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LANDSCOPE

W.A.'S CONSERVATION, FORESTS A

WONDERS OF THE SOUTHERN SEA
A look at the marine life off WA's south coast

MURCHISON HAVEN
The importance of Burnerbinmah Station

KARAKAMIA SANCTUARY
A special place for wildlife in Perth's hills

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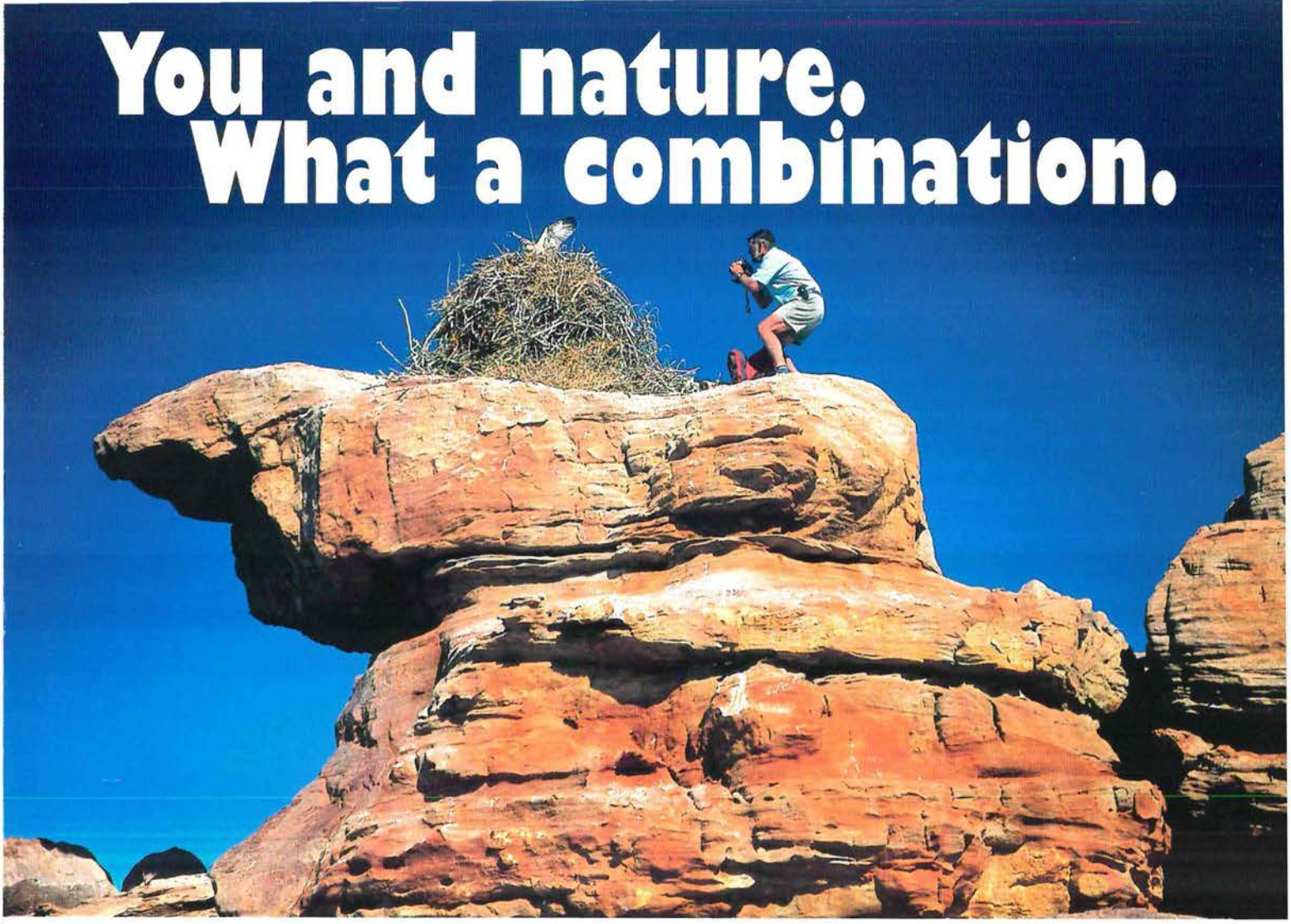

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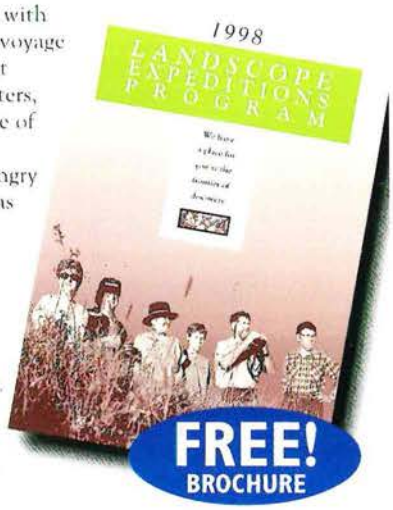

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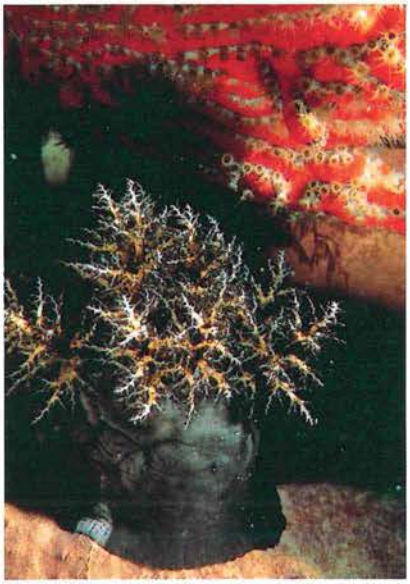
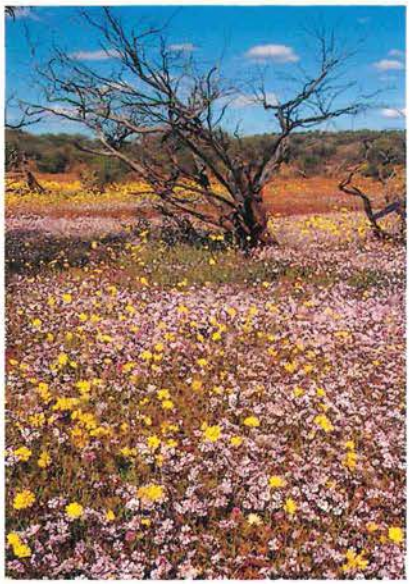


The waters off Western Australia's south coast are home to a rich diversity of marine plants and animals. Read about them on page 28.



Burnerbinmah Station, in WA's Murchison Region, fills an important gap in the State's flora and fauna reserve system. See page 42.

LANDSCOPE

VOLUME THIRTEEN NUMBER 2, SUMMER 1997–1998

Was it created by a meteorite crashing to Earth, or more slowly over time? Find about Curiosity Swamp on page 50.

Imagine a commercially-owned and managed sanctuary in the hills east of Perth and you have 'Karakamia Sanctuary'. Find out how it was created on page 17.

The Western Blue Gum, a commercial variety of the Tasmanian bluegum, was developed for WA conditions, but tree breeders continue to improve the strain. See page 36.

COVER

Is the forest red-tailed black-cockatoo rare or just rarely seen? Find out the answer to these questions on page 10.

Illustration by Philippa Nikulinsky

FEATURES

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Published by Dr S Shea, Executive Director
Department of Conservation and Land Management,
50 Hayman Road, Como, Western Australia

MARINE TREASURE TROVES

The results of a marine biological survey off our southern coast (see Wonders of our Southern Seas) provides some idea of the beauty and uniqueness of our marine environment. But the area surveyed represents only a small sample of the 12 500 kilometres of coastline that stretches from the warm tropical waters of the Timor Sea to the cool temperate waters of the Southern Ocean.

Our coastal resource also includes treasure troves, such as the crystal clear waters surrounding the shelf-edge reefs of the Rowley Shoals Marine Park, the extensive coral reefs and mangroves of the Kimberley and Pilbara coasts, Australia's largest fringing coral reef within the Ningaloo Marine Park, and the world's most extensive seagrass meadows and oldest living lifeforms (ie stromatolites) in the Shark Bay World Heritage Area.

The presence of the southward flowing Leeuwin Current adds to this richness by allowing tropical marine life to thrive much farther south than normally occurs in the world's oceans. The resulting mixture of warm-water and cold-water species is most pronounced along the central west coast, where a continuous limestone reef stretching between Dongara and Perth provides a marine environment that is unique in Australia.

As well as providing many recreational opportunities for the local community, our marine environment is also very important to Western Australia's economy. Prawning and pearl culture in the north and the rock lobster fishery in the south are among our important fishing industries. Similarly, the petroleum industry on the North West Shelf makes a multi-billion-dollar contribution to the local and national economy. The emerging marine, "job rich", nature-based tourism industry, currently centred around whale-watching off Perth and Albany, the Monkey Mia dolphins in Shark Bay and the whale sharks off Exmouth, has great potential to become another significant marine-based industry in Western Australia. The rich diversity of marine life in our waters potentially contains numerous medicinal substances that may be of great benefit to mankind.

Striking a balance between the conservation of our marine environment and the management of the above recreational and commercial uses is not an easy task. Recent changes to the CALM Act, which came into effect in August this year, have provided an improved capacity to achieve these dual objectives. These changes include the creation of a Marine Parks and Reserves Authority (MPRA) as a vesting authority and as an advisory body to the Minister for the Environment. A Scientific Advisory Committee has also been established to provide advice to the Minister and the MPRA. Other important changes ensure commercial and recreational stakeholders and local communities play an integral part in the marine reservation process from the very beginning.

CALM is committed to achieving a balance between the conservation and the many uses of our marine environment. The new legislation provides Western Australia with a unique opportunity to ensure that the qualities of the marine environment valued so highly by Australians are there for the benefit of future generations.

The Publisher

ENDANGERED COCKATOOS RAISED IN CAPTIVITY

One of Western Australia's most threatened native cockatoo species has been successfully raised in captivity, heralding a new approach to the conservation of birds listed as threatened with extinction.

Cockatoos have been raised from eggs and nestlings collected in the wild under a joint partnership between the avicultural industry and the Department of Conservation and Land Management (CALM).

The initiative followed a call for expressions of interest in 1995 for captive breeding or similar programs based on wild-captured birds.

Carnaby's cockatoo (*Calyptorhynchus latirostris*) was chosen, as it had suffered in the wild because of loss of nesting trees through land clearing for farming, and it had been the target of poachers.

The partnership between CALM and an avicultural syndicate, including Rainbow Jungle (a native parrot wildlife park at Kalbarri), also looked at the extent to which a controlled harvest of birds could be undertaken that would most benefit the conservation of the species.

CALM's Wildlife Branch staff collected 34 eggs and 34 newly hatched chicks from 68 nests. These were given to five aviculturists for rearing and resulted in 26 chicks from the eggs and 31 from the nestlings.

Carnaby's cockatoos generally lay two eggs but research has shown that as a rule only one egg hatches. If both hatch, one of the nestlings dies.

Further monitoring of the nests from which the eggs and chicks were taken revealed that 42 cockatoo chicks were successfully raised in the wild from the remaining eggs and nestlings. This level was in line with past research observations. This meant that when combined with the captive breeding program, the number of chicks that survived was more than double the rate that would occur naturally.

CALM will sell 10 of the raised birds by tender to licensed aviculturalists to provide more resources for continuing conservation efforts, including restoring nest sites in the wild.

All of the captive-raised birds are being DNA-tested and having micro chips inserted for identification. The DNA tests will also help determine the sex of each bird so they can be paired up before they begin breeding in about three years' time.

CALM's field survey work has also identified significant new breeding populations and provided valuable information on nesting behaviour for the species.

The program has shown how private landholders and Government agencies can play an important role in helping conserve nesting and feeding areas for the cockatoo.

This will help increase the availability of the species in aviculture and reduce the incidence of nest-robbing in the wild.

The program will continue for a further two years. Efforts in the second year will include repairs to additional potential nest sites with the aim of directly increasing the number of cockatoo pairs breeding successfully in the wild.

Short-billed black-cockatoo (commonly known as Carnaby's cockatoo).

Photo – Babs & Bert Wells/CALM

A message to our sponsors from the Gouldian finch.

You're terrific. Thanks to you and the *LANDSCOPE* Conservation Visa Card from BankWest, the Gouldian finch's threatened habitat at Pumpkin Spring is increasingly protected. Your support—and this card—are helping other threatened species and ecological communities: the dwarf bee orchid, Gilbert's potoroo, mound spring communities, the western spiny-tailed skink etc.

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TROPICAL MARINE FISHES GUIDE WELCOMED BY DIVERS

A close encounter with a toxic scorpionfish was just one of many incidents during extensive fieldwork to produce a comprehensive field guide for anglers and divers called *Marine Fishes of Tropical Australia and South-East Asia*, which has just been published by the WA Museum.

The incident brought four hours of excruciating pain to the book's author Gerry Allen, who has logged more than 5 000 hours of diving time in remote reefs around the world.

The breathtaking colours and shapes of 1 635 species of exquisite reef fish are brought to life with full-colour illustrations by Roger Swainston and Jill Ruse.

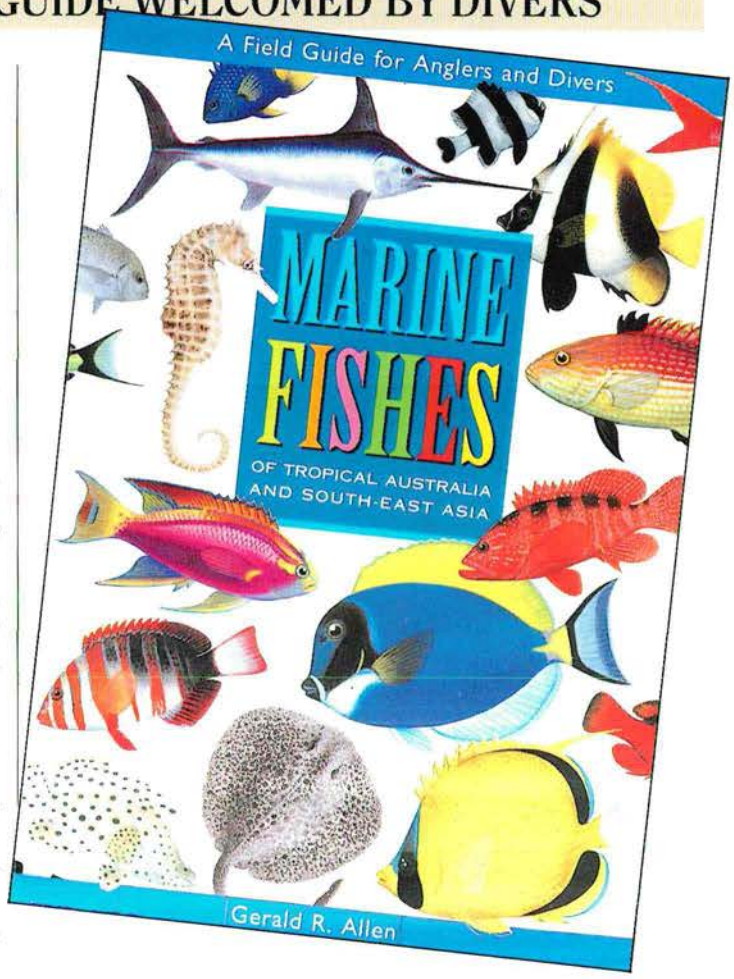
The book is highly recommended to anyone with an interest in marine wildlife. It is a great tool to help divers and snorkellers to identify some of the estimated 4 000 species of fish that occur in this fauna-rich region.

There are fascinating boxes about the lifestyles of many fish groups and practical advice on subjects such as fish photography and dangerous fish.

The book was written in response to requests and was spurred by the current boom in recreational diving.

"In the past few years there has been a boom in recreation diving out of places such as Broome, and more divers are venturing to offshore reefs such as Rowley Shoals Marine Park and Scott and Ashmore Reefs—which were not covered by an earlier field guide," said Gerry.

Marine Fishes of Tropical Australia and South-East Asia is available from all major bookshops and the WA Museum, and retails for $29.95.



NEW STRATEGY TO GIVE TOURISTS A QUALITY EXPERIENCE

A nature-based tourism strategy to establish Western Australia as the leading eco-tourism destination in Australia has been developed as a joint initiative between the Western Australian Tourism Commission (WATC) and the Department of Conservation and Land Management (CALM).

The aim of the strategy is to ensure that Western Australia's natural assets are recognised and managed for sustainable nature-based tourism, while at the same time protecting the natural environment. The underlying basis for the new strategy is the integration of conservation and tourism, and it is believed that if properly managed, nature-based tourism can become one of the major ways to help conserve WA's spectacular landscapes and native wildlife.

Research shows that nature-based tourism is one of the world's fastest-growing industries. Travellers are now more environmentally conscious and they are seeking more eco-based information about the destinations they visit.

The research also shows that Western Australia can expect a 25 to 30 per cent increase per year in nature tourism up to and beyond the year 2000.

Nature-based tourism operators will also benefit in the development of their businesses in an ecologically sustainable manner, while providing their clients with a unique experience.

Two of CALM's most recent initiatives will help tour operators market their product more effectively.

One is the CD-ROM *Wild about Western Australia* developed by CALM and the Department of Human Movement at the University of Western Australia.

The second is a database, listing licensed tourism operators on NatureBase, CALM's Internet site, which can be accessed on: http://www.calm.wa.gov.au

A feature of the CD-ROM is a trip planner which, apart from helping people to plan tours, also provides contacts for CALM-licensed tour operators, of whom there are around 200. (See page 8: Who Goes Where? Tour Operators On Line.)

The State government will allocate $500 000 over three years to the WATC to implement the strategy.

Key areas that impact on the future growth of nature-based tourism have been identified. They include accommodation, investment in infrastructure, zones of opportunity, product development, Aboriginal tourism, marketing and promotion, information and training, and community involvement.

FRUSTRATED FROGS IN QUACKING FRENZY

Frog researcher Dr Dale Roberts from the University of Western Australia took this astounding photograph of these quacking frogs, which sometimes engage in bizarre and spectacular mating behaviour.

The quacking frog (*Crinia georgiana*) is a familiar species on the coastal plains and in the forests of south-western Australia. The species has a prolonged breeding season, with most breeding activity occurring between July and October. Males congregate where there is ample shallow water, and call to attract females. Particularly favourable sites are found around granite outcrops in the Darling Range. The call is a short and remarkably loud 'quack ... quack... quack', hence the common name of this species. Females are attracted to a chorus of calling males and select a mate. On an average night a mating pair enter into a sexual embrace termed 'amplexus', where the male lies on the back of the female and clasps her firmly around the back legs. Eggs are released, then fertilised externally by the male releasing sperm over them.

This form of mating behaviour is common among most frog species. On certain nights, however, when large numbers of males appear at the breeding sites and competition for females is intense, males desperate to mate may attempt to join already amplexed pairs. Amplexed males attempt to discourage interlopers by lashing out with their powerful hind legs, however this evasive action is often to no avail and several males may also gain hold of the female. It is not uncommon for four or five males to join a mating pair and in extreme instances up to nine males have been observed to mate with a single female. The outcome is a writhing ball of frogs desperately struggling to fertilise the female's eggs.

Genetic analyses reveal that a male placed in the normal, upper position, and a male amplexed underneath on the lower abdomen can both fertilise eggs, but other males may not do so well. Multiple male matings may be the best that they can do if females are scarce. For females there may be real costs: lower fertilisation success, because males are squabbling rather than concentrating on the job, or even death, probably from asphyxiation, if the males are too vigorous. Male quacking frogs have massive forearms but females are slender and delicate. This gender difference suggests that wrestling for a position, or holding on in the ventral position, has had a long history in this species.

Multiple paternity is rare in frogs. Quacking frogs offer some unique opportunities to understand costs and benefits to both males and females of having several fathers for a single clutch.

For Dr Roberts and Phil Byrne of the University of Western Australia's Zoology Department, this is a continuing study.

Quacking frogs mate. Note the released eggs below, waiting for the male to fertilise them.

Photo – JD Roberts

WHO GOES WHERE? TOUR OPERATORS ON LINE

Western Australia has some of the best places in the world for people seeking nature-based holidays. From the beehive-like formations of the Bungle Bungles in the far north, to the lush green forests of the south-west, WA has something for everyone.

Currently there are around 200 licensed operators who run tours to these fascinating areas, but until now, it's been a little difficult to find out just who goes where.

In July this year, CALM officially launched its first CD-ROM, *Wild about Western Australia*. Apart from the many tempting pictures of WA's natural attractions, one of the things the CD-ROM offered was a searchable database of CALM-licensed tour operators.

CALM issues licences to tour operators so it can monitor access and use of lands under its control, and to ensure that the conservation values of these areas are maintained. By protecting these values, the licensed tour operator will be able to return frequently to popular locations, knowing his or her clients will enjoy them in their unspoiled condition.

The ability to search for operators who run tours to various national parks and other attractions is an obvious advantage to anyone wanting to visit WA, so obvious that the facility has now been extended to CALM's multi-award-winning Internet site, NatureBase.

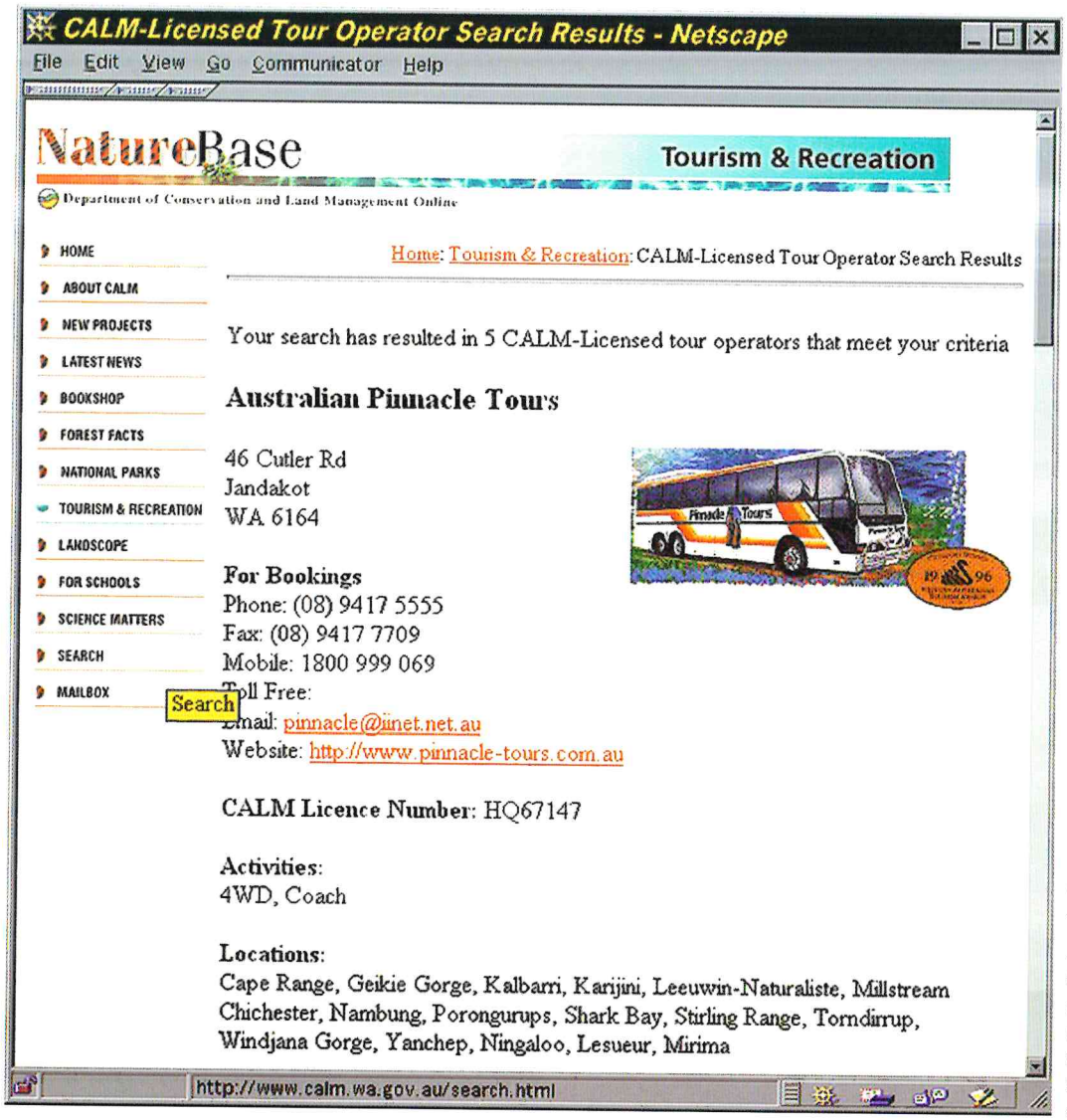
Visitors to NatureBase can search an up-to-date list of operators by their name, type of tour on offer, location of tour and/or home location of the operator. The more options (fields) used in the search, the more specific the search results obtained.

When the user clicks on the mouse button, up pops a list of tour operators running tours that meet the chosen criteria. And if the tour operator has his or her own Internet site or Email address, users can visit that operator's site or send an Email off to them requesting specific information, such as dates, costs and availability.

"This provides an instant on-line service for our licensed operators," said CALM's Executive Director, Dr Syd Shea. "Furthermore, it provides an international shop window for their tours."

To ensure that the most up-to-date information is available to potential tourists, CALM staff will regularly update operators' details and add new operators as they become licensed.

"This service has the potential to attract increasing numbers of overseas and interstate visitors to Western Australia, and that can only mean success for the many small businesses involved in nature-based tourism," said Dr Shea.



This screen grab illustrates the first of five tour operators who met the search criteria.

Each operator's listing gives name and contact details, Email and Website addresses (if they have them), activities or types of tours offered and locations of tours. Operators also have the option to include a photograph.

QUOKKAS AND EASTER BILBIES - INDICATORS TO A SUCCESS STORY

Evidence of the success of the *Western Shield* program continues as the Department of Conservation and Land Management (CALM) pursues its fox-baiting activities.

As fox predation is significantly reduced over broader areas, native animals that had formerly been threatened, or even thought to be extinct in a particular area, are being found.

One example is the new population of quokkas (*Setonix brachyurus*) found recently near a rehabilitated bauxite mine in the northern jarrah forest. The quokkas were found in an area that had been baited for fox control as part of *Operation Foxglove*, an initiative between CALM and Alcoa of Australia in the forest between Collie and Mundaring.

The discovery brought to three the number of new quokka colonies found in the forest around Jarrahdale in the past two years. The three new sites were all north of Jarrahdale between the Albany and South Western Highways, and represents a significant northern extension of the quokka's current known range on the mainland.

As public confidence in the *Western Shield* program increases, help to rebuild populations of threatened animal species is arriving. One example is a $14,500 grant from the Australian Conservation Foundation to bring the bilby (*Macrotis lagotis*) back from the brink of extinction.

The grant will be used to maintain the bilby breeding populations at Shark Bay and Kanyana Native Fauna Rehabilitation Centre in Gooseberry Hill.

The grant was part of the funds raised from the sale of chocolate Easter bilbies through Coles Supermarkets for the *Save the Bilby Fund.* The drive to replace the traditional European Easter bunny with an animal representative of Australia evidently struck a chord with parents and children alike, and the Easter bilby looks set to become part of Australia's folklore.

An important spinoff expected from this campaign is increased community and corporate interest in the animal itself, and with it further support for efforts to conserve the bilby and other threatened Australian animal species.

Meanwhile, Western Australia's nature conservation initiative—*Western Shield*—reached a further milestone over a recent two-month period when, for the first time, the whole of the south-west native forests were baited for foxes.

CALM extended its fox-baiting program into all the forests, including major national parks such as the Shannon, D'Entrecasteaux and Leeuwin-Naturaliste. This brought the total area of conservation lands being targeted for fox control under *Western Shield* to 3.4 million hectares.

Corporate sponsorship by Cable Sands has funded the extension of the baiting program into areas such as the Shannon and the D'Entrecasteaux National Parks, the sunklands between Nannup and Busselton and the Donnelly catchment.

The intensive program saw aircraft, equipped with global positioning systems and computers, flying pre-determined flight lines, along which baits containing the naturally occurring toxin—1080—were dropped.

The computerised navigation system meant that strategic bait-free buffers, some up to 500 metres wide, were left around non-targeted areas such as private property and constructed recreation sites in the forest areas. Smaller buffers were retained around major public roads.

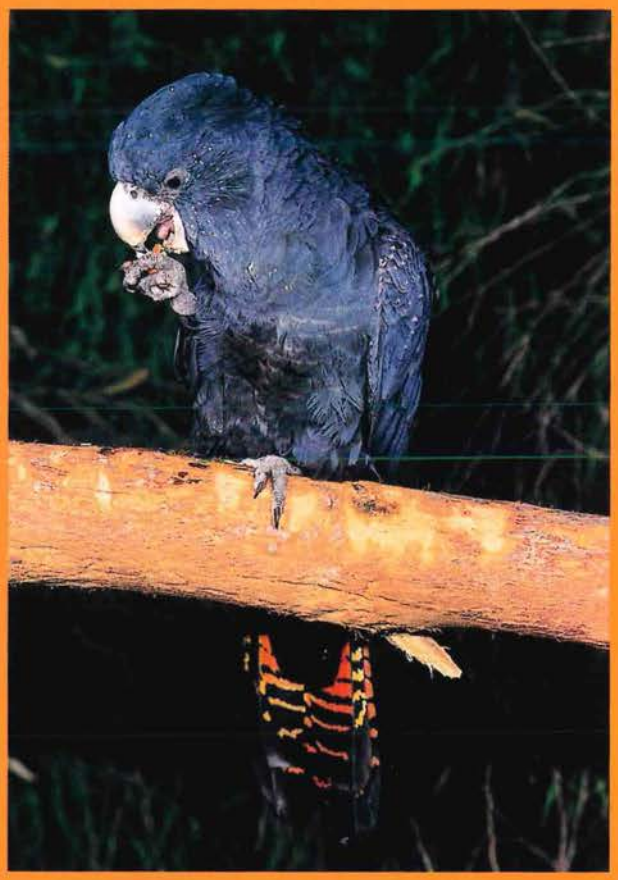
Local communities were cautioned to be aware that 1080 is lethal to cats and dogs as well as foxes and there was no 'safe' period. They were encouraged to either leave household pets at home or at least muzzle them.

Tony Passchier, Alcoa Mine Environmental Scientist and Antoinette Tomkinson of Curtin University with a six-month-old quokka at the most recently discovered quokka site.

Photo – Paul de Tores

Counting Cockatoos

The status of the forest red-tailed black-cockatoo



Is this bird rare or just rarely seen? Has human impact had anything to do with its apparent rarity? A recent survey by CALM helps shed some light.

BY IAN ABBOTT

Restricted to the forests of the lower south-west of Western Australia, the forest red-tailed black-cockatoo is rarely encountered by ornithologists and bird-watchers. But is it truly rare, or does it just appear to be rare because it lives in remote areas infrequently visited by ornithologists? And if it is indeed rare, should we blame humanity's impact on the natural environment? Over the past two years staff from the Department of Conservation and Land Management (CALM) have attempted to find the answer to these questions.

The forest red-tailed black-cockatoo of south-west Western Australia was first made known to science in 1836 as *Calyptorhynchus naso*, but it is now recognised as one of four subspecies of the red-tailed black-cockatoo (*C. banksii*), which is distributed over much of Australia. Our subspecies, *C. banksii naso*, is restricted to the south-west corner of Western Australia from Perth southwards to Albany.

At close quarters, the male is quite distinctive, with its sooty-black plumage, long thick bill, rounded helmet-like crest and bright red panels in its tail feathers. The female is duller and is lightly spotted and barred in yellow; its tail-feather panels are orange-yellow, barred with black.

Like other cockatoos, the forest red-tailed black-cockatoo is a seed-eater. Its chief source of food is the large, hard seeds extracted from the base of the woody fruit of marri (*Corymbia calophylla*), but the seeds of jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*), Albany blackbutt (*E. staeri*) and the common sheoak (*Allocasuarina fraseriana*) are also eaten. Breeding begins in September and October, and the nest sites are large hollows in standing trees. Suitable hollows are found in trees with a diameter of more than 60 centimetres at chest height (taken as 1.3 metres). Incubation of the single egg (occasionally there are two) takes about a month and the young bird is fed in the nest for nearly three months.

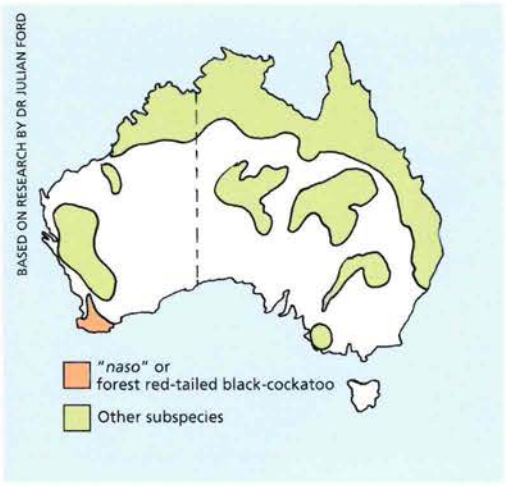
HOW UNCOMMON IS IT?

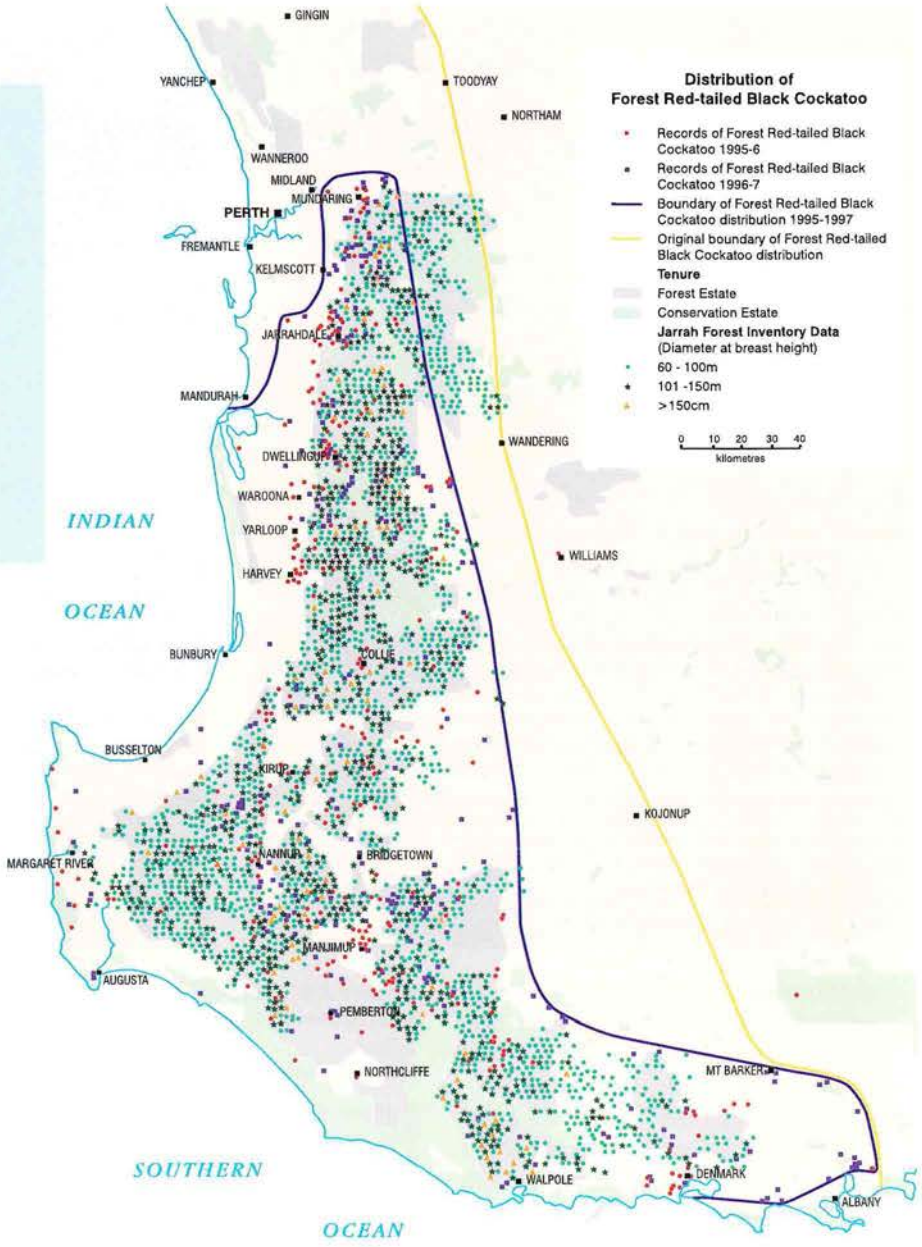
Three lines of available evidence seem to suggest that the forest red-tailed black-cockatoo may be uncommon. Firstly, a local and international search of major museum collections of Australian birds revealed the existence of only 44 specimens, most of which were collected in the period 1866–1916. The most recently collected specimen found was dated 1994. Secondly, a search of the ornithological literature for the period 1900–94 turned up fewer than 50 publications referring to the forest red-tailed black-cockatoo. Most of these were based on sightings at one or only a handful of localities. One publication, however, mapped 52 localities based on published and unpublished records over a period of 26 years. Lastly, there are many published bird lists for localities in the south-west of Western Australia, and in many of these the forest red-tailed black-cockatoo was not recorded.

Taken together, these historical sources of information might suggest that the forest red-tailed black-cockatoo either truly is uncommon, if not rare, or is only encountered on rare occasions by ornithologists because it lives in remote places.

Previous page
Jarrah forest, country of jarrah and marri trees.
Photo – CALM
Inset: Female red-tailed black-cockatoo.
Photo – Jiri Lochman

Left: A pair of forest red-tailed black-cockatoos.
Photo – Simon Nevill





THE COCKATOO SURVEY

There has been some speculation that the commercial exploitation of large trees has decreased the availability of suitable nesting hollows to the extent that the cockatoos can no longer breed to capacity.

In 1995, CALM decided to investigate this matter, choosing spring and summer of 1995–96 and 1996–97 for a survey program. The surveys were carried out from October to February inclusive, as this period spans the breeding season when the cockatoos are least likely to wander far from their nesting sites. Copies of a carefully constructed survey form were distributed to CALM staff and to members of the public chosen for their knowledge of ornithology, as well as to environmental officers working for Alcoa of Australia Limited and Worsley Alumina Pty Ltd. These mining companies lease large tracts of forest land within the range of the cockatoo and their environmental staff take a keen interest in matters of conservation importance. The information requested on the survey forms included details of the locality where cockatoos were observed, the date of observation, numbers of birds seen, where in the landscape they were seen, the type of forest they were frequenting, the criteria used for identification and any evidence of breeding.

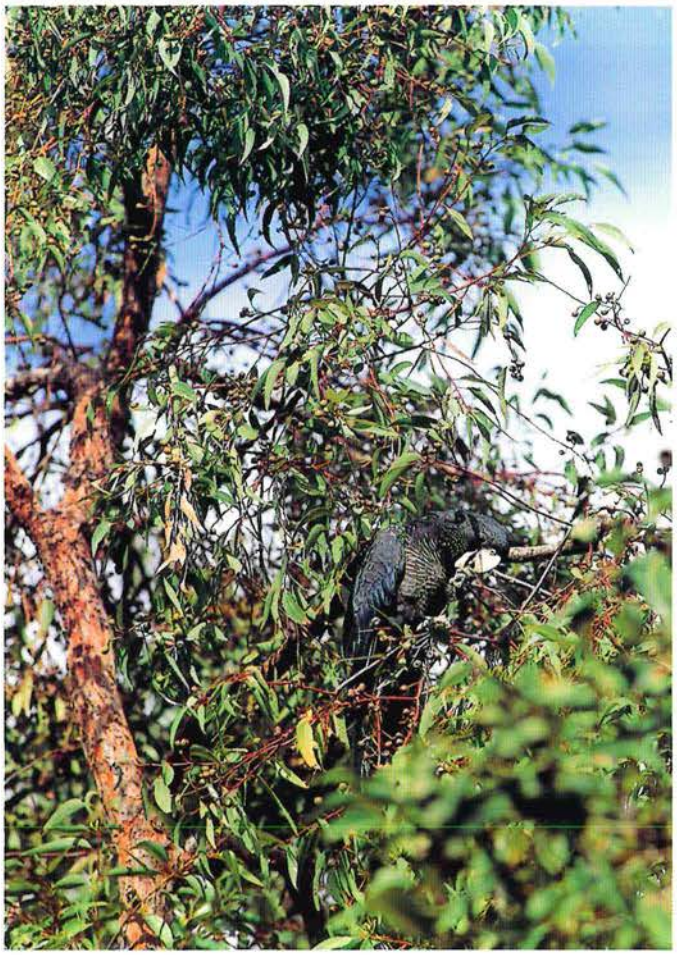
In scientific terms, the hypothesis to be tested by the survey was that logging, by selectively removing large merchantable jarrah trees, has reduced the number of available nesting sites—large hollows in standing trees—resulting in a contraction in the distribution of the forest red-tailed black-cockatoo. A testable prediction of this hypothesis would be that cockatoos should, in the breeding season, occur only in or close to large tracts of unlogged forest set aside from commercial forestry.

THE FINDINGS

The two surveys together yielded 615 sightings, distributed widely over the lower south-west of the State. They confirmed that the cockatoo appears now to be locally extinct over most of the Swan Coastal Plain, in the area between Dandaragan and Mt Helena, and in the area east of a line joining Mt Helena to North Bannister. Apart from two isolated records (which were presumed to be 'vagrants', or wanderers), the species was not recorded in the eastern parts of its former breeding range, from Wandering (due east of Mandurah) to Mt Barker (north of Albany).

The cockatoo's absence from the Swan Coastal Plain is only to be expected, given the extent of woodland clearance for urban and agricultural development, and the fact that this species is known to be rather intolerant of human disturbance. However, there is little doubt that they did once inhabit the area, given that the Perth suburb of Karrakatta, west of Kings Park in Perth, means 'hill of the red-tailed black- cockatoo' in the Nyoongar language (*karrak* = the red-tailed black-cockatoo; *katta* = hill).

The survey results were considered to be reliable, as nearly all recorded the sighting of the distinctive red panels on the tail feathers and the unmistakable call—'*koorark*'. A check of the 60 records based solely on call (when the observers



could not view the tails of the cockatoos satisfactorily) showed that all but four were by observers who had sighted the tails of this species at other times.

Interestingly, the location of records was split almost exactly evenly (48.7 and 51.3 per cent) between the northern and southern forests (the border being taken as the Preston River). The average number of cockatoos seen per record was 6.9 in the north and 5.1 in the south. The largest flocks recorded were 50 (both north and south). Although most records were in jarrah-marri forest (84 per cent in the north, 76 per cent in the south), cockatoos were noted in a wide range of forest and woodland types. These included yarri (*Eucalyptus patens*), wandoo (*E. wandoo*), karri, tuart (*E. gomphocephala*), Albany blackbutt, yate (*E. cornuta*) and flooded gum (*E. rudis*). There were even records from bluegum (*E. globulus*) plantations and pine plantations, and there were two road kills.

The only major difference found between north and south concerned the location of records in the landscape. In the north, 38 per cent were in valley locations while only 26 per cent were on ridges. In the south, however, the order was reversed, with 41 per cent of the sightings on ridges and only 22 per cent in valleys. This difference may reflect the variable niches of marri, whose seeds form a large part of the cockatoo's diet. In the north, this tree reaches its optimum development below the level of the laterite soils in the uplands, whereas in the south, it tends to occur more in upslope areas, being displaced on the lower ground by karri, yarri and flooded gum. Of the two jarrah forests, the southern one has a greater volume of marri timber than the one in the north. The proportion of midslope sightings was similar in both regions, with 16 per cent in the north and 17 per cent in the south.

Above left: Female red-tailed black-cockatoo extracting seed from jarrah fruit.
Photo – Simon Nevill

Above right: Adult male red-tailed black-cockatoo. Note the shining black plumage, black beak and helmet-like crest.
Photo – Jiri Lochman

LOGGING: TESTING THE PREDICTION

If logging of forest were threatening the long-term survival of the forest red-tailed black-cockatoo, the survey should have found many more records in southern forest than in northern forest. This should follow from the vast area of unlogged forest in the south (365 390 hectares) relative to that in the north (41 190 hectares). Yet the survey showed that the cockatoos were just as well represented and widespread in the north as in the south.

Data collected by Kim Whitford of CALM's Dwellingup Research Centre provide key information about the abundance of hollows in standing trees in jarrah forest. He studied 239 felled trees, ranging in diameter at chest height (1.3 metres) from 20 to 200 centimetres, and found that hollows suitable for use as nest sites by forest red-tailed black-cockatoos occurred in trees more than 60 centimetres in diameter. Kim found that 4.7 per cent of the jarrah and 12.2 per cent of the marri in these larger size classes had potential nest-site hollows.

To this valuable information, we can add data gathered from over the whole jarrah forest in CALM's 1989–91 Forest

Inventory (see 'Shooting from the Stars', *LANDSCOPE*, Summer 1989–90). This inventory was carried out in two phases. Phase 1 involved interpretation of aerial photographs of plots taken at the rate of one per 50 hectares. Phase 2 was a ground check of 10 per cent of the plots studied in Phase 1 to confirm the accuracy of the interpretations.

The inventory established that on average there are 13.3 trees per hectare with diameters greater than 60 centimetres. Trees of this size occur in jarrah forests throughout the State forest, with 85 per cent of the 2 900 measured ground samples containing at least one tree with a diameter larger than 60 centimetres.

Most of the current geographical range of the forest red-tailed black-cockatoo is in jarrah-marri forest. In the 67 per cent of multiple-use jarrah forest available for timber production, four 'habitat trees' per hectare are specifically marked for retention, although many other unmarked trees of large diameter are also retained. Although the home range of a breeding pair of cockatoos has not yet been accurately established, an informed estimate can be made based on a cockatoo's body weight of 600–610 grams. On this basis, each pair should have a large breeding home range of the order of 116–187 hectares. At four habitat trees per hectare in multiple-use jarrah forest, this translates into a minimum of 464–748 specially marked and retained trees of a size suitable for cockatoo nesting, and in which the breeding pair must find a suitable nesting hollow. However, the Forest Inventory data indicate that there is an even greater number of trees of sufficient size with the potential to have developed a suitable size of hollow—some 1 543–2 487 trees per home range. When Kim Whitford's data are applied to these latter figures we can conclude that each home range could possibly include 104–167 trees with hollows suited for nesting use by the cockatoo.

What of the disappearance of the forest red-tailed black-cockatoo from the 210 000 hectares of State forest east of Mt Helena and North Bannister (three per cent of its original range)? It seems unlikely that this is because of insufficient large trees, as in this sector the Forest Inventory recorded an average of 7.9 trees per hectare with diameters exceeding 60 centimetres. Although this is a lower figure than the 11.6 per hectare in those State forests occupied by forest red-tailed black-cockatoo to the west, it is still a healthy state of affairs.

The cockatoos are sometimes presumed to be threatened by the harvesting of marri in the southern jarrah forest and by woodchipping operations. Marri, however, is clearfelled mainly from karri forest, which occurs over only about eight per cent of the current geographical range of the cockatoo. Moreover, about half of the karri forest has been reserved in perpetuity in national parks and in road, river and stream reserves.

Therefore, the broad distribution of cockatoos in State forests, and the satisfactorily high proportion of large trees throughout the State forest estate, do not support the conclusion that logging of native forest threatens the forest red-tailed black-cockatoo.

WHAT ARE THE THREATS?

Presumably, a logging threat would exist only if the larger trees were cleared completely. Indeed, the decline in geographical range of the forest red-tailed black-cockatoo may well have been in response to widespread clearing of jarrah forest and/or woodland and wandoo woodland for agriculture, to the west, east and north of the extensive State forests. It has been calculated that this

13-day-old red-tailed black-cockatoo chick.
Photo – Jiri Lochman

is the reason why 36 per cent of the cockatoo's original range is no longer occupied.

Forest red-tailed black-cockatoos do not seem to be averse to using marri trees left as remnants on roadsides, in paddocks or in towns (e.g. at Jarrahdale and Manjimup), as they were often recorded in such situations during the survey. However, most of these records (95) came from areas adjacent to State forest.

In 1916, the ornithologist Tom Carter wrote that the forest red-tailed black-cockatoo had rapidly diminished in numbers since he first observed the species in 1887. He gave several possible reasons for this decline. One was the clearing of timber following agricultural development and increased settlement, while another was the shooting of birds for their handsome tail feathers or simply for sport. Carter noted that if one of a flock was shot and fell wounded to the ground, the rest of the birds would hover close to it, and thus afford an easy target to a shooter. However, they were seldom shot for food as 'there is not much meat on them', and since they are not considered to be orchard pests they would rarely have been shot by fruit-growers.

HOW MANY ARE ENOUGH?

Radio-tracking or colour-banding nesting cockatoos would allow us to make more precise estimates of home range sizes in the breeding season. Catching and marking birds would also help us understand the composition of flocks. For example, do the six birds in an average flock consist of two breeding pairs and their progeny from the previous year, and do most pairs breed successfully each year? More field work is needed, but the forest red-tailed black-cockatoo is difficult to catch.

However, the news is probably good. About 2 000 forest red-tailed black-cockatoos were recorded during each of our two surveys, but it is uncertain how many birds may have been counted more than once. Based on nearly 400 censuses of birds in small, defined areas in the south-west forests between 1976 and 1991, the average density of the forest red-tailed black-cockatoo is one per 100 hectares. Extrapolation of this figure to the total area of State forest in which the cockatoo occurs suggests a total population of about 16 000 birds. If we use the estimate outlined above of one nesting pair to 116–187 hectares, the total figure could be between 16 000 and 26 000 birds. We can conclude that this is probably a satisfactory population level.

Above: Adult female red-tailed black-cockatoo eating marri seed. Note the yellow spots on the plumage and the colour of the beak (light horn).
Photo – Jiri Lochman

Below: Marri fruit, the seeds of which are a staple food in the diet of the red-tailed black-cockatoo.
Photo – Babs & Bert Wells/CALM

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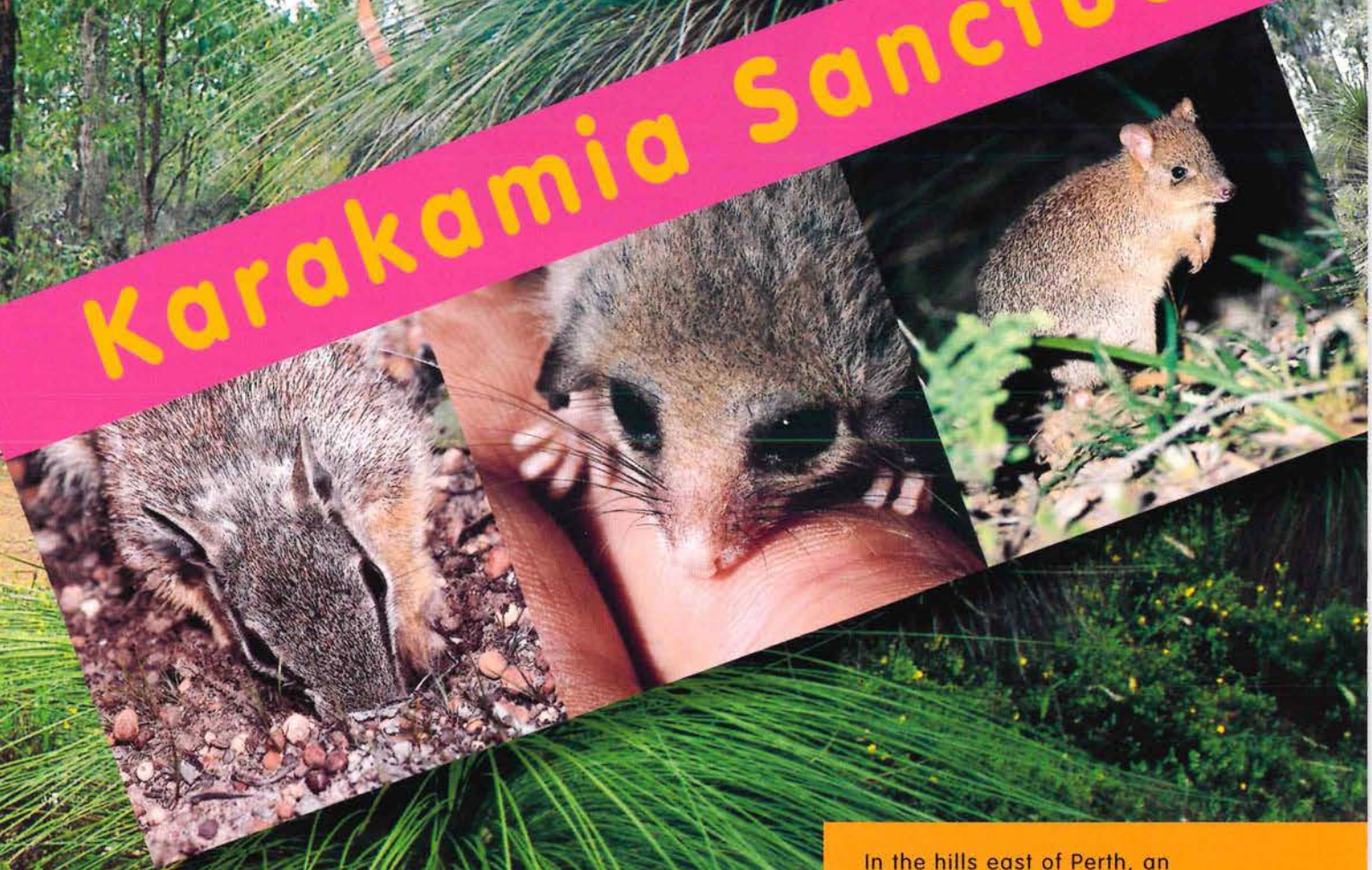
The author wishes to thank the staff of CALM, Alcoa of Australia Limited, Worsley Alumina Pty Ltd, and members of the public who participated in the surveys.

Karakamia Sanctuary



In the hills east of Perth, an exciting new conservation project is developing. With the support of the Department of Conservation and Land Management (CALM), Western Australia's first private wildlife sanctuary is being established—a place free from foxes and cats, where native wildlife can flourish.

by André Schmitz and Martin Copley

Photos by Ann Storrie

The experience of an encounter with one of Western Australia's native animals is always a memorable one. Strolling along a bush-track at night, the rustle of leaves from beneath the shrub layer makes you stop in your tracks and focus your attention. A hint of movement, and then a tiny nose pokes out, sniffing the breeze for any scent. Slowly a head appears, then suddenly disappears as the animal senses a hint of danger. In time, the quenda (*Isoodon obesulus*), commonly called the southern brown bandicoot, comes out of hiding and into the open. Keep still long enough and you may be able to watch the animal dig for earthworms. You can't hold still any longer and a sneeze or cough, or the slightest movement, sends the animal scurrying for cover, not to be seen again.

This wonderful experience is sadly now a rare event for many people. When spotting a quenda during a walk at Karakamia Sanctuary the inevitable question is asked, 'what was that?'—a sad reflection that most Western Australians these days do not know what a quenda is. Because of fairly low numbers in the wild and the fact that it is nocturnal, the species is rarely seen. This charming little animal is, in many ways, an Australian icon. Before the advent of fox-baiting programs such as *Western Shield,* (see 'Western Shield', *LANDSCOPE,* Winter 1996), it was well on the way to joining the ranks of Australian mammals threatened with extinction by introduced predators, namely the European fox and feral cat. It was for this reason that the quenda was chosen as Karakamia Sanctuary's logo: it represents a previously familiar mammal that is now still fairly rare.

Although numbers of quenda are increasing in areas where fox-baiting has occurred, Karakamia Sanctuary is attempting to help reverse their decline in the metropolitan area. And not just with quenda! A whole host of Darling Range mammal species requires intensive management to restore animal numbers to what they once were.

WA'S FIRST PRIVATE WILDLIFE SANCTUARY

The seed for Karakamia Sanctuary was first sown when Lorraine Copley organised a visit to Dr John Wamsley's Warrawong Sanctuary in South Australia in 1990. As a result, possibilities for a similar private conservation attempt in WA were considered and acted upon, using Warrawong as inspiration.

It is vital for the private sector to complement and, if necessary, challenge the conservation approach made by Government. Above all, involvement of the hearts and minds of the community is crucial.

The principal aim of Karakamia is to re-establish, within the sanctuary, Darling Range wildlife communities as

Previous page
Main: The grounds of Karakamia Sanctuary.
Insets: (from left) Numbat (*Myrmecobius fasciatus*), pygmy possum (*Cercartetus concinnus*) and woylie (*Bettongia penicillata*) – some of the native animals protected at Karakamia.

Above: The establishment of walk trails allows people to view animals within the sanctuary.

Left: Dunnarts (*Sminthopsis griseoventer*) are now common at Karakamia following the eradication of introduced predators.

The quenda (*Isoodon obesulus*), Karakamia's logo, can now be regularly seen foraging at night in the sanctuary.

they were before European settlement. Medium-sized ground mammals, have suffered most since European colonisation. The glaring difference between the hills bushland now and 200 years ago is the dramatic decline of this group of animals and their habitat. The sanctuary's objective is to provide people, especially children, with the opportunity to experience native mammals.

However, it's not just mammals that the sanctuary is concerned with, but the entire forest ecosystem. This is reflected in its name 'Karakamia', which means 'home of the red-tailed black cockatoo' in the local Nyoongah language (*karak or karrak* = red-tailed black cockatoo, *mia* = home or habitation).

ESTABLISHMENT

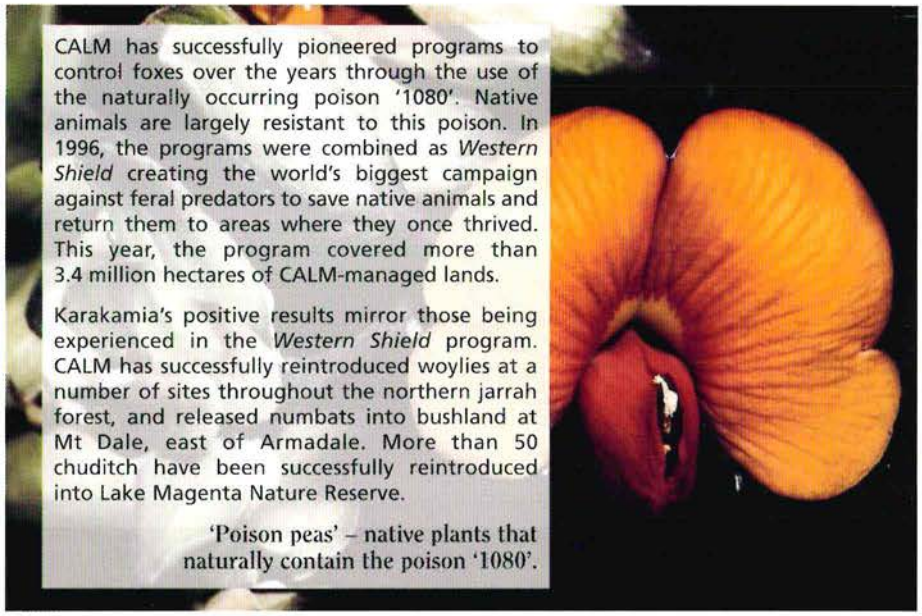
The search for an area suitable for the establishment of the sanctuary was much more problematic than first expected. Private land in the area had been grossly modified for commercial purposes. It came as quite a revelation when it was discovered that areas of high quality bushland were as difficult to find as a needle in a haystack! Fortunately, in 1991, the Karakamia team struck gold. A property was found near Chidlow, east of Perth, which met all the selection criteria and more. The 180-hectare bushland was in an undisturbed state. It had a variety of habitat types and was only an hour's drive from Perth, making it easily accessible to the metropolitan region. In addition, it was stunningly beautiful with spectacular views and a pristine creek.

The land consists of a variety of vegetation communities that are representative of the northern jarrah forest. It also contains a number of recognisable distinct habitats. Jarrah is found predominantly on the lateritic caps, while downslope, more marri is intermingled with the jarrah. Extensive outcropping of granite creates a different environment, reflected in the vegetation of expansive heathlands of verticordia and calytrix, and shrublands of hakea. The granite weathers into clay, and below the outcrops, wandoo woodland predominates with a distinct understorey creating a wonderful patchwork of vegetation.

The permanent creek line, consisting of dense sedge and rush communities, provides a crucial habitat for many species. A large lake, formed when previous owners dammed the creek line, gives rise to open water habitat where water birds such as black swans and yellow-billed spoonbills are often seen.

It is extremely rare to find all these habitats in one location in the jarrah forest, and this is the fundamental reason why the site was chosen for the sanctuary project. By having a variety of habitats, it provided the best possible chance for the long-term survival of a wide range of native species.

Surveys of the sanctuary revealed a diversity of plant species, with more than 240 species identified, pressed and mounted in a herbarium. Ongoing vegetation survey work assures that management does not inadvertently compromise the flora of the site, particularly with regard to grazing pressure by animals like western grey kangaroos and especially after fire. This became an important issue after 20 hectares of Karakamia were burnt-out during the Chidlow wildfires in February 1996. Results so far show very good recovery rates compared with similar areas outside the sanctuary. In



CALM has successfully pioneered programs to control foxes over the years through the use of the naturally occurring poison '1080'. Native animals are largely resistant to this poison. In 1996, the programs were combined as *Western Shield* creating the world's biggest campaign against feral predators to save native animals and return them to areas where they once thrived. This year, the program covered more than 3.4 million hectares of CALM-managed lands.

Karakamia's positive results mirror those being experienced in the *Western Shield* program. CALM has successfully reintroduced woylies at a number of sites throughout the northern jarrah forest, and released numbats into bushland at Mt Dale, east of Armadale. More than 50 chuditch have been successfully reintroduced into Lake Magenta Nature Reserve.

'Poison peas' – native plants that naturally contain the poison '1080'.

conjunction with the vegetation work, vertebrate populations are monitored, and Karakamia now holds six years' biannual data. Surveys have revealed a rich fauna on the site, with 92 species of birds, 23 species of reptile and nine species of amphibian.

However, the surveys revealed an expected paucity of mammal species. These species were predominantly those able to persist in the face of fox and cat predation—such as bats, western grey kangaroos and echidnas. Two susceptible species, the brushtail possum and western brush wallaby, persisted in very small numbers, but all the medium-sized ground-dwelling mammals were completely absent.

OUT-FOXING THE FOXES

The key to Karakamia's success lies with the absolute exclusion of exotic predators. To achieve this, six-and-a-half kilometres of sophisticated electric fencing created a fox and cat-free haven. The fence was designed and erected with the help of Dr John Wamsley, from Earth Sanctuaries in South Australia. Dr Wamsley has many years experience excluding cats and foxes from his sanctuaries 'Yookamurra' and 'Warrawong', and in many ways is considered a pioneer of this type of fencing in Australia. The Karakamia fence uses the latest technology to prevent invasion of the enclosure by predators, as well as to monitor any breaches in the fence line. A series of alarms and back-up systems prevents the failure of the electric system in times of power loss, and the fence is checked daily for physical damage.

The Karakamia eradication program was conducted in collaboration with the former Agriculture Protection Board, now part of Agriculture WA. Foxes, cats and rabbits were removed using a variety of techniques including the use of the naturally occurring poison '1080' in baits. Native animals have a high tolerance to this poison, as it is found in the native plant genus *Gastrolobium*.

Above left: A feral-predator proof fence separates the sanctuary from farmland.

Left: Major rehabilitation work has been carried out on the Sanctuary's dammed lakes.

To assess fox and rabbit numbers, the sanctuary was divided into 50-metre grids and all vermin activity along the lines was mapped. This included all warrens and dens, scats and diggings. At the end of mapping, Karakamia staff had a very good indication of the prevalence and distribution of feral animals within the sanctuary.

Over an eight-month period, fewer and fewer locations recorded feral activity. To ensure that no foxes remained, sand pads of about one metre square were constructed throughout the sanctuary and lures used to attract foxes. Lures consisted of anything from dead rabbits to offal, while attractants such as fish oil were also used. All sand pads were visited regularly, but visitation slowly reduced over time until lures remained undisturbed. Karakamia was now ready for the next phase—the return of the mammals.

READY FOR REINTRODUCTIONS

An important aspect of the project is that only mammals known to have previously occurred in the region, and within the available habitats at Karakamia, were considered candidates for reintroduction. A provisional list of species was established with the guidance of experts from CALM's Science and Information Division. The initial releases included numbat, quenda and woylie. Subsequent reintroductions included western ringtail possums and mainland quokkas.

Monitoring of released animals involves comprehensive radio-tracking for a set period after release. This period is variable for different species and, in the case of numbats remains ongoing. After a period of radio-tracking, species such as woylies and quendas were monitored through regular surveys using cage and Elliott traps. All this information is stored in computer databases, and the sanctuary contributes to the knowledge of these species, particularly with regard to reintroduction programs. Status reports are written at regular intervals summarising information gained through fieldwork.

MANAGEMENT

Karakamia is run under a management agreement between the sanctuary and CALM, with day-to-day management coordinated through an endorsed management plan. An advisory panel, comprising two representatives from each organisation, meets at regular intervals to guide management decisions. Like all good partnerships, there are benefits to both parties. The State and wider community benefits by having another private organisation involved in the conservation and research of threatened fauna. Karakamia benefits by gaining relevant expertise from CALM with regard to both the management and research phases of sanctuary work.

Cage trapping is undertaken on a regular basis to monitor animal populations.

RESULTS

All reintroductions at Karakamia are considered to be successful and, in the case of some species, spectacular results have been achieved. Woylies and quenda increased significantly since their initial release and now occupy all areas of the sanctuary. Quenda respond particularly well to predator-free environments and breed fairly rapidly under such circumstances. Seventy-eight individual quenda were trapped during the surveys of autumn 1997, corresponding to an estimated population size (using mark-capture-release methods) of more than 160—and all this from an initial release of about 12 animals!

Numbats, too, are breeding well. As the population grows, animals are added or exchanged, to maximise genetic diversity and to reduce the likelihood of in-breeding. It seems fitting that these animals now regularly utilise abandoned rabbit warrens.

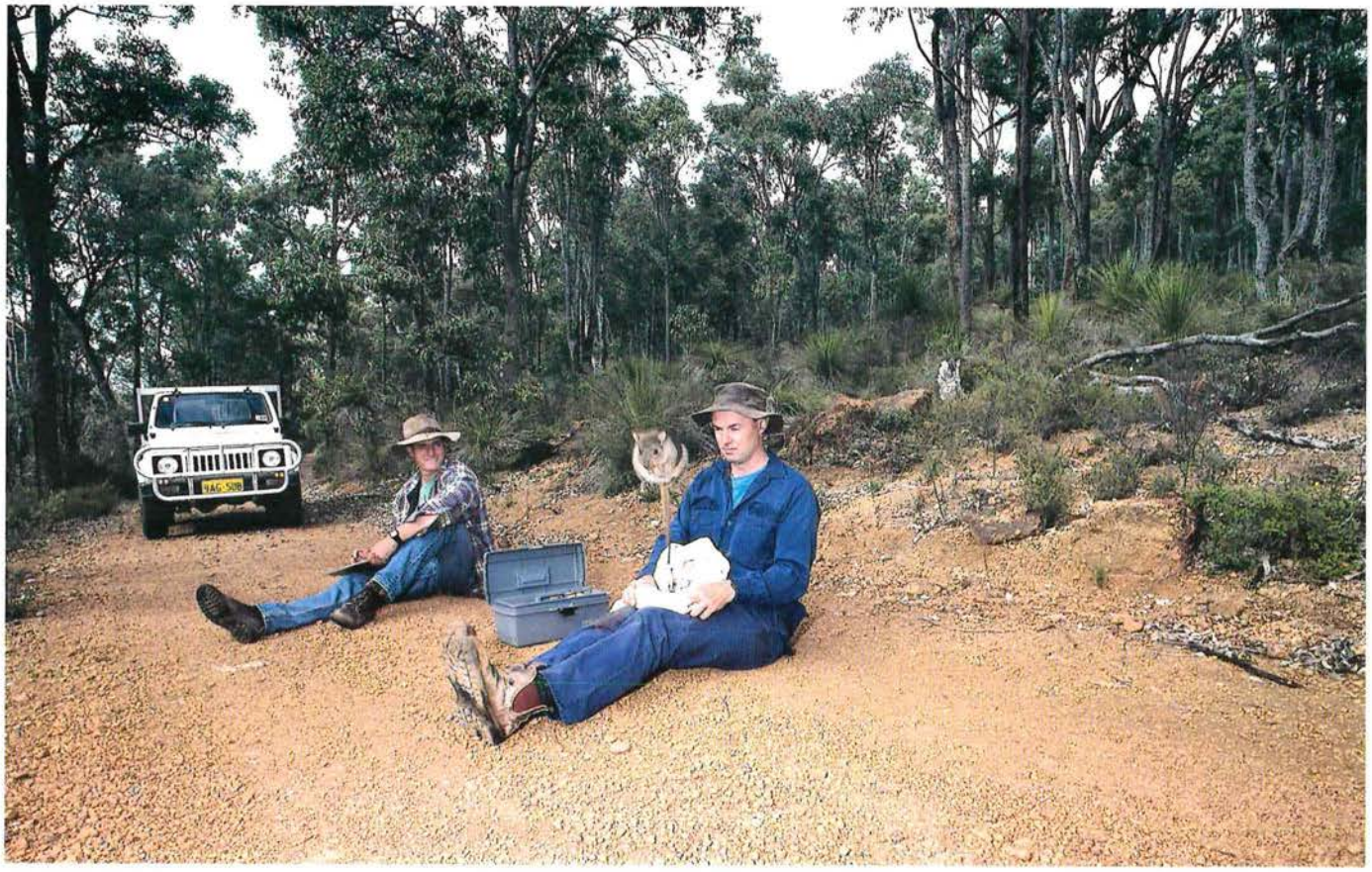
As the populations of reintroduced species have increased, individual animals have begun to occupy areas not normally associated with that species habitat. For example, quenda are normally found along creek lines or wetlands, but at Karakamia they occupy upland jarrah sites as well. It appears that fox and cat predation forces medium-sized mammals into refuge habitats; without predation, threatened native mammals can re-occupy land previously unavailable to them.

If this is the case, it is further evidence that a turnaround in the current extinction crisis facing native mammals can be achieved through fox and cat control. Another example of this is the woylie, which has recovered well at Karakamia in the absence of foxes. This mirrors the success of CALM's introduction of fox control into many areas of the jarrah forest, which has resulted in the woylie being removed from the Commonwealth and State threatened species lists.

FURTHER SUCCESS

In addition to the success of reintroduced species, there have been marked population increases in the remnant species at the site, including brushtail possums and western brush wallabies. Brushtail possums are now regularly seen on the ground—a resource that only becomes available to this opportunistic animal when fox and cat predation are abated.

Surprisingly, species not known



Woylie leaping to freedom after being trapped for monitoring.

from the area, including pygmy-possums and dunnarts, have now appeared. These species were probably always present, but in numbers too small to sample through regular pit-trapping. Since the eradication of introduced predators, they have been recorded on a number of occasions. As these two species are generally regarded as under the critical weight range of mammals susceptible to predation by foxes and feral cats, it would be interesting to test if the correlation is genuine, or coincidental and related to other factors such as climate.

The possibility of further research at Karakamia is unlimited, particularly within the confined space of the sanctuary. For example, we can ask, 'what is the carrying capacity for individual species in the jarrah forest in the absence of cats and foxes?', or 'with the planned reintroduction of tammar wallabies, how are resources partitioned between the grazers and browsers?', or 'how do predation rates relate to habitat utilisation, and will populations be self-regulating in the long-term?'

Many questions are raised in this kind of project. Nevertheless, early results are encouraging and further demonstrate the implication of fox and cat predation in the regional extinction of medium-sized ground-dwelling mammals. Furthermore, Karakamia has already achieved an important milestone in that the populations of some species within the sanctuary already offer a source of founder stock for other areas.

THE FUTURE

Clearly, private conservation initiatives are viable and have a significant role to play in the State. But it is important to afford them appropriate legislative protection so that similar projects can follow in confidence. This, in turn, will mean that privately owned havens for local wildlife can be established in the different habitats representative of the rich and diverse biological heritage of Western Australia.

Karakamia is looking toward the future with optimism, particularly with regard to long-term viability, and the establishment of affiliated projects in other areas. The sanctuary is currently establishing an education package and interpretive walk, so that visitors will soon be able to experience encounters with local wildlife on a regular basis. Indeed, Karakamia has recently been involved in CALM's Hills Forest *Go Bush!* program, and many people have experienced a preview of things to come.

Building upon its success at Chidlow, the Karakamia team is now rising to an even greater challenge of linking Walyunga and Avon Valley national parks with a privately owned and managed, predator-free wildlife corridor. The key to this project will be community involvement in fox and cat control and the revegetation of cleared areas in the scenic valleys in the hills near Perth. But that's another story for another time.

André Schmitz is the Manager of Karakamia Sanctuary and holds a degree in Environmental Management. André manages the daily operation of Karakamia. He can be contacted at the sanctuary on (08) 9572 3169.

Martin Copley is the owner and founder of Karakamia Sanctuary. He fervently believes that private sector initiatives in conservation are fundamental to preserving biological diversity and ultimately our own existence on this planet.

WATCHING THE GRASS GROW

BY GRAEME BEHN, CHRIS DONE AND ADRIAN ALLEN

The vegetation of Western Australia's north-west has suffered significant degradation since pastoralists sought the lush grasslands for stock grazing in the late 18th century. During the past 30 years people have begun to realise the extensive damage, grazing and wild cattle have had on the Kimberley's ecosystem and a number of steps have been taken to promote and foster grassland regeneration. Through the use of latest technology and satellite imagery the success of regeneration programs can now be measured.

Australia is an ancient continent. The entire history of the planet is encoded into its geological features—to the fascination of earth scientists and lay people the world over. Perhaps more than any other region, the Kimberley evokes a mood of mystery and timelessness, whispered secrets of patient evolving forces stretching for an eternity into the past. Yet barely more than a century ago, the merest drop in a bucket of geological time, the introduction of cattle onto its fragile grasslands was to wreak devastating damage, leading in the last ten years to intensive rehabilitation efforts. Now, in a still more ironic juxtaposition of the old and the new, the latest state-of-the-art technology—remote sensing using satellite images—is enabling land carers to monitor the progress of their work as never before.

THE EARLY STAMPEDE

Explorer Alexander Forrest's account of his journey from the De Grey River to Port Darwin, in 1879, inspired many pioneering pastoralists to take up vast areas of grasslands in the harsh dry climate of the south-east Kimberley. First to arrive was Nat Buchanan who staked his claim at the junction of Forrest Creek and the Ord River in 1884. With around 4 000 head of cattle owned by partners William Osmand, a mine owner from Stawell, Victoria, and Joseph Panton, a Melbourne magistrate, Nat Buchanan established the well known Ord River Station. Not far behind were the McDonalds, who bought Fossil Downs Station on the Fitzroy River and whose descendants still own and run the station today. The Durack family—well known for its long association with stations in the east Kimberley area—soon followed. As more and more pastoralists sought land, cattle numbers increased rapidly, particularly on the lush pastures of the Ord River. It took only 20 years for Ord River Station alone to reach around 80 000 to 100 000 cattle.

These pastures had previously evolved under much gentler pressure from typical Australian grazers such as kangaroos, wallabies and the grazing termites. The effects of the much harsher grazing cattle on the Ord frontage country were disastrous, as vast areas began to erode at an alarming rate. By 1967, the growing degradation had prompted the Western Australian Government to recover several grazing leases in the area. This enabled rehabilitation measures to begin so that the then new Ord River Irrigation Scheme would be less threatened by massive silting.

On the eastern side of the Ord, measures were taken to reduce stock numbers, and extensive fencing was constructed to control the remaining cattle. A great deal of work was also done to foster the re-establishment of grasses by ripping hardpan areas and seeding with pasture species. On the western side, however, no measures were undertaken to control cattle grazing until the mid-eighties, when commercial mustering and shooting from helicopters removed some 25 000 head of cattle and 4 000 feral donkeys. Some small areas of grass were ripped up to allow water penetration, but most of the eroded areas were allowed to regenerate without any ripping or seeding.

Since the area was declared the Purnululu National Park and Conservation Reserve in March 1987, the Department of Conservation and Land Management (CALM) has undertaken feral donkey and cattle control, keeping numbers to a minimum in the park. As a direct result of the removal of these hard-hoofed grazers, regeneration of grassland has been spectacular in some areas.

REMOTE SENSING

When the technology became available to them, scientists at CALM decided to use remote sensing to monitor the land management programs in Purnululu National Park.

Remote sensing is a means of collecting and interpreting information using a much broader range of the electromagnetic spectrum than that of visible light (black and white or colour photography). Using multi-spectral scanners (a particular type of remote sensing device that senses radiation in multiple wavelength regions of the visible, near infra-red, middle infra-red and thermal infra-red regions of the electromagnetic spectrum), scientists can obtain a more detailed picture of a land area, and the changes that occur to it over time, than could be provided by any conventional photograph.

Different land cover features reflect the sun's energy in varying, and often characteristic, non-visible wavelengths (such as the infra-red). Consequently, satellite sensors capable of detecting these wavelengths provide added information, beyond the visible light spectrum, which help to identify an object or land cover feature.

Multi-spectral scanning devices digitally record the reflected energy in a number of defined wavelength 'channels' or 'bands'. The principle is the same as using filters on a camera to photograph limited parts of the visible spectrum.

The information representing a predetermined area of the ground is composed of discrete picture elements,

Previous page
Gully heads eating back into areas where vegetation was largely destroyed by overgrazing. Removal of the heavy grazing pressure has allowed regeneration to occur and stability to be restored to many areas.

Below: Regeneration in this area near the Blue Holes cattle yards was aided by ripping the soil to allow easier penetration of water and lodgement of windblown seed.
Photos – Chris Done

or pixels. These are arranged into discrete brightness levels and are allocated a number between one and 255. Low numbers are associated with dark targets (for example, shadows) while high numbers are associated with bright targets (for example, white sands).

DETECTING THE CHANGES

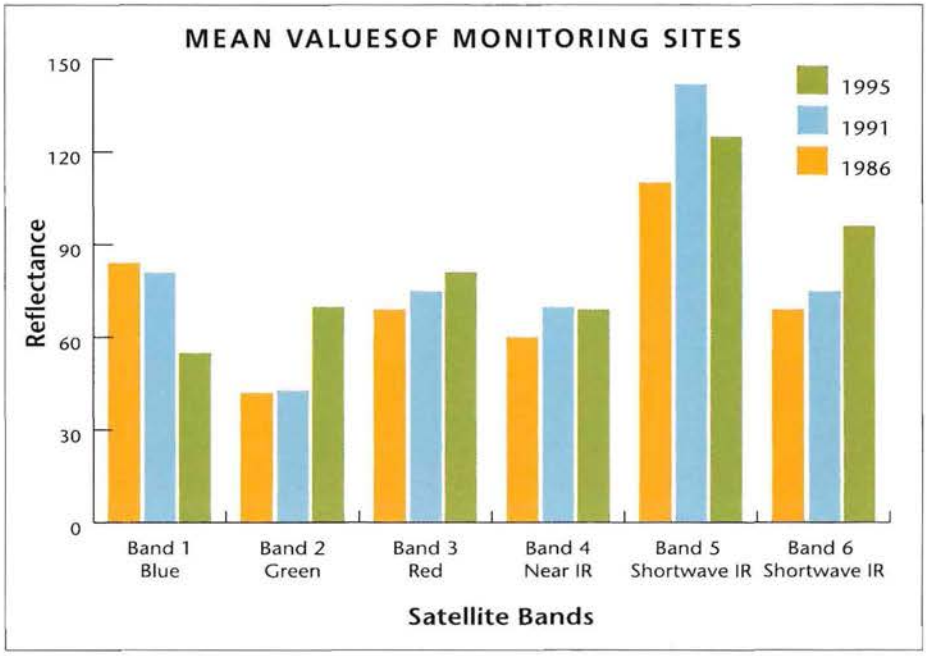
In this way, remotely-sensed data can be used as a tool to detect, monitor and evaluate changes in ecosystems, and to develop future management strategies. Its big advantage over traditional ground-based monitoring is that it provides the time sequence, the required coverage and the ground resolution needed for accurate assessment of management programs such as grass regeneration. Because satellites pass over specific areas time after time, the land in those areas can be viewed regularly and images taken to assess changes in vegetation levels.

These 'change detection' techniques were used to detect grass regeneration in the park between 1986 and 1995. The use of carefully processed historical satellite imagery enabled grass areas to be identified, giving a clear idea where vegetation cover had changed or had stablised over time.

ANALYSING THE IMAGES

The images from 1986, 1991 and 1995 (on page 26) were co-registered and calibrated to each other, and the information required to highlight the grass growth over time was extracted from them. The Purnululu National Park boundary was superimposed on the images to aid visual inspection and locational reference.

From the location of the monitoring sites, it was possible to extract the digital spectral information, which indicated the condition of each site at the time the image was captured. Information about these sites was then analysed for each of the spectral bands from the three-date image sequence, and was correlated to the site data to identify variations that might suggest that grass-regeneration had occurred. Individual bands from both the visible and infra-red portions of the spectrum showed specific spectral trends that could be used to identify grass regeneration within the national park. These spectral trends, from the three dates, could then be applied to the whole image sequence to determine the regeneration of similar grass types.



Above: About 25 000 head of cattle and 4 000 donkeys have been removed from the park since 1985.
Photo – Chris Done

The graph (above) clearly shows that the bands in the visible light portion of the spectrum (bands 2 and 3) and the short-wave infra-red (band 6) correspond well with the grass regeneration. The green part of the spectrum (band 2) indicates a similar increase to that of the red part of the spectrum (band 3). In broad terms, these increases can infer an increase in leaf pigment cover, but the significant spectral band is band 6. This band shows similar increases over the three image dates and represents a general increase in ground cover with less exposed soils.

BACK ON THE GROUND

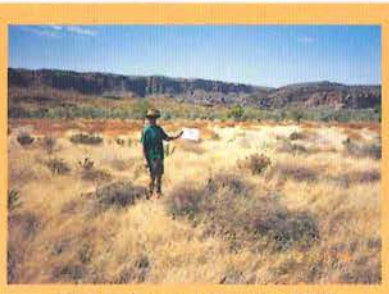
Several ground-based sites were also established within the grasslands to monitor the impact of grass regeneration after de-stocking. The program was principally based on the measurement of perennial vegetation on selected small sites that were visited each year. Although this ground-based site data is much more difficult to gather and monitor than the satellite information, it does provide tangible visible information with which to compare the satellite imagery.

WHERE NOW?

It will take more than a decade or two to mend the damage of more than a century of grazing. Regenerating grasses is not a finite project with a clear beginning and end. Like the slow evolution of a landscape itself, it is a continuous process. But this is a patient landscape. Satellite imaging and remote sensing enables us to watch the process unfold, moment by moment, and to marvel at both the technology of the toolkit and the awesome slow processes of nature to which it is being applied.

A) Bare ground from 1986

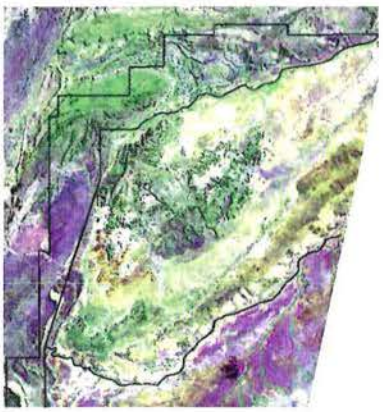
B) Partial grass regeneration 1990

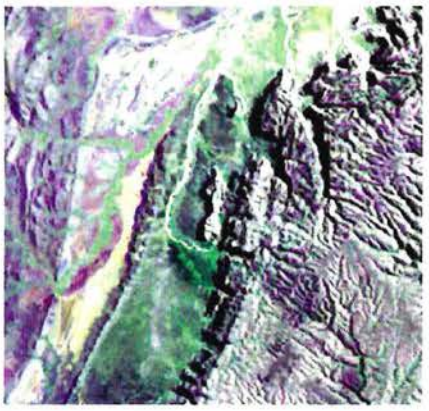


C) Good grass recovery 1996

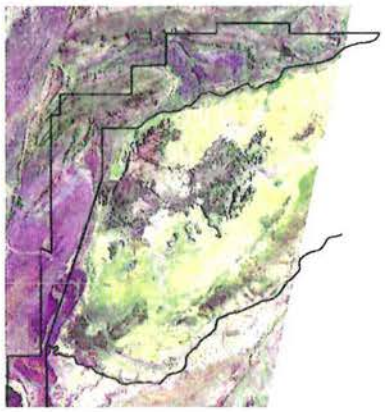
From the sequence of ground photography it is possible to show the grass regeneration achieved.
Site data indicates the positive results of the de-stocking program within the park.

1986

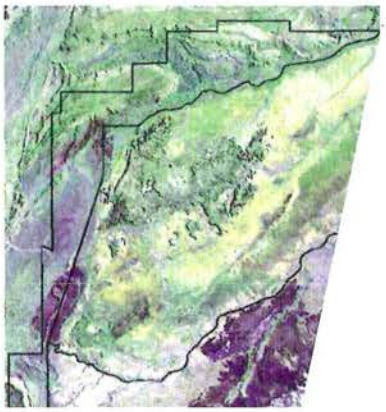




1991



1995



Facing page: Imagery that covered the park was acquired during the dry seasons of 1986, 1991 and 1995. The imagery was co-registered and calibrated so that areas of change or modification to vegetation surface characteristics, over the nine-year time period, could be assessed.

Below: The final satellite image of the Purnululu National Park shows the application of the results. The increased grassland change (shown below in yellow) was overlaid onto the 1995 image to give the visual impact of the success of the regeneration program. The location and extent of grass regeneration along the river frontage is clearly evident. The area was then assessed for accuracy by field site inspection and from ground knowledge.

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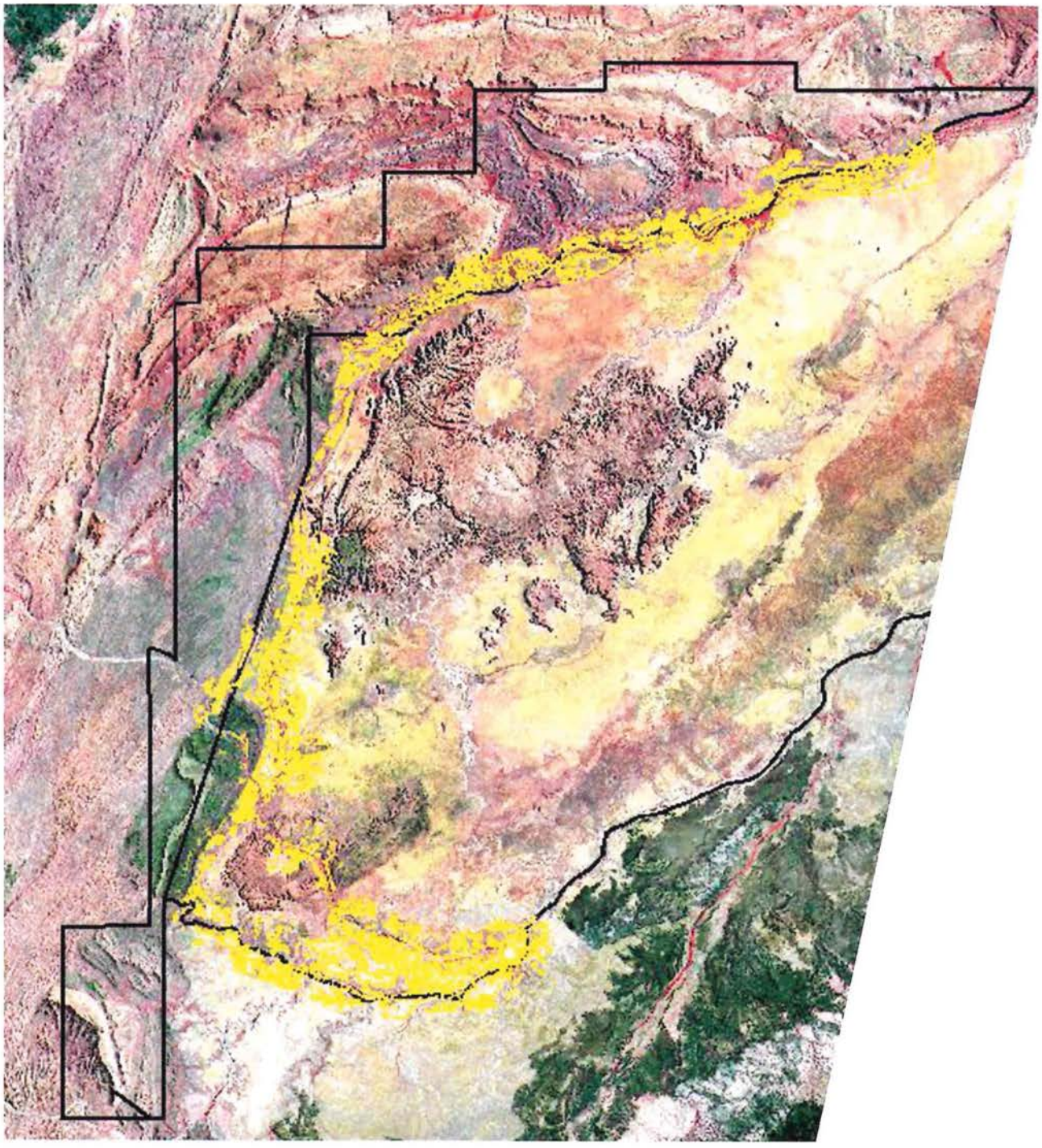
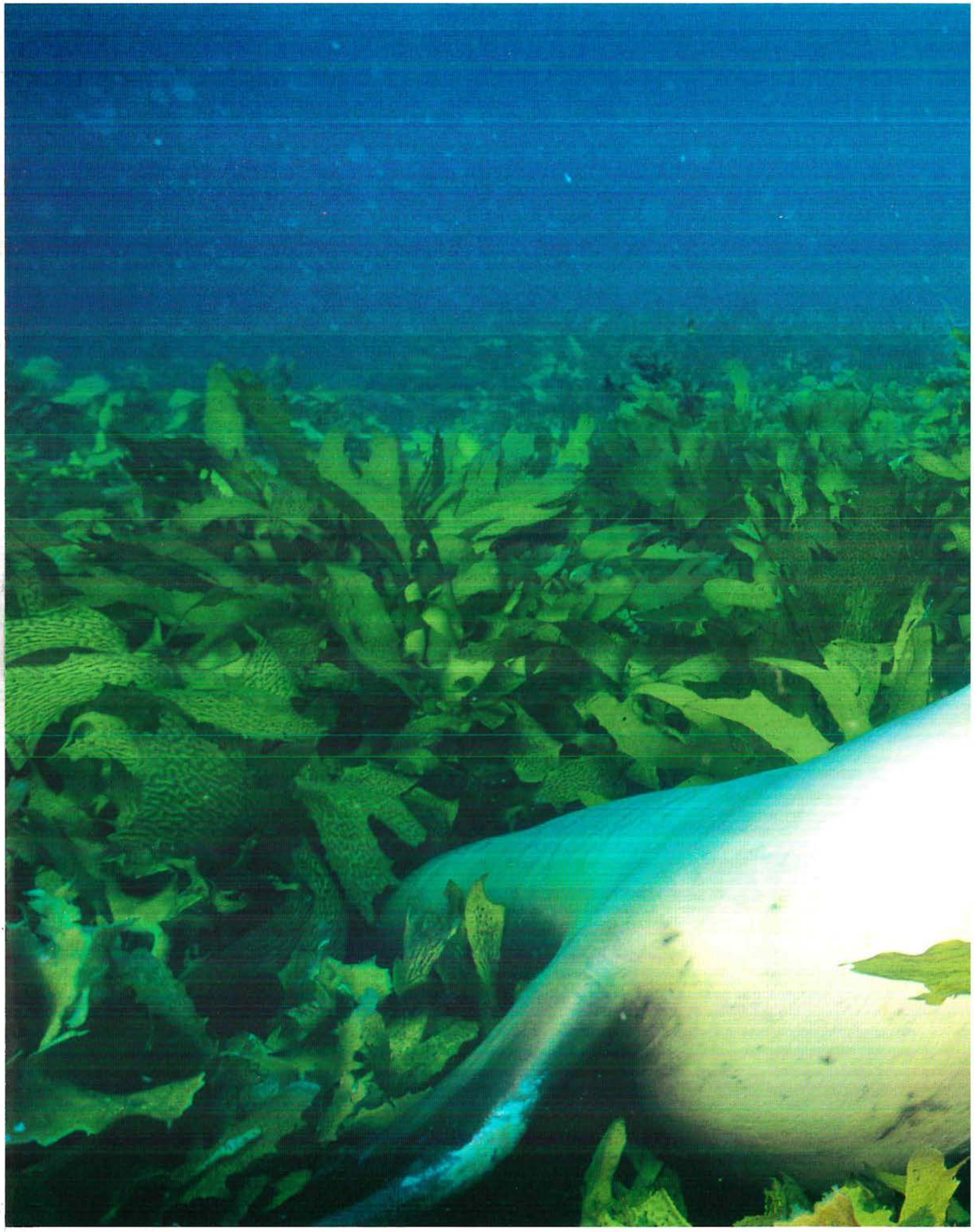
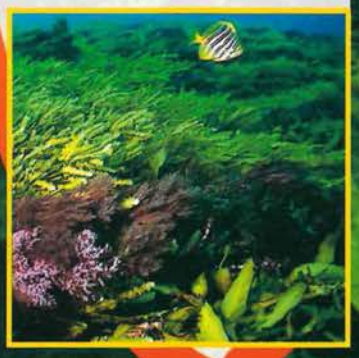




Wonders of our Southern Seas

Western Australia's south coast region is famed for its diversity of wildflowers, and remote and spectacular landscapes. Although the region has some of the State's oldest and largest national parks, and an extensive system of nature reserves, little was known about the marine environment.

Now, a detailed marine biological survey of the area has produced some outstanding results.



A MARINE SURVEY OF THE FITZGERALD REGION

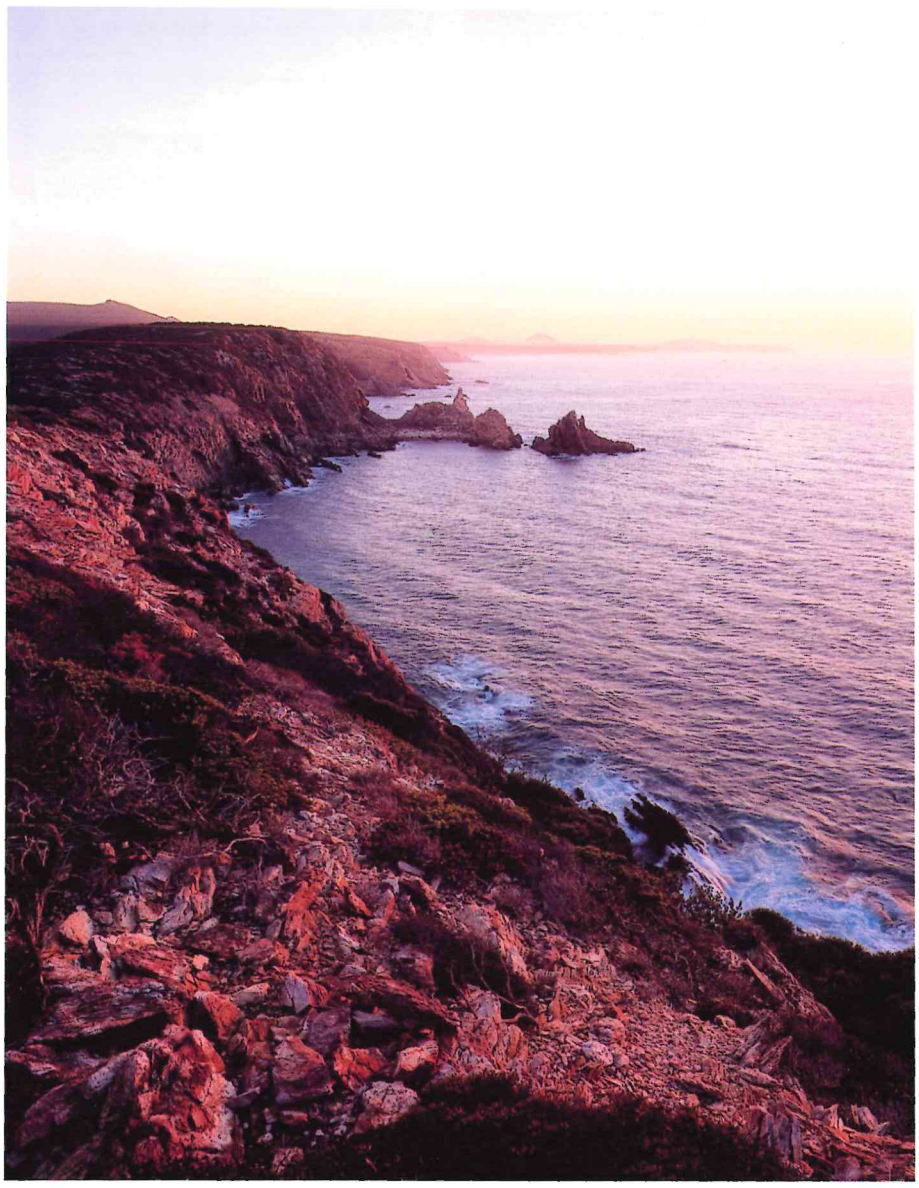
by Jeremy Colman

Western Australia's south coast is remote and sparsely populated, and bears the full force of the Southern Ocean. For much of the year, the shores are pounded by heavy swells, generated farther south in the Roaring Forties. Most of the coastline consists of south-facing headlands and beaches exposed to strong wave action, and bays that are wide and open to the prevailing swell and winds. Consequently, this is a dangerous stretch of coastline with few areas where vessels can shelter from bad weather, or anchor in safety. However, relatively calm seas can occur in late autumn and early winter, thus creating occasional opportunities when the inshore waters are easily accessible to small boats and conditions are suitable for exploring the underwater habitats.

In March 1997, the Department of Conservation and Land Management (CALM) mounted an expedition to survey the inshore waters across about 250 kilometres of coastline between Starvation Boat Harbour (east of Hopetoun) and Groper Bluff (west of Bremer Bay). The CALM-led team included marine scientists from the Department's Marine Conservation Branch, Murdoch University and Edith Cowan University, two marine ecologists from the University of Tasmania, a shrimp biologist from Sweden, a professional underwater photographer, support staff and volunteers. The MV *Sea Lion,* a large fishing and diving vessel from Esperance, was chartered for a period of two weeks to provide living quarters and to serve as the diving and working platform for the expedition.

OUT FROM THE BIOSPHERE

The area chosen for the survey included the inshore waters adjacent to Fitzgerald River National Park. The park is one of the richest and most significant areas for plants and animals in Western Australia. It forms the 'core' of the larger notional Fitzgerald Biosphere Reserve, one of 12 internationally recognised biosphere reserves in Australia (see *LANDSCOPE,* Spring 1997). Its status was originally granted because of the park's extremely high floral diversity (it contains 20 per cent of the State's described plant species). In 1994, the Marine Parks and Reserves Selection Working Group, in its report *A Representative Marine Reserve System for Western Australia*, recommended that the coastal waters adjacent to Fitzgerald River National Park should be considered for reservation, as a part of a Statewide system of marine protected areas. A key step in the process of establishing a marine reserve is to assess the conservation values of a candidate area, and this includes gathering information on the biological, economic and cultural attributes of the proposed reserve.



Previous page
Main: Australian sea lion
Inset: (from top) Western cleaner clingfish on a sponge; silver drummers in a cave; and a variety of seaweeds.
Photos – Eva Boogaard

Above: Seaweed-covered granite boulders in the intertidal zone at Bremer Bay.

Left: Sunrise over schist and quartzite cliffs in the eastern part of Fitzgerald River National Park.
Photos – Bill Belson/Lochman Transparencies

Researchers photographing some of the invertebrate life in a kelp bed.
Photo – Eva Boogaard

The objective of this expedition was to carry out a detailed survey of the marine plants and animals in coastal waters adjacent to the Fitzgerald Biosphere Reserve, and to examine the biological diversity of the seabed communities. This survey forms part of a major project, undertaken by the Marine Conservation Branch in conjunction with CALM's South Coast Region. It is funded by Environment Australia under the National Reserves System Cooperative Program, which is investigating relationships between the terrestrial, estuarine and marine environments across the south coast. While there are no existing marine reserves on the south coast at present, the project will provide recommendations on the integrated management of any adjoining terrestrial and marine reserves in the future.

COASTAL TYPES

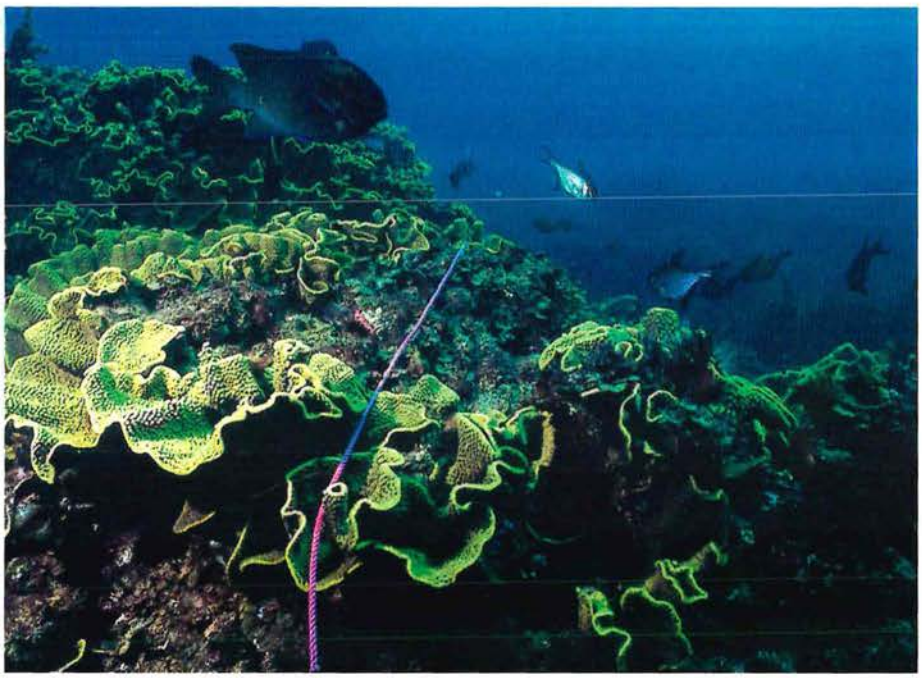
The coastline covered by the survey broadly consists of four distinct coastal types. The first area, which is also the most eastern, stretches from Starvation Boat Harbour to the mouth of Culham Inlet. It comprises limestone shores with narrow reefs and platforms running parallel to the shore. In the second zone, along the eastern part of the Fitzgerald River National Park, the schists and quartzite rocks of the Mount Barren Ranges extend right to the sea, resulting in precipitous cliffs and rocky shores.

The third coastal zone stretches from the mouth of Dempster Inlet south to Doubtful Island Bay. Here, there are a series of wide bays with sandy beaches, generally protected from the prevailing south-westerly swell. This area is characterised by a shallow-shelving, sandy seabed and extensive seagrass meadows beyond the surf zone. Southern right whales (*Eubalaena australis*) are frequently seen in this area during winter and spring, particularly in the sheltered waters around Point Ann and Point Charles. In recent years, a seasonal whale watching industry has developed in the area, which is being enhanced by the sighting of increasing numbers of humpback whales (*Megaptera novaeangliae*) in the same area during the winter months.

The fourth section of coastline, from the Doubtful Islands to Groper Bluff, consists of a series of granite headlands. The headlands are often separated by small curved bays and sandy beaches, such as those seen in Bremer and Dillon Bays. They are exposed to the open ocean swells and have steep cliffs and wave-swept slopes. Granite boulder fields often occur on the more sheltered sides of the headlands, and there are a number of deep offshore reefs with steep or vertical sides. The seabed around Point Hood and the Doubtful Islands drops away steeply to depths of 50 metres or more a short distance from the shore. These very different coastal types provide a variety of habitats for marine plants and animals.

COUNTING AND COLLECTING

Forty-two sites, on limestone reefs, seagrass meadows and granite slopes and boulder fields, were investigated during the expedition. The selected sites were generally shallow, ranging from 5–12 metres in depth. Site depth was largely limited by the divers' air consumption rates, and the number of tasks that had to be carried out at each site. On arrival at each location, the MV *Sea Lion* anchored offshore and a team of divers was ferried inshore to the site, using an inflatable dinghy. Once the exact location had been determined, a 200-metre weighted and scaled rope was laid across the seabed from the inflatable. The task of the first pair of divers entering the water was to swim the length of the survey line and record the number of large fish species seen in an area five metres either side of the line. An estimate of the length of each fish was also recorded. Next, a second pair of divers swam along the line, searching through the weed and kelp on the bottom, recording the number of small fish and bottom-dwelling animals, such as sea stars, urchins, sea cucumbers, snails, crabs and lobsters, found within



one metre of the line. Samples of some plants and animals were collected for later identification back on the MV *Sea Lion*, and some were also preserved to form a reference collection.

The percentage cover of different species of seaweed was also recorded at a number of set points along the line. In seagrass meadows, once a census had been taken of large fish swimming across the top of the meadow, a diver swam along the length of the survey line filming a one-metre-wide strip of the meadow using an underwater video camera. This footage will be used to determine the percentage cover of the different species of seagrass. Seagrass samples were also collected from each site to investigate the productivity, or 'health', of the meadow. This information will provide useful comparisons with data from meadows across the south coast, such as those in Two Peoples Bay and around Albany. At each site, photographs and video footage were taken of the most visually striking plants and animals. One site, on the western side of Dillon Bay, provided excellent diving and spectacular video footage, including shots of a giant cuttlefish (*Sepia apama*), a huge school of swallowtails (*Centroberyx lineatus*) and several western blue devils (*Paraplesiops meleagris*), a striking fish covered in iridescent blue spots.

SWELL AND SURGE

Strong south-easterly winds and heavy swells during the first week of the expedition prevented the team from investigating the limestone reef area along the exposed stretch of coastline east of Hopetoun. It is hoped that this part of the coast can be visited during a future survey. Heavy bottom surge at some of the shallow sites occasionally made working conditions difficult—sometimes it was necessary to hang on to kelp or rocks to

Top: The CALM-led marine research team preparing to survey a site.

Centre: (left) Reeling up the survey line on completion of sampling. (right) Collecting seagrass samples to estimate productivity.

Left: The survey line crossing a patch of 'cabbage' coral (*Turbinaria* sp.). Photos – Eva Boogaard

avoid being washed away from the survey line. Generally, the conditions were very good, with warm clear water and little current movement at most sites. Unexpected problems included curious Australian sea lions (*Neophoca cinerea*), who sometimes played 'tug-of-war' with divers trying to reel up the survey lines. One particular individual, obviously very interested in the information the divers were recording, took to coming right up and placing its nose on the top of the underwater slate as a diver was trying to write on it! The sea lions were much less timid than the more numerous New Zealand fur seals (*Arctocephalus forsteri*), which generally kept their distance. Both of these species are listed under the State's *Wildlife Conservation Act* as species that are in need of special protection.

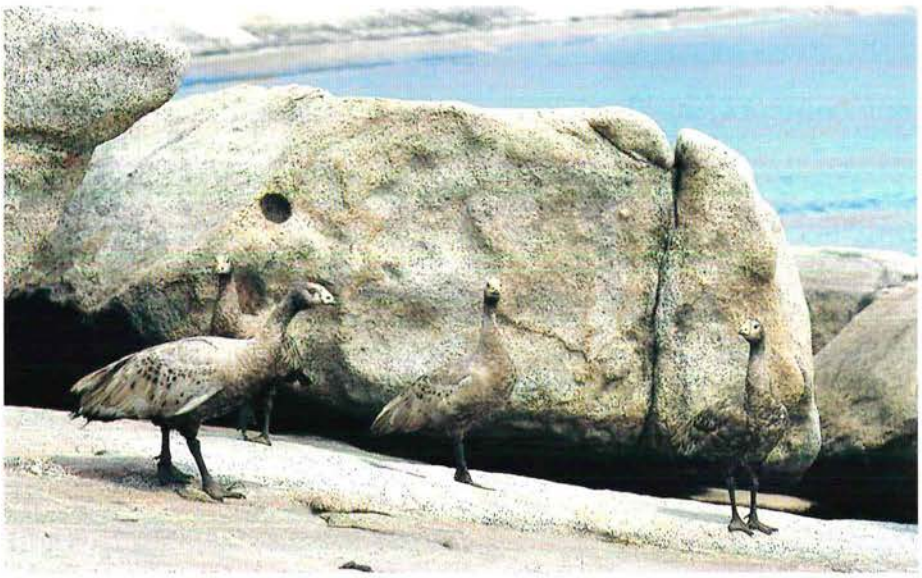
The exposed granite reef sites are characterised by a heavy cover of kelp (*Ecklonia radiata*) and other brown seaweeds (particularly *Cystophora* and *Sargassum* species). These plants need light to photosynthesise, but here they grow at depths down to 30 metres or more, as a result of the clear inshore waters of the south coast. No major rivers run directly out into the sea in this region. Most of them discharge into inlets or estuaries that are either seasonally barred, or open to the sea only once every few years. Very low sediment inputs from rivers mean that there is generally little suspended material, contributing to high water clarity.

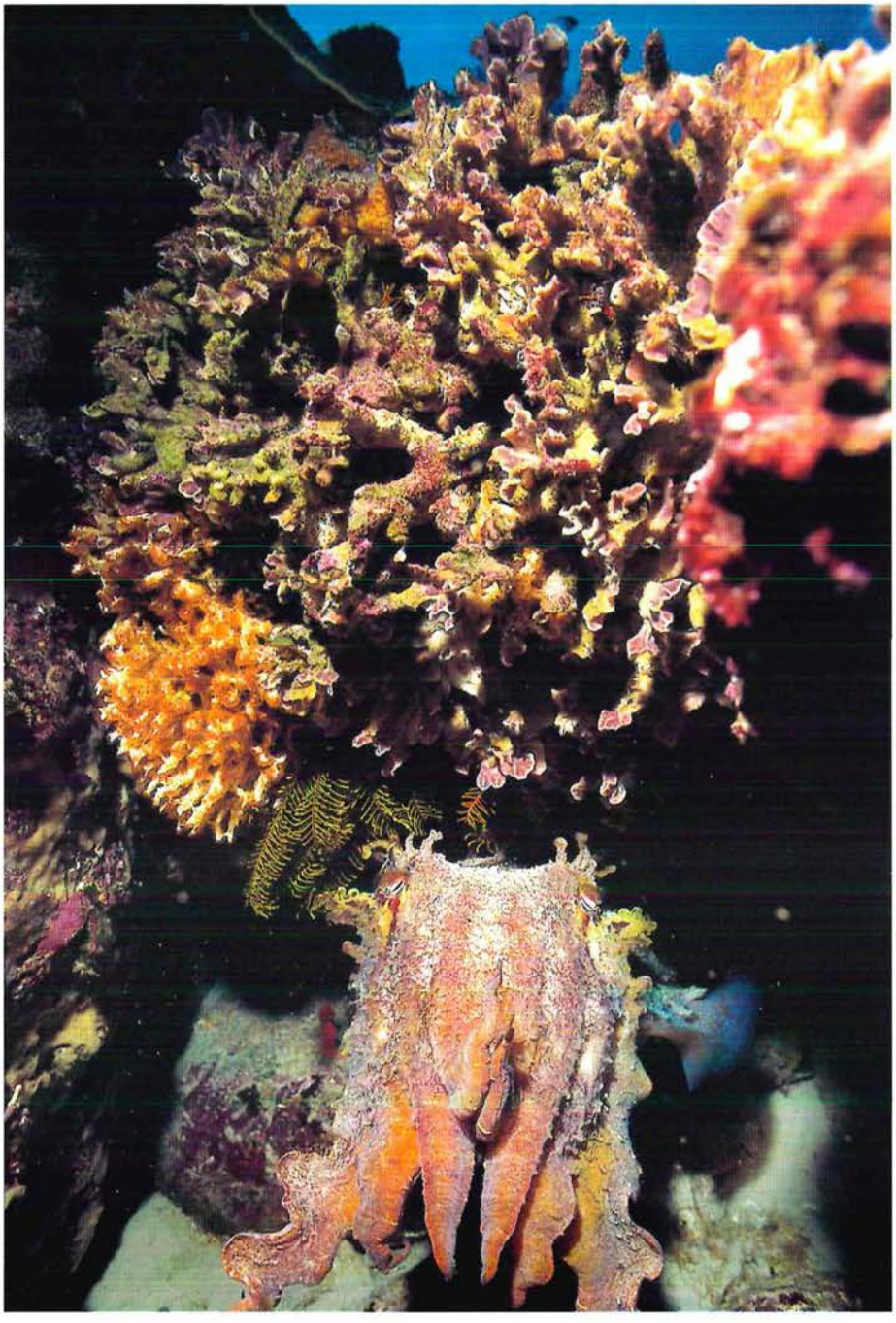
Below 30 metres or so, as light is filtered out, dense communities of sponges, sea squirts, fan corals and soft corals replace the seaweeds. Any rock surface, particularly the vertical walls of boulders and crevices, is covered in spectacular and colourful displays of these diverse animals.

The more sheltered sites on the western side of headlands were inhabited by large colonies of 'cabbage' coral (*Turbinaria* species). These impressive, multistorey structures, up to three metres in height, shelter a variety of fish, including large western blue groper (*Achoerodus gouldii*), harlequin fish (*Othos dentex*), small but colourful, black-headed pullers (*Chromis klunzingeri*) and schools of bullseyes (*Pempheris* species). Other fish commonly encountered over weed and seagrass patches surrounding the

Above: A variety of sponges in different colours and growth forms encrust the granite rocks.

Below: The black-banded seaperch was one of a large variety of reef fish recorded during the survey.
Photos – Eva Boogaard





coral heads included queen snapper (*Nemadactylus valenciennesi*), old wives (*Enoplosus armatus*), toothbrush leatherjackets (*Acanthaluteres vittiger*), herring cale (*Odax cyanomelas*) and the familiar silver drummer or buffalo bream (*Kyphosus sydneyanus*).

DIVERSE AND UNIQUE LIFE

Australia's temperate marine environments have some of the highest levels of biodiversity in the world. High proportions of the plant and animal species are not found anywhere else. The temperate coastal waters on the south of the continent have much richer and more diverse floral communities than those of the tropical waters of Australia. An illustration of this is that about 1 155 species of green, brown and red seaweeds have been recorded in temperate waters, about three times the level recorded in Australia's tropical regions. The high levels of biodiversity and endemism in temperate coastal waters mean they are particularly important from a global conservation perspective.

The expedition recorded more than 300 species of marine plants and animals from the nearshore waters adjoining the Fitzgerald Biosphere Reserve. Preliminary analysis of the results indicates that this area has very rich and diverse marine plant and animal communities. In general, the species found were typical of warm-temperate waters, the northernmost limit of their range usually being the reefs of the Houtman Abrolhos Islands or Rottnest Island. A small number of subtropical species were also recorded, including fish such as the western king wrasse (*Coris auricularis*) and Woodward's pomfret (*Schuettea woodwardi*), both of which range from Shark Bay south to the Recherche Archipelago, east of Esperance. The presence of these subtropical species on the south coast is probably a result of the warm Leeuwin Current, which moves

Above left: The offshore islands of this remote coastline support populations of the Recherche Cape Barren goose.
Photo – John & Val Butler/Lochman Transparencies

Left: A giant cuttlefish (*Sepia apama*) rapidly changes colour to blend in with its surroundings.
Photo – Eva Boogaard

south down the west coast of Western Australia, round Cape Leeuwin and eastwards across the south coast into the Great Australian Bight. This current, strongest in winter and early spring, probably assists in the dispersal of some subtropical species (such as the hard coral *Turbinaria*) farther to the south and east of their normal ranges.

Outstanding features of these nearshore waters include abundant numbers of some large fish species, such as the western blue groper and queen snapper. This was particularly the case in granite reef areas. Large specimens of these species, highly prized by recreational fishers, have been greatly reduced or have largely disappeared from heavily fished temperate reefs elsewhere in Australia. Commercially important species, such as the greenlip abalone (*Haliotis laevigata*), were also reasonably abundant throughout the area. Comparisons with similar temperate areas in other parts of Western Australia and elsewhere suggest that this part of the south coast is relatively undisturbed by human activities, probably due to the isolated and exposed nature of much of this coast. The survey confirmed the high conservation status of these waters suggested by the Marine Parks and Reserves Selection Working Group.

REMOTE ISLANDS

The opportunity was also taken to visit a number of small offshore islands and isolated parts of the mainland. At these locations, team members counted seabird, seal and sea lion populations. These surveys had two significant outcomes—firstly, a rare sighting of two mature male sub-Antarctic fur seals (*Arctocephalus tropicalis*), and secondly, the verification of a reported haul-out site for New Zealand fur seals on the mainland. Both adults and pups were found, meaning that this site, at Cape Knob, could be a breeding site. If this were so, it would make it the first confirmed breeding location for this species on the Western Australian mainland. Sightings of the threatened Recherche Cape Barren goose (*Cereopsis novaehollandiae grisea*) were also recorded from Red Island, an isolated outcrop offshore from the central wilderness area of the Fitzgerald River National Park (see *LANDSCOPE,* Spring 1993). The expedition also visited Investigator Island, a remote horseshoe-shaped island 25 kilometres from the coast to the east of Starvation Boat Harbour. The island, rarely visited other than by the occasional fishing vessel, has two northward pointing arms that form a protected natural anchorage. It is home to a colony of New Zealand fur seals and is also a breeding site for Australian sea lions.

Spectacular granite cliffs and boulders are typical of the coastline around Bremer Bay and the Doubtful Islands.
Photo – Eva Boogaard

NEW AND UNUSUAL SPECIES

Significant results of this first detailed survey included the discovery of a shrimp species that is new to science, and of another species of shrimp that may be a new record for Australian waters. A number of the sponges collected may well prove to be undescribed species. Another important result was the discovery of a specimen of the rarely seen large-tail cardinalfish (*Vincentia macrocauda*). Only a handful of specimens of this fish have been collected, most of them from the south coast by Dr Barry Hutchins from the Western Australian Museum. The specimen collected during this survey was unexpectedly found inside a sea squirt, where it might have taken shelter when disturbed by divers.

Overall, the survey was a resounding success, mainly due to the collaboration between CALM and marine scientists from Western Australia, interstate and overseas, who provided an extremely high level of expertise. This approach provides an appropriate model for future investigations of the State's marine environment that will be undertaken by the Department's Marine Conservation Branch.

As the MV *Sea Lion* headed west towards Albany on the last day of the survey, the expedition members and crew were treated to a glorious day with a cloudless blue sky and calm seas. The spectacular, diverse and relatively untouched marine environment of the Fitzgerald region, combined with its wealth of marine wildlife, offers considerable potential for future diving and marine nature-based tourism activities. Expedition members have brought home lasting impressions of a profusion of underwater life and outstanding underwater scenery, mirrored by a stunning backdrop of granite monoliths and the rugged outlines of the Mount Barren Ranges.

Jeremy Colman is a marine ecologist with CALM's Marine Conservation Branch. He has 15 years experience in marine research and management, which has included studying deep sea communities in the north-eastern Atlantic and 30 months at an Antarctic base as a marine biologist for the British Antarctic Survey. He can be contacted by phone on (08) 9432 5110 or by email to jeremyc@calm.wa.gov.au.

BY LIZ BARBOUR

Breeding better Blue Gums

Since the breeding of the Western Blue Gum, scientists at the Department of Conservation and Land Management have been working continually to improve its quality through artificial cross-pollination. The results so far have been better than expected.

For years, scientists at the Department of Conservation and Land Management (CALM) have been searching for the ideal plantation tree—one that will grow quickly and economically to produce high quality pulpwood for the paper industry. In 1980, attention focused on the Tasmanian bluegum (*Eucalyptus globulus*) and after planting trials at Busselton, Manjimup and Dwellingup showed promise, CALM embarked on a full-scale program to develop a new breed of tree to suit Western Australian conditions. The project was successful and the 'Western Blue Gum' was born. (See 'The Western Blue Gums are here', *LANDSCOPE*, Summer 1994-95).

CALM's research scientists are not resting on their laurels, however. They aim to refine further the genetic stock of their new tree in much the same way that agricultural scientists continually improve cattle and sheep breeds, by the controlled breeding of superior individuals.

In recent years our understanding of the science of genetics has progressed rapidly. Many of its new techniques and tools are extremely complex and 'high tech', such as those used in mapping the genes in plant and animal cells, while others are relatively simple such as the one described here, a new method for streamlining controlled pollination. Our new technique, simple and practical as it is, speeds up the discovery process by reducing costs and allowing for greater numbers of operations and replications to be undertaken. The breakthrough is that our controlled pollination method allows for every single flower on a superior tree to be utilised for seed production, however few flowers there might be. It is also quick and easy, and produces more seed per capsule than traditional methods.

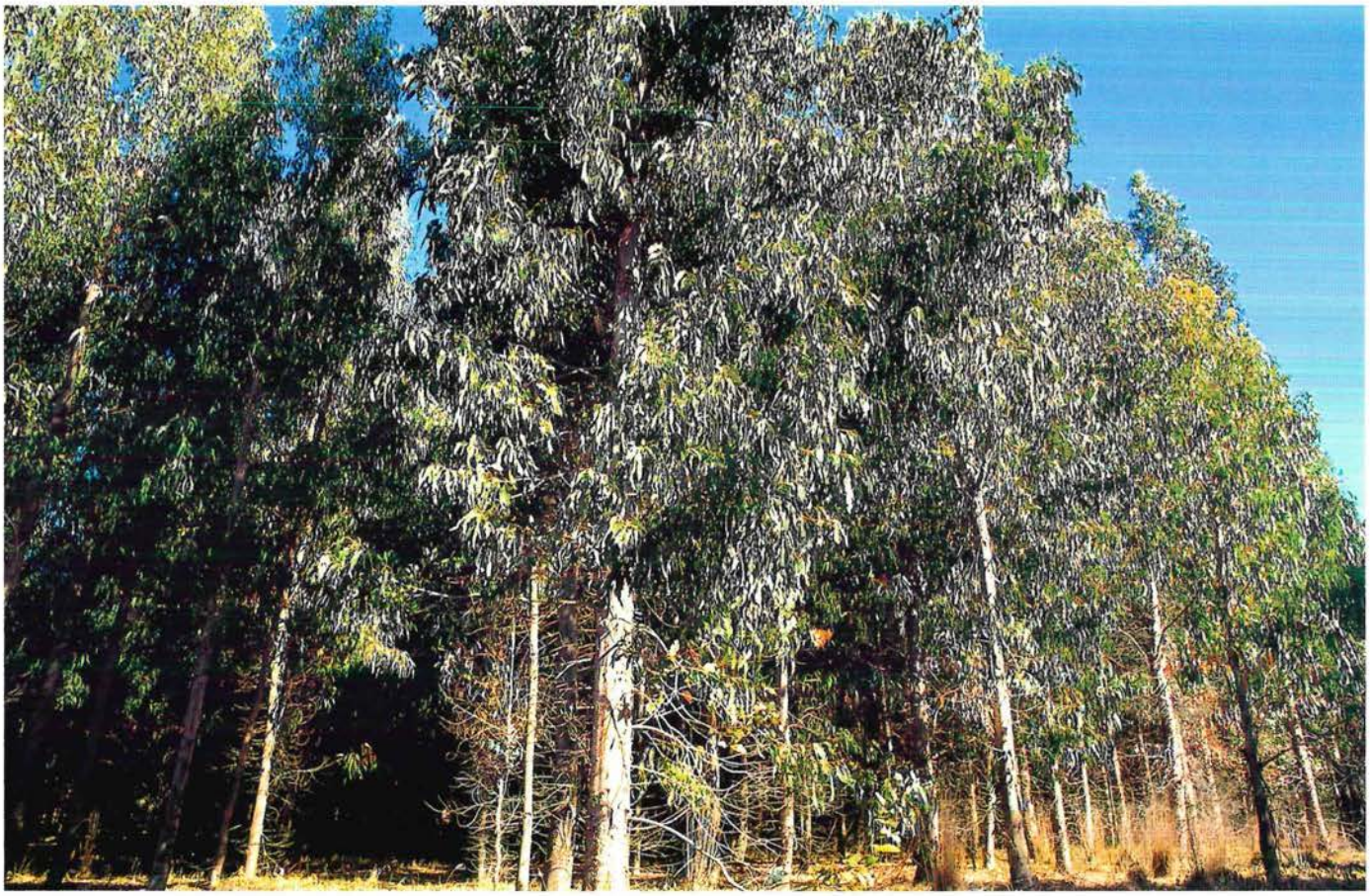
The controlled pollination process is essential if scientists wish to achieve the greatest possible genetic gains from trees selected with a range of desired qualities, including greater height, straightness of bole or faster growth rates. It is carried out by manually fertilising the female parts of the flowers of one outstanding tree with the (male) pollen from another outstanding tree to produce seed with superior qualities of both parents. It is of the utmost importance that unwanted pollen from other trees is kept well away from the female flowers that are to be fertilised.

Previous page
Western Blue Gum seedlings growing in the CALM Manjimup nursery.

Below: A plantation of mature bluegums. The Western Blue Gums will produce more uniform trees, with greater wood volume.
Photos – Marie Lochman

ARTIFICIAL POLLINATION—OLD STYLE

The classic artificial pollination method involves isolating a number of flowers on a whole branch of the tree. In the case of *E. globulus*, with its large flowers, this has proved to be inefficient and wasteful as only one or two flowers can be used on a branch of 10 or more. Previously opened flowers and buds still to open, have to be removed to prevent their pollen contaminating the 'ripe' flowers that are to be artificially pollinated. A 'ripe' flower is recognised when the operculum or bud cap separates from the base of the bud and can be lifted off with the fingers.

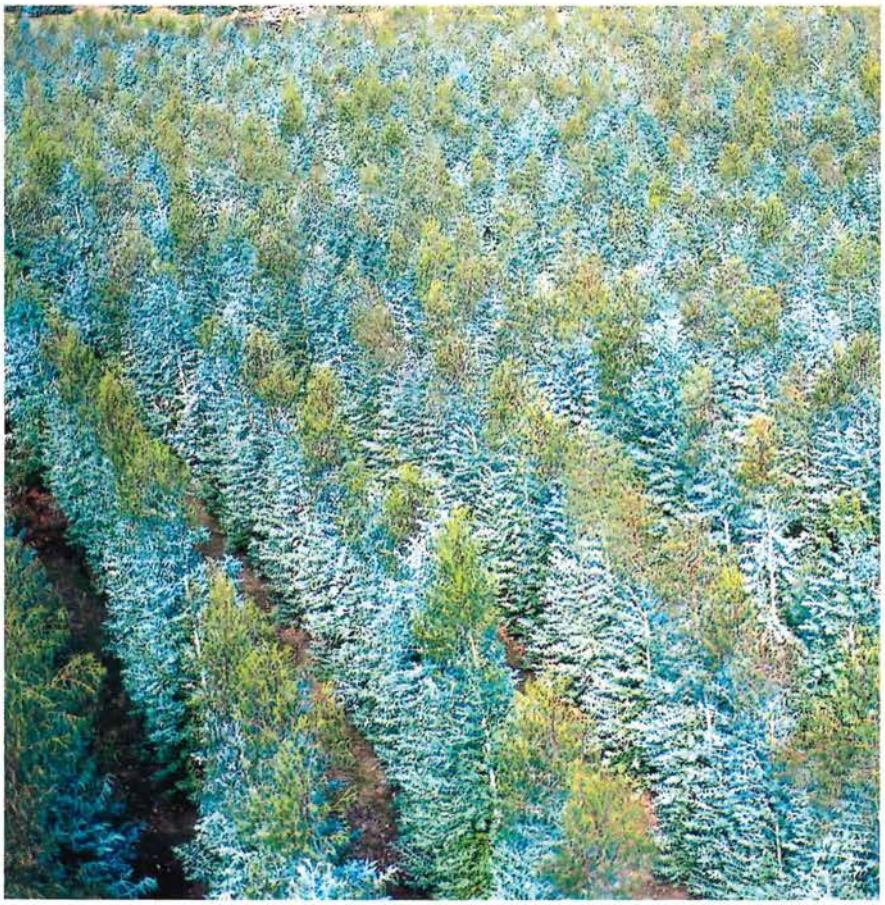


Right: Open flowers of *Eucalyptus globulus* with the yellow anthers attracting the insect pollinators.

Below right: Buds and control-pollinated flowers at various stages in the process. Daily visits to a flowering tree are needed to ensure all flowers are used for control pollination.

Far right: The technician for the Genetic Deployment Unit, Nic Spencer, in the accelerated orchard, control-pollinating the flowers.
Photos – Liz Barbour

Below: A young plantation of blue gums.
Photo – Jiri Lochman



The technique involves first the careful removal of the pollen, contained in anthers of each of the 'ripe' flowers. Following this, the exposed female parts of the flowers, the styles, are washed with water to remove any contaminating pollen. The whole branch is then isolated by encasing it in a wire frame covered by an isolation bag, sealed tightly at both ends. The frame keeps the bag material from damaging the styles, while the isolation bag material is designed to stop insect entry but allow air and heat exchange. This ensures the environmental conditions inside the bag are similar to those experienced by flowers in the open. After four to seven days, depending on weather, the bag is opened at one end and the pollen from the selected 'father' tree is applied to each female stigma using a matchstick. The stigmas are recognised as receptive when they turn red and exude a sticky substance which will stimulate pollen germination. The bag is then resealed for a week or two while the fertilisation process takes place and is then removed to allow the maturation of the seed capsules.

ARTIFICIAL POLLINATION—NEW STYLE

The new single flower artificial pollination method was developed for the 'accelerated orchard'. Created of grafted plants from the best Western Blue Gum selections, this seed orchard is managed to produce earlier flowering and accelerated seed production. The grafts are potted to restrict root growth as this promotes earlier flowering than normal. In addition, a growth-retardant chemical, paclobutrazol, is applied to trees to stunt their growth, which has the added effect of stimulating flowering. The trees are purposely kept stunted to allow scientists easy access to the flowers for controlled pollination work. However, a side-effect of stunting is a reduction in the number of flowers as the trees' food supplies cannot support large flower numbers. As the pace of breeding and genetic deployment programs is determined by the number of crosses made and the amount of seed produced by controlled pollination, it was necessary to find a pollination method in which every flower could be used.

A number of methods to isolate single flowers were tried. Bagging the individual

flowers with various materials was time-consuming and it was difficult to stop the bag material from rubbing against the styles and stigmas and damaging them. In Tasmania, tree-breeders tried gluing straws over the style, but this time-consuming process also met limited success. CALM staff developed the idea of using a very small plastic tube to protect the style and stigma from unwanted pollen contamination and found this method to have the greatest success.

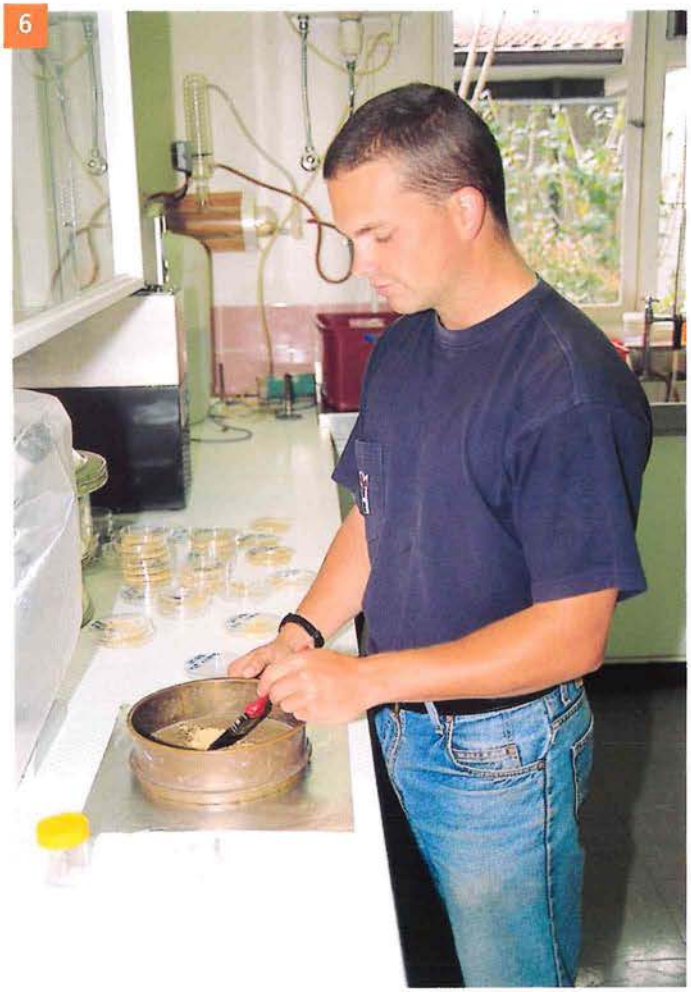
The method is simple. Every flower can be used as it becomes ripe. The bud cap is removed, the anthers are cut and collected for pollen extraction and the exposed style and stigma are washed to remove any contaminating pollen. A plastic tube, pinched closed at the apex, is then placed snugly over the style. These tubes need to be available in different sizes as style shape can vary between different Western Blue Gum clones. Each pollination is identified by a number scratched into a soft aluminium tag tied to the branch just below the flower and the details are recorded in a computer database system.

After a day or two when the stigma is receptive, the tube is removed and selected pollen is applied. The tube is then replaced. It appears to hold the pollen at the stigma surface, an advantage as the pollination program is carried out in winter, when wind and rain are more common. To indicate flower pollination the aluminium tag is folded in half. When the fertilisation process has taken place and the capsule is swelling in size, the style shrivels and falls off together with the tube. The seed capsule remains with the tag to be collected nine months later.

The success of this artificial pollination process is not only determined by the method but also by the quality of the pollen applied. Pollen will fall from the anthers within 24 hours of the flower opening. To ensure that majority of pollen is collected, the anthers are collected from the flowers in a sterile petri dish as the flowers are cleaned for control pollination. In the laboratory the anthers are dried in a desiccator to reduce or remove any risk of fungal contamination. Drying also makes the pollen easier to separate from the anthers through a sieve. The clean pollen can then be stored in small air-tight vials and checked for its viability.

The method used to check pollen viability involves assembling sterile plates which contain a solidifying agent together with a sucrose and boron mix. The sucrose-boron mix mimics the exudate produced by the receptive stigma and stimulates the pollen to germinate. Viable pollen will germinate after 24 hours incubation and can be observed under a scanning electron microscope.

We have produced as many as 92 seeds from a single capsule using the single flower isolation method and a vigorous pollen. However, this case was exceptional. On average, the single flower controlled pollination method produces 25 seeds per capsule compared with the average of 10 seeds per capsule produced by open pollination. These figures are low as they include flower abortion, which is a problem with *E. globulus*. Some clones suffer this abortion problem more than others and, in a few cases, it has been found that they can only be used to provide pollen in a crossing program.



The new single flower control pollination method. *1*) The cap is removed from the bud with the fingers. *2*) A scalpel blade is used to carefully remove the male anthers to expose the female style. *3*) The pollen on the anthers is collected in a petri dish for further processing. *4*) The style is washed with water to remove any contaminating pollen. *5*) The style is covered with a tube to isolate it from any contaminating pollen. This tube is removed when the known pollen is applied and the tube replaced whilst the pollination process occurs. *6*) The anthers are dried in the laboratory and then sieved to separate the pollen from the debris. *7*) The sieved pollen is collected on the tin foil, brushed together and stored in a small, labelled tube. Once this pollen has been tested for its viability it will be used to pollinate flowers on the trees.
Photos – Liz Barbour

The rapid development of the *E. globulus* plantation program in the State's south-west to approximately 15 000 hectares per annum has placed huge demands on CALM's tree-breeding program. Although producing seed by controlled pollination is expensive, CALM is committed to using this process as it is one of the most important steps in accelerating both the breeding and genetic deployment program.

It is critical, however, that the method is a precise exercise. The pollen needs to be pure and viable and there cannot be possible contamination in the controlled pollinator process. Accurate records of the process also need to be kept, particularly the percentage of the extracted seed. Using the new single flower method, only about five control pollinations are needed per cross on a wide selection of trees to move the breeding program into the next stage. This process allows CALM to maintain a closely spaced, stunted orchard right on the doorstep of its Como offices in Perth, allowing for easy access for intensive work during the flowering months. The simple technique of single flower control pollination will help us meet the demands of a growing industry.

THE FUTURE

Australia is not alone in recognising the outstanding economic potential of *E. globulus*. It has become one of the most sought-after species for pulpwood production, particularly in Portugal, Spain and Chile, where climates are ideally suited for its growth. By the end of the year 1995, 1.7 million hectares of *E. globulus* had been planted worldwide, 350 000 hectares of which had been planted in the five years between 1991 and 1995. By 1999 world plantings are expected to total 1.87 million hectares. A similar rate of growth of plantation expansion is already taking place in Western Australia. It can be confidently predicted that CALM's genetically superior strains of Western Blue Gum will be in demand not only in our own State, but also in an ever-expanding international market.

Liz Barbour is a research scientist and the manager of CALM's Forest Resources Services, Genetic Deployment Division. Her work has centred on the development of genetically superior Western Blue Gum strains and the single-flower pollination method. She can be contacted at CALM's Operational Headquarters in Como on (08) 9334 0302 or email lizb@calm.wa.gov.au.

MURCHISON HAVEN

by Sue Patrick, Jon Brand and Mike Meinema

In about 1884, Frederick Clinch built a mud bat home at the head waters of Lake Monger in the Murchison. Little did he know that in just over a century it would become a focus for environmental research. His early house is now part of the homestead at Burnerbinmah Station, bought by the Department of Conservation and Land Management in 1995 to conserve and promote the regeneration of sandalwood in Western Australia, and to serve as a base for the study of local plant and animal life.

Burnerbinmah Station, its name meaning red ground, is north-west of Paynes Find in the Murchison Region. The original lease (much smaller than the current station) was taken up by John Morrisey in 1878. Other leaseholders followed, and seven adjoining leases were acquired. In about 1884, Frederick Clinch travelled more than 200 kilometres inland from the coast, south of Geraldton, to take up the lease. He rode on horseback through Ninghan country, following the high water mark of a large flood the previous year along the upper reaches of Lake Monger. He made camp at the spot where the homestead of Burnerbinmah Station stands today.

In 1918, the station, covering 59 000 hectares between Yalgoo, Mt Magnet and Paynes Find, was transferred to his three eldest sons, Charles, Fred and Jack. It was transferred again, in 1924, to Charles and Jack (Albert) Clinch. At about this time Jack married Neata Palmer. Her father built them a new home close to the original homestead. Although it was later abandoned, this homestead remains standing today.

Life was hard for the pastoralists of those days. Alex Palmer, in his history of the station, relates that Charles showed great fortitude as a young man. Working at a mill one day, he was bitten on two fingers by a snake, which he knew to be very poisonous. He chopped both fingers off at the knuckle, with a hatchet, and after bandaging the hand, returned on horseback to the homestead, where he collapsed. According to Jack, their father dressed the hand and kept Charles walking for several hours afterwards. He survived this ordeal. From 1951 to 1983 Burnerbinmah Station was held by a daughter of the Clinch family, Neata, and her husband, David Craven. Don and Rhonda Anderson took over the lease in 1983.

FILLING IN THE GAP

The station lies within the southern part of the Murchison Region which has an arid climate of unpredictable summer and winter rainfall. There are few conservation reserves in this part of the arid zone or Eremaean Botanical Province. No lands managed by the Department of Conservation and Land Management (CALM) occur within 100 kilometres of the station, and plant life in the area is poorly known.

Burnerbinmah is less rugged than many of its neighbours, and many plant communities are represented within its

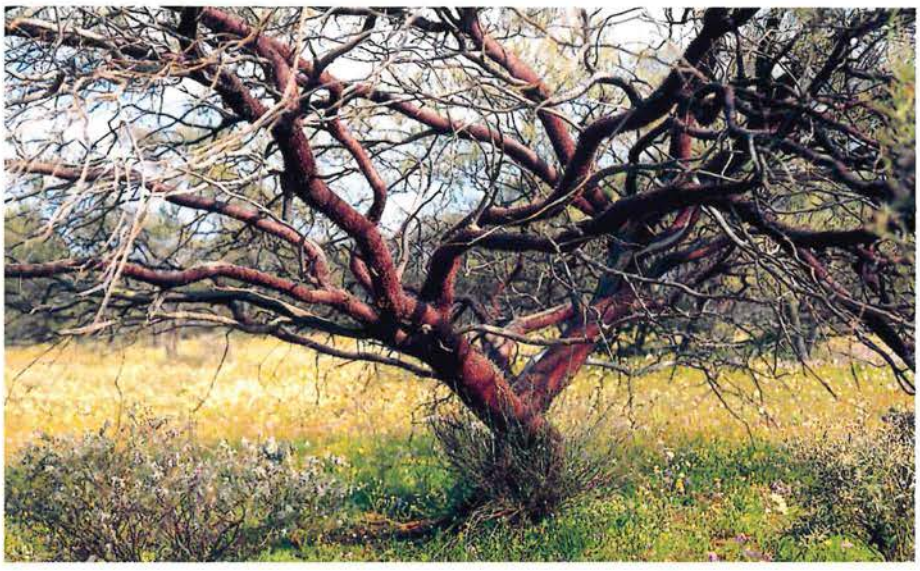
Previous page
Main: The shearing shed at Burnerbinmah, once a focus for wool production now a useful venue for meetings.
Photo – Sue Patrick
Insets: (left) Spring flowering cotton bush (*Ptilotus obovatus*) grows widely over the station.
Photo – Daphne Edinger
(right) Rosy velleia (*Velleia rosea*), a low growing plant that flowers in September.
Photo – Jiri Lochman

Historical photos: (from top left clockwise) Members of the Craven family with their horse Springarra at Burnerbinmah (c1940). Barnes' truck loaded with Burnerbinmah wool in the 1940s. The great flood of 1948, which reached to the fence of the homestead. The original homestead (c1940), which is still in use.
Photos – Courtesy of D & R Anderson

Left: The abandoned homestead, which was built about 1920.
Photo – Sue Patrick

boundaries. Close to Lake Monger there are large areas of alluvial plains, dunes and floodplains, with salt tolerant vegetation, bluebush, saltbush and samphire flats and open mulga *(Acacia aneura)* shrubland. The lake serves as a major saline drainage system bisecting the station. On higher land, to the west and east, there are low breakaways, granite hills and exposures, calcareous plains and broad valleys that support a wide variety of plant communities. Acacia shrublands grow on the shallower soils of granite exposures, and low mulga woodlands in the broad valleys. On sandier soils, white cypress pine *(Callitris glaucophylla)* grows in the mulga woodlands. Small areas of spinifex sandplain add to the species richness, as do several wetland areas, which include Cooryalgo Pool, with permanent fresh water, a gorge and creek (west of the pool) lined with swamp sheoak *(Casuarina obesa),* and several rock holes on the eastern side of the lease. Two areas of mallee woodland, mainly rough-barked mallee *(Eucalyptus hypochlamydea),* add further diversity.

The drought resistant nature of much of the station has meant that the vegetation has suffered less during dry periods than some of its neighbours. It has been grazed since 1884, carrying up to 12 000 sheep with some cattle and horses. Sheep numbers fell to about 4 000 in the last decade and they were removed early in 1996. Windmills and water points were closed down, but feral goats continue to exert some grazing pressure. Despite an active control



Top right: The nest of a wedge-tailed eagle (*Aquila audax*) in a mulga tree (*Acacia aneura*), above everlastings.
Photo – Sue Patrick

Centre right: (main) One of the station tracks runs through a pink carpet of rosy velleia.
Photo – Daphne Edinger
(inset left) Corrialgo Pool, an area of permanent fresh water, lined with vegetation. (inset right) Cotton bush (*Ptilotus obovatus*) grows protected from grazing at the base of a shrub, surrounded by pompom everlasting (*Cephalipterum drummondii*).
Photos – Sue Patrick

Right: Grasby's wattle (*Acacia grasbyi*) has minni-ritchi bark flaking in curls from the stem and branches.
Photo – Daphne Edinger

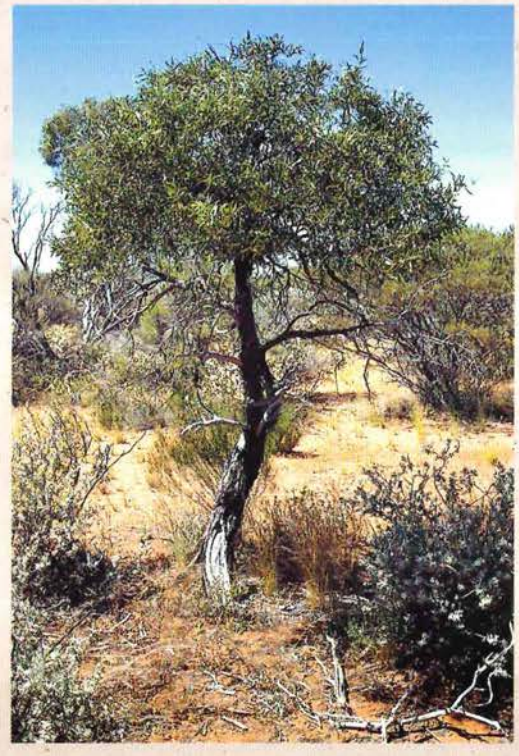
SANDALWOOD, FRAGRANT TREASURE

Burnerbinmah contains many stands of the highly valued Western Australian sandalwood (*Santalum spicatum*). Aromatic timber from WA sandalwood was one of the primary export earners for our fledgling State. Early settlers soon realised the value of the local sandalwood, and large quantities were harvested in the Wheatbelt. Today, the industry is much smaller, and harvesting occurs mainly on pastoral leases on the Goldfields and in the Midwest. Western Australian sandalwood is exported to countries in south-east Asia, where it is powdered and used to make joss sticks.

Observations and sandalwood inventory show that regeneration is generally very poor on developed and grazed pastoral leases. Sandalwood is heavily grazed by domestic and feral herbivores, such as sheep, goats and rabbits. To conserve sandalwood and promote regeneration in the rangelands, CALM has purchased a number of pastoral leases in addition to Burnerbinmah. These include: Jaurdi, Mt Elvire and Goongarrie on the Goldfields. The returns from sandalwood harvesting operations throughout the State will fund conservation and management of the species.

Sandalwood sampled on Burnerbinmah in March 1996 was made up of relatively large mature trees. There were no sandalwood saplings or seedlings present. The smallest sandalwood tree was 170 centimetres in height, and the smallest stem diameter was 65 millimetres, 15 centimetres above the ground. Sandalwood is a slow growing species and stem diameters only increase one to two millimetres (at 15 cm) per annum in the Murchison and Goldfields. Therefore, it is likely that the sandalwood trees sampled on Burnerbinmah were at least 40 years old. The absence of regeneration is probably due to heavy grazing by sheep and goats for more than 100 years. Removal of stock should enable sandalwood seedlings to survive and grow into small trees.

Sandalwood is a root hemi-parasite—although it is capable of photosynthesis, it requires some mineral nutrients and water from host plants to survive. Fine feeder roots attach to host roots through a cup-shaped organ called a haustoria. The haustoria can be up to two centimetres in length, and a single tree can produce hundreds of haustoria. Seed enrichment trials are being conducted to identify suitable host plants and land types to grow sandalwood in the rangelands. Long-term trials will monitor the growth and survival of sandalwood in the region for the next 10 years.



Above: Three-month-old sandalwood seedling growing beneath Grashy's wattle.

Left: Sandalwood tree growing on a washplain with acacia scrubland.

Photos – Jon Brand

program, it is unlikely that goats will ever be completely eradicated without goat-proof barriers on all boundaries.

LEARNING ABOUT THE PLANTS

In 1994, work began on a Wildlife Management Program for Declared Rare and Poorly Known Flora in the CALM Geraldton District. This extends from the coast near Dongara to the vermin fence north of Kalbarri and inland for more than 500 kilometres to beyond Sandstone. All but a few of the 35 declared rare plants occuring in the district grow on the wetter coastal strip. However, many of the 266 poorly known plants grow only in the arid zone where, until Burnerbinmah was purchased, there were no conservation reserves to protect their populations.

In September 1996, a *LANDSCOPE Expedition* travelled to Burnerbinmah. These expeditions, offered by *LANDSCOPE* in association with the University of Western Australia Extension program, provide paying volunteers with an opportunity to work on CALM research projects. They aim to promote wider cooperation in addressing conservation and land management challenges in Western Australia.

A thorough plant survey was planned, to see which of the declared rare and poorly known plants were growing at Burnerbinmah. Fortunately, it was a good year, with plentiful rain at strategic times, particularly for the spring-flowering ephemeral plants.

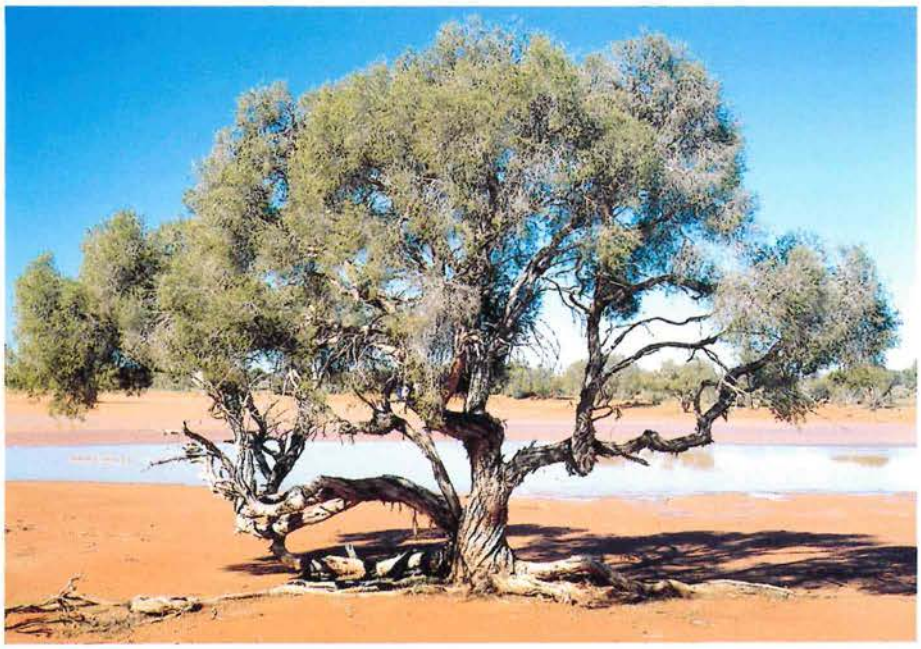
The 12 expeditioners divided into three teams, and were able to record and sample a total of 28 quadrats, each 20 metres square. These were placed throughout the station, to cover as many of the land types and plant communities as possible.

A species list of 350 plants was identified, and many interesting and important records were made. Six of the poorly known or 'priority taxa' were found; four were not previously known to occur in the district. These included *Hyalosperma stoveae*, a very small member of the daisy family, which has only been found once before in Western Australia, and only four times in all. The discoveries highlighted the fact that plants in Western Australia, and particularly in this area, are not well

known, and that intensive collecting brings to light small, unobtrusive plants that would otherwise seldom be collected. It was helpful to conduct the work in a wet year when so many of the ephemeral species were well represented. Six other plants that were collected had not been known to occur in the area. A further six were poorly collected generally, but known to be relatively common.

In March 1997, with the help of the Western Australian Naturalists' Club, records of summer flowering species were made. A second *LANDSCOPE Expedition,* in August, aimed to find earlier flowering plants. As conditions were drier, access was available to areas not visited in 1996. All the original quadrats were rechecked, and six more quadrats were sampled. It was good to observe that in some areas the vegetation appeared to be thriving, partly in response to the rain during the previous year, but also as a result of the reduction in grazing pressure.

Without the valuable help of *LANDSCOPE* expeditioners, this type of work would not be possible. Further volunteer effort from three of the 1996 expedition participants has produced the list of 370 species so far identified. Voucher specimens have also been incorporated into CALM's Western Australian Herbarium, to add to our knowledge of the flora of the State. Additionally, a reference herbarium set up at the station will be a valuable identification tool at the station. Work continues on the collections made in March and August of 1997, and there are high hopes that more important discoveries will result, particularly from the March expedition, as summer flowering species are poorly collected.



Top right: Some members of the *LANDSCOPE Expedition* team in August 1997.
Photo – Cleve Hassal.

Centre right: Don Anderson talks to members of the Western Australian Naturalists' Club at Coonthiago Rockhole.
Photo – Sue Patrick

Right: A paperbark (*Melaleuca* sp.) on one of the numerous claypans along the drainage system.
Photo – Daphne Edinger

Left: The spiny-tailed skink (*Egernia depressa*) is one of many reptiles found on the station.
Photo – Sue Patrick

Below left: Euros (*Macropus robustus*) live on rocky areas of Burnerbinmah.
Photo – Peter Marsack/Lochman Transparencies

ANIMAL LIFE

The station provides habitat for a wide range of animals. Larger mammals include the red kangaroo and euro, while smaller species are represented by the spinifex hopping-mouse and two dunnart species. Goats, foxes and rabbits are less desirable residents. One-hundred-and-five bird species have been recorded; five were added to the list by the WA Naturalists' Club during their Easter visit, and new records continue to be made. Of the reptiles, Gould's monitor is plentiful and often encountered during summer, but the larger perentie is seldom seen. Skinks, geckos, dragon lizards and several snake species have also been recorded. The permanent pools provide a breeding place for tortoises and frogs, as well as many freshwater invertebrates. Twenty-seven butterfly species have been found here, but further work is needed to find out more about the animal life.

THE FUTURE

Until its purchase by CALM, sheep and wool production were the primary goals of the station. Shearing teams, windmill and water runs, and mustering were part of everyday life. The future for Burnerbinmah has a completely different outlook. Fencing checks are still conducted, but now it is to ensure that feral goats and neighbouring stock are kept out of the station, rather than keeping Burnerbinmah's stock in. The shearers quarters now cater for a variety of CALM staff and other groups involved in surveying and recording, and the shearing shed provides a great venue for meetings and evening slide shows.

Don and Rhonda Anderson have taken the opportunity to stay on at the station as caretakers and CALM volunteers. This provides them with an opportunity to continue a lifestyle they enjoy. As honorary CALM officers, they provide security for the station, and serve as a vital contact point for neighbouring stations.

CALM has embarked on a feral goat control program in conjunction with members of the Yalgoo Land Conservation District Committee and neighbouring pastoralists. Continuing success in the reduction of feral goats will provide the best possible protection for the regenerating flora and fauna, particularly sandalwood. Burnerbinmah has also been identified for future inclusion in CALM's Western Shield nature conservation initiative.

The station will provide pastoralists, naturalists, school groups and other visitors to the Midwest with a window into the flora and fauna of the area. It is hoped that the successful regeneration of its vegetation will encourage support for the conservation of more land within the pastoral region.

Sue Patrick is a senior research scientist in CALM's Science and Information Division. She will revisit the plants of Burnerbinmah during a *LANDSCOPE Expedition* 'New Moon over the Murchison' with Government Astronomer Dr James Biggs, from 17-24 October, 1998. Sue can be contacted at CALM's Western Australian Herbarium on (08) 9334 0485 or by email at suep@calm.wa.gov.au

Jon Brand is a research scientist based in CALM's Science and Information Division at Como. He can be contacted on (08) 9334 0298 or by email at jonb@calm.wa.gov.au

Mike Meinema is Manager of CALM's District Office in Geraldton. He can be contacted on (08) 9921 5955 or by email at mikem@calm.wa.gov.au

ENDANGERED!

WESTERN RINGTAIL POSSUM

Until a few years ago, the ringtail possums that occur in the south-west of Western Australia were thought to be the same species as the common ringtail of eastern Australia. Now, they are recognised as a separate species, the western ringtail possum (*Pseudocheirus occidentalis*). In common with most medium-sized Australian mammals, they have declined in abundance and distribution, and are now listed as threatened.

Western ringtails once had a patchy distribution from near Geraldton to the edge of the Nullarbor Plain. By 1990, they occurred only in the far south-west, mostly near the coast from near Bunbury to the Waychinicup National Park east of Albany. The only inland populations remaining were in the Perup and adjacent forest blocks, and in the lower Collie River valley. Near the coast, they inhabit peppermint (*Agonis flexuosa*) woodland, where they often build 'dreys' (nests in the canopy). Elsewhere, they shelter in tree hollows, hollow logs or even in dense vegetation on the ground. Interestingly, ringtails are common within Busselton and Albany townsites, where they may live in house roof spaces.

Research by the Western Australian Museum and the Department of Conservation and Land Management (CALM) has shown that predation by foxes is a major threat. Since 1991, western ringtails have been translocated to areas where foxes have been controlled under CALM's *Western Shield* feral predator control program. The first translocation, to Leschenault Conservation Park at Bunbury, has been very successful. Other translocations, still being monitored, have been to Yalgorup National Park, Lane-Poole Conservation Park and Karakamia Sanctuary near Gidgegannup (see story in this issue).

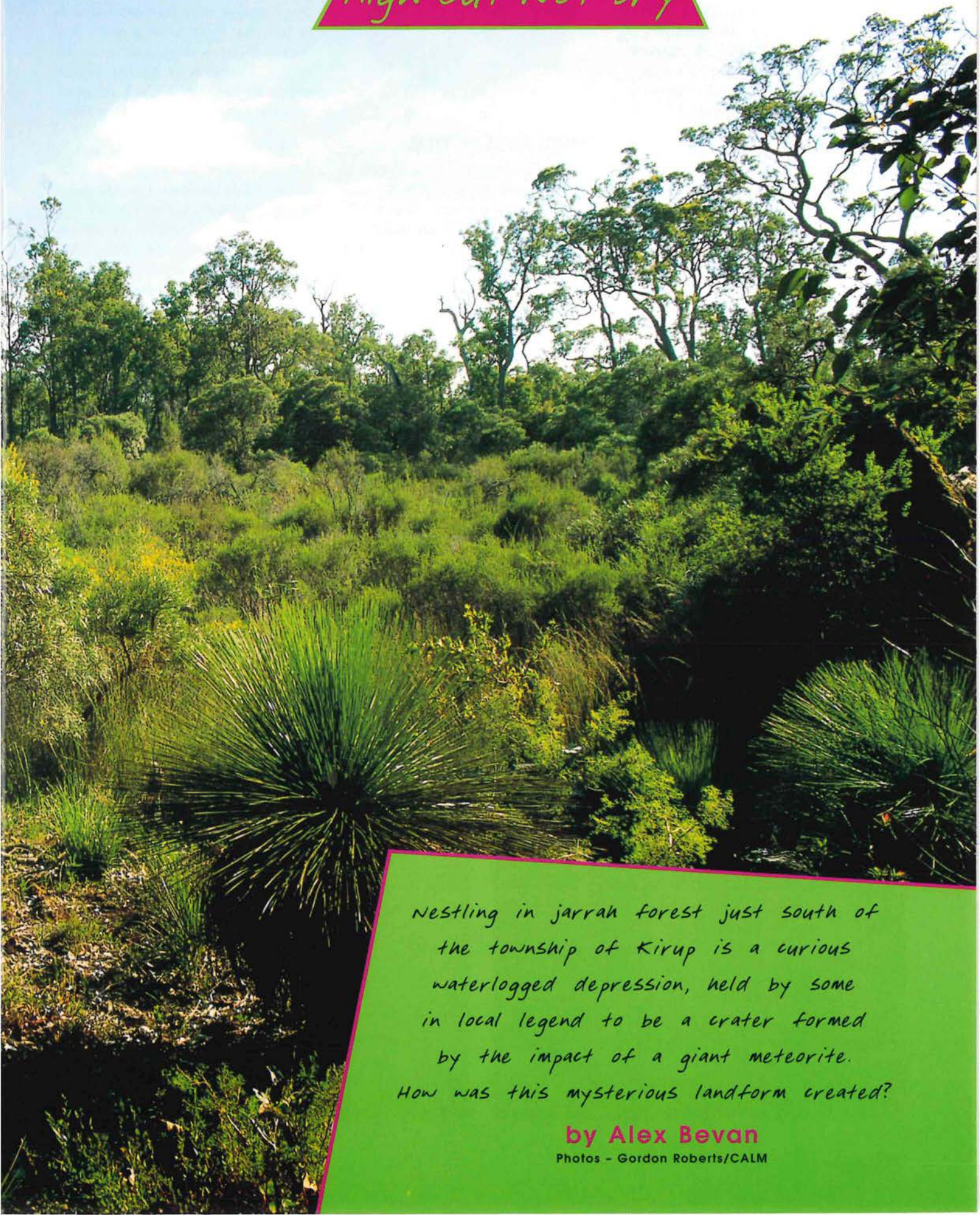
Another significant problem for western ringtails is clearing of their habitat for urban development, particularly between Bunbury and Augusta and near Albany. CALM is working with planning authorities and local councils to minimise the impact of clearing on the possums. In some cases, ringtails whose habitat has been destroyed have been successfully translocated. Wildlife carers are also helping the recovery of this species by caring for derelict ringtails from urban areas and preparing them for release back into the wild.

By Andrew Burbidge

Photo – Babs & Bert Wells/CALM

CURIOSITY SWAMP

High But Not Dry



Nestling in jarrah forest just south of the township of Kirup is a curious waterlogged depression, held by some in local legend to be a crater formed by the impact of a giant meteorite. How was this mysterious landform created?

by Alex Bevan
Photos - Gordon Roberts/CALM

The aptly named Curiosity Swamp is perched on the crown of a small round-topped hill in State Forest managed by the Department of Conservation and Land Management (CALM). It is unusual to find a swamp perched on top of a hill. Moreover, the flora that the swamp supports appears quite alien to its immediate surroundings. The origin of this 50-metre-wide depression, however, is far more complicated and less dramatic than a simple whack from an invader from space. To understand how such a structure could form in that location, we have to look into the geological history of the moulding and erosion of the landscape over many millions of years.

Previous page
Curiosity Swamp has formed in a 50-metre-wide depression on top of a hill.

Below: The blue lady orchid (*Thelymitra crinita*) grows at Curiosity Swamp.

Below right: Drumstick isopogon (*Isopogon sphaerocephalus*).

GOING BACK IN TIME

Millions of years ago, the climate in the south-west was quite different from that which we enjoy today. More humid conditions prevailed all year round, and intense chemical weathering and leaching of the land surface gradually produced a capping of laterite on most rocks and deposits.

All along the Darling Range, and in many other places in the State, we can see reddish-brown or chocolate-coloured laterites sitting on the granites and other rocks from which they formed. The torrential downpours of rain that once percolated through the soil, removed silica and other soluble materials. What remained in these leached soils were highly stable oxides and hydroxides of iron and aluminium, which are not soluble in the soil water of humid climates. Excessive accumulations of earthy materials such as limonite (hydrous iron oxide) and bauxite (hydrous aluminium oxide) led to the formation of laterite, which eventually hardened as thick, irregular rock-like layers full of rounded nodules carpeting the terrain.

What has this got to do with Curiosity Swamp? Our first clue to the origin of the swamp is that it is formed in a thin layer of iron-rich laterite that caps the hill. The rocks beneath the laterite are ancient metamorphosed sediments. Only a few patches of this kind of laterite are found in the immediate vicinity, but it was once more widespread. During the major period of laterite formation in the area, erosion continued. Gradually, rivers and creeks cut their way through the laterite and underlying rocks, sculpting the land into the valleys and residual hills we see today.

AN OLDER TERRAIN

The hill on which Curiosity Swamp sits is one of the highest found in the divide between the headwaters of the

Capel River, which flows to the north-west, and the Blackwood River, which flows to the south-west. These drainage systems and their tributaries are largely responsible for moulding the landscape we see in the area around Kirup and Balingup today. In some places, the laterite has been completely eroded away; in others, it may never have been formed. A few patches, like the one at Curiosity Swamp, remain as testimony to an older terrain and past climatic change.

The oldest superficial deposits now occupy the highest spots in the landscape. On that ancient surface, erosion produced humps, hollows and creeks, much as it does today. Local drainage systems developed, eventually drying up and leaving a series of depressions. Laterisation of the rocks and deposits continued. Some of these depressions gradually became lined with mud, clay and humus, and periodically held water. Small swamps were formed and developed their characteristic flora. Other similar shallow depressions can be seen in the laterite capping in areas of the Darling Range today. Characterised by melaleucas and fringed by swamp banksia (*Banksia littoralis*) and grass trees (*Xanthorrhoea priessii*), Curiosity Swamp is a haven for frogs and a larder for tiger snakes. Although these areas largely dry out in summer, they still retain their swamp-like appearance.

So our mystery is nearly solved. What remains is an explanation of how we can discount the meteorite impact theory. Small meteorite craters have distinctive shapes with raised rims formed by upturned rocks. The laterite at Curiosity Swamp dips gently to the north and, other than from the roots of trees, appears otherwise undisturbed. And whereas recently formed craters generally have fragments of the meteorite projectile associated with them, none has been found at Curiosity Swamp. Finally, the intense shock associated with the formation of an impact crater leaves distinctive microscopic damage in the minerals of the target rocks. These have not been found in the rocks at Curiosity Swamp.

Gradual isolation of the swamp may have preserved a relict flora and fauna, that is possibly unique and worthy of study and conservation. We often underestimate the power of the relentless forces of weathering and erosion that have produced the landscape and that continue at a gentle pace today. It was in this way that Curiosity Swamp was left high, but not so dry!

Top: A bobtail skink shelters in lateritic rocks in which the swamp has formed.

Above: There is a fringing vegetation of jarrah and grass trees (*Xanthorrhoea priessii*).

Right: Fragments of a meteorite have never been found at Curiosity Swamp.

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Dr Bevan thanks John Dell, Mark Cowan and George Kendrick for their help.

URBAN ANTICS!

An Octopus's Garden

For those of us who live along the seacoasts of the world, it is difficult to realise how many millions of other people have never seen an ocean and have never stood alone in the tangy mists of a rocky coast or a sandy beach watching massive waves that thunder in from the open sea. Such an experience gives a unique view of our planet, and tugs at some primeval instinct flickering deep within our minds.

The first and strongest impression of the sea to a terrestrial being is the powerful smell of salt and rotting seaweed cast up by the tide. Unfortunately, most people are exposed to seaweed when, as dead flotsam, it slithers like a serpent around our bodies in the shallows, or as beach litter, either prickles our bums or accosts our nostrils.

The underwater vegetation off our coast is made up of two types. Seagrasses, which are like land grasses, with leaves, fibrous roots, flowers that produce pollen and creeping stems that spread similar to lawn runners, and seaweeds, which are in fact *algae*.

About 14 species of seagrass out of 50 throughout the world are found in the Perth area. This richness in numbers is due to shelter from offshore reefs, and a combination of clear, sun-lit, low nutrient water, a clean sandy sea-floor and little run-off from the coastline.

Ribbonweeds *(Posidonia spp.)*, with their long strap-like leaves, and wireweeds *(Amphibolis spp.)*, which have wiry stems with bunches of leaves on the ends, are the two dominant genera around Australia. Other species form small communities in patches of bare sand or in areas that have greater water movement.

After storms, heaps of ribbon-like leaves mixed with wireweed are a familiar site to Perth beach walkers. Along the tide line one can also see 'hair balls', which are formed from the fibres of *Posidonia australis* leaves as they break up and roll around the sea floor. In summer, the small green fruits from ribbonweed are often found washed up.

Seagrass meadows teem with life. They are the nursery of rock lobster and herring, while many other fish live on the filter feeders, molluscs, worms, crabs, shrimps, starfish, urchins and algae that live there. When the seagrass sheds its leaves after a few months of growth, attached organisms and algae, and the leaves themselves, are broken up by wave action to form an important source of food and nutrients.

Seaweed (algae) encompass a large number of biologically simpler plants. They can be visually appealing or grotesque and either edible or poisonous to humans. The seaweeds can absorb food-building nutrients through their entire body surface and need no root system other than a sucker-like base called a 'holdfast' to anchor them to rock or seagrass.

The foliage of seaweed is not always leaf-like and is therefore called the 'thallus', or 'lamina' or 'blade'. Some have a stalk-like 'stipe', while others have masses of delicate tissues emanating from the holdfast. Some have wide beautiful fleshy platforms and others look like ugly blobs of jelly.

Two forms recognisable on Perth shorelines are the bright green sea lettuce *(Ulva lactuca)* on most rocky waterlines, and the large brown shaggy thallus of Ecklon's kelp *(Eklonia radiata)* washed up on beaches.

Whilst we might think that dead vegetation on our beaches is just nuisance rubbish, we can rest assured, that the nearby ocean is in the good hands of mother nature. It is essential that seaweeds and seagrasses grow in profusion, for they are the pastures of the sea.

BY JOHN HUNTER

DID YOU KNOW

- *The rhizomes (horizontal underground branches) of ribbonweed seagrass meadows form a dense mesh, which stabilises underwater sandbanks, while the canopy leaves protect the substrate (ocean floor) from wave or current action.*
- *Forty times more animals live in seagrass than on adjacent 'bare sand'. Once destroyed, some meadows, such as ribbonweed, take decades to grow back. Sometimes they never do.*
- *Seaweeds do not bear flowers and seeds. They reproduce their kind by releasing thousands of single cells (gametes and spores) from the surface of the foliage.*

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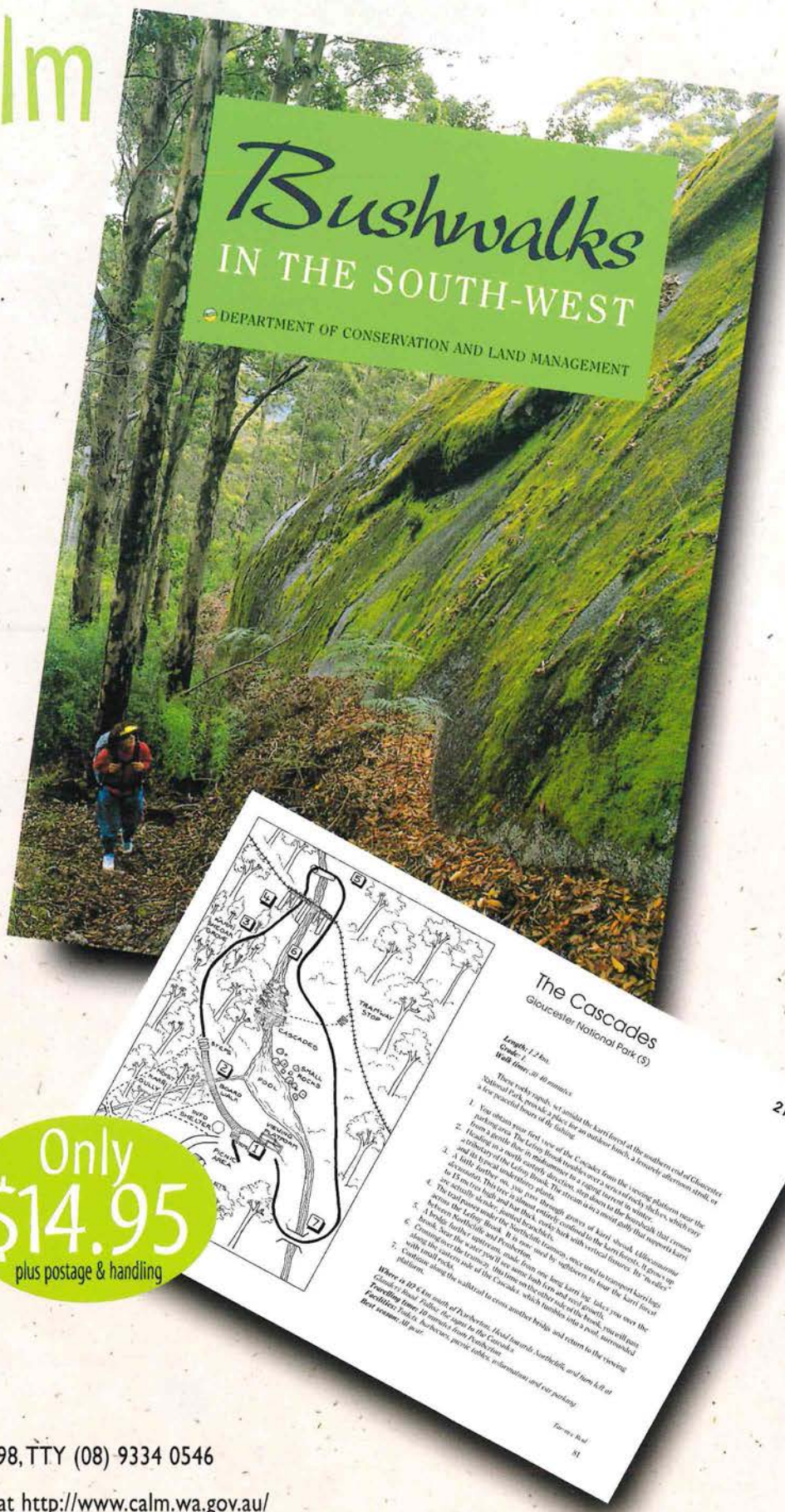

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A comprehensive survey of the marine environment between Bremer Bay and Hopetoun has brought to light the wonders of Western Australia's southern seas. Here, a footballer sweep hovers over a large orange finger sponge, a sea star and communities of seaweed.

Photo – Eva Boogaard

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