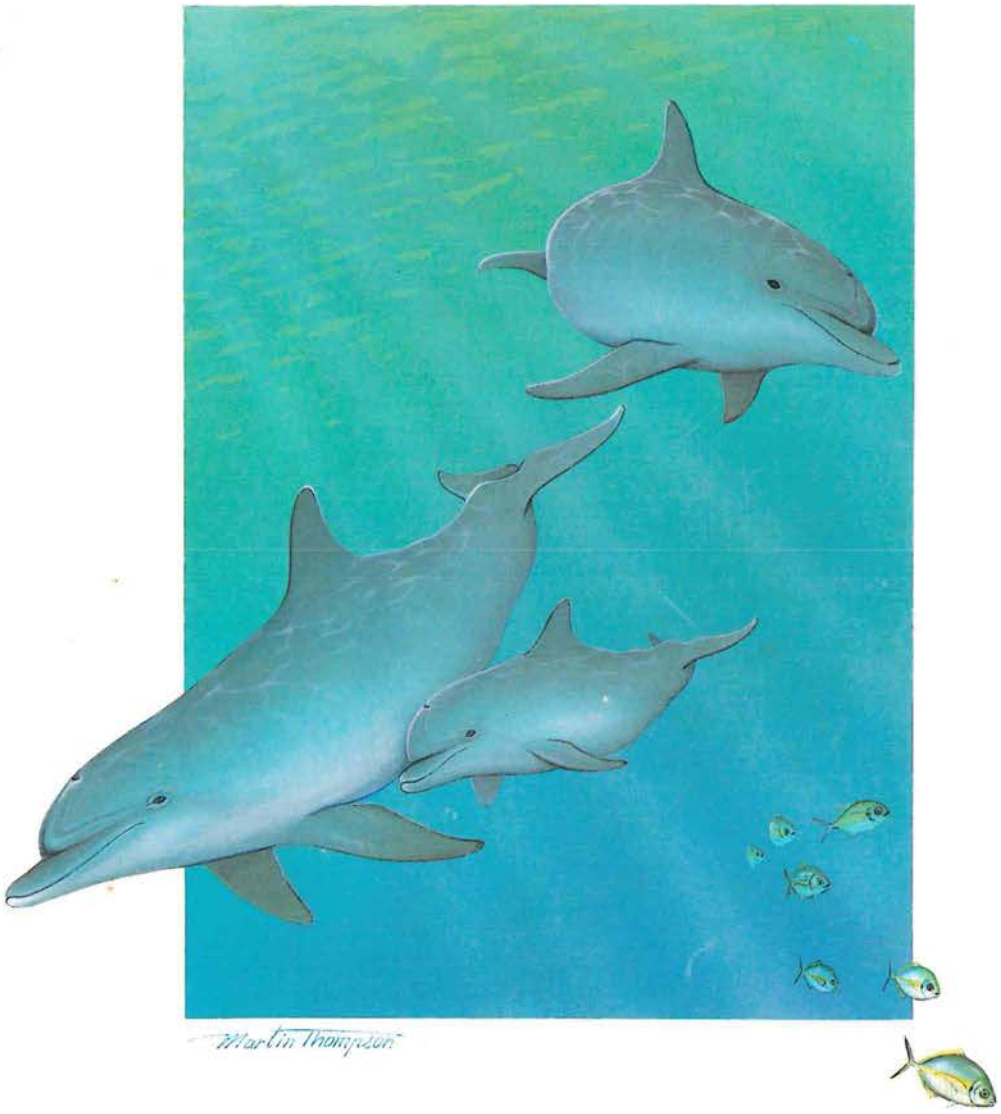
LANDSCOPE

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



CORAL REEFS

Hidden depths

MAMMALS

Why they're threatened

THE NULLARBOR

Just what's out there?

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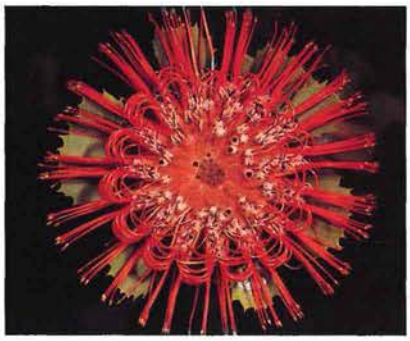
LANDSCOPE

VOLUME SIX NO. 1 - SPRING EDITION 1990

In the central Kimberley, a screw-pine-surrounded creek - just one of the threatened areas in this fragile frontier. Turn to page 22.

Until 1984 more was known about what was underneath the Nullarbor than what was on top. But with such a vast area to study, where do we start? See page 16.



Public awareness and involvement is vital in the conservation of WA's rare and endangered flora. Page 49.

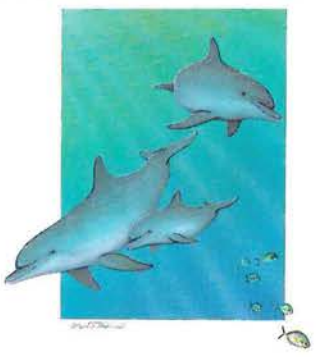
Ten WA mammal species have become extinct in the last 200 years. What can be done to ensure no more are lost forever? Page 28.

Forests protect our environment. They also provide timber. How do we strike a balance? Turn to page 35.

COVER

Dolphins and whales are perhaps the best-known inhabitants of Western Australia's coastal waters. But this unique area is also home to an astonishing range of marine flora and fauna, from sea-turtles and coral reefs in the north to sea-grass banks and great white sharks in the south. See page 10.

Illustrated by Martin Thompson.



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SUSTAINING OUR STATE

The 1980s saw almost universal community recognition of the significance of environmental degradation. All the signs are that the 1990s will be characterised by a focus on finding solutions to our environmental problems.

The concept for this decade is sustainable development.

The opinion polls that have identified the environment as a major community concern also show there is an overwhelming belief that with good sense, good management and good will it will be possible to reconcile our desire for a good life with protection of the environment.

Environmental scientists and managers also support ecologically sustainable development. They know that the answer to the apparent dilemma is better knowledge and better management, but that both are expensive and funds will not be available unless wealth is generated.

Western Australia is an island on an island, with some of the earth's oldest land and life forms. Even in this vast State, man's impact is ubiquitous and often destructive. But if we understand the processes and preserve the genes which make these bizarre ecosystems successful in some of the world's harshest environments, we can develop management systems that will not only resolve our problems but help other nations solve theirs.

This edition of LANDSCOPE will provide visitors to the World Conservation Union (IUCN) with a snapshot of the Western Australian environment, its problems and possible solutions. We wish the delegates success in their endeavours to develop an international strategy which accommodates both nature and humanity.

Syd Shea

FLYING HIGH

Congratulations on the consistently high standard of your *LANDSCOPE* publication, to which I am a regular subscriber.

Will you extend my thanks to Jim Lane for his very fine article on avian aerodynamics? He must have had my request letter in front of him, and has proved himself an excellent communicator with John Citizen.

Thanks again.

ROY GRACE
KINGSLEY

RED CEDAR, RED FACE

I read with interest the article on the early timber industry at Cannington in the winter 1990 issue of *LANDSCOPE*. I have a particular interest in the early development of the timber industry and its devastating impact on the rainforests in the Illawarra region of southern New South Wales.

I noted with some alarm that a photograph which is quite familiar to me appeared in the article but was certainly not taken in Western Australia. The photograph on page 44 is of two pit sawyers and was taken in the Illawarra region. The photograph shows pit sawing of red cedar (*Toona australis*), probably near the end of the days of the cedar getters towards the end of last century. The photograph was taken in subtropical rainforest on the rich volcanic soils near Kiama, where much red cedar was taken out up until about the 1880s. The dense vegetation can be seen in the upper right hand corner of the photograph and the trunks of the cabbage palm (*Livistona australis*) to the right of the man sitting down.

The photograph is part of the Weston Collection and originates from the Weston family, which has been printing the *Kiama Independent* newspaper for over 100 years. Prints of the old photograph have appeared in several publications that I am aware of, and the originals are housed in the Wollongong City Public Library, who I think should have been given credit for the photograph.

Readers may be interested to know that the term "underdog" came from the position of the lower sawyer, as shown in the photograph!

DR KEVIN MILLS
UNIVERSITY OF WOLLONGONG

Your letters are welcome. Please address any correspondence to
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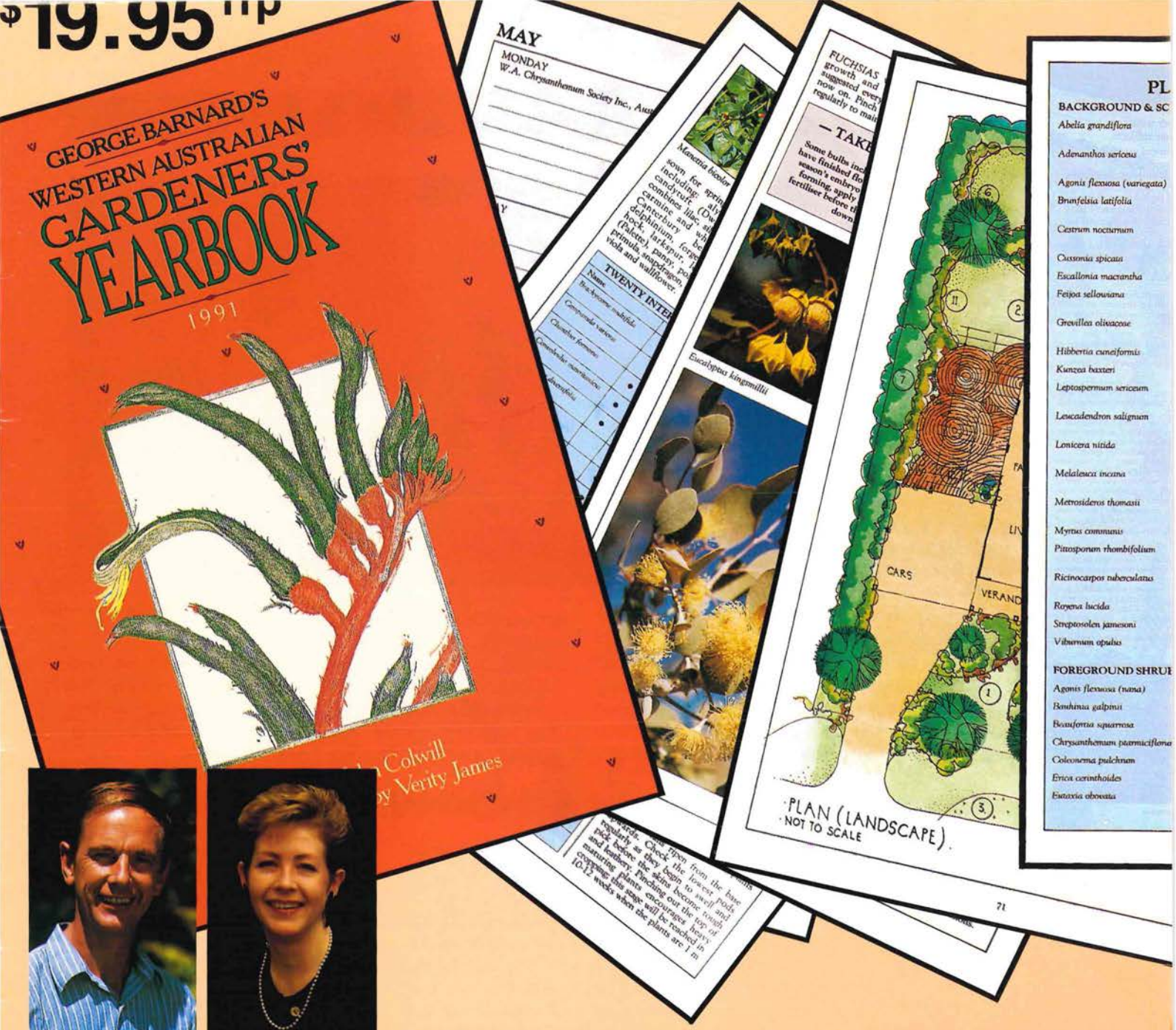

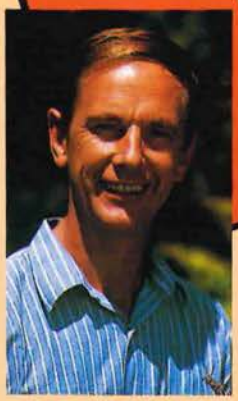

JOHN COLWILL

VERITY JAMES

One of Australia's top gardening authorities, John Colwill, has taken over the anchor role for this year's book. John can be heard on the ABC 6WF Phone-In Gardening shows and is a regular presenter on Gardening Australia. He has been ably assisted by ABC personality and keen gardener Verity James. Together they have compiled a practical all year round collection of expert advice on gardening.

A PRACTICAL GARDENING BOOK CONTAINING EXPERT ADVICE SPECIFIC TO WESTERN AUSTRALIAN GARDENING CONDITIONS INCLUDING

- How to eradicate unwelcome pests
- Monthly care and maintenance
- Planting and pruning times
- Gardening nostalgia
- Comprehensive plant index
- Special gardening features
- Brickpaving techniques and diagrams
- Water conservation, reticulation hints
- Daily tips and reminders
- Gardening charts etc.
- How to start a new garden series
- Identifying common weeds and problems

The Yearbook also contains a diary section for keeping notes to build a useful history of your own garden. It will be available in early October from all leading bookshops. newsagents, nurseries and garden centres or post this coupon to guarantee your copy.

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ZOO STORY

"Truly conservation-minded" is how Perth Zoo describes itself these days.

It has adopted a mission - as stated in 1988 - "to contribute to the conservation of wildlife and to encourage the development of positive community attitudes towards conservation of life on earth."

Issues now addressed by the Zoo's exhibits include degradation of soil, the need for conservation and wise use of energy, the global overview and motivation of realistic action by governments, organisations and individuals.

Forty-four animal species kept at Perth Zoo are the subject of Australian and international conservation programs. Three programs have been developed with the Department of Conservation and Land Management (CALM) to ensure survival of the western swamp tortoise, numbat and chuditch. The zoo is the only place in the world where the numbat can be seen on display. The numbat exhibit itself - the way the animal is presented and the supporting interpretive materials - won this year's Australian Heritage Award for Nature Conservation.

The Zoo recently opened two new exhibits - Microworld and the Conservation Discovery Centre - and will open an African Savannah exhibit later this year. A joint venture between CALM, the Zoo and academia, now being developed, will see an Endangered Species Centre established just outside Perth. The proposed centre has attracted Commonwealth and State funding and is expected to become a centre for conservation biology training and research in south east Asia and Australasia.

A young Sumatran orang-utan. Photo - Jiri Lochman

WAYCHINICUP: NEW NATIONAL PARK

Two new areas of national park in the Waychinicup area near Albany have been gazetted. These areas, together with the existing Mount Manypeaks and Arpenteur Nature Reserves, complete stage one of the Waychinicup National Park. The park now extends from Normans Beach, across Mount Manypeaks and the Waychinicup River mouth, to the Cheynes Beach area.

The next stage is to extend the park from the coast, inland across the main Waychinicup River valley, to the South Coast Highway. Cheyne Road Nature Reserve will also be included, completing stage two. The various areas of national park and nature reserve will then be amalgamated formally to establish the Waychinicup National Park.

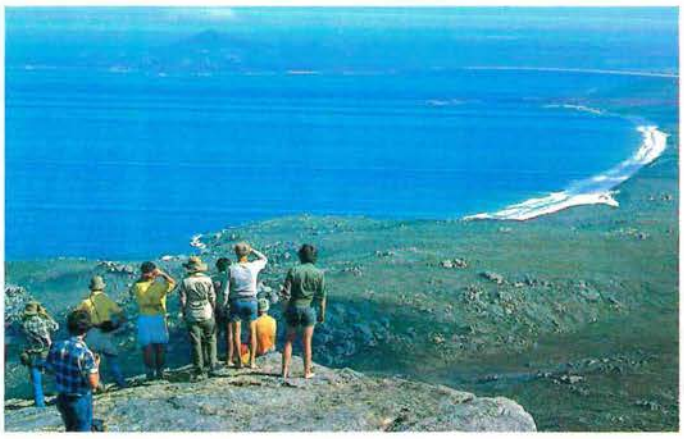
The original proposal to create the national park was made in 1981 by John Watson, CALM South Coast Regional Manager. It was supported by the EPA South Coast Reserves Working Group for the Albany Shire coastline, and subsequently by the Albany Shire Council and the EPA.

The Waychinicup area is very scenic, with unusual granite rock formations and views both inland and along the coast. It is already popular for bush walking, rock climbing, fishing and family recreation, and when completed will form a relatively small yet magnificent national park of approximately 14 000 hectares.

Additionally, it is an area of very high conservation values. It contains several species of restricted or declared rare flora, including *Banksia verticillata*, *Banksia brownii*, and *Asplenium obtusatum* (shore spleenwort), which was recently found at only its second known mainland location. The area contains a similar number of flora species to that found in the famous Stirling Range National Park, which is approximately ten times the size. According to CALM Senior Research Scientist Greg Keighery, the coastal heath around Mount Manypeaks is exceptionally diverse - possibly the most diverse in Western Australia.

Restricted or declared rare fauna include the elusive dibbler and the noisy scrub-bird. The latter was reintroduced to the area between 1983 and 1985 and its population has subsequently expanded, indicating local breeding.

The recent progress towards the establishment of Waychinicup National Park is a highly significant step in nature conservation and the development of Australia's national park system.



Looking west from the summit of Mt Manypeaks. Normans Beach and the western addition to the park are in the middle distance, Mt Gardner and Two Peoples Bay beyond. Photo - John Watson

FROM BEING SEEN TO SEA BEING

The water quality in three marinas on Perth's metropolitan coast will determine the siting of a sea oceanarium for Atlantis Marine Park's nine dolphins.

Atlantis closed in August and Two Rocks, Hillarys and Mindarie Keys marinas are being considered for the dolphins' temporary home by the Department of Conservation and Land Management and the owners of Atlantis, the Tokyu Corporation. Both parties are engaged in a program to rehabilitate and return the dolphins and most other captive animals to their natural habitat. The program is being funded by Tokyu at a cost estimated to be more than $2 million.

Rehabilitation, expected to take three years and attract international attention, is being run by marine mammal expert Dr Nick Gales under the direction of CALM. Working with him are several key CALM staff and seven dolphin handlers from Atlantis. The eventual aim is to release the dolphins as a family pod.

However, several hurdles face the dolphins on their path to freedom: they have to get used to normal bacterial levels associated with living in the sea (Atlantis pools were chlorinated), learn to feed for themselves on live fish, adapt to the move into a contained ocean environment, learn to respond to new signals, and get used to (and follow) a boat on 'training runs' in the wild. Their movements will be monitored by transmitters and time depth recorders attached to their dorsal fins.

Bottlenose dolphin numbers in the waters off the metropolitan area are being surveyed to determine pod size and structure, daily movements, and foraging activity. This information will be vital for the dolphins' eventual release, and will provide previously unavailable research data on the local dolphin population. Similar research will continue to ensure the animals integrate with the wild population.

Meanwhile, eight sea-lions from Atlantis are being released off the South Coast, their original stamping ground, and the park's sub-Antarctic fur seals will soon be released off the continental shelf south of Augusta. A group of five fur seals and one Australian sea-lion unable to be released will be relocated in zoos and other marine parks.

Two dolphins and calf in the Atlantis pool.
Photo - Doug Coughran

WHALE TALES

Each spring, humpback whales migrating to feeding grounds shelter near Perth. CALM guide-lines ensure whales are protected.

Underwater World, with the Pacific Whale Foundation, provides whale watching trips. For information call 09 447 7034.

CONSERVATION UNION

The alarming rate of species extinction in Australia, and the achievements made by scientists to prevent further loss, will be two of the subjects presented to an international conservation conference in Perth (November 28th to December 5th).

'Conservation in a Changing World' is the theme of the 18th general assembly of the IUCN - the World Conservation Union.

The IUCN was founded in France in 1948, under the sponsorship of the French Government, the Swiss League for the Protection of Nature, and the United Nations Educational, Scientific and Cultural Organisation (UNESCO). It is the world's conservation union and its mission is to provide knowledge and leadership for the sustained use of the planet's natural resources. Members of the IUCN include the World Wide Fund for Nature, the Sierra Club, the Royal Society for the Protection of Birds, and the Fédération Française des Sociétés de Protection de la Nature.

IUCN members will be visiting the Mt Lesueur area (above) and Marmion Marine Park.
Photo - Robert Garvey

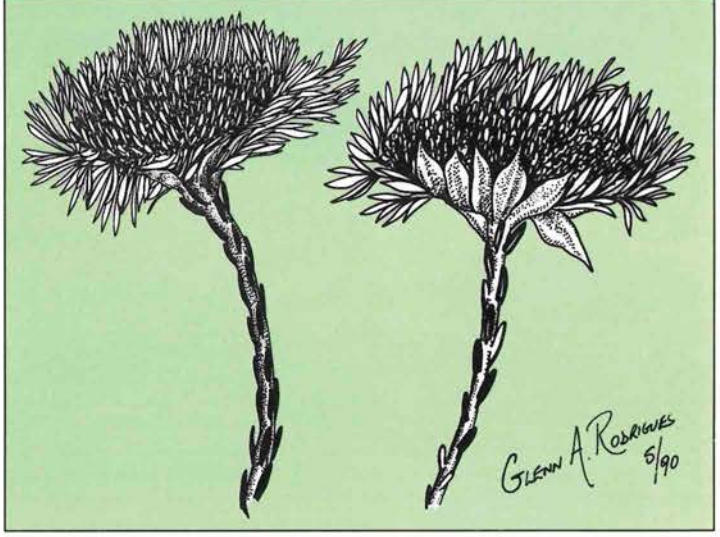
An overall IUCN strategy for the 1990s will be adopted at the Perth assembly. Vital global conservation issues - including the draft World Conservation Strategy for the 1990s and IUCN's Antarctic Conservation Strategy - will also be addressed.

The Western Australian presentation to the conference is being co-ordinated by the Department of Conservation and Land Management, with extensive consultation with other Government bodies and the voluntary conservation movement. The presentation will examine changing attitudes towards the environmental estate and illustrate how solutions for Western Australia's unique environment are beginning to emerge. It will focus on the major issues of land degradation, conservation and management of WA forests, marine conservation and the decline and extinction of unique wildlife species.

A wall of yellow anemones, Marmion Marine Park.
Photo - Dick Beilby

Technical and sightseeing tours for IUCN members will be run throughout WA. These include tours to the Shoalwater Islands Marine Park, wetlands recognised by the international RAMSAR Treaty, Marmion Marine Park, Mt Lesueur, Herdsman Lake, and eucalypt tree plantations.

A DAISY BY ANY OTHER NAME...



Actinodium calocephalum *(left) and* A. cunninghamii *(right). Illustration - courtesy WA Herbarium*

When is a daisy not a daisy? In the State's South-West, botanists were presented with just that question when it appeared there were two different species of the Albany daisy, and three scientific names.

The Albany daisy, a member of the eucalyptus and bottlebrush family Myrtaceae, has puzzled botanists for nearly 200 years. It was first collected by botanist Robert Brown in 1802 from King George Sound, the site of present-day Albany. Pressed and dried, the Albany daisy was sent to many of the large herbaria of Europe.

The Albany daisy was officially named *Actinodium cunninghamii* in 1835 by an Austrian botanist. Two years later, another specimen of the same species was named *Triphelia brunioides* by Robert Brown, who was unaware of the earlier publication of *Actinodium cunninghamii*. In 1849, to compound the confusion Russian botanist Nicholas Turczaninov believed he had a species different from *Actinodium cunninghamii* and published the name *Actinodium proliferum*. Turczaninov was unaware of the name *Triphelia brunioides*, and also unaware he was putting a third name to the Albany daisy.

Meanwhile, back in Western Australia, the puzzle continued when colonial botanist James Drummond noted a different type of Albany daisy. In a letter to the director at Kew, Drummond said he recognised a new species of *Actinodium* and sent a pressed specimen. Botanists at Kew displayed Drummond's find with specimens of the original *Actinodium cunninghamii*.

How many types of Albany daisy could there be? At CALM's Western Australian Herbarium, taxonomic research (the study of classifications of species) found the answer. CALM botanists Neville Marchant and Greg Keighery observed a great deal of variation in the specimen folders of *Actinodium* at Perth. Greg Keighery discovered what he thought was a new species - could there be yet another type of Albany daisy?

Granted a Churchill fellowship to study original Western Australian collections in Russia, Neville Marchant had a chance to see the original gathering of Drummond's Albany daisy in the collection of Nicholas Turczaninov in Kiev. This was the species Turczaninov had named *Actinodium proliferum*. Neville found this similar to the presumed new species Greg Keighery had discovered and the same as the one described as *Actinodium cunninghamii* by the Austrian botanist in 1835.

Neville's and Greg's taxonomic research revealed that in fact there are two species of Albany daisy: the original *Actinodium cunninghamii*, which flowers in summer and occurs from Albany west to Busselton; and a second species which has remained unrecognised since its original discovery by James Drummond in 1849. Soon to be named *Actinodium calocephalum*, this species flowers in the spring and occurs from Albany east to the Young River.

So if you go to Albany to view the wildflowers, look in moist localities for a flower with creamy white radiating petal-like structures that lie in a pink-centred, flat-topped cluster. Like many Western Australian wildflowers, the flowers themselves are small, but are aggregated into heads from 30 to 45 cm in diameter. But don't be confused when you see lots of variations in size and shape!

CHANGING SPOTS

This leopard seal (*Hydrurga leptonyx*) seen at Lancelin this month is one of the more unusual visitors to our coast.

The seals are normally found in sub-Antarctic and Antarctic regions, but in late winter and early spring they are sometimes seen along the southern Australian coast. Six leopard seals have been stranded on the WA coast since August this year.

The animals have a long slim body and a disproportionately large, reptilian-looking head.

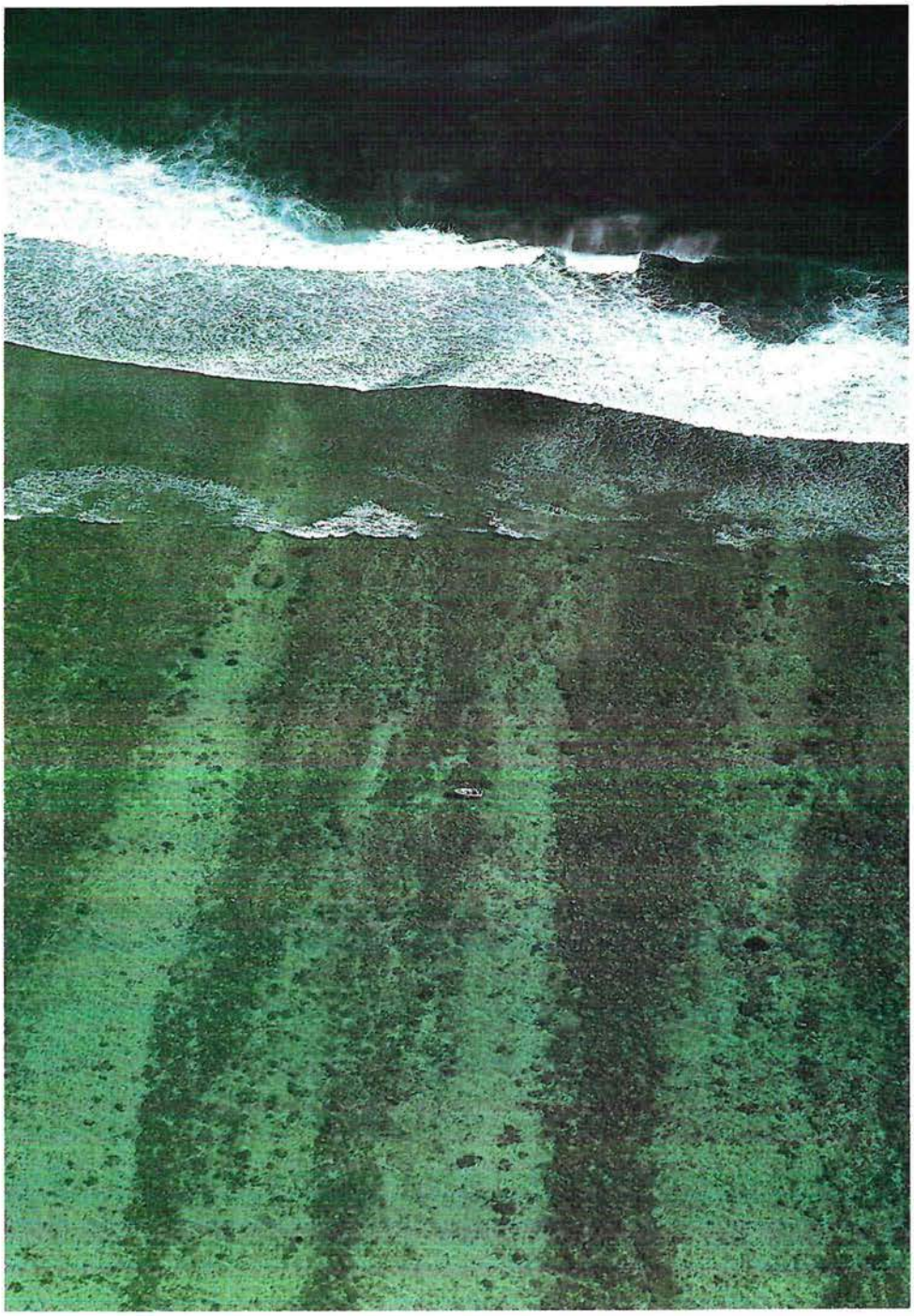
They are carnivorous and feed on several species of penguins and other birds, such as giant petrels, as well as young crabeater, weddel and elephant seals, and krill.

Wildlife Officer Doug Coughran said that when there was a stranding, officers from the Department of Conservation and Land Management set up a barricade tape to protect both people and the animal.

"We monitor the animal's condition and call a vet if required," he said, "but they usually just need to rest up until they are ready to return to the sea."

Photo - Doug Coughran

A Range of Reefs



BY **BARRY WILSON**

Western Australia sits astride the Tropic of Capricorn. The far northern coast faces the verdant tropical island states of south east Asia; the far southern coast faces the Southern Ocean, a vast, uninterrupted tract of cold sea separating our shores from the frozen continent of Antarctica. Imagine the riotous variety of fauna and flora that populates this extensive coastline...

No other sovereign state has such a long coastline covering such a wide range of marine habitats. In keeping with this climatic and habitat diversity, the coastal marine fauna and flora of Western Australia are extremely varied. In the north there are sea-turtles, giant saltwater crocodiles, mangroves and coral reefs. In the south there are sea-lions, penguins, sea-grass banks and great white sharks.

The island-filled axis between the south east Asian and Australian continents, which separates the Indian and Pacific Oceans, is both ecologically productive and geologically complex. The diversity of marine species is extremely high; there is probably no place on earth where there are more living species. Northern Australia is part of that centre of high diversity.

Of all coastal ecosystem types, perhaps none is so species-rich and of such universal interest as coral reef. The Western Australian coast has extensive coral reef systems of great scientific interest and value to the recreation and tourism industries.

CORAL BANKS, PLATFORM REEFS, AND SHELF-EDGE ATOLLS

Because most corals do not like muddy waters, coral reefs are not common along the northern shores of Western Australia. There are many mud-tolerant corals growing on these rocky shores, but coral reef habitats are poorly developed. The extensive onshore coral banks of One Arm Point, in the Kimberley, are an exception.

Offshore, it is another story. On the wide continental shelf off the Kimberley coast there are many large coral banks, some of which bear islands. Little is yet known about the marine communities of these coral reefs, although there is evidence that they may be as rich in species as the reefs of Indonesia, which are only a flip of a whale's tail away.

Still further out lie some of the wonders of the Western Australian marine environment. The edge of the shelf in this region is faulted, and there is a series of shelf-edge fault blocks upon which coral atolls have formed. There is a chain of these atolls. From north to south they are Seringapatam Reef, Scott Reef, and the three reefs comprising the Rowley Shoals: Mermaid, Clerke and Imperieuse. The oceanic waters surrounding these atolls are crystal-clear and ideal for luxuriant coral growth.

The North West shelf-edge atolls lie in a line in the path of the tropical water originating in the Pacific and flowing through the Indonesian island chain and down the Western Australian coast. No doubt their existence is partly due to these warm currents, their faunas

The backreef of Ningaloo Marine Park is safe and easily accessible to divers in small boats.
Photo - Robert Garvey ◄

Morning Reef, part of the Wallabi Group in the Abrolhos, is recommended for declaration as a marine park.
Photo - Patrick Baker ►

The reef and lagoon of Imperieuse Reef, Rowley Shoals, exhibit classical habitat zonation.
Photo - Patrick Baker ▼

Clerke Reef, Rowley Shoals, a typical example of a shelf-edge atoll.
Photo - Patrick Baker ►►

Divers can examine the delicate corals in extraordinarily clear water in Mermaid Reef lagoon.
Photo - Gerhardt Saueracker ▲

A small wrasse sleeps at night among the protective folds of a giant anemone - Morning Reef, Abrolhos.
Photo - Barry Wilson ▶

enriched by larvae carried from the fabulously wealthy faunas to the north.

The Rowley Shoals have been described as the most perfect examples of shelf atolls in Australian waters. They are strikingly similar in dimension, shape and orientation. Each is pear-shaped, rising with near vertical sides from very deep water, and with a rim of reef-flat which bares at low tide. The outer sides of the reefs are exposed to heavy wave action, but inside there are protected lagoons.

Mermaid Reef is 14.5 km long and 7.6 km wide. The reef-flat is 500-600 m wide, shelving into a shallow, coral-rich back-reef zone and then into the lagoon. In this atoll the lagoon is large and up to 20 m deep. There is a single, narrow entrance channel at the north-eastern corner, allowing small vessels to enter the safe anchorage.

Clerke and Imperieuse Reefs are similar to Mermaid but have more complex lagoon systems, and small, unvegetated sandy islands on the reef-flats at their northern end.

Although these atolls are typical of oceanic atolls in many respects, they are unusual in having a very high tidal range. When the tide is low, their reef-flats stand like dam walls enclosing huge lakes, several metres above the level of the surrounding sea. Water gushes from the passages in powerful torrents, like waterfalls. At high tide the reefs disappear beneath the sea, with only the sandy islands visible.

The Rowley Shoals support an oceanic marine fauna richer than that of the inshore coral reefs. There is a coral fauna of at least 233 species in 56 genera, and an incredible fish fauna of 688 species in 258 genera at last count. The molluscs and other invertebrates appear to be similarly diverse as well as abundant in these amazing reservoirs of oceanic biodiversity.

On the whole the remoteness of the Rowley Shoals has protected them from exploitation, and they remain almost pristine. They are increasingly popular with tourists as dive sites and have not been fished to any extent: even the great cods, so susceptible to spear-fishing, may still be seen there in numbers. These friendly giants, at the top of the reef food chains, have been long gone from almost all accessible coral reefs throughout the world. The Rowley Shoals are already justly famous for them alone.

THE NORTH WEST SHELF COASTAL REEFS

The inshore waters along the Pilbara coast are rather muddy, and in this respect very different from the crystal-clear oceanic waters of the shelf-edge, where the atolls have developed. The coral reefs and banks of the inner part of the shelf are not only poorer in species, but have different physical structure and ecosystems.

The best development of coral reefs on the Pilbara coast occurs along the seaward sides of the outer Dampier Archipelago Islands and the Montebello Islands. In the Dampier Archipelago 209 species of coral of 57 genera have so far been recorded after fairly intensive study. Generic diversity is highest in the mid-shore regions of Mermaid Sound, with abundance and reef development greatest on the fringing reefs of the outer islands. The relatively high diversity is no doubt due to the wide range of habitats in the archipelago.

The coral reefs and faunas of the Montebello Islands have not yet been studied, but in view of the structural complexity of these reefs, an abundant and diverse ecosystem is certain to exist there.

NINGALOO REEF

The ocean currents flowing down the shelf-edge past the Rowley Shoals flood the shore of the mainland along the western side of the Cape Range Peninsula. There too we find major coral reef development.

On the western side of the peninsula the continental shelf is very narrow. Heavy ocean swells wash clear ocean water over the reef. These warm, clear, well-oxygenated waters provide ideal conditions for the growth of corals.

The famous Ningaloo Reef is a nearly continuous wall of coral reef, a veritable 'wall of mouths', stretching 250 km along the coast south of North West Cape (see *LANDSCOPE*, Spring 1988). It is one of

the world's major coral reef systems and supports an assemblage of marine plants and animals typical of Indo-Pacific coral reefs. It is a very large, mainly self-perpetuating system, but there is no doubt that it regularly receives new recruits to its community in the form of planktonic larvae carried by ocean currents from the north.

Ningaloo Reef is a quite different structure from the shelf-edge atolls and fringing reefs of the North West Shelf. The corals grow on ridges of the ancient limestone that forms the huge anticline of the Cape Range Peninsula. For much of its length the reef makes up a rampart protecting a shallow sandy lagoon between itself and the shore. In some places it is possible to swim to the reef from the beach; in other places the reef is several kilometres from shore. Nowhere else on the Australian coast is there a coral reef of such size and quality so easily accessible from the shore. For this reason alone Ningaloo Reef has very special importance as a site for recreation and tourism, but at the same time poses particularly difficult management problems. This is a coral reef which will be easy to 'love to death'.

THE ABROLHOS

Three hundred kilometres further south, close to the shelf-break some 50 km offshore, lie the Abrolhos Islands, yet another maritime wonder of the west coast. The islands are a series of sandy islands and limestone rocks surrounded by a complex maze of coral banks and channels. Some of the larger islands were connected to the mainland during the Pleistocene Period, several thousand years ago, and they still support relict terrestrial flora and fauna species of that time. Some of them are nesting sites for sea bird colonies and have extreme conservation value for that reason. But the Abrolhos are most noteworthy for their remarkable coral reefs.

Coral growth has been intermittent at the Abrolhos since the beginning of the Pleistocene. They lie between latitudes 28°S and 29°S, far south of the tropical zone. Yet the modern reefs of the present time are extraordinarily rich in coral species and genera, and in many areas the growth of *Acropora* and *Montipora*

The friendly giant cods of Rowley Shoals Marine Park are a special feature of these atolls.
Photo - Eva Boogard ◄

Islands of the Easter Group, Abrolhos, are surrounded by a complex system of coral reefs, channels, and deep 'blue holes'.
Photo - Barry Wilson ▼

species is exceptionally luxuriant and spectacular. Although the low, wind-swept islands offer a harsh (though interesting) environment for the human visitor, the underwater scenery and biological richness provide for some of the best diving in the country.

The Abrolhos coral reefs seem to owe their existence so far south of the tropics to the southerly-flowing Leeuwin Current, which brings warm water and the larvae of tropical animals from the reef systems further north. Besides the corals there are many tropical marine species of fish, molluscs, crustaceans and other invertebrates in the reef communities. But there are also many species of southern, temperate origin. It is partly this unique blend of tropical and temperate species which makes the Abrolhos reefs of such exceptional scientific interest.

Another aspect of particular interest is the dominance of brown algae in some parts of the reefs. The algae appears to contribute the vast amounts of organic material that drive the ecological energy cycles of this exceptionally productive ecosystem. In this respect the Abrolhos reefs are very different from those of the truly tropical north.

It is only during the last decade that the Abrolhos coral reefs have received the scientific attention they deserve. Studies by State Government, CSIRO and university scientists have documented the fauna and flora of the reefs and shown them to be exceptional in many ways.

A CORAL REEF RESERVE SYSTEM

The coral reefs of Western Australia comprise a remarkable collection of very different types. There are mid-shelf platform reefs and coral banks, shelf-edge atolls, a large and outstanding example of the fringing reef type, and a group of very unusual pseudo-atolls far south of the usual tropical coral reef zone. The State's marine reserve system seeks to represent a selection of these areas and to ensure that they are wisely used and preserved for posterity. Two coral reef marine parks are already declared, and several others are under consideration.

THE ROWLEY SHOALS MARINE PARK

Of the three atolls in the Rowley Shoals, Clerke and Imperieuse Reefs are now marine parks. The invertebrate animals there, including the shells, are protected under fisheries legislation. Recreational fishing is controlled under the recreational fishing regulations. The giant cods are also fully protected. The Department of Conservation and Land Management, in collaboration with the State Fisheries Department, will prepare a management plan for these marine parks defining some areas as recreational fishing places and others as fauna sanctuaries. The main objective will be to manage these remote atolls as marine wilderness areas, accessible to divers and students of coral reef natural history, but preserved forever as two of the world's last unexploited coral atolls.

NINGALOO MARINE PARK

Ningaloo Reef, its lagoon, and the waters within a 10-nautical-mile offshore boundary, have been reserved as marine park. The inner area is reserved under Western Australian State legislation, the outer under Federal legislation.

Adjacent as it is to the arid and wildly beautiful Cape Range National Park, the Ningaloo Marine Park is destined to become one of Australia's most popular recreational areas. Its easy accessiblity from the shore makes it particularly valuable as a recreation and tourist resource. But with people come increasing problems. Management objectives for the Ningaloo Marine Park are aimed at providing access to the joys of this fabulous reef, while ensuring that its natural values do not become degraded by excessive use.

Green turtles mating on the reef-flat, Ningaloo Marine Park.
Photo - Barry Wilson ▲

Branching and plate colonies of *Acropora* corals dominate the back-reef habitat of the Ningaloo Marine Park.
Photo - Robert Garvey ▼

MARMION MARINE PARK

There are no coral reefs south of the Abrolhos, but many species of tropical coral extend their range much further south into the temperate waters of the State. There are at least a dozen species in Marmion Marine Park near Perth, living as isolated colonies attached to rocks on the sea bed. They add a different dimension to the underwater landscapes of the park.

PARKS IN THE PIPELINE

On the North West Shelf, close attention is being given to two areas as candidates for marine parks: fringing reefs of the Dampier Archipelago, and the platform reef complex of the Montebello Islands.

The first of these marine areas surrounds islands which themselves are important conservation and recreation reserves. Like the Ningaloo Marine Park, management there would emphasise recreational use and the protection of the coral reefs and other sites, such as the turtle and sea-bird nesting sites. On the other hand, the Montebello Islands are remote from shore, and recreational use is limited. It is likely that more emphasis would be given to protecting the reef ecosystems, or parts of them, from any interference.

Another example where special environmental management is needed are the Abrolhos. These islands and reefs have very high scientific and conservation values, yet they are also the site of valuable existing fishing and potential tourism industries.

Several years ago the State Government undertook to develop a management strategy which would strike an appropriate balance between these competing uses. Resulting from this, most of the islands (excluding the areas where the fishers live) will become a national park. Three marine areas of special quality from the scientific and tourism points of view will become marine parks, while the remainder will be declared a special fishing management area under the State's fisheries legislation. Plans for implementing these proposals are well advanced.

The outer sides of the shelf-edge atolls rise from great depths as vertical walls, draped with delicate soft corals and gorgonians.
Photo - Barry Wilson ◄

The accessible reef and lagoon of the Ningaloo Marine Park is backed by the arid hills of Cape Range.
Photo - Robert Garvey ▼

TO CARE AND PROTECT

In 1897, fisheries biologist Saville-Kent visited the Abrolhos and wrote these prophetic words:

At some future date, when the Colony of Western Australia shall have passed its present lusty adolescence, and arrived at that maturer age when it shall possess its own University and Chairs of Natural History, it may be safely prophesized that these Abrolhos reefs, within a twenty-four hour journey from Perth, or but three or four hours' sail from Geraldton, will constitute one of the happiest and most productive hunting grounds and fields for biological investigation to the associated students and graduates in Natural Science.

He continued:

In addition to the unprecedented facilities here offered for the most exhaustive study of living Stony Corals or Madreporaria, either individually or in bulk, abundant material is also to hand for the observation and record of the numerous phenomena of wider scope relating to the formation and growth of the reefs, to their environments and food supply, and also to the complex questions of their rise or subsistence.

Western Australia is no longer a colony and, though it may remain 'lusty', it has certainly passed its adolescence. With four universities, several marine research agencies, and such easy access to a range of coral reefs, the natural sciences have outstanding opportunities to explore the intricacies of coral reef biology and geology in this State.

For the community as a whole, the Western Australian coral reefs offer unparalleled opportunities for recreation and enjoyment of one of Earth's most fascinating and beautiful ecosystems. We must explore them and use them with care and respect. ◘

Barry Wilson is Director for Nature Conservation at CALM. He can be contacted at the Crawley office on (09) 386 8811.

Scouting the Treeless Plain

By N.L. McKenzie

The Nullarbor region of Australia is a typical example of the Western Australian dilemma: large, remote, with a long history of pastoral use, and invaded by exotic weeds, herbivores and predators. Yet its biology is poorly known. What is happening to the native flora and fauna? Which areas should be set aside as examples of Nullarbor ecosystems? What is needed to retain their richness and intricacy?

ALL over Western Australia, changes are happening to the land. Huge pastoral areas are degraded to a fraction of their former productivity. Weeds are invading tracts of the few remnants of vegetation left in the Wheatbelt, while salinity is poisoning others. Exotic predators are everywhere, and many native species are endangered or vulnerable. Our ignorance of patterns and changes in plant and animal communities is almost as big as the State.

We urgently need to take an inventory of the Western Australian biota, and to document its distribution before the patterns are further disrupted. We need to identify the optimum positions for reserves, and find out what is happening, and where, so that we can make the best use of our limited conservation funds.

Nowhere is this more true than on the Nullarbor Plain. It is as big as the United Kingdom, yet the gradients of its geology, soils and climate are so gentle that monotony will confound any impatient traveller. The night sky and the silence are endless.

The gentle undulations that barely texture its surface conceal one of the largest limestone karst structures on Earth. The limestone strata are honeycombed with underground drainage systems, often widening into caverns. These contain rare halite speleothems, new mineral species, large lakes, important fossil deposits, Aboriginal sites, and an endemic cave-dwelling fauna. The underwater passages of caves such as Cocklebiddy and Weebubbie are among the largest known and are unequalled for recreation anywhere; Cocklebiddy Cave has been referred to as the Mount Everest of cave diving, with more than six kilometres of underwater passages explored so far.

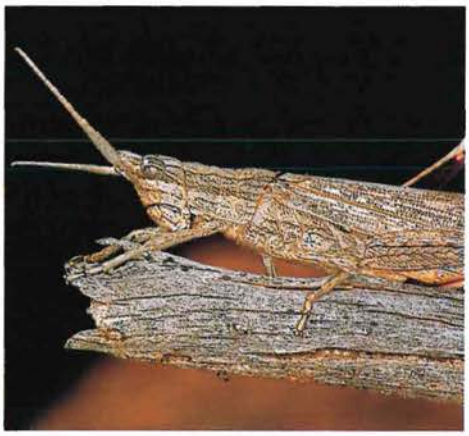
Until 1984, thanks in no small part to the caving activities of the WA Speleological Group and other cavers, more was known about what was under the Nullarbor than what was on top.

NULLARBOR SURVEY

So what is happening to the Nullarbor's flora and fauna? Are there any places that contain such a wide variety of the Plain's plants and animals that they would make the best nature reserves? What else can we do to protect the region's highly complex ecosystems?

The Nullarbor Plain extends across two States. This section of the Plain is in South Australia, near the Nullarbor Motel.
Photo - Tony Robinson ▲

Previous page - The cliffs where the treeless plain meets the Southern Ocean; and a botanist looks at the damage done to the vegetation by the rabbits.
Photos - Peter Canty and Norm McKenzie



Native grasshopper at Muckera, camouflaged on a stick.
Photo - Peter Canty ▲

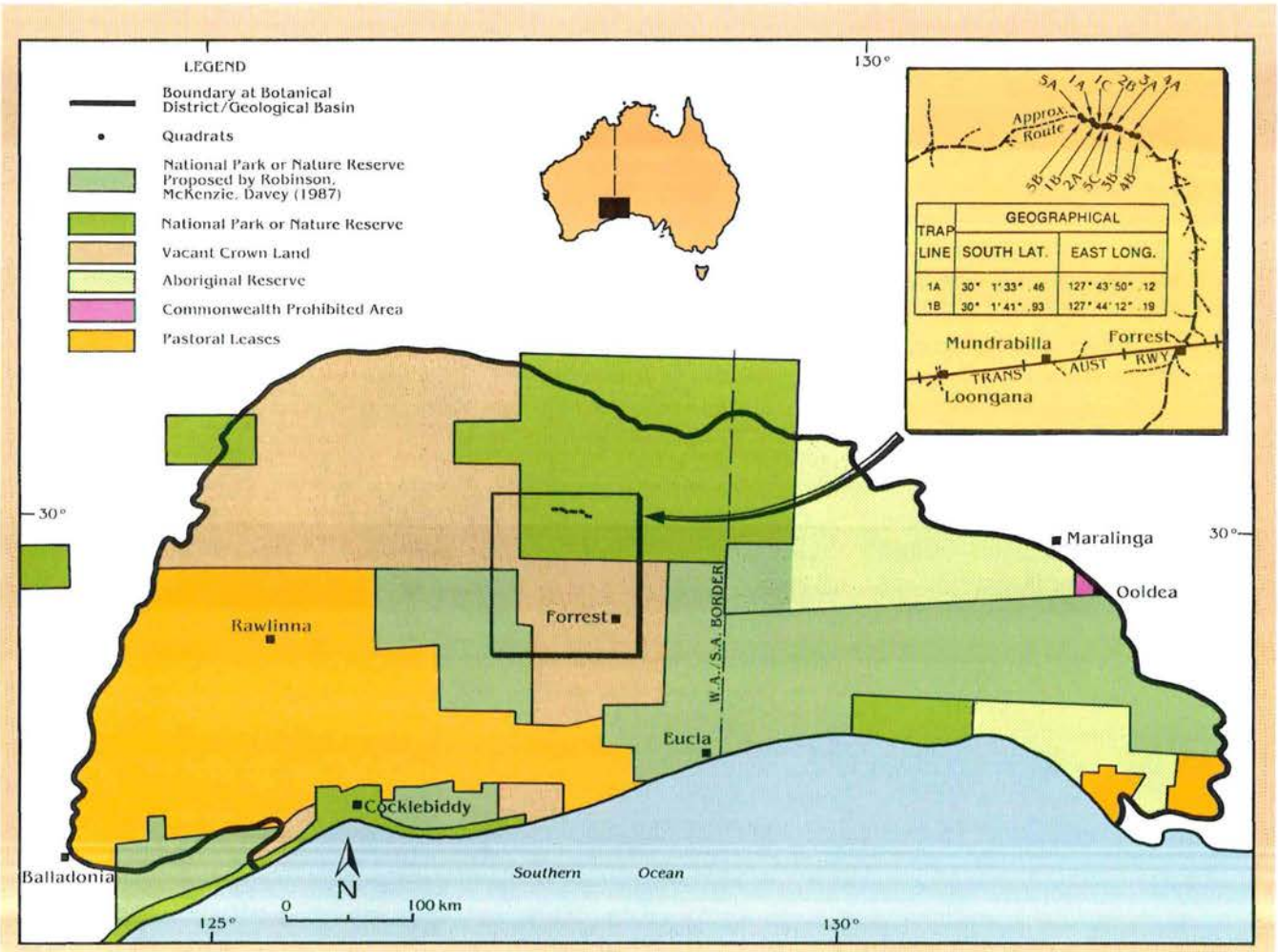
To answer these questions, an ecological survey of the Nullarbor Plain was carried out in 1984.

The area is far too large (220 000 square kilometres) for ecologists to survey everything everywhere. It includes many different communities, each with thousands of species in various combinations. Most of the species are minute. Consistent systems of classification have only been developed for the largest of these organisms - essentially, the plants and the vertebrates. Even though the survey team members could not survey the communities' every detail, they still had to develop a sampling method that could reveal their patterns of distribution across the landscape.

First, we selected a number of sites (called quadrats) positioned throughout the region, so as to sample as many of its ecosystems as possible. These quadrats had to be replicated often enough to allow for variation within each ecosystem.

Second, we sampled an array of different types of species, in order to build a better picture of the intricacy of the ecological network on each quadrat. This meant, for example, that we would be aware of (say) a large shrub and a tiny lizard, whose presence in a network contributes to its complexity.

By March 1984, sites had been chosen for 82 quadrats. This was done during a long, hot and dusty field trip in February. The subsequent autumn and spring sampling programs were divided among



Australian Survey Office

MONITORING

The quadrats were permanently marked (see map) so that they can be re-sampled (monitored) in the future. Observed changes in the species composition of the quadrats can be analysed in terms of the various land management strategies being imposed on various parts of the region. This includes land use by humans, but also areas that are left alone; these can still suffer invasions (e.g. by weeds) and disturbances (e.g. by feral cats). Databases derived from region-wide networks of quadrats allow local fluctuations to be distinguished from regional trends. Such insights provide an objective basis for setting priorities among wildlife management options, especially because the sorts of species involved in the changes are likely to point to the causes.

four teams of biologists, each staffed by a botanist and several zoologists. At each quadrat they tried to make a complete list of trees, shrubs, grasses, lizards, birds and small ground-dwelling mammals.

Many of the 349 species they found were not previously known to occur in the region: 5% of the plants, 2.5% of the birds, 13% of the reptiles and 19% of the mammals. On the other hand, many of the mammals that were prominent through the region during the 1930s, such as bandicoots, native cats and hare-wallabies, have become extinct.

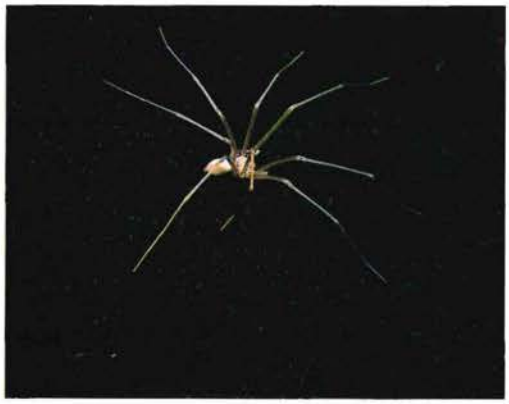
CHOOSING A RESERVE

Using a computer, we found that we could classify the species into 14 groups, based on how often we recorded them at the same quadrats. We gave equal weighting to every species, whether large shrub or tiny lizard. A computer program produced regional "contour" maps to show how the species composition changes in each of the 14 groups.

In October 1986, we tested our 14-layer ecological model of the Nullarbor by sampling another 10 quadrats far from any of the original quadrats. We wanted to know if our maps, derived from only 0.15% of the Nullarbor's total area during just 3% of a single year, could really be used to predict the presence or absence of such a wide array of species. With 14 groups per quadrat over ten

Pogona nullarbor, a lizard endemic to the region and an inhabitant of the treeless plain.
Photo - Ron Johnstone ▲

Sunset and bore at Catacombs where the treeless plain meets the coast.
Photo - Peter Canty ▲



A blind spider found in Thampanna Cave on Mundrabilla Station. It lives only in the underground caves.
Photo - Norm Poulter ▶

quadrats, our finding was remarkable: in all but 13 of the 140 cases, the predictions were better than 80% correct.

Our 14 maps could then be used to decide the optimum positions for reserves. These would best represent the biodiversity of the Nullarbor. An ecologist would describe the positions as the places where the fewest, smallest reserves would be most likely to represent the region's biological complexity. The existing network of reserves in the Nullarbor was assessed using these maps; the network apparently includes the complexity of only about six of the 14 groups. The reserves proposed as a result of the Nullarbor survey encompass all but two of the remaining eight areas.

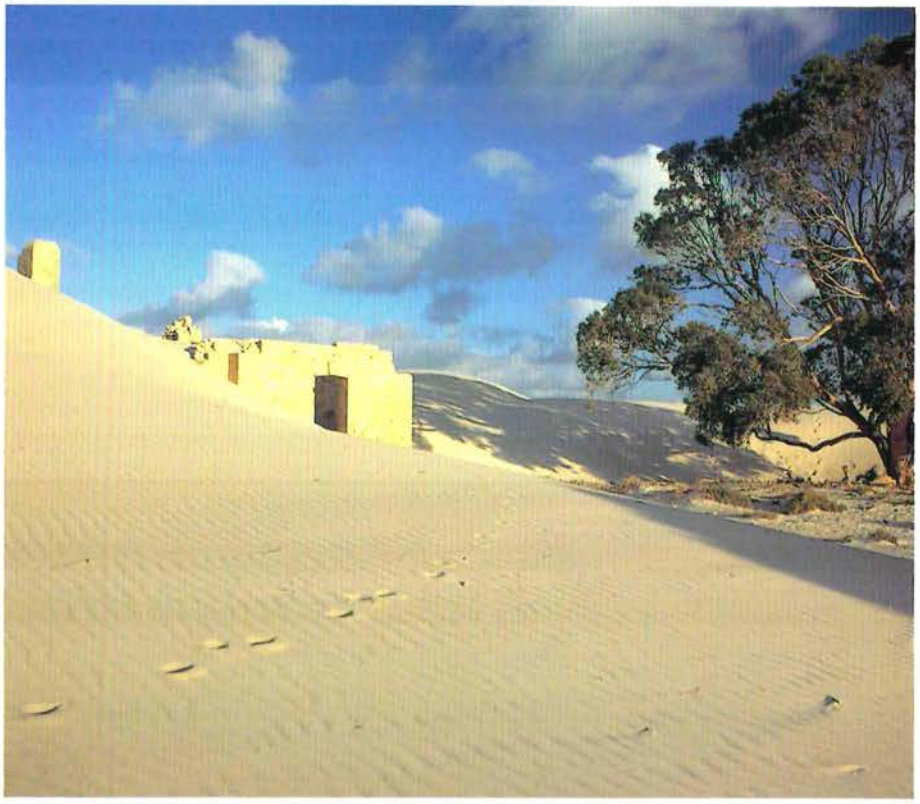
THE CAVES

The caves of the Nullarbor are renowned around the world for their size, complexity and beauty. The cave fauna is rich in endemic invertebrate species specialised to cave living. Some provide roosts for breeding colonies of chocolate bats. Others are treasure houses of sub-fossils, great deposits of bones that preserve a history of the region's fauna. The low humidities and constant temperatures of the caves preserve animal tissues. For instance, two mummified thylacines about 4 000 years old were found in Murra-el-elevyn and Thylacine Hole caves in the 1960s.

The caves were not included in the survey, as there was a considerable amount known about them already. Conservation strategies mainly involve protecting the cave entrances and controlling access by people. Cave entrances have been eroded by people and stock; in many caves, careless or thoughtless visitors have eroded sand dunes, trampled crystal deposits at lake edges and rare mineral crusts, disturbed bat maternity colonies, removed fossils and broken speleothems.

PESTS

The Nullarbor survey has also provided data on exotic species. Foxes, cats and rabbits are found almost everywhere in the region and, along with grazing by domestic stock, are the most prominent causes of degradation. The extent of the damage that can be caused by rabbits was dramatically illustrated by quadrats in the southern parts of the Nullarbor's largest nature reserve, an area that has never been used for pastoral purposes. Only a scatter of rotting stumps remained, mute evidence of the myall woodland



The abandoned telegraph station at Eucla with sand blow.
Photo - Stephen Kelly ▲

Dingo on the treeless plain amongst the blue bush. They eat rabbits, young cats, mice, lizards, insects and road kills.
Photo - Tony Robinson ▲

Master's snake *(Notechis mastersii)*, near Cocklebiddy, a snake common in the marine dunes of the southern margin of the Nullarbor.
Photo - Ron Johnstone ▲

The Nullarbor survey was conducted by CALM and the South Australian Department of Planning, with financial assistance from the Australian National Parks and Wildlife Service.

and bluebush shrubland that covered this landscape 25 years ago.

The exotic weed *Carrichtera annua* has become alarmingly common on the treeless plain. It is especially common along the edge of tracks and roads, suggesting that it is being dispersed partly by vehicles. Even more worrying, it's about the only plant that rabbits won't eat - the healthiest patches were found on top of the rabbit warrens. Its prevalence next to the mill-troughs where the stock drink suggests that even sheep and cattle avoid it.

Yet another factor appears to favour this weed. Unlike the other ephemeral plants of the region, it dries as brittle sticks that take years to decay, withholding plant nutrients that are likely to be limiting in these calcium-rich, but nutrient-poor soils. Combined, these observations could explain why quadrats infested with this invasive weed were so poor in species compared with equivalent, but uninfested, quadrats elsewhere on the plain.

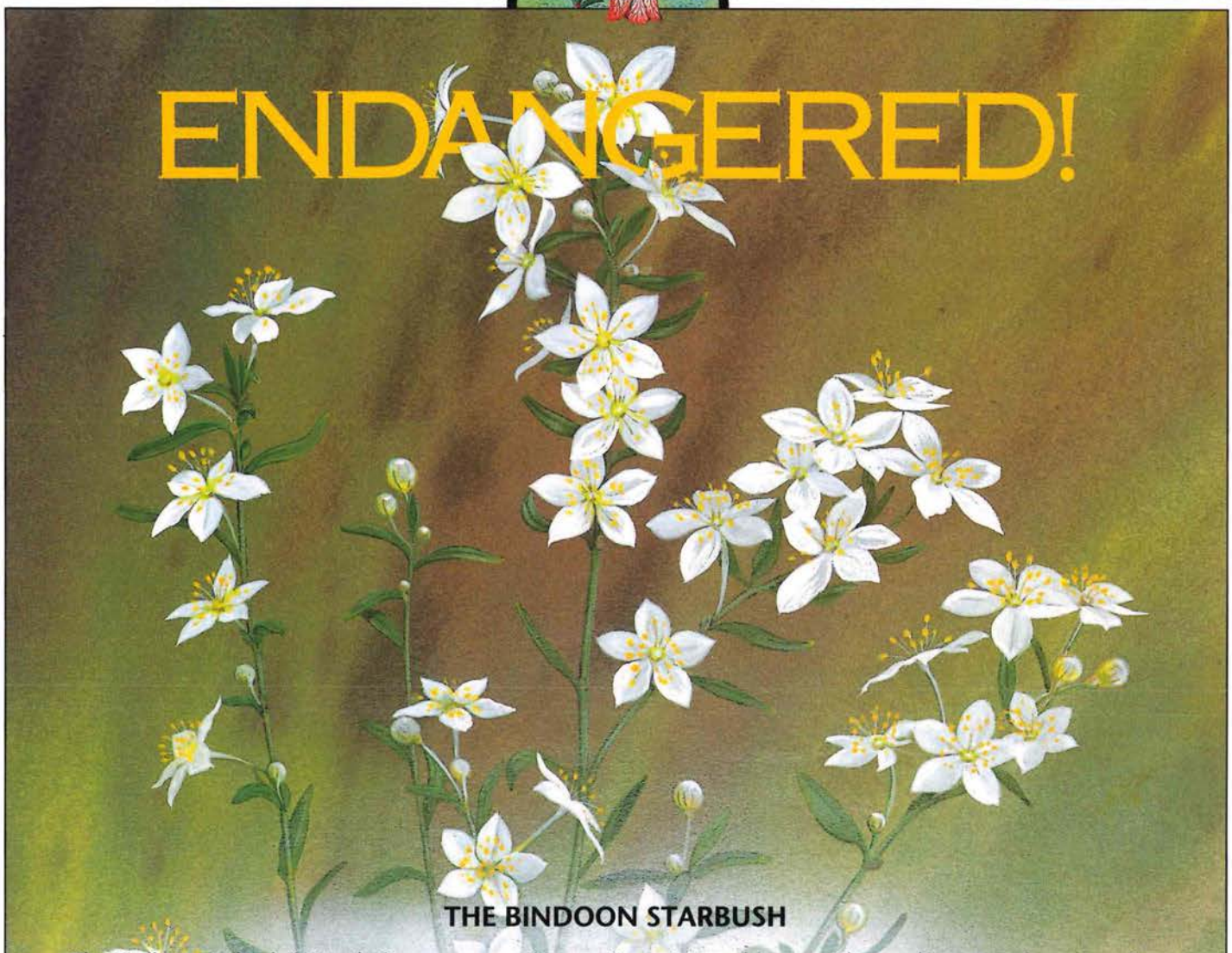
THE DISTINCTIVE PLAIN

The Nullarbor's indigenous communities comprise species adapted to this low-nutrient environment with its harsh climate. Many vertebrates and plants are known to be endemic to the Plain, or have their geographic distributions centred on it. Others are endemic to the marine sand dunes that were isolated on its coast by rising sea levels some 10 000 to 12 000 years ago.

The peculiarly stunted types of vegetation of the treeless plain give the central Nullarbor its distinctive character. Despite their sparse, apparently species-poor appearance, we have as much obligation to conserve these communities as to conserve the richer, superficially more attractive ecosystems, such as rainforests, found elsewhere in Australia.

Norm McKenzie is a Principal Research Scientist at CALM's Wildlife Research Centre at Woodvale. His interests include the design of ecological surveys. He can be contacted on 09 405 5100.

ENDANGERED!



THE BINDOON STARBUSH

The Bindoon starbush (*Asterolasia nivea*) is one of the State's rarest and most endangered plant species. It is now known from only one population north of Bindoon, where ten mature plants exist on roadside verges.

The species was first collected in 1963 near Bindoon by the late Charles Gardner, government botanist. It was not collected again until 1966 from south of the Moore River. Since then, extensive land clearing has destroyed much of its habitat. As a result, the starbush was gazetted as Declared Rare Flora in March 1982 under the Wildlife Conservation Act (1950).

This species shows an abundance of pure white, star-shaped, five-petalled flowers (August to October), growing on a straggly, multi-stemmed shrub up to 50 cm in height, with weak, slender branchlets.

In 1987 Kings Park and Botanic Gardens began shoot culture trials, and in 1988-89 seed and seed embryo culture trials were added to the program in an attempt to achieve micro-propagation of the species. Some success was achieved in *in vitro* shoot multiplication and research is continuing into the problem of rooting of shoots.

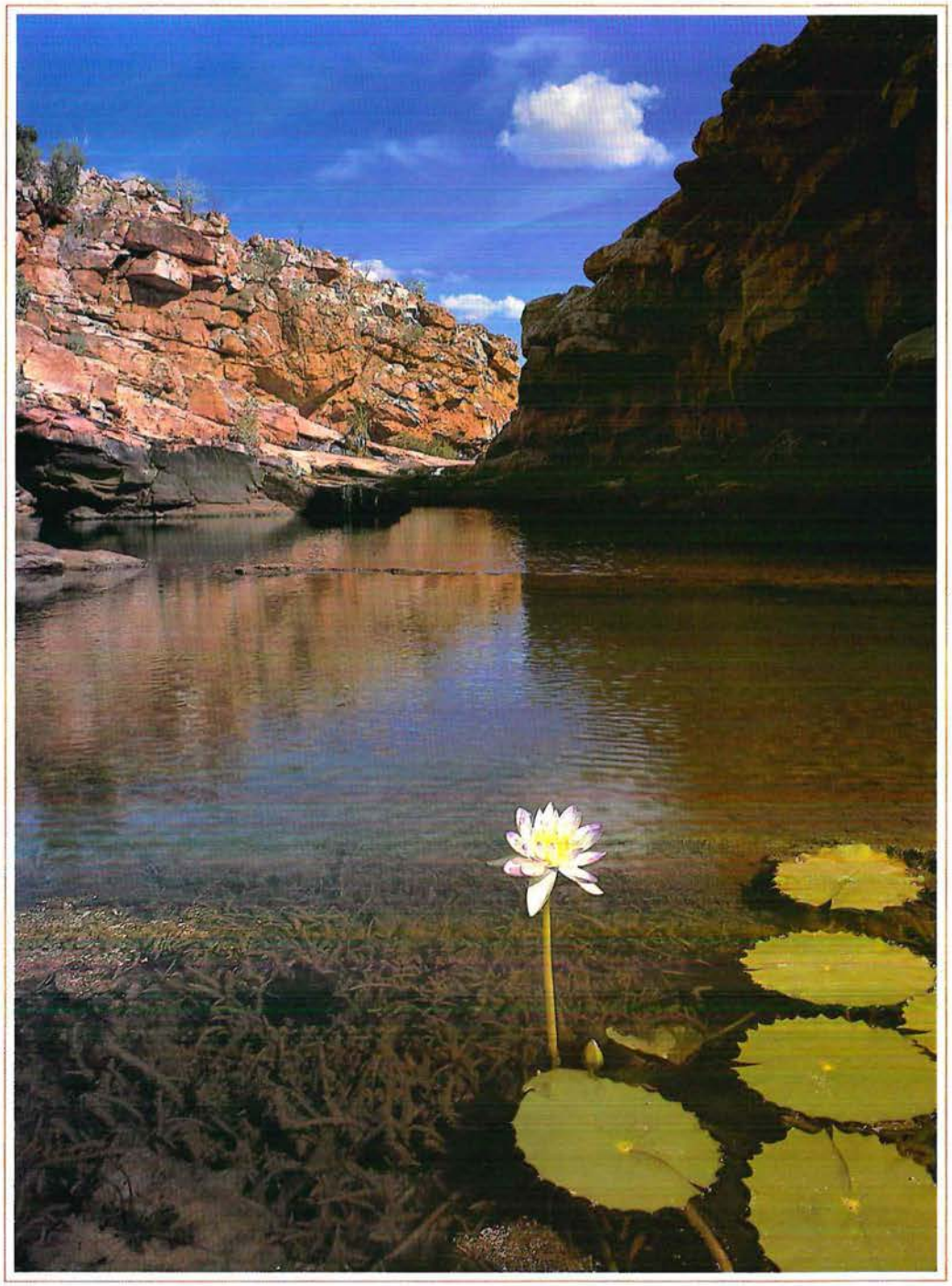
During 1988, some 80-90 Bindoon starbush seedlings were found on a road verge. Twenty-four at risk were moved to other areas within the road reserve and to a nearby nature reserve. To ensure that the dieback fungus was not introduced into the nature reserve, samples of roadside soils were extensively tested.

On 30 July 1988, under the guidance of Kings Park Senior Horticulturalist Bob Dixon, CALM staff successfully transferred the 24 seedlings. Specially fabricated cylinders were pushed down to a depth of 30-35cm around each plant, then gently extricated with seedling and soil intact. Since planting, these seedlings have been inspected, watered and measured every 3-4 weeks during the summer.

The results are most encouraging - a 100% survival rate, maintained up to 24 November 1989. Subsequent rabbit damage to two seedlings in the nature reserve instigated the immediate placement of protective wire netting over each individual plant. An application of *in situ* leaf mulch to maintain soil moisture caused severe insect damage to nine seedlings, and ultimately death to five of them. This mulch was immediately removed.

Of the remaining 19 seedlings, 15 plants are in a good healthy condition with a 50-150% increase in growth height. The remaining four plants are in a fair condition. Although it is premature to predict success for this project, the indications are encouraging. We may achieve a 150% increase in population numbers of *Asterolasia nivea*, which could ultimately ensure the long-term conservation and preservation of this species.

LES ROBSON



THE FRAGILE FRONTIER

by Carolyn Thomson, Chris Done and Allen Grosse

The Kimberley is remote to most of us, but it has a lot to offer. Enthralling gorges, sweeping plains; plateaux hundreds of metres high; sandy deserts speckled with oases; and rocky outcrops clinging to each other in formations which defy gravity.
It's a place of haunting loveliness. Yet the Kimberley's very beauty is getting it into trouble.

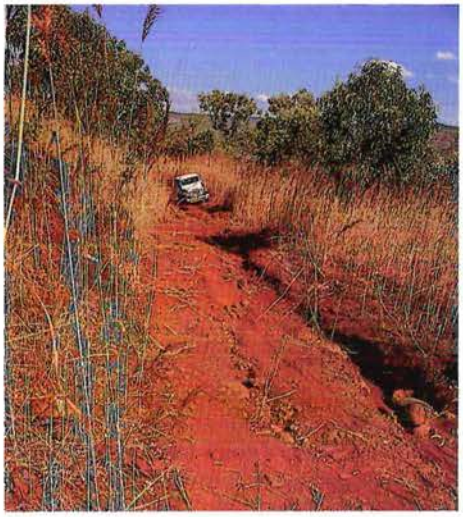
THE Kimberley is one of the world's last wild places. To begin with, it is huge. It covers more than 320 000 square kilometres of Western Australia, which makes it bigger than the State of Victoria. The terrain is not only ancient but varied - broad plains, ranges of rugged hills, flat-topped mesas, and broad tidal flats. The Indian Ocean sculpts showplaces into the coast; at Walcott Inlet, for example, tidal water rises 10 metres into a natural inlet behind. Inland, vast waters cleave through rocky gorges, carving chasms through schist and shale. The rugged landscape is patchworked by gorges, waterfalls and rainforests, which act as a haven for wildlife. Aboriginal rock art, including the stylised figures of the Wandjina, decorates overhanging rock ledges throughout the land.

Ironically, the same spectacular, varied beauty that attracts people in their thousands may yet be the cause of its downfall. The Kimberley caters to a wide range of visitors seeking a variety of experiences, from solitude to group touring, from bush walking to flying. Intriguing natural features like Geikie Gorge, and the Bungle Bungle massif with its eroded beehive mounds, are increasingly famous drawcards for visitors. The region now has seven declared national parks and several major nature reserves, but it needs many more. Some of its most fragile and beautiful areas are gradually being damaged.

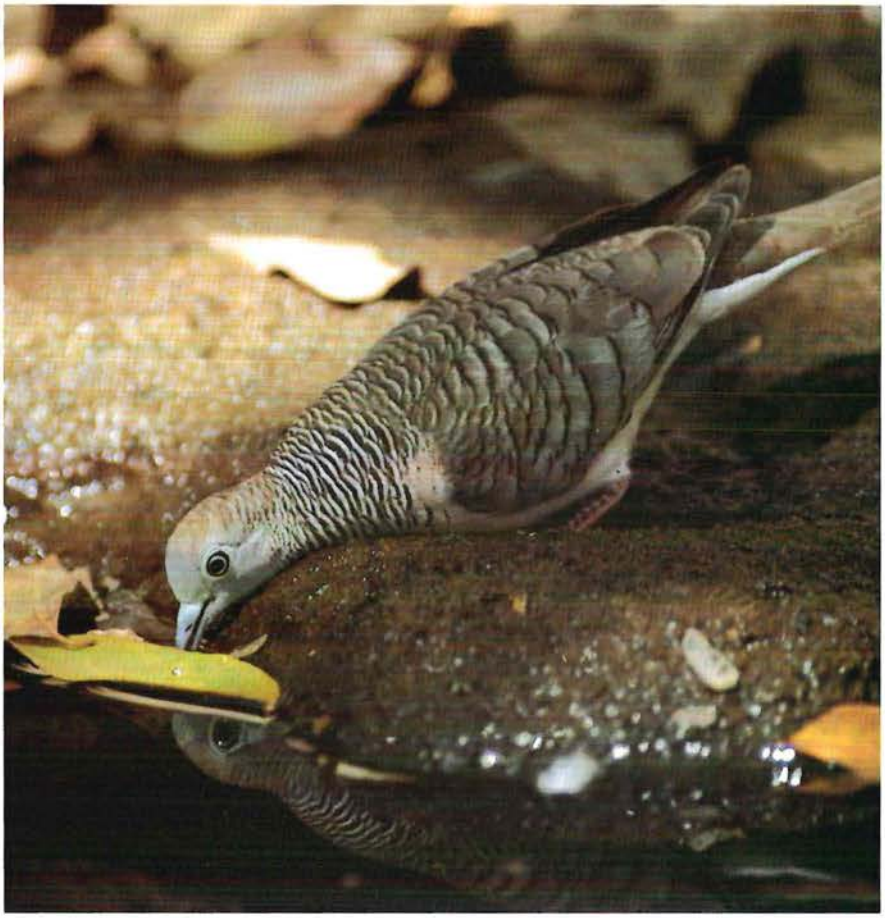
In the last decade, the Kimberley - although thousands of kilometres north of Perth - has become accessible to large numbers of eager, four-wheel-drive tourists. Visitors are welcome in the Kimberley, but those who have no care where they go and what they do are leaving a most unwelcome mark. Even taking the best care, large numbers of visitors can cause the vegetation of this fragile land to deteriorate. With heavy traffic the soil is compacted, preventing plants from regenerating. Because of this compacting, water cannot penetrate the soil, and during heavy rainfall it runs off into other areas, causing erosion and silt.

The kapok bush *(Cochlospermum fraseri)* found typically in dry rocky areas of north-western Australia.
Photo - Jiri Lochman ▲

A billabong at peace - one of the quiet places of the Kimberley.
Photo - Marie Lochman ▼



Large numbers of visitors can cause the fragile land of the north to deteriorate.
Photo - Marie Lochman ▲



The widespread extinctions that have occurred in the rest of the State have not taken place in the remotest parts of the Kimberley - almost all fauna species that should be present are still there.
Photo - Jiri Lochman ▶

OPENING UP

After Alexander Forrest led a land expedition through the Kimberley and spoke of "well-watered land suitable for pastoral purposes", pastoralists began to open up the country along the Ord River Valley and the Fitzroy River basin. Today about 225 000 square kilometres of the Kimberley is taken up with some form of pastoral activity, supporting 99 leases and carrying up to 600 000 head of cattle.

Now a different form of "opening up" is taking place. In some previously inaccessible areas, tracks have been put down over the last 20-30 years by pastoralists or mining exploration companies, allowing admission to adventurous visitors.

OVERUSE

The results are clear to see. With increased use, pristine caves in the Oscar Ranges have deteriorated rapidly in the last few years. Stalactites have been broken off, and some caves have been defaced and covered with graffiti. In another part of the region, travelling the Gibb River Road used to be one of the great outback adventures. The rugged country it traverses is punctuated at regular intervals by inviting creeks, shady campsites, gorges and waterholes. Among its attractions are Bell Creek, Galvans Gorge and Adcock Gorge. But now, large numbers of travellers have discovered the road. When too many people visit a fragile area which can't cater for them, the consequences include damage to tracks, littering, vegetation removal, bushfires and gully erosion.

Camping areas can become denuded of vegetation, especially because people tend to burn off the land to clear it for camping. Take the case of Manning Gorge, a once pretty part of the Kimberley region. Originally a quiet spot known and enjoyed only by a few, it is now the haunt of hundreds. It became such a popular place that toilets and other amenities were erected, tourists paying a fee for the privilege. After two years the camping site deteriorated - what was once a pleasantly grassed river area became a dustbowl. The case of Manning Gorge is not an isolated incident; many such cases occur throughout the region.

Some shires have organised rubbish collections from a small number of areas. But other people have installed barbecues and rubbish facilities without arranging for maintenance or collection.

CONTROLLING THE PROBLEM

The increasing interest in these areas is creating a dilemma for tourism and conservation authorities. The problem is that although the Department of Conservation and Land Management (CALM) manages national parks and nature reserves, no single authority is responsible for managing other places.

The fact that these uncontrolled and increasing visits could cause environmental damage has been recognised since the 1960s, when the Australian Academy of Science made recommendations to conserve flora and fauna in the region. In 1977 the Environmental Protection Authority (EPA), through its System Seven Report, recognised the need to bring areas of the Kimberley under active management. Those areas are often the same ones now coming under increasing visitor pressure because of the accessibility of their spectacular landforms.

In 1987 submissions to the State Government called for up to 40 new national parks and reserves to be set up in the Kimberley. Major areas which have yet to be reserved include Packsaddle Swamp near Kununurra, and the proposed

Mitchell Falls, on the Mitchell Plateau, is a drawcard for visitors to this remote area. There are plans to include it in a national park.
Photo - Jiri Lochman ▲

Seeing freshwater crocodiles in their natural habitat is one of the highlights of a visit to the Kimberley.
Photo - Ian Duncan ▼

Roebuck Bay Marine Reserve. The Rowley Shoals, whose atolls boast some of the world's best pristine coral formations, has just been declared a marine park.

The Mitchell Plateau, 270 kilometres west-north-west of Wyndham, is one of the most scenic and biologically important areas in the State. The Mitchell River, flowing northwards, drains into Walmsley Bay and Admiralty Gulf, carving gorges and waterfalls into the underlying sandstone. With the plateau fast becoming a tourist attraction, co-operation between CALM, the Western Australian Tourism Commission, the Department of Sport and Recreation and a bauxite mining company interested in the land has resulted in signs being erected and brochures about access being made available for tourists. These are simple but major steps towards fuller protection of the environment.

In addition, a lot of work has been put into the Kimberley Regional Planning Study by members of the public, interest groups and CALM. The report of the study should offer further encouragement for the creation of new parks and reserves.

NORTH-WEST BOUND

The number of visitors to the Kimberley continues to swell. The lands they visit are sometimes highly vulnerable, and CALM is pushing for some of them to be reserved. In the meantime, the travelling public needs to be informed about conservation of the Kimberley environment - starting with basic do's and don't's, such as staying on existing tracks and leaving no litter behind. As far as the Kimberley is concerned, the best kind of tourist is the one who does not leave a mark.

CALM has just published a book entitled *North-West Bound*, a useful and attractive guide for tourists, which has something to say on the matter:

"Throughout the Kimberley there are a number of wild and remote areas. Some are so isolated and have terrain so rugged that, since the original Aboriginal inhabitants left the land, few people have visited them, except by boat. There is no road access to the Prince Regent Nature Reserve and no public access to the Drysdale River National Park and Walcott Inlet.

"In most of these places all of the original animal species remain, unlike most other places in WA, where some animals have become extinct and others teeter on the brink of becoming so.

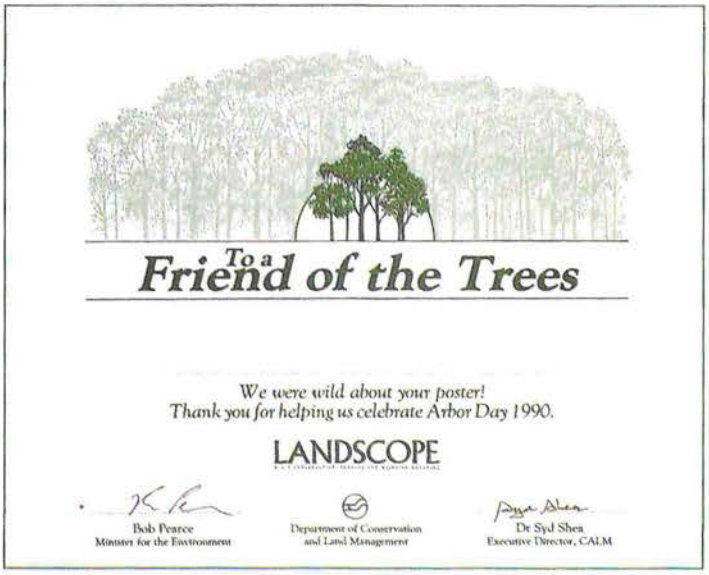
"These are fragile, sensitive places . . . they are important refuges for fauna, which can breed and multiply in peace."

We couldn't have said it better! ◘

Chris Done is CALM's Regional Manager of the Kimberley Region, Allen Grosse is District Manager of the West Kimberley and Carolyn Thomson edited CALM's new publication *North-West Bound*.

Kids and Trees

Arbor Day 1990 Poster Competition



The 'thank you' award given to each of our young entrants.

THE recent Arbor Day 1990 Poster Competition, sponsored by *LANDSCOPE* magazine and Radio 6WF, attracted a staggering 7 474 entries from primary age children in over 150 schools, as far afield as Cockatoo Island in the north and Albany in the south.

The children did a beautiful job of telling us how important they think our trees are. If this is a reflection of their environmental awareness, our schools are educating a new crop of 'green' decision-makers for the future.

Many of the children incorporated slogans such as 'We love trees', 'Trees give us oxygen', and 'Please plant more trees'. One entry effectively used our most recent cult figure, a Teenage Mutant Ninja Turtle, with the message 'Plant a Tree Man!' Some entries showed the way trees provide habitats and food for wildlife, while others explored the recreational use of trees, as shade for picnics, or for hammocks, swings and tree houses. Yet others reflected the ongoing debate about logging by objecting to trees being cut down.

Some of the winning entries showed a particular insight and artistic talent.

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

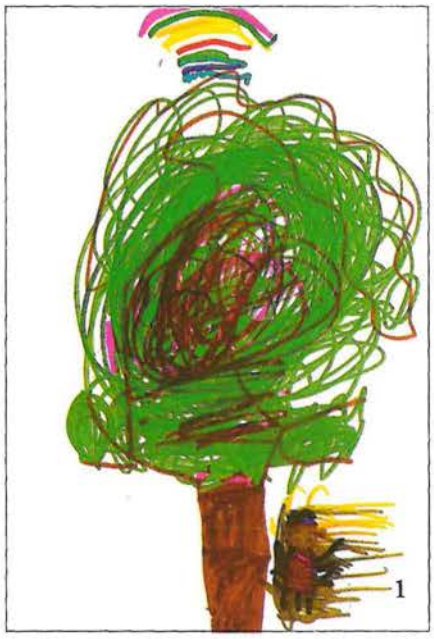
- Woodlupine ECU, Perth (Years K, 1 and 2)
- Samson Primary School, Samson (Years 3, 4 and 5)
- North Innaloo Primary School, Perth (Years 6 and 7)

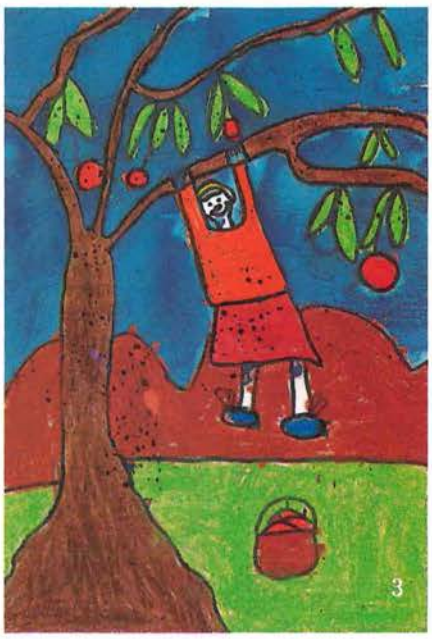
A special award was made to Gooseberry Hill Primary School for outstanding entries in all classes.

Media personality Ted Bull, who, with Environment Minister Bob Pearce and CALM Executive Director Dr Syd Shea, announced the winners during his Radio 6WF 'Breakfast Session' on Arbor Day, was impressed by the level of awareness and concern for environmental issues expressed by WA's primary school children.

"I believe that as long as children care there is a future," he said.

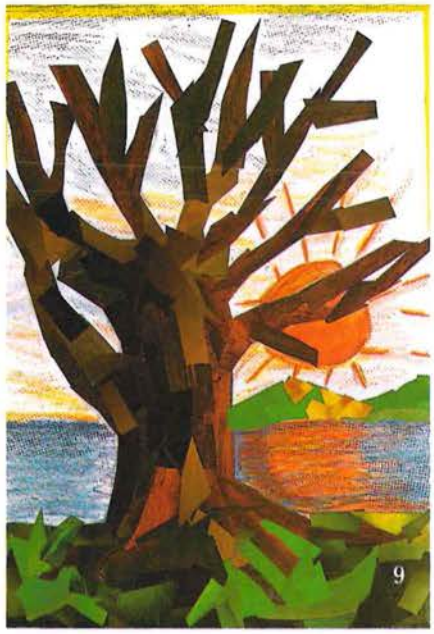
Ted visited a number of schools, with a CALM Ranger and *LANDSCOPE* staff, to present the category prizes, and every student who submitted an entry was sent a certificate of recognition.

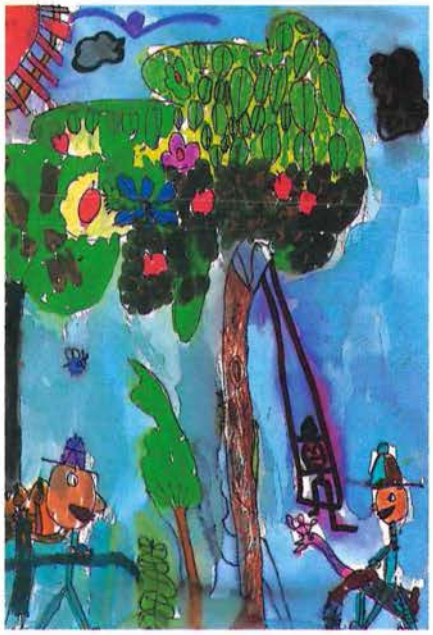


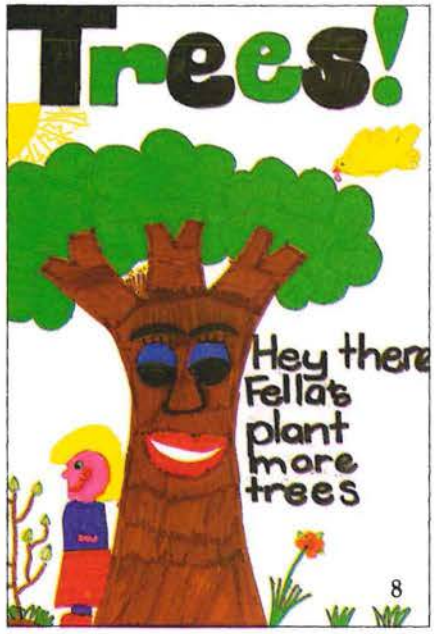


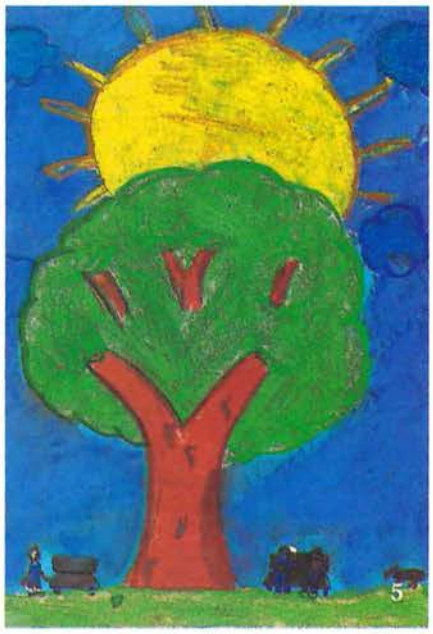
THE WINNERS

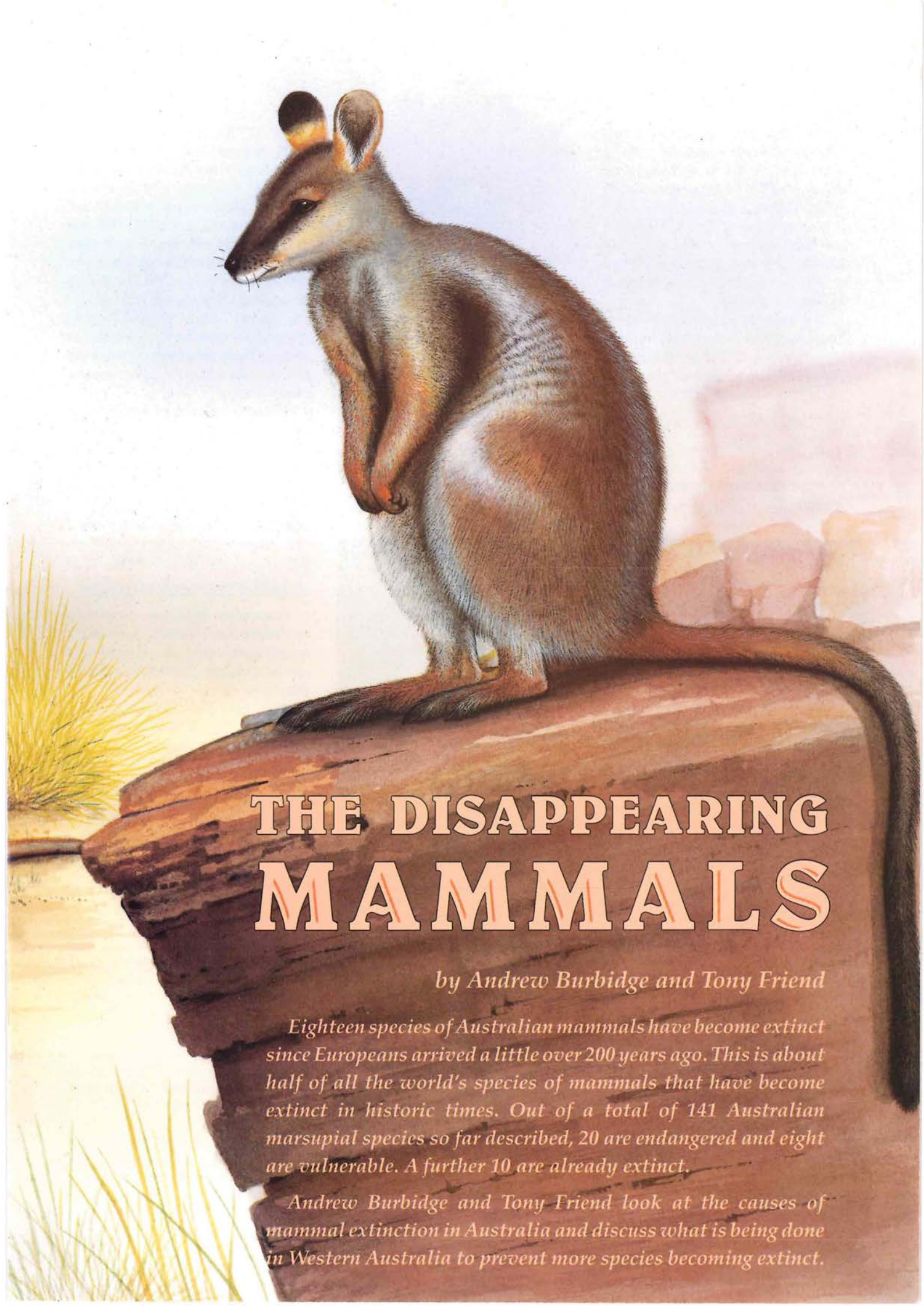
1. Pia Colreavy Year K (Pre-Primary)
   St Thomas Primary School, Claremont
2. Tracey Murdoch Year 6
   Heathridge Primary School
3. Joanna Lee Year 3
   Samson Primary School
4. Tim Hall Year 1
   Gooseberry Hill Primary School
5. Stephen Burgess: one of the 'best class' entries from North Innaloo Primary School
6. Mark Albertsen Year 7
   Gooseberry Hill Primary School
7. Callum Poultney Year 2
   Flinders Park Primary School, Albany
8. Jacqui Smith Year 5
   South Kalgoorlie Primary School
9. Garreth Harker Year 4
   St Brigids, Collie











THE DISAPPEARING MAMMALS

by Andrew Burbidge and Tony Friend

Eighteen species of Australian mammals have become extinct since Europeans arrived a little over 200 years ago. This is about half of all the world's species of mammals that have become extinct in historic times. Out of a total of 141 Australian marsupial species so far described, 20 are endangered and eight are vulnerable. A further 10 are already extinct.

Andrew Burbidge and Tony Friend look at the causes of mammal extinction in Australia and discuss what is being done in Western Australia to prevent more species becoming extinct.

AUSTRALIA has a worse record than any other continent for rates of mammal extinction. We are lucky that it isn't even poorer. Of the surviving species of Australian mammals, eight now occur only on continental islands. If Western Australia's Barrow, Bernier and Dorre Islands did not exist, or had been affected by introduced predators, a further four species would be gone.

Not only has Australia lost a great many mammals forever, but there are also many species that are endangered or vulnerable. Why has Australia such a bad history of mammal conservation?

CRITICAL WEIGHT RANGE

A recent scientific paper by two CALM research scientists has shown that extinctions and dramatic declines in range among Australian mammals are virtually

confined to non-flying mammals with mean adult body weights between 35 g and 5 500 g; this was termed the *critical weight range* (CWR). The many smaller mammals (marsupials such as dunnarts; rodents such as native mice) are still common, as are the larger kangaroos and big wallabies. CWR mammals that have declined or become extinct are not restricted to one or two families but come from most groups of marsupials and native rodents.

Extinctions and declines have not happened equally in every part of the continent. The more arid an area, the more species that are extinct or endangered - one third of the native mammals of the deserts of the interior are either locally or totally extinct, and almost all of the remaining CWR arid zone species are endangered. At the other extreme, no mammals of the wet tropics of Western Australia are either extinct or endangered. Biology and habitat also have some effect. Ground-dwelling mammals are more likely to be endangered or extinct than are tree-dwelling species or those that live in rock-piles (such as rock-wallabies).

There have been many hypotheses as to why particular species or suites of species have declined in, or disappeared from, various parts of Australia. These include clearing for agriculture, draining or salination of wetlands, grazing and browsing by introduced animals, changed fire regimes, introduced predators, disease, and overkill by hunters.

ELIMINATED HYPOTHESES

Some of the hypotheses can already be dismissed as common causes of the disappearance or decline of an array of species throughout their former ranges.

Disease

There is no direct evidence that disease has led to the extinction of any Australian mammal. Disease might possibly have removed mammals a long time ago when there were no biologists to study the effects; but if disease were a primary cause of extinction or decline in a significant number of species, it is curious that it should selectively affect the CWR species, especially those occurring in arid regions.

Illustration - previous page.
From left - Red-tailed phascogale, western barred bandicoot, rufous hare-wallaby and black-footed rock-wallaby.
Illustration - Martin Thompson

The western barred bandicoot, now restricted to Bernier and Dorre Islands in Shark Bay, was once common in much of southern Australia.
Photo - Wade Hughes ◄

Once common in the WA Wheatbelt, the dalgyte (or bilby) is now restricted to remnant populations in the northern deserts.
Photo - Jiri Lochman ►

Hunting

While many species of Australian mammals have been hunted for thousands of years by Aborigines (many were hunted by early Europeans too), and while hunting of some species continues today, there is no evidence that post-European declines and extinctions have been the result of excessive harvesting. Most species exterminated by overkill elsewhere in the world were large; in Australia, larger species, such as kangaroos, have suffered no major declines except where their habitat has been destroyed, while many CWR species that have never been hunted by Europeans have disappeared.

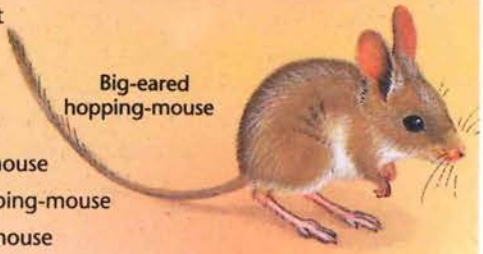
Clearing

Clearing has been confined to a small proportion of the continent of Australia, and few if any mammals were restricted to areas that were cleared at the time they became extinct. While clearing has doubtless been responsible for the local decline and disappearance of several mammal species, it could not have been the primary cause of total extinction for many.

Likewise, drainage and salination could not have affected many species, since few were restricted to areas that have been so affected. The only exception was the only non-CWR mainland species that is extinct - the toolache wallaby, which occurred in the south-east of South Australia and the west of Victoria. Swamps formed a significant part of its habitat, and most are now drained. This destruction, which also included the clearing of vegetation, was the major cause of the toolache's demise.

GONE FOREVER: EXTINCT SPECIES OF AUSTRALIAN MAMMALS

Thylacinus cynocephalus, thylacine
Perameles eremiana, desert bandicoot
Chaeropus ecaudatus, pig-footed bandicoot
Macrotis leucura, lesser bilby
Potorous platyops, broad-faced potoroo
Caloprymnus campestris, desert rat-kangaroo
Lagorchestes leporides, eastern hare-wallaby
Lagorchestes asomatus, central hare-wallaby
Onychogalea lunata, crescent nailtail wallaby
Macropus greyi, toolache wallaby
Conilurus albipes, white-footed rabbit-rat
Pseudomys fieldi, Alice Springs mouse
Pseudomys gouldii, Gould's mouse
Leporillus apicalis, lesser stick-nest rat
Notomys macrotis, big-eared hopping-mouse
Notomys longicaudatus, long-tailed hopping-mouse
Notomys amplus, short-tailed hopping-mouse
Notomys mordax, Darling Downs hopping-mouse



BOX 1

PROBABLE CAUSES

The remaining possible causes - introduced herbivores, changed fire regimes and exotic predators - are widespread in their distribution and effect.

Introduced Herbivores

Rabbits, goats, cattle, sheep, donkeys, pigs, camels and so on, are widespread in Australia. Pastoralism (open-range grazing) is the major land-use of much of the arid zone, but many exotic species extend into conservation reserves and unoccupied deserts. The effects of introduced herbivores on the native vegetation and habitats have been significant. However, there is nothing to suggest that introduced herbivores have much affected the spinifex communities that dominate the sandy and stony deserts, although rabbits may have eaten out the nutrient-rich refuges that the native species depended on in hard times.

Fire Regimes

Fire is one of the most significant modifiers of habitat in Australia, but while there are several studies on the effects of single fires on mammal populations there are few data on the effects of the frequency, extent, and season of fires on the status of CWR mammals.

Fire regimes are known to have changed significantly in parts of Australia since European settlement. The propensity of Aborigines for burning the country was noted by some early European visitors. In much of the western desert the movement of Aborigines to settlements has occurred only in the last 25 to 60 years, and it is possible to crudely reconstruct the pre-European situation. Here it has been suggested that the fire regime changed from one where numerous, mainly small fires occurred throughout the year to one dominated by infrequent, large, summer fires. As a result, the vegetation has apparently changed from one with small patches in different stages of recovery following fire to one with much larger, less diverse patches.

It is thought that many mammals depended on the recently burnt country for food and the adjacent, denser vegetation for cover. Research has shown that the disappearance of mammals from the deserts of Western Australia, north-western South Australia and the south-western Northern Territory coincided with the depopulation of the area by Aborigines and the subsequent change in the fire regime.

INTRODUCED PREDATORS

Three exotic predators are now widespread in Australia. The dingo is thought to have been introduced between 3 000 and 8 000 years ago, and it is usually assumed that its effects on mammals pre-dated European settlement. In contrast, the feral cat and the red fox are much more recent arrivals.

The cat occurs throughout the continent and appears to have been present for a long time. There is no doubt that cats prey upon CWR mammals as large as rufous hare-wallabies, which weigh about 1600 g. However, extinct CWR mammals such as the pig-footed bandicoot (350 g), the desert rat-kangaroo (890 g) and the central hare-wallaby (1500 g) persisted in the western deserts until at least the 1930s and probably as late as the 1950s (*LANDSCOPE*, Winter 1987), which suggests that the cat has not been the primary factor in their decline.

The fox arrived later, around the mid 1800s. It spread rapidly from Victoria, colonising most of the continent except the wet tropics by the 1930s. The lack of mammal extinctions in the wet tropics and in Tasmania (apart from the thylacine) is consistent with the distribution of the red fox, and foxes have been implicated in the demise of many native Australian mammals. But the relationship is not absolute; in some parts of Australia it seems clear that the native mammals had begun to decline or had disappeared before foxes arrived.

It has been known for some time that foxes can eliminate island populations of CWR mammals. Recent research in Western Australia by Dr Jack Kinnear and colleagues from CALM (see *LANDSCOPE*, Summer 1988-89, Summer 1989-90 and Winter 1990) has demonstrated that fox control around remnant mammal populations leads to a rapid increase in numbers of native mammals such as numbats, woylies (or brush-tailed bettongs), black-footed rock-wallabies, Rothschild's rock-wallabies, common brushtail possums and, surprisingly, western brush wallabies, which have an adult body weight of eight kg. Control of foxes is now considered a pre-requisite for both the management of remnant CWR mammal populations and for the successful re-introduction of CWR species to parts of their former range.

NEARLY GONE: EXTINCT ON THE MAINLAND, NOW RESTRICTED TO ISLANDS

Dasyurus viverrinus, eastern quoll
Tasmania

Perameles bougainville, western barred bandicoot
Bernier & Dorre Is, WA

Bettongia lesueur, boodie or burrowing bettong
Barrow, Bernier & Dorre Is, WA

Bettongia gaimardii, Tasmanian bettong
Tasmania & Bruny I, Tasmania

Lagostrophus fasciatus, banded hare-wallaby
Bernier & Dorre Is, WA

Thylogale billardierii, Tasmanian pademelon
Tasmania & 16 other Tasmanian islands

Leporillus conditor, greater stick-nest rat
Franklin Is, SA (recently introduced to Salutation I, Shark Bay, WA)

Pseudomys praeconis, Shark Bay mouse
Bernier I, WA

Burrowing Bettong

BOX 2

The banded hare-wallaby, once abundant in WA's South-West, now occurs only on Bernier and Dorre Islands.
Photo - Marie Lochman ▶

CALM researchers are studying the western barred bandicoot on Dorre Island as a precursor to preparing a recovery plan to extend its range.
Photo - Tony Friend ▼

WHAT HAS BEEN DONE?

For many years mammal conservation was based largely on the protection of habitat, where this was possible. Many very important conservation reserves have been set aside to protect endangered mammals. In Western Australia Barrow Island was reserved in 1908 to protect its amazing suite of mammals and Bernier and Dorre Islands were reserved in 1957. The rapid growth in the conservation estate in the 1960s and 1970s protected a number of important mammal sites. However, slowly it became clear that, on the mainland, habitat protection was not enough; species were being lost from reserved areas.

Over the past two decades there has been a revolution in mammal conservation in Australia. All around the country studies have commenced into endangered mammals, looking for the reasons for their decline and aiming to develop conservation techniques. Research has been carried out mainly by the State conservation agencies, but universities have also been involved. Recently, the financial assistance of World Wide Fund for Nature Australia (WWFA) and the Australian National Parks and Wildlife Service (ANPWS) has speeded up this vital work.

Western Australia has been in the forefront of these studies. Research has been conducted into the numbat (*LANDSCOPE*, Winter 1990), the woylie, the tammar wallaby, the chuditch (*LANDSCOPE*, Winter 1987) and many other species. Research has concentrated on fire ecology and on the effects of introduced predators. The results of all these studies have been incorporated into management guidelines for CALM-managed lands where the species exist.

WHAT'S TO BE DONE?

Huge reductions in numbers and range have left the mammals that we now label "endangered" with small, restricted, often fragmented populations. Urgent priorities in research and management are to pinpoint the processes now threatening those populations, and to act to reverse their effect. Fox control programs are being expanded, protecting remnant populations of endangered mammals and allowing re-introduction of some species into parts of their former ranges. However, there are still a number of endangered species in Western Australia about which we know little beyond their status. There are still only a few about which we know sufficient to confidently engage in full-scale recovery programs.

Australia's endangered mammals fall into three categories.

Restricted to Islands

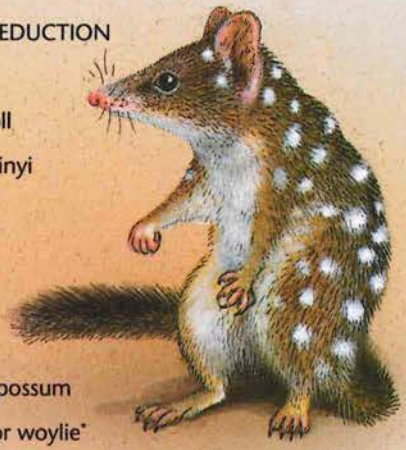
Firstly, there are those that are extinct on the mainland and only persist on offshore islands, most of which are free of introduced predators (see Box 2). Apparently these species are unable to survive in the face of ecological changes on the mainland since white settlement. Other species equally intolerant of change that did not have island populations became extinct (Box 1, except for the thylacine, which became extinct on an island). Species in this group are fairly secure in the short term, but those dependent on small islands in particular are extremely vulnerable to catastrophe. In the case of the Shark Bay mouse, which is only on one small island, and the banded hare-wallaby and western barred bandicoot, which are only on two, the loss of even one population must be prevented at all costs. The security of these species will be enhanced by the establishment of new populations in predator-free places, preferably within their previous ranges.

In Western Australia, research into re-introducing mammal species to the mainland and introducing them to islands has begun. In 1990 a captive-bred group of the greater stick-nest rat was introduced

ENDANGERED AND VULNERABLE WESTERN AUSTRALIAN MAMMALS

A. RESTRICTED TO MAINLAND; MASSIVE REDUCTION IN RANGE AND NUMBERS.

Dasyurus geoffroii, chuditch or western quoll
Dasycercus cristicauda, mulgara or minyi-minyi
Phascogale calura, red-tailed phascogale
Sminthopsis psammophila, sandhill dunnart
Myrmecobius fasciatus, numbat or walpurti
Macrotis lagotis, dalgyte or bilby or ninu
Pseudocheirus occidentalis, western ringtail possum
Bettongia penicillata, brush-tailed bettong or woylie*
Pseudomys australis, plains rat
Pseudomys shortridgei, heath rat
Pseudomys occidentalis, western mouse
*Introduction under way to islands in South Australia.



Chuditch

B. OCCUR ON ISLANDS; MASSIVE OR SIGNIFICANT REDUCTION IN RANGE AND NUMBERS ON MAINLAND.

Parantechinus apicalis, dibbler
Isoodon obesulus, southern brown bandicoot or quenda
Isoodon auratus, golden bandicoot or wintarru
Lagorchestes conspicillatus, spectacled hare-wallaby or wampana
Lagorchestes hirsutus, rufous hare-wallaby or mala
Petrogale lateralis, black-footed rock-wallaby or warru
Macropus eugenii, tammar

Dibbler

BOX 3

A Shark Bay mouse from Bernier Island. This species has not been recorded on the mainland since 1858.
Photo - Marie Lochman ◄

Dorre Island, Shark Bay. A nature reserve that is the refuge for three species of mammals now extinct on the Australian mainland.
Photo - Tony Friend ▼

onto Salutation Island, Shark Bay, from Franklin Island, off the South Australian coast. If a new population is established here, this project will have significantly increased the total number of stick-nest rats and reduced the vulnerability of the species to extinction.

Restricted to the Mainland

The second group of endangered mammals comprises those species that have experienced massive declines in range and numbers since white settlement, and persist only as remnant populations on the mainland. They constitute the most endangered group, because where a historic decline in range happened, it is likely that the causal factors are still operating, or might be re-activated. These species appear, however, to have some temporary ecological refuge on the mainland that has allowed them to survive so far despite the changes that so greatly reduced their numbers.

Again, an increase in the number of populations of these species through re-introduction and exchange of individuals between isolated populations to maintain gene flow should place these species in a more secure position. CALM has begun a program of re-establishment of numbat populations in areas being maintained fox-free, and this will continue until the number of secure colonies is adequate. The woylie and chuditch are two more obvious candidates for this strategy. In addition, CALM scientists have this year begun studies on the western mouse (funded by WWFA) and on the red-tailed phascogale (supported by ANPWS) to define strategies for managing and increasing populations of these two small mammals.

Those species that are widely but thinly distributed in non-agricultural areas, such as pastoral country or the deserts, may be somewhat more secure but it is difficult to locate populations in order to study and manage them. In Western Australia, this group includes the sandhill dunnart, the dalgyte (or bilby) and the mulgara. Further understanding of these species is required before conservation strategies can be formulated.

Island and Mainland Survivors

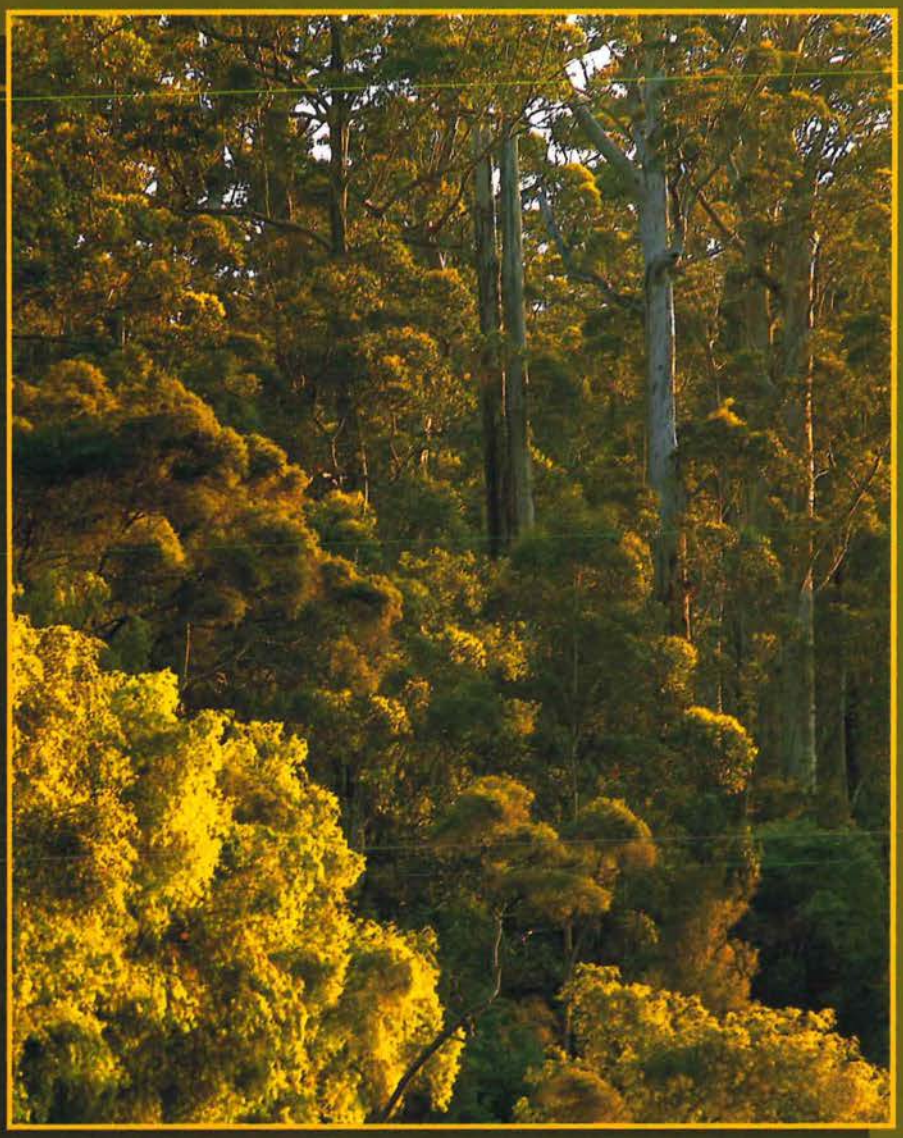
The third group consists of those that occur on offshore islands but also have remnant, low-density populations surviving on the mainland, despite large historic declines. Western Australian examples include the dibbler, golden bandicoot, tammar, black-footed rock-wallaby and spectacled hare-wallaby.

Species in this group are better off than those in the other two groups, as they appear to have some temporary mainland ecological refuges as well as predator-free island refuges. They offer the opportunity to study population dynamics on islands and the mainland, in order to isolate factors causing declines on the mainland.

The fox has already been shown to be a major threat to CWR mammals. While control programs using highly selective poison baits are effective, they are also expensive and limited in application. A long-term solution to the fox problem currently being evaluated is the use of a specific viral agent that suppresses reproduction. The effective dispersal of this agent will rely on accurate knowledge of the ecology and socio-biology of the fox in Australia, and this research is currently being carried out by CALM scientists in Western Australia, with support from ANPWS and WWFA.

Too many of our mammals are extinct. So many more are endangered or vulnerable. Lessons have been learned and management has begun. But much more research and management will be needed before Australians can be sure that no more mammals are lost forever.

Andrew Burbidge, Director of Research, and Tony Friend, Senior Research Scientist, both work from CALM's Wildlife Research Centre at Woodvale. They can be contacted on 09 405 5100.



FORESTS FOR THE FUTURE

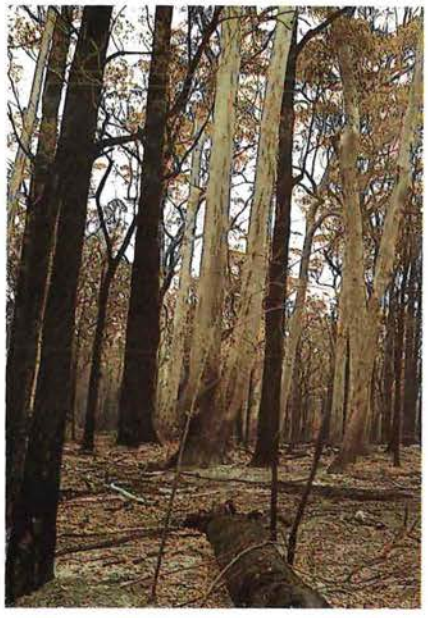
by Syd Shea and Roger Underwood

We need our forests. They mean protection for our wildlife, our water, our vegetation, even our oxygen. They are also beautiful and interesting places, with values which we would sorely miss if they were gone. But we have also found a myriad of uses for the timber - and although we may wish otherwise, timber can only be obtained by felling trees. Fortunately, the forests can be sustained - in ways that will protect all our values. Syd Shea and Roger Underwood explain how forests function and how, with good management, they can be used and sustained.

WHEN Europeans first arrived in the South-West of Western Australia, it was densely wooded. It is this fact that encourages some people to believe that the land was virgin - having had no management, no 'interference'. But Aborigines, who had lived and travelled throughout the South-West for at least 40 000 years, had most certainly 'managed' the land. They fired the forests to make hunting easier and to regenerate favoured plants, and they used forest products - including timber - to construct shelter, to use as fuel, and to make canoes.

Even before the Aborigines, the 'virgin' forests were not static, idyllic ecosystems. In the short time since scientific observations of the forest began, catastrophic disturbances of forest ecosystems have been regularly noted. They have come from fire ignited by lightning, and from cyclonic windstorms. These have caused dramatic changes in the forests. In 1961 the Dwellingup wildfire, which was started from 18 lightning strikes, resulted in 200 000 hectares of forest being burnt - causing extensive mortality of flora and fauna.

We will never know in detail the composition of our ancient forests, but we can partially reconstruct it by careful counting of tree ages in different 'virgin' stands and by analysis of historical data. Forest scientist Martin Rayner is one of many to have attempted this task. His analysis of the structure of karri forests, achieved by determining the age distribution of trees in 'virgin' stands, provides us with some objective data.



Wildfires and other major natural catastrophes, such as cyclones, have had a major impact on forest structure and composition.
Photo - Rick Sneeuwjagt ▲

Thousands of old growth karri trees were killed or severely damaged by a wildfire in the Walpole-Nornalup National Park in 1987.
Photo - Lachlan McCaw ◄

Some areas of the forests originated as large stands of trees of equal ages, almost certainly as a consequence of a large high-intensity fire, while in others the patches of such evenly aged forest were smaller. In still other areas there is an irregular distribution of ages, probably as a consequence of a series of smaller, less intense wildfires. Historical measurements of the structure of karri forest stands demonstrate how, as a consequence of rapid growth and intense competition between trees, the structure of a forest stand changes dramatically over time.

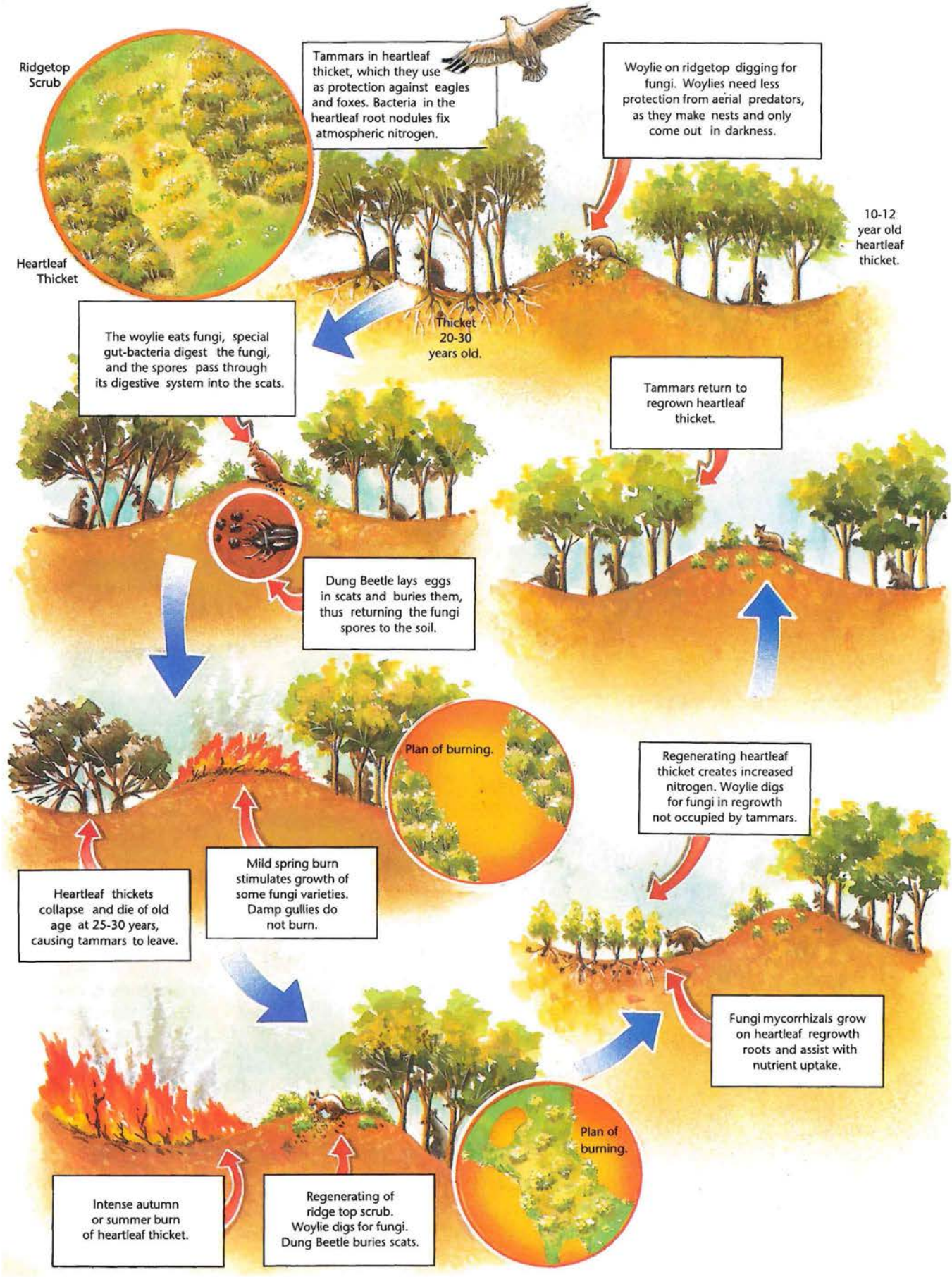
Fire and other catastrophes have played a major role in forest structure and composition, but superimposed on these random events is the response of site characteristics and the forest ecosystem to disturbances. For example, on more fertile sites there is greater accumulation of litter, making them more prone to frequent high-intensity fires. In the karri forest, the seed-cycle is a further factor. Karri trees are killed by hot fires but do not produce abundant seed crops annually; after a hot fire, therefore, the karri would regenerate either abundantly or hardly at all, depending on the state of the seed crop in the tree crowns.

Even before Aborigines began to manage the forest, its age and structure would have been constantly changing. At any one time, the karri, jarrah and wandoo forests probably consisted of a mosaic of stands of different ages and structures. The size of each patch of forest would have fluctuated over time, and the trees could have been young, old or mixed, depending on the sequence of natural events in the preceding years. The only constant factor in our forest ecosystems is change.

How do animals and plants survive in such a ruthless environment? Individual plants and animals don't; but nature's compensation for its terror is to develop bizarre synergistic processes that help to ensure the survival of the species. The benchmark work of CALM forest ecologist

THE COMPLEX WEB

CALM's FIRE MANAGEMENT IN THE FOREST MAINTAINS THE COMPLEX WEB OF INTERACTING NATURAL PROCESSES



Dr Per Christensen on the ecology of the tammar wallaby and the woylie demonstrates how plants and animals have developed systems that enable them to survive in these forest ecosystems.

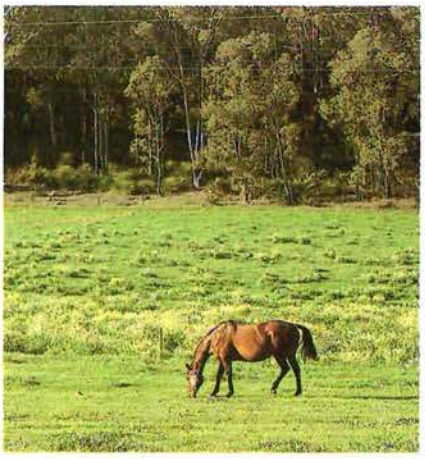
This complex web of interacting processes, far from being fragile, needs the trauma of periodic hot fires to function. This system is vulnerable - not to violence, but to changes that impose uniformity, and to the introduction of factors not subject to nature's checks and balances. Imposing a no-burn regime in this ecosystem would eventually eliminate the tammar and possibly the woylie, while introducing the fox to WA has posed a threat to these animals second only to the clearing of native vegetation.

THE EUROPEAN IMPACT

The arrival of Europeans in Western Australia had a traumatic impact on the forests of the South-West. For them, forests were either an impediment to agriculture or a seemingly endless storehouse of valuable timber. Between 1830 and 1930, millions of hectares of forests and woodlands were cleared for crop and pasture, and further millions were taken up for sheep and cattle grazing. The hardest hit were the Wheatbelt, with its magnificent York gum, salmon gum and wandoo woodlands, and the karri country, where group settlers ringbarked over 20 000 hectares of prime forest to create dairy farms. During the same period a large timber industry was established, producing timber for export, for building work in the growing cities, and for the railway lines snaking off across the new farmlands of the State.

It was not the tree-clearing in itself that had a great impact. It was the extent of the clearing. What took place allowed men and women to settle the country, and they and their successors' endeavours have created much of our wealth today. But one cost was a large reduction in the area of native forest.

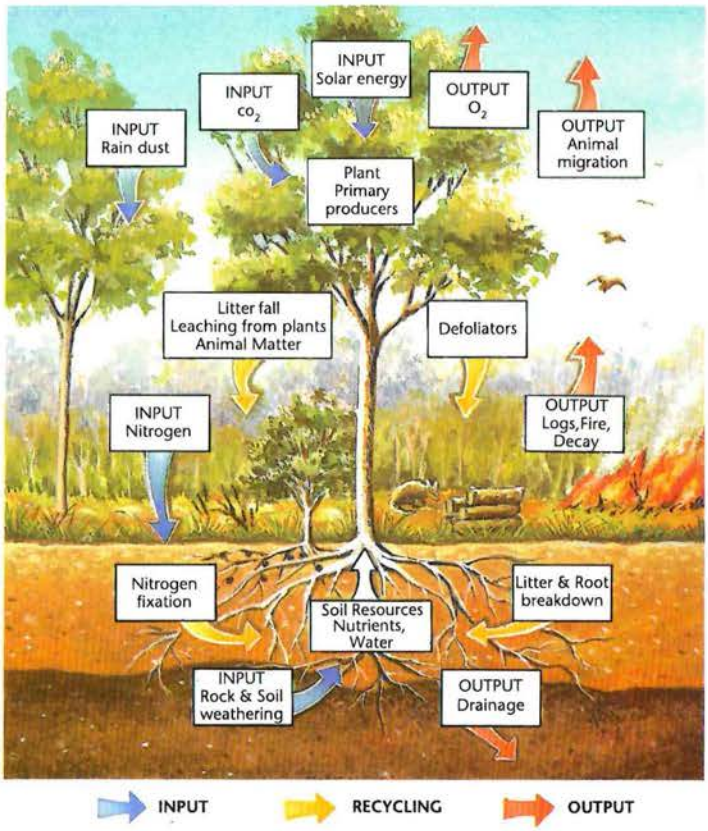
Every Conservator of Forests, since that position



was created in 1896, has fought to secure the native forest. The battle became so bitter that early foresters like Charles Lane Poole were forced to resign because of the stand they took to protect the forests. Farming interests, miners, industry groups and shire councils saw the creation of new State forests as a land grab, with areas of potential development being locked away. Unlike today, there was no vocal community voice in support of conservation.

In the early days of European settlement, millions of hectares of forest were cleared for agriculture.
Photo - Jiri Lochman ▲

Forests are solar powered and are the ultimate example of recycling.
Illustration - Yeon Hee Kim ▼



By 1933, however, the area of State forest had increased to 1.2 million hectares. There was a setback in the years immediately following World War II, when superb wandoo forests in the Tone River area were cleared for soldier settlements (against the recommendation of the Forests Department) but by 1970 1.8 million hectares of forest were at last permanently reserved and made secure.

SUSTAIN THE YIELD, MAINTAIN THE FOREST

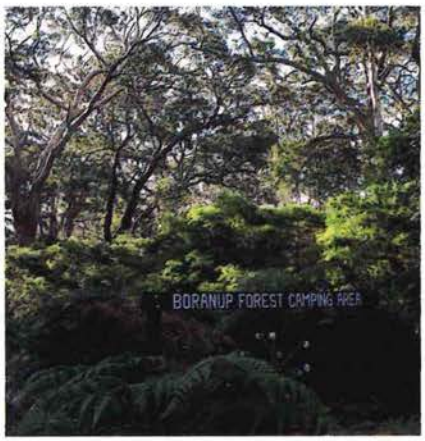
The success of the earlier foresters in securing the forest estate was not only signficant for conservation and the forest industries. If large areas of the forest had been cleared for agriculture, it is probable that the water that now comes from forests and catchments of the South-West of the State would have been too salty for human use. Ironically, whereas the forest managers of the past fought bitter battles to secure the forest estate, today they are portrayed by some as the enemies of forest conservation.

The way our public forests are managed and used must ultimately be decided by the owners - the community. It is the role of forest managers to provide the options, explain the scientific basis for them, and describe the environmental, economic and social consequences of each.

Australia is trying to balance environmental protection and economic development by creating strategies for ecologically sustainable development. This concept is still being debated, but the broad principles set out in the Commonwealth Government's discussion paper on the subject would be accepted by most community members. The principles are:

- integrating economic and environmental goals;
- valuing environmental assets;
- providing for future as well as present generations;
- dealing cautiously with areas of risk and irreversibility; and
- recognising the global dimension.

The endangered tammar wallaby needs vegetation aged 4-30 years to survive.
Photo - Jiri Lochman ▲



Boranup campsite, near Margaret River. Recreation is an important use of the forest, along with protection of water catchments, timber production and conservation.
Photo - Marie Lochman ◄

In forest management, the principles of ecologically sustainable development are fairly easily implemented (see box). Forests are fuelled by the sun and most of the fuel additives (nutrients) are perpetually recycled. Nitrogen, the additive that can be lost to the atmosphere because it is volatilised by fire, is replaced as a consequence of 'joint ventures' between specialised forest plants and micro-organisms. The plants provide food, the micro-organisms provide nitrogen from the limitless supplies in the atmosphere. Water is used by forests but eventually is recycled, and the interest for the loan comes in the form of pure streams and stable soils. The great bulk of the forest, and specifically the timber products that can be derived from it, is recycled carbon obtained from the atmosphere. Finally comes the bonus, one of the most important by-products of forest activity: pure oxygen.

NO MANAGEMENT - NO FOREST

No matter what balance of uses is decided for Western Australian forests, there is no option but to manage them. The natural processes that make our forest resilient are vital, but to leave them unchecked would be unacceptable to the community and would ultimately lead to severe degradation of forest ecosystems. Fauna which once had vast areas of suitable habitat are now confined to small areas of forest, because of forest clearing and predation by introduced animals. If fire alone is left to run its course, in addition to loss of life and property, whole populations of rare mammals such as the tammar wallaby, woylie and numbat could be destroyed. Furthermore, introduced pathogens such as the fungus that causes dieback have the potential, if left unchecked, to degrade forest ecosystems further.

The social and economic factors which impinge on the way our forests are used and managed rival the complexities of our forest ecosystems. But there are two major critical issues that need to be resolved if we are to achieve the goal of ecologically sustainable development of our forests.

The balance of uses. The principle of equity demands that each use of the forest - water catchment protection, recreation, conservation and timber production - is fairly provided for. With skilful management, it is possible to achieve this. Some uses, such as the production of high-quality water, can be accommodated in the same areas of forest all the time. Other uses can be accommodated by distributing them in time and space. At the time of timber harvesting, the forest cannot be used for recreation and conservation, but so long as the forest is regenerated, it can provide recreation and conservation values too. Unmanaged recreation can conflict with conservation values, but by dispersing, managing and alternating recreation sites, recreational use can be made compatible with other values.

The major forest use conflict today concerns the proportion of old growth or 'virgin' forest to be protected from timber harvesting. Even though the regrowth stands of today are the old growth stands of the future, there must be a proportion of old growth forest protected from timber harvesting and, where possible, from natural traumatic disturbance to provide for the aesthetic and conservation values that have a special significance to the community.

Sustainability. Achieving a balance of uses at one point in time, even over a full generation, is not enough. Each use of the forest must be sustainable, to ensure that future generations enjoy the same forest values.

The concept of sustainable yield in the forest is as old as the profession of forestry, and is its basic tenet. Each year, a forest produces a given quantity of wood. If the forest is to be sustained, the quantity harvested each year cannot exceed the annual increment. Where there is a succession of age classes, the concept is relatively easy to apply. But in most native forest systems, there is often imbalance between different age classes. Consequently, while overall forest growth

Boranup Forest has regenerated since the area was virtually clearfelled nearly 100 years ago. The WA Parliament has recently approved the exclusion of this forest from State forest and its inclusion into the Leeuwin-Naturaliste National Park. It will become old growth forest for future generations.
Photo - Marie Lochman ▲

is usually much greater than the amount of timber taken from it, the actual harvest of forest products may vary over time because the proportion of different ages and sizes of trees is different.

The concept of sustainability must also be applied to forest values. For example, to conserve the tammar wallaby and the woylie, we must maintain a perpetual succession of habitats. If we are to sustain all the habitats needed for flora and fauna, and to ensure that future generations can experience old growth forests, it is essential that the full range of age classes are represented. Thus the peculiar habitat requirements of flora and fauna will be met, and as the old growth forest eventually declines it will be replaced by the regrowth forests of today.

The processes that maintain the forest should not be degraded. Soil fertility must be maintained by ensuring that the soil nutrient levels are sustained and that the physical soil structure is maintained. Water quality and the flow of water through the ecosystem must be maintained at levels which perpetuate the ecosystem.

STRATEGY AND PLANNING

Western Australia's forest management practices and the way that the forests are used are set out in Forest Management Plans and the Timber Strategy, which was endorsed by the Government in 1987 after extensive community participation.

One of the major achievements of these management plans was to set up secure conservation reserves that represent every major forest ecosystem. When the reserve system is completed, there will have been a 340 per cent increase in the conservation estate within the South-West forests. In these reserves the priority use is maintenance of the ecosystem and use of the forests for recreation. All timber harvesting activities are excluded. Thirty-one per cent of jarrah reserves and 76 per cent of karri reserves are old growth virgin forests, the majority of which represent the finest examples of this age-class of forest.

The remainder of the unreserved forests are managed under the principle of multiple use, which includes timber harvesting. Features of this multiple-use strategy are:

- Every hectare of forest which is harvested (less than one per cent of State forest is harvested each year) is regenerated.
- The systems of harvesting and regeneration simulate the dynamic processes that caused changes in the structure and composition of the forest before the arrival of Europeans.
- All available scientific evidence indicates that if the forest is regenerated, the succession of animals and plants in the regrowing forests duplicates what would have occurred under natural processes.
- There is no evidence that any plant or animal species is endangered by any forest management practice, including timber harvesting.
- Extensive research and monitoring shows that managing the forest has not degraded the water quality of any stream or river in any forested catchment.
- There is no evidence that any ecosystem process (e.g. nutrient recycling) in forests managed for multiple use has been disturbed sufficiently to degrade the ecosystem.

Warren National Park, near Pemberton. A large proportion of WA's forests, representing every major ecosystem and including the best old-growth forest, are now in secure reserves.
Photos - Jiri Lochman

- The quantity of wood products removed from the native forests managed for multiple use is significantly less than the annual increment of wood.
- The area of the native forest estate has been maintained.

THE VISION - AN EVERLASTING FOREST

While existing forest management practices and uses meet most, if not all, of the principles of ecologically sustainable development, forest management, like forest ecosystems, is continually changing and improving. As a consequence of the success of the Timber Strategy (see p.42) more resources are available to refine forest management, and the greater use of forest products provides the opportunity

TREES CAN HELP TO SUSTAIN AGRICULTURE

In Western Australia agriculture has achieved high levels of production in a difficult natural environment. But there is now widespread appreciation that the replacement of native vegetation with shallow-rooted annual crops and pastures has caused a disruption to the hydrological system, which has a major adverse effect on the environment.

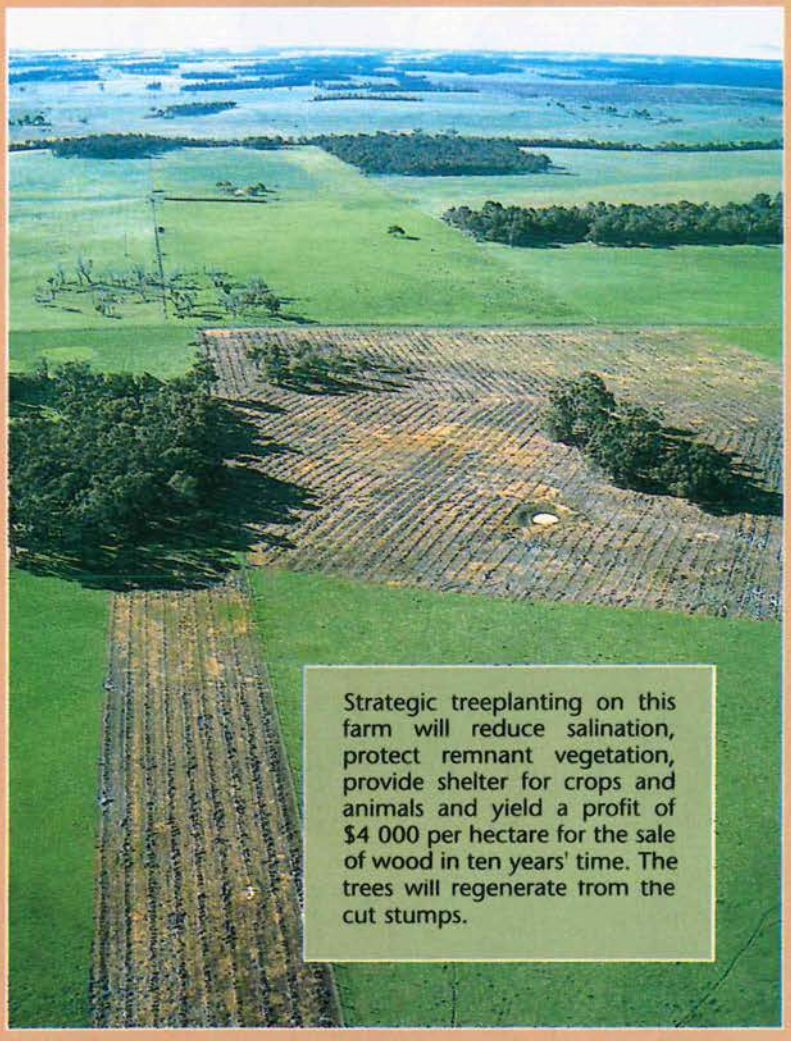
The agricultural crops consume less water than native vegetation, and as a consequence there have been marked increases in water table levels. In many areas this has led to salination of streams and rivers, and the loss of fertile valley soils because of salination and/or waterlogging. It is also one of the causes of significant degradation of native vegetation on farms.

The challenge is to retain the benefits of agricultural production while at the same time addressing these major environmental problems.

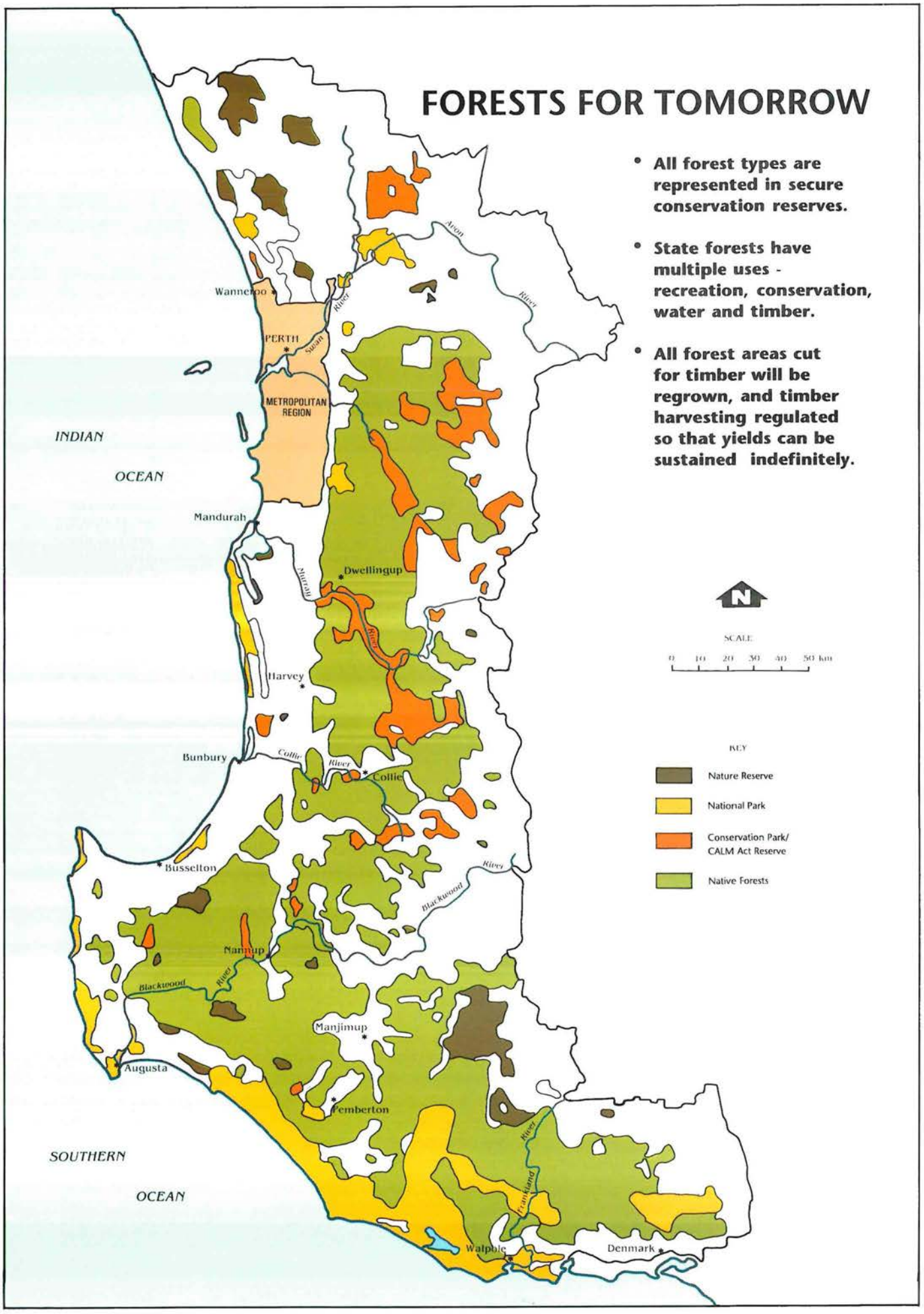
Over the past decade, major progress has been made in developing economic tree crops that can be integrated into farming practice.

It has been demonstrated that these tree crops can rapidly restore the hydrological balance by reducing the water table. In addition, research has shown that the combination of tree crops with agriculture can, if carefully planned, result in higher agriculture production because of the beneficial effects that tree shade and shelter have on crops and stock.

Over the past four years, CALM has established more than 8 000 hectares of trees on farms in partnership with farmers. In addition to solving the major regional and on-farm environmental problems resulting from the clearing of native vegetation, this project can provide a new source of income for farmers.



Strategic treeplanting on this farm will reduce salination, protect remnant vegetation, provide shelter for crops and animals and yield a profit of $4 000 per hectare for the sale of wood in ten years' time. The trees will regenerate from the cut stumps.

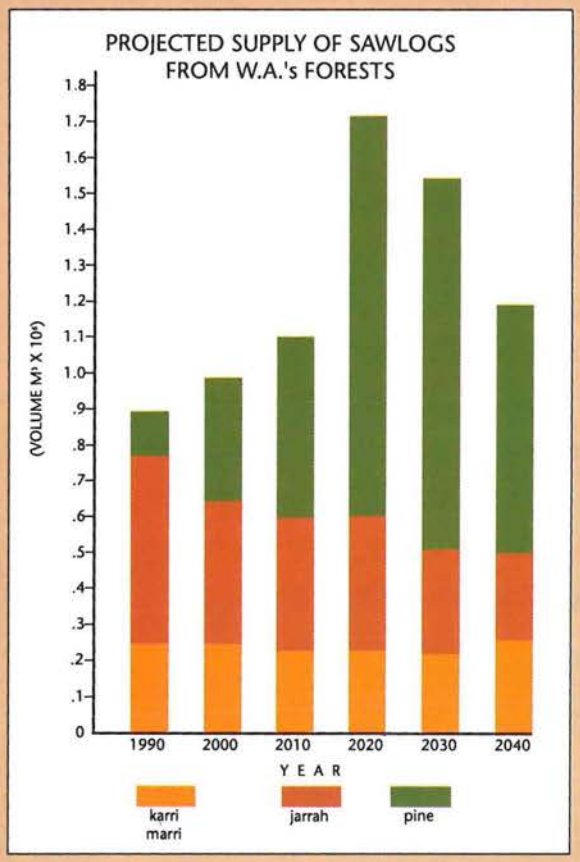

FORESTS FOR TOMORROW
• All forest types are represented in secure conservation reserves.
• State forests have multiple uses - recreation, conservation, water and timber.
• All forest areas cut for timber will be regrown, and timber harvesting regulated so that yields can be sustained indefinitely.
Wanneroo
PERTH
METROPOLITAN REGION
Swan River
Avon River
INDIAN OCEAN
Mandurah
Murray River
Dwellingup
Harvey
Bunbury
Collie River
Collie
Busselton
Blackwood River
Nannup
Manjimup
Augusta
Pemberton
SOUTHERN OCEAN
Frankland River
Walpole
Denmark
N
SCALE
0 10 20 30 40 50 km
KEY
Nature Reserve
National Park
Conservation Park/ CALM Act Reserve
Native Forests

WESTERN AUSTRALIA'S TIMBER STRATEGY

The 1987 Timber Strategy was Australia's first long-term strategic plan for any forest industry. This Strategy complemented the Forest Management Plans (which gave security to the conservation estate) and other strategies for recreation and conservation management of the forest.

Just as those concerned with forest conservation required security of the conservation estate, the forest industry's principal concern was security of its resource base. Without it, the timber industry was unable to improve its use of the forest by investing in research and new equipment and by developing new markets.

The Timber Strategy gave security, for the first time, to the timber industry's resource. In exchange for that security, the forest industry accepted the need to pay an increased price for the resource. An essential part of the Strategy was to achieve significant increases in timber royalties. When the phasing of the increases is completed in 1992, the real increase in log prices over the period since 1987 will be in excess of 38 per cent in real terms. In addition, a differential in prices paid for high and low grade logs was introduced. The increase in price and the new structure of royalty payments provided a major incentive for better use of forest resources and an increase in production of value-added products, such as furniture.



As a direct consequence of the Strategy, more than $200 million is being invested by the WA forest industries in new plant or equipment. A major proportion of this investment is directed towards increasing the value of products derived from the forests. Already there have been major improvements in forest use (logs previously burnt or directed to woodchipping are now being sawn) and a major increase in the proportion of sawn timber being produced for value-added products.

Apart from the major increases in revenue to the Government, which has assisted the funding of more sophisticated forest management techniques, the improved use of the forest is providing opportunities for more flexible approaches to forest management strategies. The current restructuring of the forest industries will ensure a more stable industry with increased employment opportunities, and will increase the wealth of the State.

to refine existing practices. It will be possible in the future to disperse forest harvesting operations further, and incorporate into forest management a much more sophisticated stream, river and road reserve system which will enhance conservation values and improve the aesthetics of harvesting operations.

We will never succeed in duplicating exactly the forces of nature which shaped the forest we inherited. But the option of leaving nature to take its course would not be acceptable anyway. However, by understanding the processes of nature in these magnificent forest ecosystems, we can employ management systems that mimic nature. While the community's demands on our forests are often conflicting and will change over time, provided that we continue to manage forests so that they are sustainable, we will ensure that, like our predecessors, we will pass on a forest with the same values as those that we inherited. ◘

Jarrah forest surrounds the Collie River in the Darling Range, providing a pleasant setting for canoeists.
Photo - Jiri Lochman

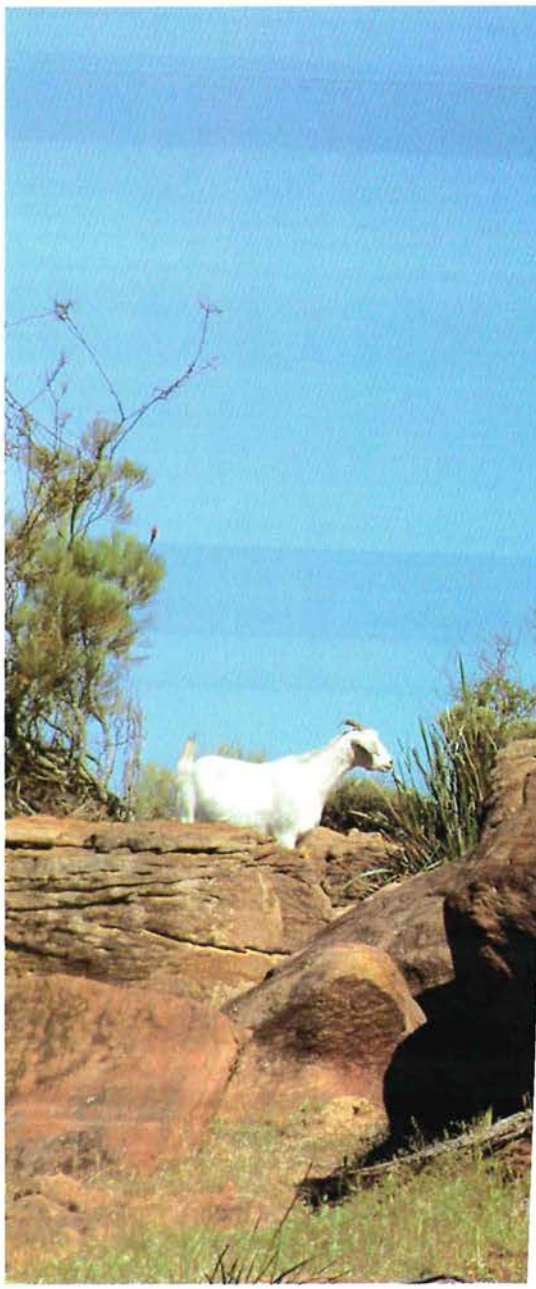
Dr Syd Shea is the Executive Director of CALM; Roger Underwood is CALM's General Manager. They can be contacted at Crawley on 09 386 8811.

Vandals in a Vulnerable Land

by Jack Kinnear, Dennis King and Keith Morris

When a wild species is introduced into areas where it does not naturally occur, it is known as an exotic species. When a domestic species reverts to the wild state, it becomes a feral species. When either begins to disrupt the native wildlife communities, it assumes the ecological role of a keystone species - and that can cause immense problems for wildlife managers.

Drifting sand: habitat degradation on Bernier Island caused by feral goats. Photo - Keith Morris ▲



IN May 1984, a radio message was received at the Wildlife Research Centre in Woodvale from a remote and desolate island at the northern end of Shark Bay. To the casual listener the message would have seemed curious, perhaps a little mundane; but to those experienced in wildlife management it heralded an important achievement. It announced that the last feral goat had been removed from Bernier Island.

As one Woodvale scientist recalls: "I remember thinking that maybe the wildlife is safe now, that maybe we've given them a chance to survive for a few more thousand years."

Introduced species can wreak havoc in Australian ecosystems. Bernier Island and its twin, Dorre Island, thin slivers of sand and limestone about 50 km off Carnarvon, were isolated by the rising sea about 8000 years ago. The sundering left alive only four marsupial and two native rodent species. They survived on the new islands and on the mainland, but the mainland cousins died out later after the arrival of Europeans.

The island populations were themselves threatened when sheep and domestic goats were introduced in the 1890s, and the goats became feral when the islands were abandoned a few years later. No systematic attempts were made to control goats until the 1950s, when the population was culled by shooting. From then onwards goat numbers were kept partially in check by periodic hunting forays, with support on one occasion from a group of the legendary Gurkha soldiers. To the relief of wildlife scientists, the goal was finally achieved through the use of traditional mustering methods and shooting with helicopter support.

What sort of damage had the goats done during the eighty-odd years of roaming the island? The most obvious damage was on the southern part of the island. It resembled the Sahara desert, complete with mobile sand dunes. Now perhaps a suitable habitat for camels, this part of the island was almost bereft of its vegetation.

The possible risk to the island's rare wildlife, and the damage to their habitat, are why the islands and their surviving fauna deserve a great conservation effort. Moreover, once we fully understand what

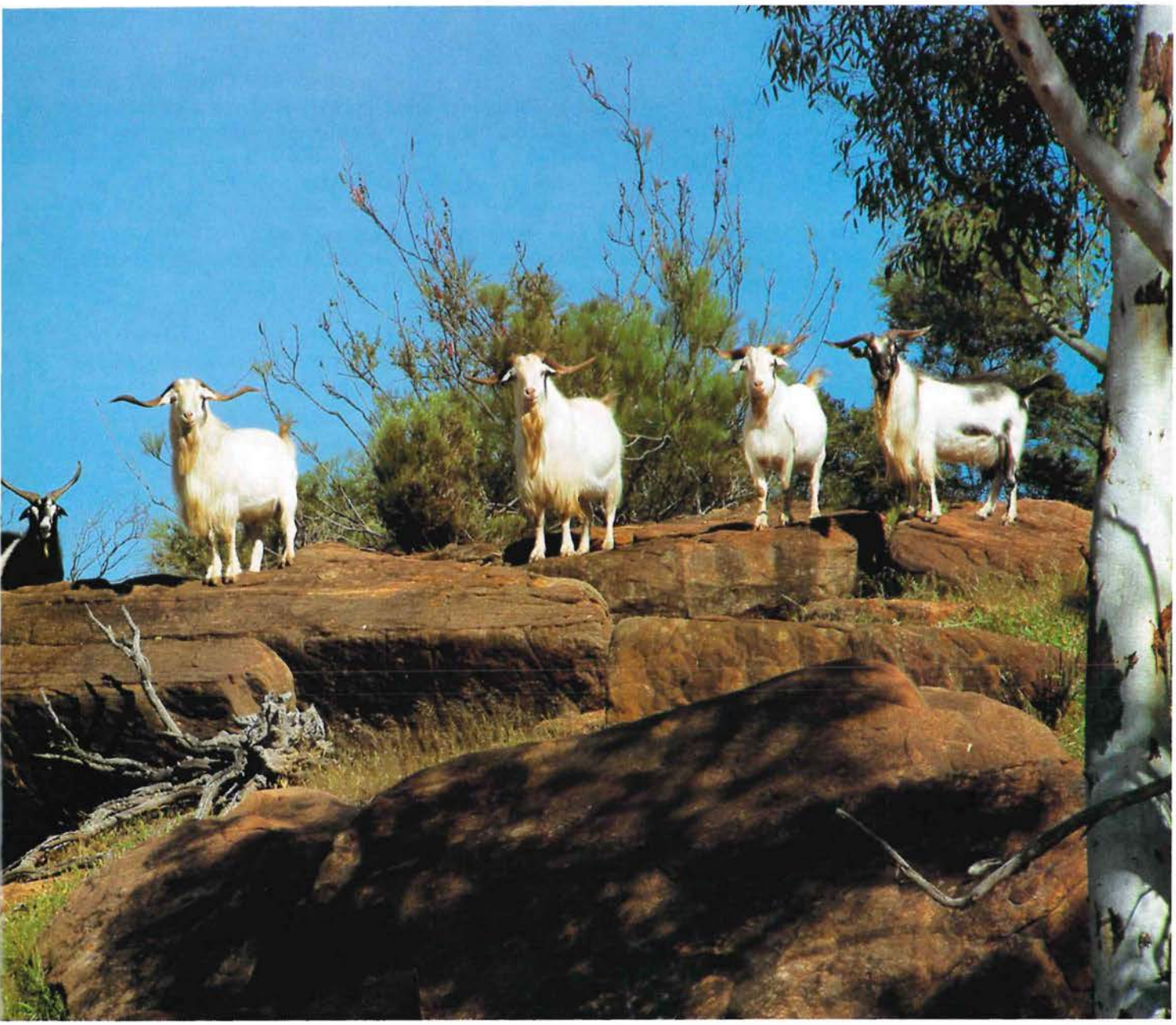


Photo - Jiri Lochman

went wrong on the mainland, it may prove possible to repopulate it using these island colonies as a source.

IMPACT

Problems caused by introducing foreign species into Australian ecosystems can sometimes be extraordinarily difficult to research. If an ecologist is asked to explain just how a feral or exotic species affects native wildlife, chances are that he or she would be hard pressed to provide specific answers. In some situations an answer may require a lifetime of research, or longer.

One thing is certain. Foreign species turn into ecological disasters when they become rampant predators of plants and animals, or when they compete with native wildlife. But while the consequences of excessive depredations are readily appreciated, the effects of competition are less familiar.

For ecologists, there are basically two kinds of competition. The first is *exploitative* competition for resources and essential things. If an introduced species wins a contest for something that a native species requires (e.g. food or shelter), the native species will decline and may even become extinct. The second kind of competition is more general, and if the competition is severe enough, the result is the same. It is known as *interference* competition, and refers to actions that affect the ability of wildlife to make a living. An example is overgrazing by goats or rabbits, which leads to erosion, soil loss and general environmental degradation. Whichever form the competition takes, it affects the birth rates or death rates of populations, or both; it may also interfere with the rearing of young.

But showing that this is what is actually happening may be a formidable task. On Bernier Island, for example, we know that the goats had reduced the southern parts to shifting sand, a classic example of interference competition. But what about the fauna? Had any species suffered an irreversible decline as the result of exploitative competition? Was there competition for food? Amazingly, the answer to these questions seems to be no. All of these precious native species are still there in reasonable abundance.

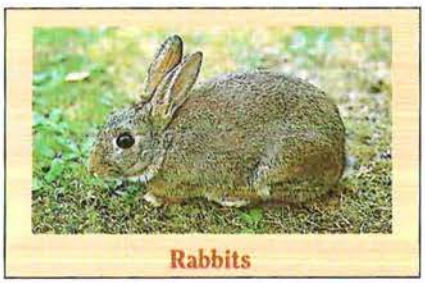
If there was competition going on, then it was not very strong - the kind of competition that is hard to detect, especially on a remote desert island. Research could take many years.

This highlights the difficulties faced by wildlife managers when they have to set priorities regarding the problems caused by introduced species. The fact that part of Bernier Island was blowing away was justification enough to remove the goats. But suppose there had not been such an obvious effect? Does one take action without such grounds?

The answer is yes. To assume that competition is not potentially damaging carries great risks. A branch of mathematics, appropriately named "catastrophe theory", warns us that things can go bad ever so slowly, but that the system can collapse quite suddenly. The possibility that feral and exotic species can be concealed time-bombs must always be borne in mind in wildlife management.

THE HERBIVORES

Although in some areas goats are a major problem (see box, p.48), the main imported plant-eaters are rabbits, donkeys, cattle, pigs and camels. The impact of camels has been described in *LANDSCOPE* (Summer, 1989-90).

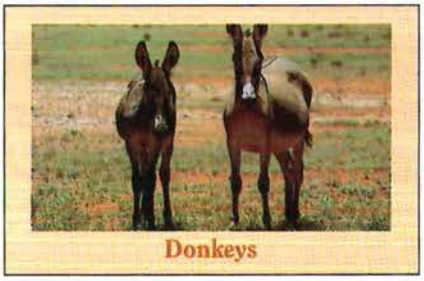


Rabbits

Rabbits spread into Western Australia from south-eastern Australia during the late 19th and early 20th centuries and reached the limits of their current distribution by the 1930s. They now occur throughout the South-West and over most of the semi-arid regions of the State. They do not occur in the Kimberley. They even occur in the desert areas, where there is succulent food (saltbush) and shelter, such as under large granite rocks which provide sites for burrows.

Rabbits graze palatable plants, thus promoting the growth of less palatable species. Severe over-grazing can denude landscapes. The land can sometimes recover from this; the removal of rabbits from Carnac Island produced a marked recovery of the vegetation within three years. More often, however, the risk is that the damage is irreversible.

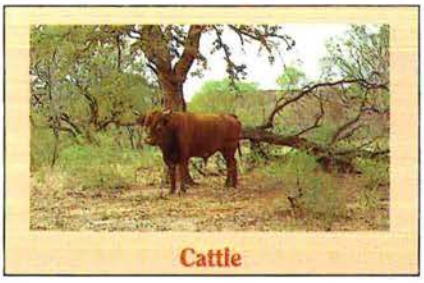
Rabbits may serve as the staple food of foxes, enabling the latter to survive in greater numbers in areas where they otherwise could not persist. The distributions of the two species in Western Australia are very similar. Foxes may have a greater impact on native prey species when rabbit numbers are low.



Donkeys

Donkeys were introduced into Australia in 1866. They were widely used as a pack or haulage animal, particularly in South Australia and Western Australia. Many were released to roam when motor vehicles became the dominant means of transport. Large feral herds formed, particularly in the Kimberley region of Western Australia, where they became widely distributed by the 1950s and 1960s. Since 1980, there has been an annual helicopter shoot in the southern part of the East Kimberley. By 1988 about 250 000 had been killed and the population, monitored by surveys conducted along aerial transects, had been reduced by an estimated 87%.

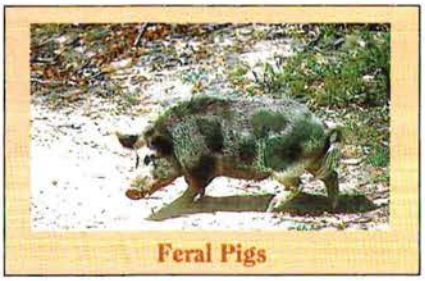
These statistics reflect how well donkeys have adapted to large areas of WA. One would expect that there is plenty of scope for interference competition, but the impact on native fauna or flora is not known.



Cattle

Beginning with the first settlers, cattle have become feral at various times throughout most of the State. In the Kimberley, feral cattle pose a threat to rainforest remnants. Undisturbed patches of rainforest escape the ravages of bush fires because they do not carry fires, but the activities of feral cattle open up rainforest patches and allow grasses to invade. The patches can then carry fire and are destroyed.

Cattle are very dependent on water and can only persist in areas with a reliable supply. They degrade the environment around natural water supplies severely, thus affecting wildlife dependent on such sites.



Feral Pigs

Feral pigs are descended from European domestic pigs which escaped or were abandoned. In northern Australia, they may come from south east Asian animals. Their distribution is patchy and discontinuous in Western Australia, where they are mostly restricted to the vicinity of watercourses and swamps. Pigs in WA are present in relatively low densities compared to eastern Australia.

Pigs eat almost anything, but their diet mainly consists of plant material. Their impact on flora and fauna is unknown; they probably consume some small fauna. Rooting of soil affects the soil fauna and reduces ground cover, and it can change the composition of some plant communities. Feral pigs are believed to spread dieback in forest areas.

THE PREDATORS

It was not very long ago that ecologists believed that predators performed a rather insignificant role in the operation of ecosystems. The effect of predators was thought to be to keep their prey alert, fit, and fleet of foot. Life was still not meant to be easy for their prey, but supposedly only the weak, the sick, and the old had to worry. The idea that predators might regulate prey numbers, or cause large population reductions or extinctions, was never taken very seriously. Instead it was believed that the balance of nature prevails, just as it does in a Walt Disney nature film.

However, modern research has revealed that in natural communities and ecosystems, predators can play an important role in how the communities are maintained. Some predators have been shown to be keystone species. Remove a keystone predator from a wildlife community and some species may become rare or extinct, while other species, previously inconspicuous, become dominant. This power to regulate natural communities has been conferred by evolutionary processes.

By removing keystone predators, ecologists have documented that profound changes can occur. Some interesting questions follow: what happens when we add a predator to an ecosystem? And what has happened in the cases of the exotic predators that have been introduced into Australian ecosytems? The answers to these questions will depend on whether a given predator has become a keystone species.

Black Rat

Rats have had a severe impact on many wildlife species throughout the world, particularly on islands. One species of rat, the black rat or ship rat, has proved to be very damaging.

The black rat was almost certainly among cargo unloaded from the First Fleet in Sydney Cove in 1788, and may have been introduced earlier to other coastal localities from shipwrecks. It is now found around most of coastal Australia, and throughout most agricultural areas. It does not penetrate the arid interior because of its high water requirements. In WA, several islands off the Pilbara and Kimberley coast also support introduced populations, primarily from careened or wrecked pearling vessels during the late 1800s. Along the north-west coast, introduced rat populations occur in the Lacepede Islands (north of Broome), Bedout Island (north of Port Hedland), several of the Montebello Islands, and those around Barrow Island.

The effect of the black rat on Australia's vegetation and wildlife has not been well documented. Elsewhere, its impact has been very severe, particularly on island faunas. Many of our islands are nature reserves and important seabird nesting sites. Black rats prey on eggs and chicks and may damage vegetation on these islands.

On the Montebello Islands, black rats were introduced in 1896 after the wreck of a schooner. The rats quickly colonised most of the islands and became such a pest for the resident pearlers that cats were introduced to control the rats. Unfortunately the cats preyed instead on the native marsupials, the golden bandicoot and spectacled hare-wallaby, both of which disappeared from the islands shortly afterwards. Even the British atomic weapons tests in 1952 and 1956 failed to eradicate either the rats or the cats.

On Middle Island just south of Barrow Island, black rats and golden bandicoots have coexisted for the last 100 years. This suggests that competition is not occurring, or that it is not very intense. The problem is perplexing. Is the rat a keystone species? Should the ecologist recommend action?

The eradication of rats and other exotic species on remote islands is often an expensive undertaking. However, the exceptional conservation values of our island nature reserves demand that this is done. An advantage is that once an exotic species has been removed, further invasion can be prevented relatively easily.

To date, the Lacepede Islands, Bedout Island, Prince, Double, Boodie and Pasco Islands (around Barrow Island) have been baited with complete success. Some islands still require rat eradication programs. The rats and cats on the Montebello Islands must also be eradicated before the spectacled hare-wallaby and golden bandicoot can be reintroduced there.

Feral Cats

Feral cats in Australia are an ecological enigma. We simply do not know what the cat is doing to the fauna or what it has done in the past. One would presume that they must be doing some damage, but the scientific facts are not available to support such a view.

There are some reasons to suspect that cats reached Australia before European settlement as shipwreck survivors, and possibly through early Asian trade links in the far north. The fact that desert Aboriginal tribes have a proper name for the cat and that they hunted cats suggests a long association. In 1896, desert explorer David Carnegie encountered Aboriginal women foraging and noted that they had killed a cat.

The diet of feral cats has been studied extensively, and it has been found that they eat a very broad range of items. When prey are not available, cats will scavenge. It is not uncommon to find cat stomachs full of insects. Feral cats kill rabbits for food, and the remains of a wide range of native mammals, birds and reptiles have been recorded from cat digestive tracts. Despite these findings, one can point to cats and wallabies coexisting quite happily in some places, or so it would seem. Rottnest Island provides an example: feral cats and quokka wallabies both thrive, as do tammar wallabies and feral cats on nearby Garden Island.

Dietary evidence incriminates feral cats as predators of native fauna, but such evidence does not help us decide if the cat has assumed a *keystone* role (performing a key role as a predator in its effect on species diversity and numbers); that is, we still do not know if feral cats threaten any native species. A great deal more research is needed of the type used on studies of fox predation.

THE KEYSTONE FOX

The Fox

Foxes were introduced into Victoria in the 1860s for sport, and native fauna has suffered ever since. It is a classic example of an introduced species with *invasive* properties. It spread rapidly,

reaching WA by the early 1900s. During the next 25 years it colonised the whole of the State except for the North Kimberley region.

As it swept through the State it left a trail of destruction, which contributed to the collapse of the mammal fauna. In its wake, scattered populations of different species survived in refuges, though they have been under siege ever since. This was never very evident, because other disturbances were going on at the same time. There were rabbit plagues, droughts, land clearing, grazing, and so on, which led to widespread habitat destruction and fragmentation.

Despite all these disturbances some recent ecological research has implicated the fox. The keystone role of the fox was demonstrated by studies involving five rock-wallaby populations persisting on isolated rocky outcrops in the central Wheatbelt. Wherever foxes were controlled, the rock wallabies increased.

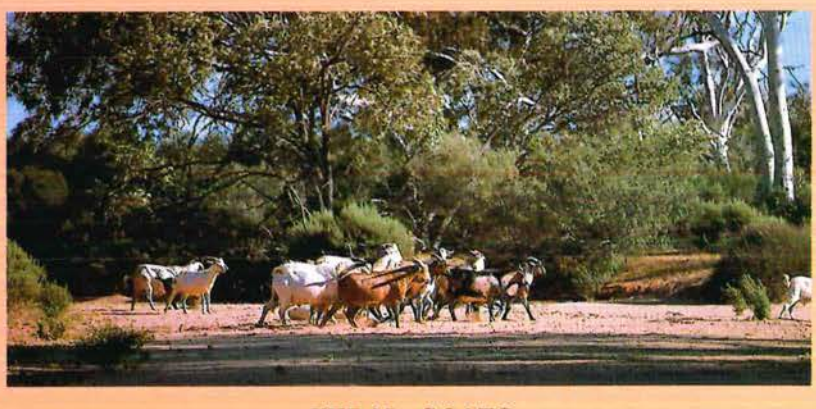
This response pattern to fox control has now been observed in six other marsupial species, all differing in lifestyle and habitat. In all cases, effective fox control has led to substantial population increases. These results confirm that the fox is a keystone species, and not surprisingly; because it did not evolve as part of any Australian community, its role has been negative and destructive.

KEYSTONE INVADERS

Many conservation problems in Australia are caused by introduced species. Such species may act as predators, competitors or pathogens (causing disease). To explain how foreign species impact on wildlife, we have introduced some ecological concepts and knowledge gained from studies on natural undisturbed ecosystems.

What has emerged is this. Foreign species which create serious conservation problems have two essential characteristics: they assume the role of a keystone species, and they are invasive.

Keystone species regulate populations; they can control numbers and affect the composition of species in a community. Native keystone species promote diversity and species richness, and some ecologists believe they foster stability. In contrast, foreign keystone species are destructive; they simplify and destabilise. If they are invasive, their impact and influence is widespread.



FERAL GOATS

Goats arrived in Australia with the First Fleet, and were widely kept by early settlers for milk, meat and fibre. Escapees or deliberately released animals have created large feral populations over most semi-arid pastoral regions in Australia. Their favourite habitat is rough, hilly country or thick scrub where there is abundant shelter, adequate surface water and an abundant supply of preferred food plants.

Goats can have a profound effect on their habitat, as a result of feeding on particular species of trees and shrubs. They are, however, less damaging than are rabbits or sheep, because of differences in feeding habits. A study by the Agriculture Department is under way near Kalgoorlie into the effect of goats on rangelands.

All of this shows that there can be *interference* competition with wildlife. There is also evidence that implies that *exploitative* competition is occurring, as both goats and rock-wallabies eat the same food plants. It is also possible that goats and rock-kangaroos compete for shelter sites such as caves.

A potential long-term impact of goats on rock-wallabies is apparent at a study site near Exmouth. Goats feed on the coastal plain and shelter in a rocky gorge, which carries a small population of rock-wallabies. A dense layer of goat droppings carpets the gorge, fertilising the rock-wallaby habitat. The food plants of rock-wallabies may thus be displaced by unpalatable plant species. This means that rock-wallabies will eventually have to forage further away from their rocky shelters, becoming more vulnerable to foxes.

It can be very difficult to identify a foreign keystone species, because its impact may be very subtle. Research generally needs to be long-term. It required 12 years of research to gather sufficient evidence to show that the fox is a keystone species.

PROSPECTS

When keystone species have a restricted distribution, eradication may be possible. CALM has successfully done this for numerous islands and the effort is continuing.

Widespread invasive species, e.g. rabbits and foxes, can only be controlled locally. Fox management programs are now operational on selected nature reserves to protect rare and endangered mammals. Reintroductions of native mammals have proved successful under fox control, and more are planned.

The cost of wide-area control is prohibitive. The only long-term solution is some form of biological control. In proposing this, we are taking into account the great advances in molecular biology and biotechnology. Research which aims to exploit these advances is in progress, with the object of bringing the rabbit and the fox under control.

A light is now beginning to glow at the end of the tunnel. With vigilance and further research, the light is going to get brighter for our wildlife.◘

Jack Kinnear and Keith Morris are from the CALM Wildlife Research Centre, Woodvale.
Dennis King is from the Forrestfield Laboratory, Agriculture Protection Board.

Growing in a Wild State

by
David Coates
and
Neville Marchant

Western Australia's flora enjoys world renown for its richness, uniqueness and colourful displays. Just under 8 000 species have been recorded, but the true figure may be more than 10 000. Some 80% of the plants in the South-West are found nowhere else in the world, and about 2 000 species are rare, endangered, vulnerable or geographically restricted. Some can be cultivated, but ultimately each of our precious plants has to get by on its own - in the wild.

Previous page - Mountain villarsia *(Villarsia calthifolia)*, a declared rare plant found among granite rocks in the Porongurup Range.
Photo - David Coates

Dieback has affected most populations of feather-leaved banksia *(Banksia brownii))*, a species found in the Stirling Ranges.
Photo - Steve Hopper ▲

ACCORDING to a recent assessment, Western Australia has 43% (1 442) of the Australian total of rare or threatened plant taxa (species, subspecies or varieties) with 83% being restricted to the South-West. About 1 500 species are used commercially in the wildflower, seed nursery, beekeeping and timber industries.

Threats to Western Australia's flora typically come from a wide range of often interrelated events. These include continued clearing of land, invasive weeds, grazing, pests and disease, inappropriate fire regimes, recreation pressures, roadworks and urban development. Studies on the geographical distribution and biology of rare or threatened species show that their vulnerability has been due mostly to the activities of Europeans. Sometimes, however, rarity is due to specific habitat requirements.

The distribution of plant species across Western Australia is uneven, many being found only in the South-West. Geologically, this region has been isolated from eastern Australia for about 30 million years. The flora has undergone immense evolutionary change in a short geological period, and the level of richness in the area is equivalent to that of tropical rainforest areas, such as the Philippines Archipelago or Malaysia.

A FLORA BESIEGED

On a map, the pattern of species-richness in the South-West would show up as a northwest-to-southeast dumbbell-shaped zone through the Wheatbelt to the northern and southern heathlands. It is here that most of Western Australia's rare and threatened plant species are concentrated, and where extensive land clearing of vegetation and modification of the environment has taken place. Many species now persist in this area in small isolated populations as remnants of the indigenous vegetation.

Any plans for conserving the State's flora need to consider the multimillion-dollar wildflower industry. Some 70% of its exports is taken from wild populations on Crown land or private property. The industry is growing; in 1989 the number of licences issued for the taking of flora for sale was 1420, compared to 653 in 1981. Most of the heavily exploited species are widespread, although a few are geographically restricted and may require research before they can give a sustainable yield.

Dieback disease, caused by the fungus *Phytophthora cinnamomi* and, to a lesser extent, other fungal diseases, is of major concern to the wildflower industry and the Department of Conservation and Land Management (CALM). In the south coastal areas there are hundreds of susceptible plant species, including many used in the wildflower trade for seed and cut flowers. Heavily exploited species, such as scarlet banksia (*Banksia coccinea*) and Baxter's banksia (*Banksia baxteri*), and rare species, such as feather-leaved banksia (*Banksia brownii*), face localised extinction in the next few years because of the disease.

Lichens and other non-vascular plants such as algae and fungi are now protected flora.
Photo - Gerhardt Saueracker ◄

Sand mallee *(Eucalyptus eremophila)*, a widespread mallee of the Wheatbelt and Goldfields.
Photo - Jiri Lochman ◄

This rare donkey orchid *(Diuris purdiei)* is found in the Perth metropolitan area and near Peel Inlet.
Photo - Andrew Brown ▲

Fortunately, it's not too late to conserve most of the State's native flora. At present, there are 94 presumed extinct plants - less than 1% of the estimated total number of plant species in Western Australia. However, this should not lead to complacency; there is still much that needs to be done in protection, research and management if the survival in the wild of many native plant species is to be assured.

PROTECTION

The Wildlife Conservation Act (1950-1987) and Conservation and Land Management Act (1985) provide the guidelines and legislation for the conservation of the State's flora.

Under the Wildlife Conservation Act, CALM is responsible for the protection of all classes of native flora on all lands and waters throughout Western Australia. From October 1987 "protected flora" included flowering plants, conifers, cycads, ferns, fern allies and non-vascular plants (mosses, liverworts, algae, fungi and lichens).

The protection of non-vascular plants has added a new dimension to conserving the State's flora. Although many species in these groups are poorly known and relatively inconspicuous, they still constitute a valuable component of the State's flora and, as such, protection under the Wildlife Conservation Act is justified.

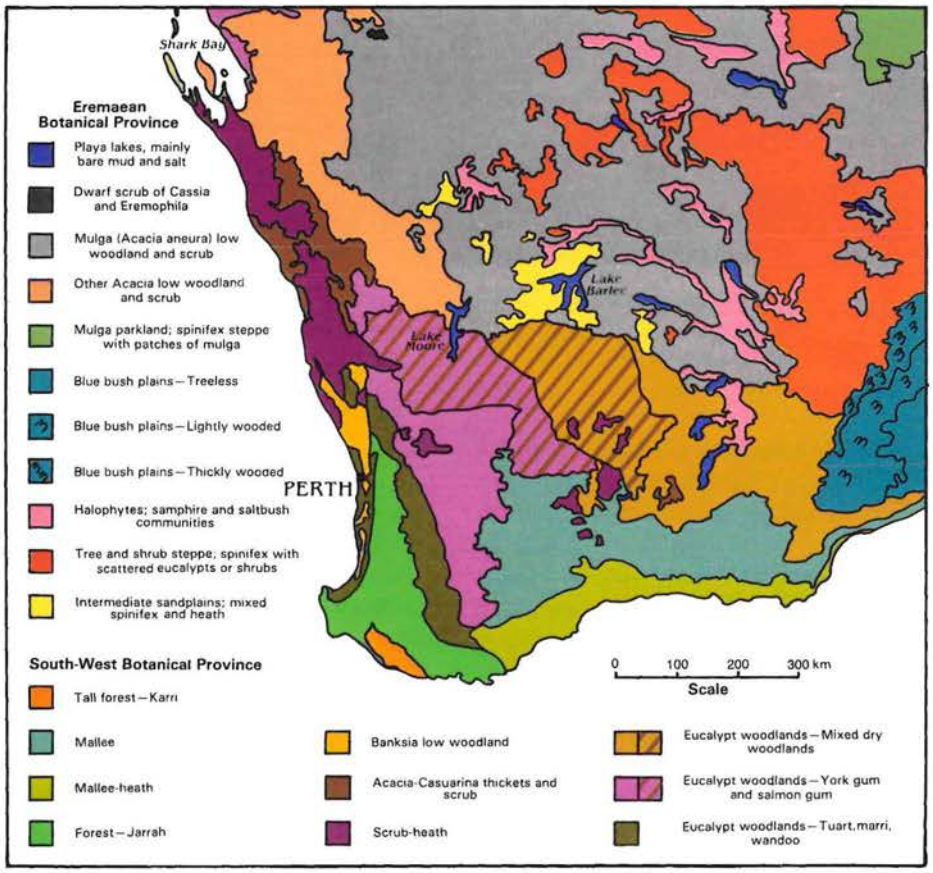
Following amendments to the Wildlife Conservation Act in 1980, additional protection was provided for plants that are rare, in danger of extinction, or are considered at risk over a longer period. Under the Act, these plants can be declared "rare" by the Minister for Conservation and Land Management. The schedule of Declared Rare Flora is reviewed annually, and plants may be added to or deleted from the list at the Minister's discretion by notice in the Government Gazette. Some 247 plants are now listed on the schedule.

This legislation has been a major incentive to work on rare and threatened plants in Western Australia. It remains the most powerful legislative protection for threatened plants in any State in Australia.

THE NEED TO SURVEY

Protection of flora has also gained impetus in recent years from increased efforts in research and management by CALM, Kings Park, and the State's universities. CALM is placing increased emphasis on plant descriptions, field surveys and the mapping of rare and threatened plants - the minimum information needed to develop plans for conservation.

Since the distribution of WA's rare and threatened flora is uneven, CALM's efforts are presently concentrated in the most highly populated area - the South-West. Here, priority areas for survey have been identified, either because of the high proportion of rare and threatened



Scarlet banksia *(Banksia coccinea)* is used extensively by the wildflower industry but is extremely susceptible to dieback. Native pollinators such as the honey possum are crucial for its survival.
Photo - Steve Hopper ▲

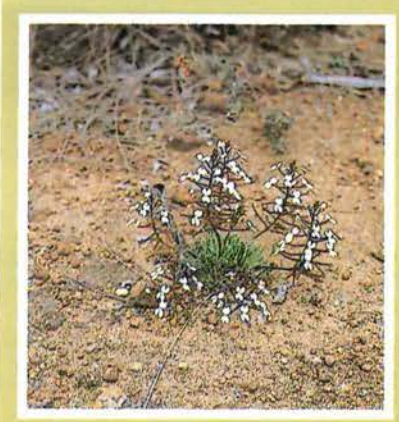
flora or because of the degree of threat (usually due to land clearing). Botanists are now surveying some of these areas in detail.

As well as relying on professional botanists for surveying and monitoring flora populations, CALM is encouraging members of the public to give a hand. Projects coordinated by CALM botanist Steve Hopper, such as the 'Banksia Atlas', the 'Survey of Rare and Poorly Known Eucalypts of Western Australia' and the 'Survey of Endangered Poison Plants of Western Australia', have relied heavily on the public for surveying and mapping plants to assess their conservation status.

DOSSIERS FOR PLANTS

Information on ecology, genetics, reproduction and dieback susceptibility is also essential in developing conservation plans for rare and threatened plants. Work on the rose mallee (*Eucalyptus rhodantha*) provides a good example. Population, genetic and life history studies by Jane Sampson (University of Western Australia) and Shapelle McNee (Curtin University) have provided the basis for a management program that should ensure its long-term survival in the few places where it persists - as remnants on private property and road-verges. These studies also found that harmful inbreeding effects in a small disturbed stand of 14 rose mallees were much higher than in larger, relatively undisturbed stands. These results show a need to maintain larger populations of the rose mallee - more than 35 - with an adequate understorey to support pollinators, such as honeyeaters and honey possums, if inbreeding is to be minimised.

The Quairading banksia (*Banksia cuneata*), now confined to seven small populations in the Wheatbelt, is another species where life history and genetic data are proving useful in developing conservation techniques. This species is of particular interest not only because of its rarity but also because it is an ancient species, of evolutionary importance, with features intermediate between banksias and a related genus, *Dryandra*. The area where it occurs has been extensively cleared or modified due to grazing and weed invasion. Recruitment into populations is dependent on fire, which is required for seed release. Research by



The Wongan Hills triggerplant
Stylidium coroniforme

A rare species known from four populations in the Wheatbelt with a range of about 100 km. Grows on exposed sheet laterite amongst low scrub. The original population had been reduced to less than 10 plants before it was fenced off to exclude stock in 1981. By 1986 the population had increased to 84 plants. Fencing has proved to be an effective management tool for protecting rare plant populations.

The rose mallee
Eucalyptus rhodantha

A rare mallee known from remnant stands in only two areas in the Wheatbelt over a range of about 100 km. It grows on grey sandy soil in flat or slightly undulating country occurring as almost pure communities in low heath. The surrounding area has been extensively cleared for agriculture and less than 500 plants remain in nine stands. A management program has been recently prepared for this species by CALM.

Byron Lamont and colleagues (Curtin University) on one population revealed that vast amounts of seed (over 17 000) were released from each plant after a fire, yet less than 5% germinated and only 0.1% of those survived the first summer drought. Sufficient rainfall following the fire-induced seed release is essential for long-term survival.

The establishment of new seedlings in populations of the pine banksia (*Banksia tricuspis*), another rare species, depends on a complex series of biological interactions for seed production and fire for seed release. Stephen van Leeuwen (CALM) and Byron Lamont (Curtin University) have found that this species is largely dependent upon pollinators such as honeyeaters and honey possums for pollination and seed set. Furthermore, about 60% of the inflorescences are eaten by moth larvae, which in turn are eaten by Carnaby's cockatoo. The cockatoos eat sufficient moth larvae to ensure that at least some inflorescences set fruit and produce seed. As with the Quairading banksia seedlings, mortality can be high because of summer drought stress, with only 0.4% of germinated seedlings surviving to five years after the fire.

Genetic studies on another rare species, the grass wattle (*Acacia anomala*), have revealed that the southern populations consist of large vegetatively reproducing clones that sprout from underground rootstocks. Seed production has never been observed. In the northern populations there is no vegetative reproduction and each individual plant is genetically distinct. Insect pollinators such as native bees ensure seed production, and seedling establishment has been observed in these populations.

OPTIONS

These and similar studies have provided valuable clues for CALM staff to develop appropriate options for conserving and managing rare and threatened plant species. Other examples include the Wagin banksia (*Banksia oligantha*), the feather-leaf banksia (*Banksia brownii*), the underground orchid (*Rhizanthella gardneri*), Purdie's donkey orchid (*Diuris purdiei*), and the Wongan Hills triggerplant (*Stylidium coroniforme*).

Because of the high number of rare and threatened flora in the South-West, adequate protection and management is a difficult task, particularly given the range of protection and management issues. For instance, in the South Coast region, most populations occur in national parks controlled by CALM, while in the cereal-growing areas many more populations occur on road reserves and private property. Liaison with property owners, the Main Roads Department and local shires is crucial for the protection and management of these populations. In this regard the production of Flora Wildlife Management Programs for Regions, Districts or other defined areas (i.e., national parks) is vital, given the number of taxa and populations now considered at risk in some areas. Although they lack the detailed biological data on individual species, these programs allow priorities to be set for future research and protection. This tells CALM staff which management actions each species requires - fencing, dieback hygiene, fire exclusion, weed control, liaison with landowners, etc. - and even whether further research is necessary at all.

Cultivating threatened plant species provides another option, namely the re-establishment of a species in the wild from cultivated stocks. Kings Park has an active propagation research program which could be used for this purpose. However, there are at present only a few species so endangered that this option is needed. Furthermore, just because a species is under cultivation, efforts to preserve populations in the wild should not be neglected; it is much better to protect and manage the genetic resources of wild populations than rely on the typically limited possibilities of cultivated species.

Pine banksia *(Banksia tricuspis)* not only depends on pollinators such as honeyeaters and honey possums for pollination and seed set, but also on Carnaby's cockatoo. The cockatoos feed on moth larvae which eat the flowering parts of the pine banksia. Sufficient moth larvae are eaten to ensure at least some flowering parts remain and seed production occurs.
Photo (left) - Michael Morcombe
Photo (right) - Steve Hopper

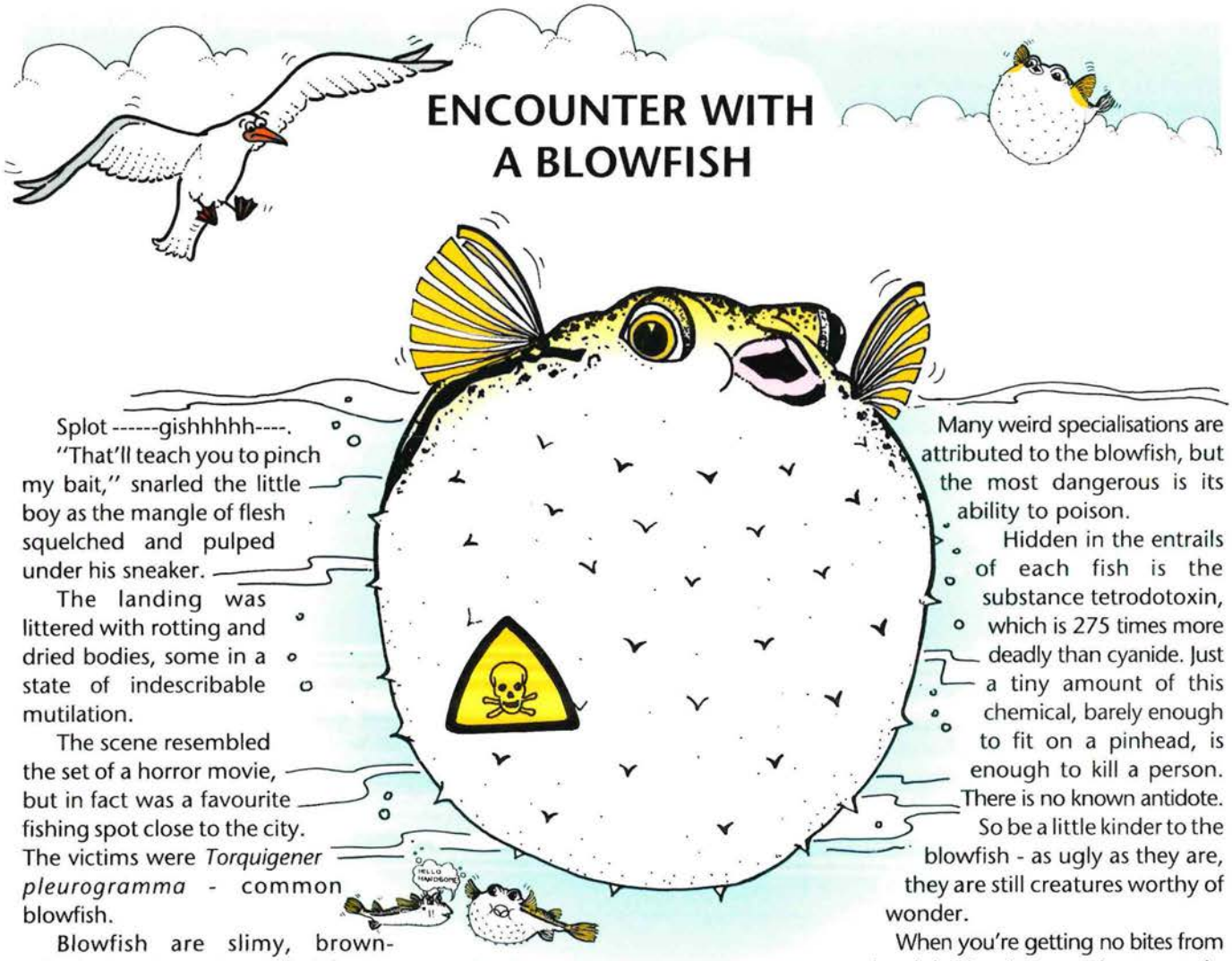
CONSERVING THE GENES

Conserving genetic diversity is a fundamental goal of State, national and global conservation strategies. Given the extreme richness and diversity in Western Australia's flora, we need to make a special effort to conserve it. Protection by the Wildlife Conservation Act is very important, but legislation alone will not suffice. One thing we need is continued efforts in research and management, but perhaps another requirement is even more important: more involvement by the public in conserving plants in the wild. This makes it an absolute necessity to increase everyone's awareness of the value of Western Australia's flora - of which three quarters are found nowhere else on the planet. ◘

David Coates, a Senior Research Scientist at CALM, is the leader of the Flora Conservation Research Program. Neville Marchant, a Principal Research Scientist at the WA Herbarium, is an editor of *Flora of the Perth Region*.

URBAN ANTICS!

ENCOUNTER WITH A BLOWFISH



Splot ------gishhhhh----.

"That'll teach you to pinch my bait," snarled the little boy as the mangle of flesh squelched and pulped under his sneaker.

The landing was littered with rotting and dried bodies, some in a state of indescribable mutilation.

The scene resembled the set of a horror movie, but in fact was a favourite fishing spot close to the city. The victims were *Torquigener pleurogramma* - common blowfish.

Blowfish are slimy, brown-splotched and goggle-eyed little beasts, which are caught by the thousands each year in the Swan Estuary and at metropolitan coastal beaches. They are perhaps the most maligned and physically abused of all urban dwellers.

The name blowfish, or puffer, is derived from the fish's ability to balloon into a sphere two or three times its original size. When frightened, excited or annoyed, it gulps water or even air into a sac on its belly. It swells inside its tough elastic skin like a tube inside a tyre, so as to discourage predators. When the fish feels safe, it releases the air or water, deflating to its normal shape.

About 100 species of blowfish are found throughout the world. Our local species may reach 300 mm in length, but a giant in the northern hemisphere reaches about one metre long and weighs some 13 kg.

Local blowfish start life in the ocean after spawning occurs off our suburban beaches in November and December each year. Eggs and larvae develop through a planktonic stage, with young fish dispersing to the nearest food source.

At about seven months old, those near Fremantle migrate into the Swan Estuary, where they stay for two years till they mature. Between October and January they head seawards with the annual breeding migration of older fish.

Very young blowfish prey on marine worms and small crustaceans. Older fish take bi-valve mussels and marine snails.

Blowfish are like the seagulls of the underwater world - they'll eat anything. Where man provides bait or any refuse, they sometimes congregate in plague proportions.

Many weird specialisations are attributed to the blowfish, but the most dangerous is its ability to poison.

Hidden in the entrails of each fish is the substance tetrodotoxin, which is 275 times more deadly than cyanide. Just a tiny amount of this chemical, barely enough to fit on a pinhead, is enough to kill a person. There is no known antidote.

So be a little kinder to the blowfish - as ugly as they are, they are still creatures worthy of wonder.

When you're getting no bites from other fish, they're great fun to catch.

JOHN HUNTER

Did you know ...

Their buck teeth and massive chewing muscles can tear apart crabs and oysters, and have been known to nip rusty fish-hooks in half.

They have iridescent blue and green eyes which are quite mobile. In some species the eyes darken automatically as light intensity increases, like the lenses of some manufactured eyeglasses.

In Japan, one blowfish species (called fugu*) is highly regarded as a food - at about $200 a serve! - even though it has caused hundreds of deaths there over the last two decades.*

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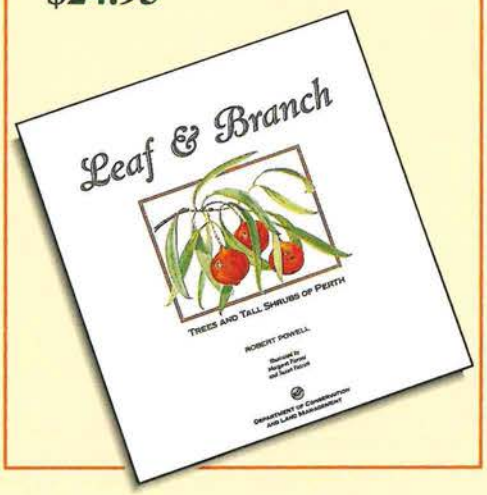

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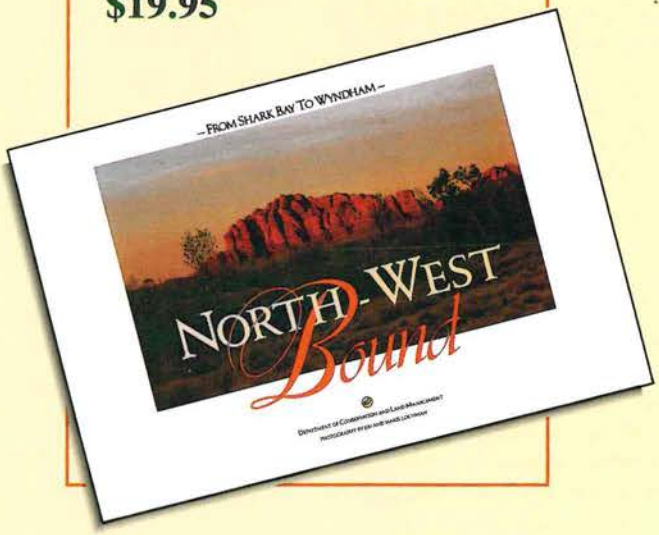

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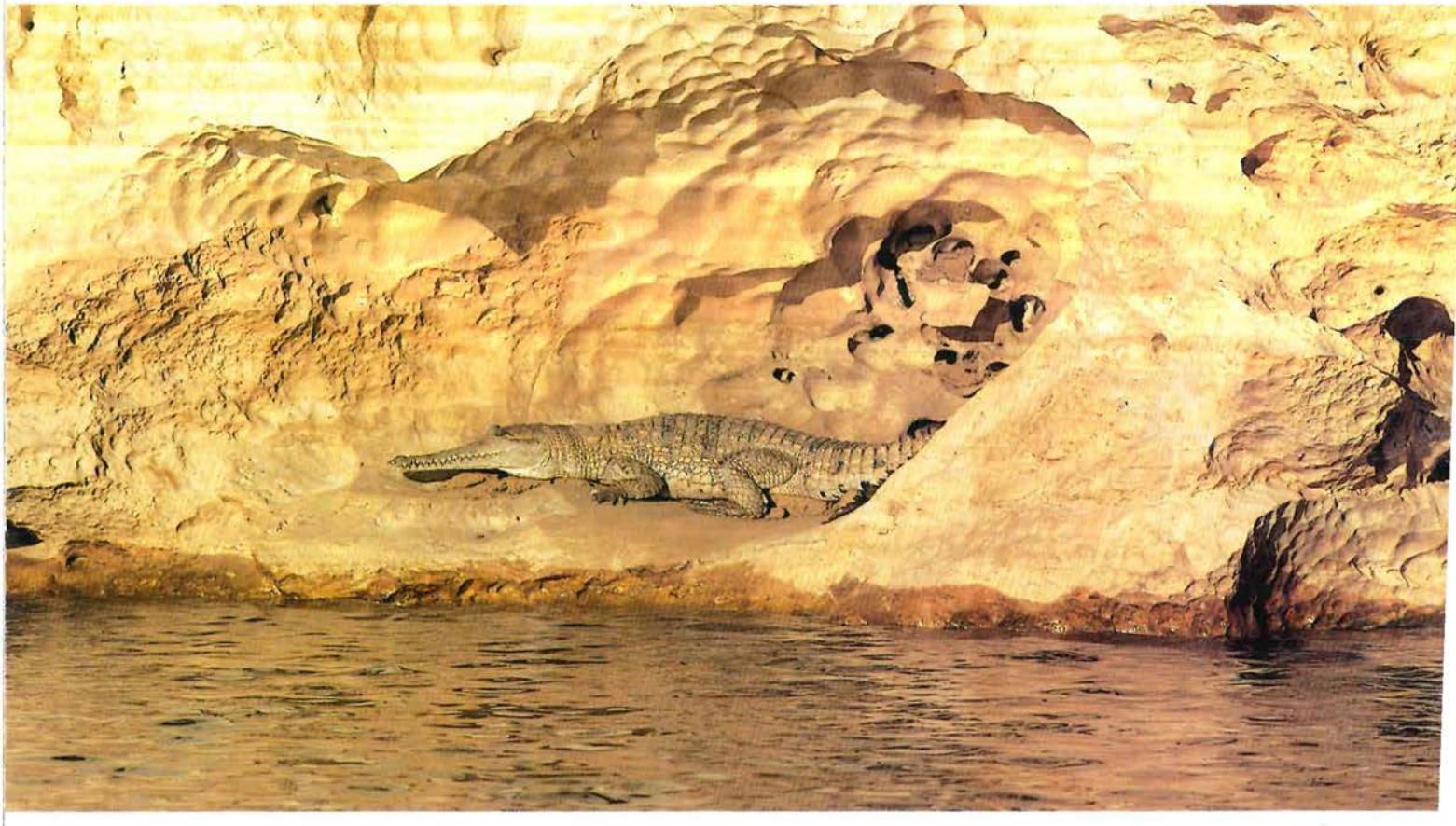

Dozing in the golden glow of an ancient coral reef, this freshwater crocodile lies beneath nests of fairy martins.

Photo – courtesy Reader's Digest