SUMMER 89/90

LANDSCOPE

$3.5/2

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

SHORE SURVIVORS

ROCKS OF AGES

WHERE KARRI MEETS THE COAST

LITTLE DID THEY KNOW, THERE WAS ANOTHER FAMILY CAMPED JUST TEN METRES AWAY.

Anyone who has gone camping down south will tell you that there's just so much to see.

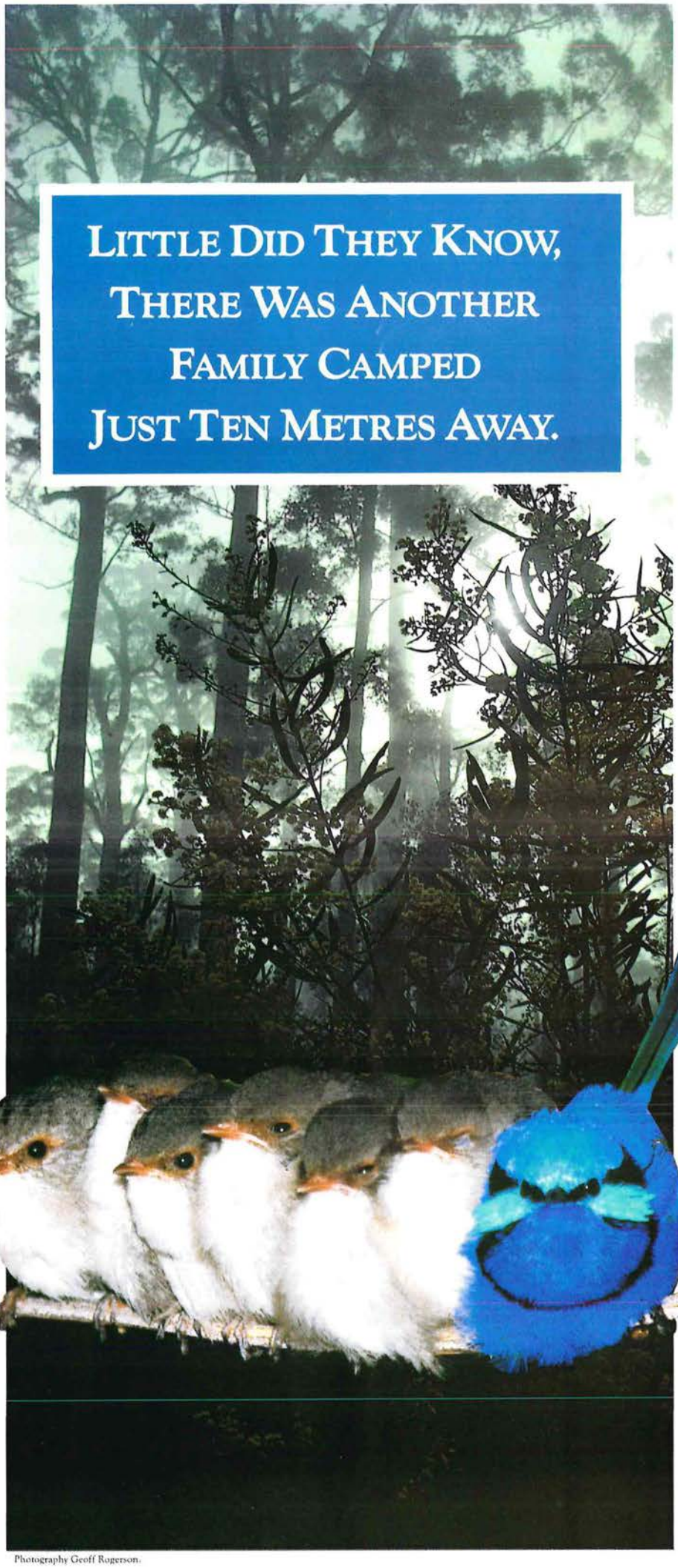
But, the fact is that people rarely see a fraction of the natural wonders that surround them.

Imagine spending 3 nights camped in the forest and not know-

ing that there was a family of blue-breasted wrens sharing your campsite.

Or trekking on the amazing Bibbulmun Track and walking straight past a small stream where, at the water's edge, you might see one of the world's rarest native cats having a drink. These are the kind of hidden delights that only an expert tour guide can open your eyes to.

discover



Photography Geoff Rogerson.

And don't think that guided tours are a compromise or a soft alternative.

Not only will you see

more on tours such as those offered by Adventure Out or Amesz Tours, you'll also do more than you'd ever dare to do by yourself.

All the information

you need to ensure that your Southern holiday is all that it can be is available from the Western Australian Tourist Centre.

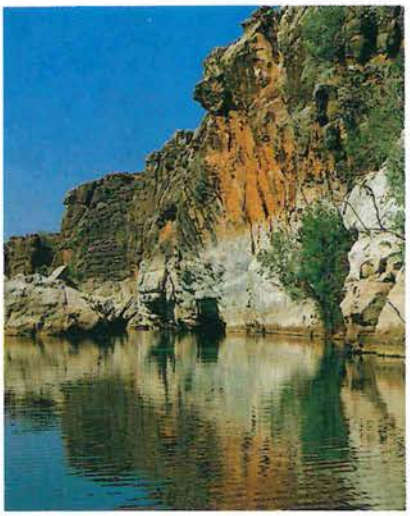
To get your free "Southern Delights" kit, which contains full tour details, simply call into 772 Hay Street or phone 322 2999 (toll free for country callers on 008 993 333) and we will send you one.

Western Australian Tourist Centre

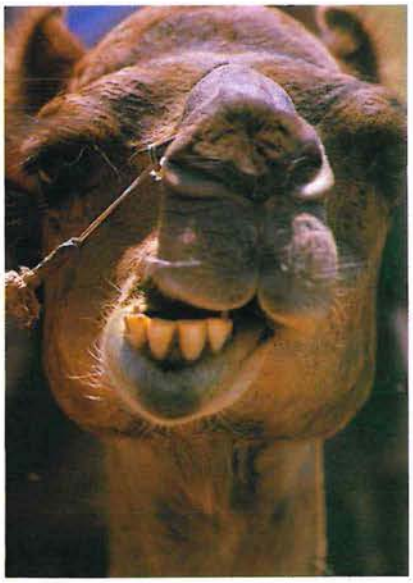
LANDSCOPE

VOLUME 5 NO 2 SUMMER EDITION 1989/1990

Dolphins, whales and seals frequently strand along the WA coast. Find out who helps them and what they do on p. 10.



Powerful forces have formed the rocks and land surface of WA over billions of years. See p. 48.



Why are the thousands of feral camels that roam inland Australia the scourge of the desert? Turn to p. 22.

Explore the fascinating subterranean worlds deep beneath the earth on p. 28.

Inlets and rivers, towering karri and tingle forests, rugged coastline and remote wilderness areas - Walpole-Nornalup National Park has it all. See p. 15.

C O V E R

Australian sea-lion (Neophoca cinerea). *Photo - Nick Gales*

F E A T U R E S

R E G U L A R S

Managing Editor: Ron Kawalilak
Editor: Carolyn Thomson
Designers: Louise Burch/Robyn Mundy
Production: Karen Addison/Margaret Wilke
Maps: Project Mapping, CALM
Advertising: Tim Langford-Smith ☎ (09) 389 8644 Fax: 389 8266

Colour Separations by The Colour Set
Printed in Western Australia by Kaleidoscope

Published by Dr S Shea, Executive Director,
Department of Conservation and Land Management,
50 Hayman Road, Como, Western Australia 6152.

NEW INNOVATIONS

At a recent international forestry conference, India's Principal Chief Conservator of Forests, S Shyamsundar, described how Cherrupunji, one of the wettest places on earth, cannot obtain drinking water for over five months of the year. This situation has resulted from the clearing of the forest and the destruction of soil structure. Whereas once the soils in the forests of this region acted as a huge sponge which delivered rainfall consistently throughout the year, now most of the water is lost as direct runoff in a three month period.

Using new innovations, foresters in India were able to successfully re-establish forests and restore the natural hydrological cycle. The technical innovations were exciting, but they were successful because they also accommodated the needs of local people. The forest was destroyed because of excessive pressure of grazing and firewood gathering. The establishment of the new forest provides for its use by local people, in a way that does not result in its destruction.

The success of the Indian scheme demonstrates that even the most degraded forests can be repaired.

There are major shifts occurring in our understanding of the natural environment. The development of new technology is rapidly removing the technical and biological barriers which in the past have prevented us restoring natural ecosystems. To capitalise on these innovations, we must make the technology affordable and socially and politically acceptable to people who depend on natural ecosystems for their livelihood.

In this edition of Landscope, *we describe how new technology is being used to make major improvements in the way we measure forests and manage fire in natural ecosystems. In future editions we will describe more of these exciting new developments, which will play a major role in helping us to achieve sustainable development without damage to the environment*

The Publisher

TINY TIMELORD

"Floral Predators" (Urban Antics) in the Spring edition of *Landscope* 1989 had the power of Dr. Who - to transport through time, to another place, another age.

Every spring, when we fossick through the bush, the little rosetted *Drosera* has the same power to bring my earliest childhood vividly to life.

It was the early 1930s when an elderly great-aunt awoke my lifelong interest in botany.

Back in those days there was time to look, watch, wonder and learn from nature. To scale gigantic granite boulders, which, years later, were strangely reduced in size to mere sitting stones.

And the little rosetted *Drosera*, with its red and green hairy leaves carpeting the bush floor, reminded my aunt of *her* earliest childhood. In the early days of South Australia, her mother, relying on sailing ships to bring news from the Old Country, squeezed the leaves of the *Drosera* to make the ink to write her diaries and her letters home.

JOAN MOUNTFORD
DONNYBROOK

WHALE FAN

I am 11 years old and really interested in whales and other marine mammals. I am very concerned about the ozone layer and how it is affecting the environment. We learn about it at school. I love your articles about whales.

I get all your magazines. I have an idea for a competition for *Landscope*; you could ask readers to do an essay about the ozone layer and how you could help it. I like the photo competition but didn't get my entry in on time.

NIKKI RUSSELL
WANNEROO

We will consider holding a competition in a future issue - Ed.

Rosetted Drosera
Photo - Grant Wardell-Johnson

CUT UP ABOUT THE PEEL INLET

I and my family enjoy your magazine. However I feel that your article on problems in the Peel Inlet needed much more unbiased research. As a retired farmer, I believe it was too critical of the farmers in the area.

Much is made of the phosphate levels contributed by these farmers without any thought as to effects that reducing the level of phosphate application would have on the primary industry of the area. Even the use of slow-release fertilisers will not be viable, as phosphate levels must be maintained to ensure economic production.

Without this application rate the area would be totally unproductive, putting more strain on other dairying areas and increasing the cost of dairy products, particularly milk, by way of increased freights from more distant areas.

Even the much vaunted tree planting program has used rates of phosphate approaching 800 kg per hectare to enable satisfactory establishment in the initial stages. No mention is made of the high input of phosphate made by the urban populations of Mandurah and Pinjarra, or the amount of phosphate coming down the Murray River through the Williams and Hotham Rivers.

It would seem that the Dawesville Cut is the most appropriate solution for the effluent problem. The "Greenie" element has had too much influence on what appears to be a sound and economical solution, bearing in mind the loss to the tourism and fishing industries if the condition of the estuary is not improved quickly.

It is often easier to blame the farmers than to accept a mutual responsibility for the situation and the mutual cooperation needed to repair it.

MALCOLM HIGHEN
MT PLEASANT

P.S. I am involved in the wetland surveys west of Coolup so I am concerned for the wildlife of the area as well as the farmers.

Trees planted as crops will require less than half the phosphate fertiliser used for pastures and will be taken up more efficiently by the trees' larger root systems - Ed.

IN PERSPECTIVE

YOUR VIEWS

More than 1500 people responded to our recent survey of *Landscope* subscribers. Thanks to all those who took the time to reply. We will print a breakdown of your answers when they have been recorded and analysed.

Here are some readers' comments:

- *It would be good to have a section in your magazine for children. My children (12 and 13) are both conservation conscious and need something to keep on inspiring them. They used to belong to the Junior Park Ranger Scheme in Perth, but up in the North-West that is non-existent. Looking after the environment is just as important here as anywhere else.*
- *Please include guest criticisms of programs and delays in implementing essential programs and electoral policies. As we now pay for this publication it should not remain a purely propaganda piece, excellent though it generally is.*
- *The photographic content is a major feature - please keep this in the forefront. Articles on whole ecosystems of specific regions are great, especially those one may wish to visit.*
- *I would like to see plastic eliminated as postage protection and perhaps more use of reusable materials such as recycled paper.*
- *A binder with wildlife emblems superimposed over a map of WA on the front cover would complete a beautiful collection.*

A binder for *Landscope* is now available for $8.95.

Pick up your binder from CALM, 50 Hayman Road, Como, or call us on 389 8644 for an order form.

Your letters are welcome. Please address any correspondence to *LANDSCOPE* EDITOR, CALM, 50 HAYMAN ROAD, COMO, WA 6152

DUGONGS

Shark Bay and Monkey Mia are well known for their dolphins.

However, a recent survey gave some surprising results - dugongs in the area outnumbered dolphins by four to one, showing that Shark Bay had one of the largest localised dugong populations in the world.

A five-person research team recorded 10 000 dugongs in the Shark Bay area, where the animals graze on extensive seagrass beds.

Previous estimates had put the dugong population there at between two to five thousand.

Hunting has severely reduced the numbers of these quiet bottom-feeding 'sea cows' in other parts of the Indian and Pacific Ocean, so the survey's findings are particularly significant.

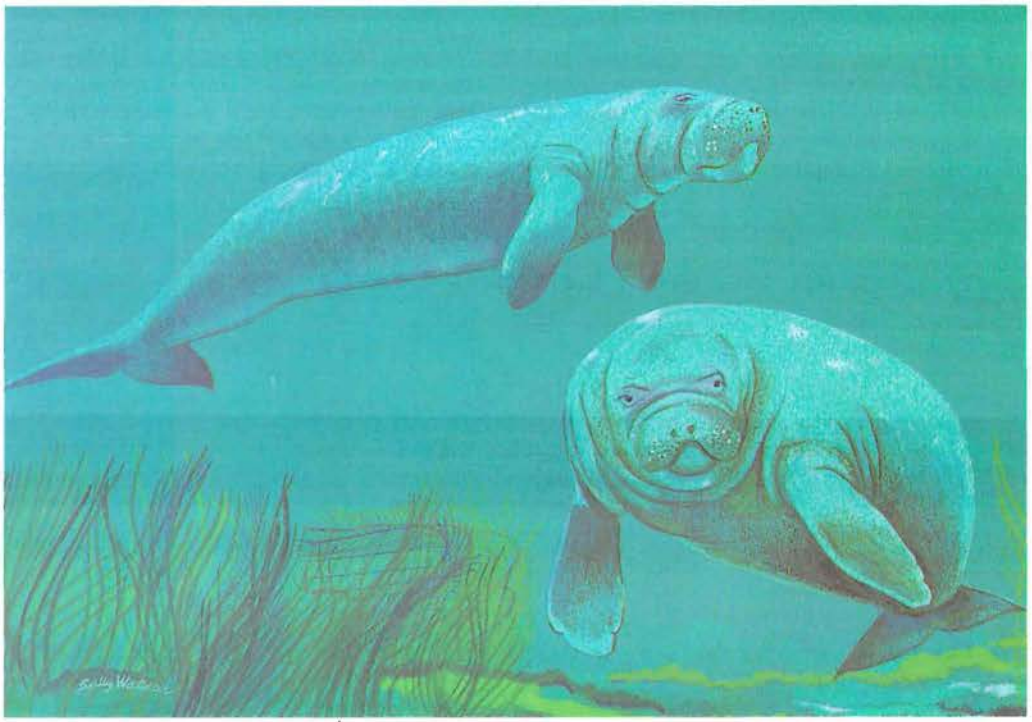
The survey was co-ordinated by CALM researcher Dr Bob Prince and directed by Dr Helene Marsh, a dugong expert from Queensland's James Cook University.

Research Assistant Keith Saalfeld and CALM's Andy Williams and Ron Shepherd formed the rest of the team.

They flew a series of transects across the bay in a light aircraft at only 450 feet.

"The dugongs were distinctive from the air - they looked just like big brown plump cows," said Ron Shepherd.

The survey changed some of the previous theories about dugong migration around Shark Bay. It became apparent that there were probably two sub-populations. One occupied the south-westerly parts of Shark Bay and there was another concentration of dugongs north-east of Cape Peron.



The dugong's extraordinary snout is adapted for shovelling in sand and extracting the choicest plants.
Illustration - Sally Watson

Dolphins, marine turtles, sharks, stingrays, humpback whales and even sea-snakes were also observed and recorded during the survey.

After spending one and a half weeks in Shark Bay the team moved to Exmouth and the Ningaloo Reef.

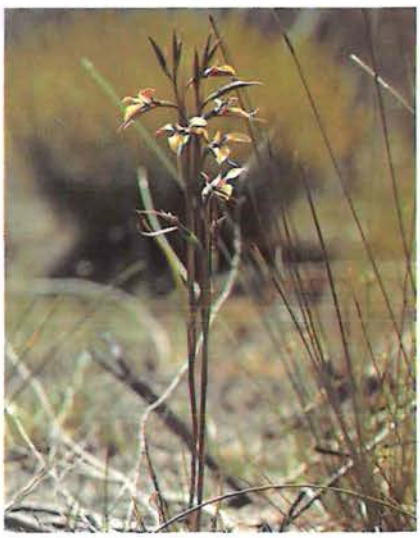
"The team was surprised at the large numbers of dugongs on Ningaloo Reef, as dugongs are not really thought to be reef animals and there was no prior evidence of extensive seagrass communities in the Ningaloo Reef area," said Ron.

"At Ningaloo we also spotted numerous very large brown masses that turned out to be salps, a small animal similar to a sea-squirt that lives in colonies in tens of thousands. These colonies form large spirals which a diver can swim through," he said.

"Beyond the reef, we counted an unexpectedly high number of whale sharks for this time of the year."

RARE ORCHID

The rare Purdie's donkey orchid (*Diuris purdiei*) has been successfully propagated by Kings Park and Botanic Gardens research botanists.



Purdie's donkey orchid stands up to 45 cm tall and has five to 10 narrow, spirally twisting leaves.
Photo - Stephen van Leeuwen

Eight seedlings have so far been grown since the identification of the microfungi needed by the plant.

According to Kings Park research botanist Kingsley Dixon, the orchid is extremely difficult to grow; it produces dust-like seed and will only germinate on a special medium combined with the right fungus.

Purdie's donkey orchid is found in only eight sites in Western Australia. A new population was recently discovered by a CALM forester after an autumn burn on a reserve east of Peel Inlet.

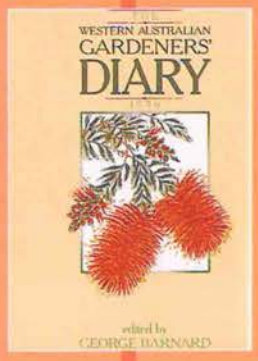
A wildlife management program is being developed to ensure the orchid's long-term survival.

Developers who own land containing two orchid sites in the metropolitan area have provided funds for a four year research program to be run by CALM.

BOOK REVIEW

THE WESTERN AUSTRALIAN GARDENERS' DIARY 1990 may well become a bible to serious Western Australian gardeners.

It contains tried-and-tested information on growing herbs, vegetables and flowers, including natives, and its month-to-month format gives ample room for daily entries and notes for future reference.



Each month has separate chapters on general garden maintenance and many coloured photographs and diagrams. Its plastic-coated cover is perfect for protecting it from grubby, soiled hands.

Edited by leading Western Australian gardening expert George Barnard, it contains tips and handy hints on successful gardening.

George's straightforward writing style will inspire anyone to help make their "domestic backyard deserts" bloom to their full potential.

Specific gardening books for WA are rare but this one has been tailored to suit our harsh and often difficult growing conditions.

The diary is available from leading bookshops, newsagents, nurseries and garden centres for $19.95.

Sadly, on December 5, 1989, George Barnard died suddenly. He will be missed by his many friends and thousands of readers and listeners.

AURORA AUSTRALIS THE SOUTHERN LIGHTS

Photo - Courtesy of the Perth Observatory

A phenomenon rarely seen in Western Australia has been visible this year.

The biggest display of the Aurora Australis, or the southern lights, occurred over three nights in mid-March, with another strong showing in October.

It appears as a pink, green or white glow in the southern sky and can change to blood red if conditions are right.

Stars are visible through the glow, and there are often vertical white streaks, known to astronomers as "curtains", that move along the southern horizon from west to east, or east to west.

The aurora can be confused with the glow in the sky of a distant bushfire.

The phenomenon is caused by activity on the sun. Solar flares (which cause sunspots) eject streams of charged particles which the earth sometimes runs into as it moves in its orbit around the sun.

The particles excite the gases in the upper atmosphere, which glow in the same way as a fluorescent tube does when an electric current is passed through it.

The curtaining effect is caused by particles being channelled into the lines of the earth's magnetic field.

Most of the activity occurs around the earth's magnetic poles and is best seen from around the North and South Poles, but in times of strong solar activity the aurorae are visible from regions well away from the poles.

The sun is presently approaching a period of maximum activity as part of its 11 year cycle. It will peak in June 1990 but the level is already above that of the peak of 1979.

The increased number of solar flares also cause interference with radio transmissions around the world.

Aurorae are difficult to predict. They usually occur within two days of a solar disturbance, but the effects are not visible from all locations.

Because of the high level of solar activity at present it is likely that further auroral activity will be noticeable over the next six to ten months.

PETER BIRCH
PERTH OBSERVATORY

THAR SHE BLOWS!

Whale-watching tours have provided an excellent platform to undertake research and photograph humpback whales on their southern migration down the WA coast.

The tours are based from Hillarys boat harbour and are run in Marmion Marine Park and adjacent State and Commonwealth waters.

Over 300 confirmed sightings of humpback whales were recorded by Underwater World, one of the tour operators.

Individual whales have been identified from photographs showing the patterns on the underside of the tail flukes and on their backs.

One whale seen in Shark Bay last July while migrating north was photographed twice in the waters between Rottnest and Hillarys, during a three day period in October. This gives an indication of the time spent in this area by some whales.

At least 50 individuals have been identified this season, including one very conspicuous whale with no tail flukes.

This animal has been seen in the same area in previous years in a pod of four to six whales. For this whale to continually travel such vast distances without any flukes is a major feat.

An estimated population of 2000 humpback whales migrate along the WA coast each year.

They feed on the large concentrations of krill (zoo plankton) in Antarctic waters during summer, then move north from March to April to mate and calve in the warmer waters of the North-West.

When they migrate south from August to December they follow the coastal reefs and bays at a more leisurely pace, especially the females and newborn calves.

A catalogue of identified animals is being maintained at the WA Museum by John Bannister, with various people and organisations contributing to it.

Analysis of the data is continuing and should shed some more light on this mysterious creature.

One whale (above) travels thousands of kilometres each year with no tail flukes. It is thought that the other whales in the pod may help to support it by swimming close to it.

This whale - identified by its distinctive markings - was photographed first at Shark Bay (left), then near Perth (below).
Photos- Chris Burton

CROC OF GOLD

Crocodiles are very effective hunters, but up in the north of the State the tables are being turned - about 90 saltwater crocodiles are to be caught for a new crocodile farm at Wyndham.

In fact humans have hunted crocodiles all around the world for their valuable skins for many years.

About 25 000 saltwater crocodiles are believed to have been harvested in WA from 1945 until they were legally protected in 1970. Freshwater crocodiles were also taken.

As a result, crocodile numbers dramatically declined.

In 1977-78, it was estimated that there were about 2 200 non-hatchling saltwater crocodiles in WA. The population was resurveyed in 1986 and estimated to be around 2 400.

In 1988, after a number of applications, the Government decided to allow crocodile farming on a trial basis.

A farm is now being established at Wyndham, based on a combination of breeding in captivity and ranching (taking eggs or hatchlings from the wild and raising them in the farm).

This crocodile gives its hunters the evil eye.
Photo - Cliff Winfield

For initial stocking, the farm may catch 90 saltwater crocodiles from the Cambridge Gulf and its associated rivers and 200 freshwater crocodiles from Lake Argyle.

Before CALM granted permission for catching to proceed, scientists were contracted to survey saltwater crocodile nesting areas in tidal rivers of the Kimberley and freshwater crocodile numbers in Lake Argyle and Lake Kununurra.

The farm's existence should help safeguard the wild population; under its license conditions, it has to supply crocodiles to restock the wild population if monitoring proves it is warranted.

CALM officers supervise catching operations, which must take place outside existing or proposed conservation reserves and important breeding areas.

A four-person team searches the river in a small punt at night, when the animals are most active.

"You see their blood-red eyes shining in the spotlight," said Wildlife Officer Russell Gueho.

The light dazzles the crocodile and allows its hunters to get close to it.

The hunters catch the animals with light ropes. The crocodiles are brought to the boat and nooses and cord are used to truss their jaws.

The animal is then put in the boat, and a hessian bag is placed over its head to quieten it down. The back legs are also restrained.

"It's important to treat the animals with respect. They are constantly rolling and splashing about until you get them on a boat, and even the small ones could probably take your hand off," said Russell.

Only crocodiles up to four metres long are caught - the larger animals are left in the wild.

The farm has collected quite heavily from around the Wyndham boat ramp and launch area.

"However there is evidence that new crocodiles have already moved back into the Wyndham area - it may be quite a dynamic population," said Russell.

A BIRD IN THE HAND...

Did you know that one Western Australian hospital is strictly "for the birds"?

The WA Native Bird Hospital cares for sick, injured and orphaned birds.

Referrals to the hospital come from CALM, the Perth Zoo, RSPCA, veterinarians and members of the public.

Over 700 birds are admitted each year suffering from road accidents, cat attacks and poisoning. Orphaned chicks also find their way to the hospital.

After being examined on arrival, "patients" are settled into a cosy, warm "ward" where they can eat or rest quietly.

Once settled, any broken wings are splinted and other needs attended to.

Feeding wild birds is a difficult task and meals may consist of seeds, fish, mice or live insects.

Fledgelings are fed every few hours and are raised until they are old enough to be placed in aviaries with other birds that have recuperated.

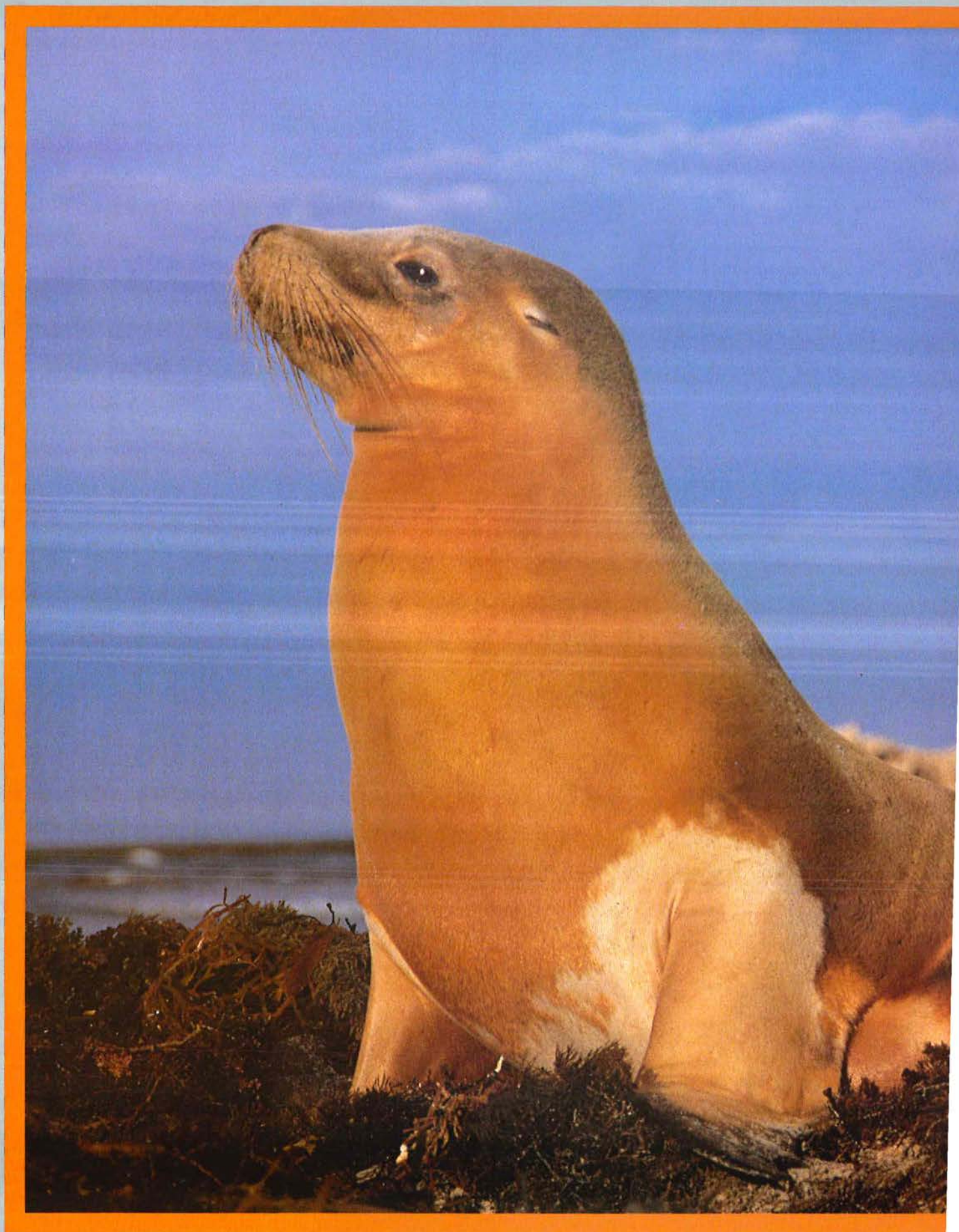
Once in aviaries, the birds may exercise and learn to fend for themselves. Eventually, identification bands are attached to their legs and they are released.

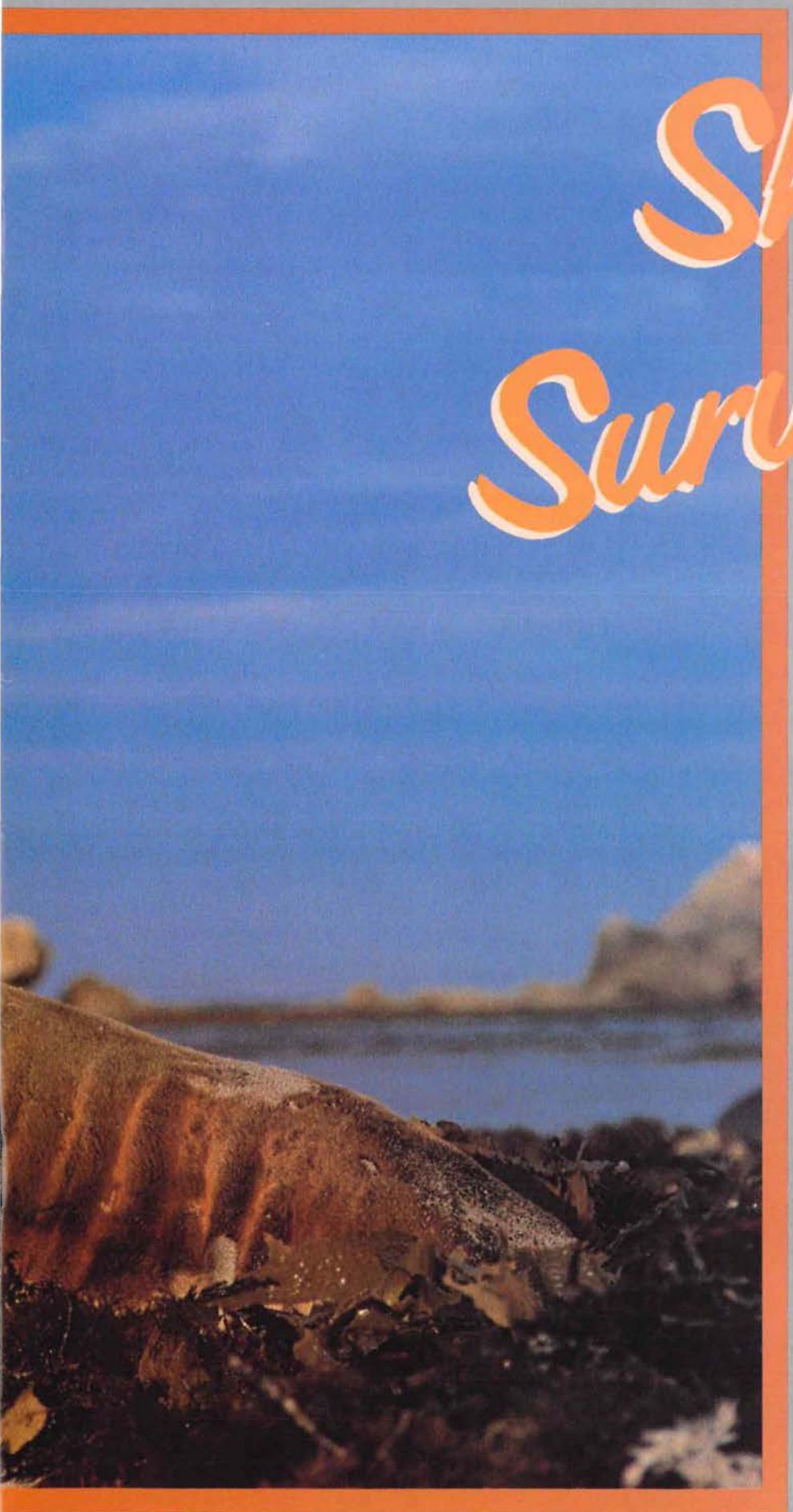
The hospital provides qualified veterinary care. It is run by dedicated volunteer staff who manage to raise funds through raffles, donations and sponsorship.

A sponsorship scheme is available to individuals who want to do their bit to help care for our native birds.

By filling out a "Sponsor-A-Bird" application form and enclosing $20 per bird, sponsors receive a package containing a certificate of sponsorship, a self-adhesive decal and information on their bird's injury and its progress.

An application form and further information is available from the WA Native Bird Hospital, PO Box 232, Mundaring, WA, 6073.





Shore Survivors

The waters around Western Australia are home to a diverse group of marine mammals. When a marine mammal is sick or injured, whether it is a massive baleen whale, a small fast-swimming dolphin or a furseal, its instinctive reaction is to beach itself so it doesn't drown, and suddenly these normally elusive animals are thrust into our world.

THE reasons for these strandings aren't always clear. Nobody really knows why certain species of whale, such as false killer whales (*Pseudorca crassidens*) and pilot whales *(Globicephala melaena)*, sometimes beach themselves in large numbers.

Strandings - many of them single animals - occur much more frequently than most people realise. During the first half of 1989 11 Australian sea-lions, seven bottlenose dolphins, three common dolphins, 24 striped dolphins (from a single stranding), and four whales (beaked whale, long-finned pilot whale, sperm whale and humpback whale) were found injured or dead on Western Australian beaches. However, when things do go astray there is a network of Department of Conservation and Land Management (CALM) officers, Atlantis Marine Park staff, volunteer organisations and the public, ready to spring into action.

CALM wildlife officers are usually the first people called to the scene of a stranding. They have learnt from experience to keep an open mind when they arrive. In one instance, an animal reported to be a stranded dolphin turned out to be a dead groper. There are also visitors from places as far away as the sub-Antarctic. Leopard seals, sub-antarctic furseals and even elephant seals have been washed up on the beach; they lose their way and are found exhausted, emaciated and often injured. None of these creatures are normally found on the WA coast.

A beached animal doesn't always need assistance - sometimes it only needs some time to rest on the beach. However, if it is injured or stressed, a veterinary opinion is sought and appropriate action taken.

Each stranding has its own special set of circumstances and provides a valuable contribution to our knowledge of marine mammals.

There are many heart-warming success stories. In May 1988 beachwalkers on Penguin Island found a stranded juvenile bottlenose dolphin (*Tursiops truncatus*). Fortunately CALM was contacted almost immediately and a wildlife officer and a vet were soon on the spot.

The dolphin was about four weeks old and totally dependent on its mother, so it was driven to Atlantis Marine Park for emergency care and held overnight. It responded well to an injection of an anti-stress drug and was walked in a pool by staff until it could swim shakily.

The next day wildlife officers patrolled the waters near the stranding site and were rewarded with the sight of a pod of bottlenose dolphins "milling" near the stranding site and behaving in an unusual way. Channel 7 volunteered their helicopter to lift the dolphin to Shoalwater Bay, where it was transferred to a CALM boat. The helicopter located the dolphins from a high altitude then broke away to avoid upsetting the pod.

The young dolphin was released into the pod and within seconds it had disappeared and, it is hoped, was successfully reunited with its family group.

Then there was the young male sea-lion (*Landscope* Summer 1988) found near Geraldton injured and unable to feed. He had been gashed in the face by a boat propeller. CALM officers drove him to Perth where his damaged eye was removed in an emergency operation at Murdoch University. After spending several weeks recuperating at Atlantis and learning how to swim and fish with only one eye, the animal, known affectionately as Popeye, was eventually released at Beagle Islands near Geraldton.

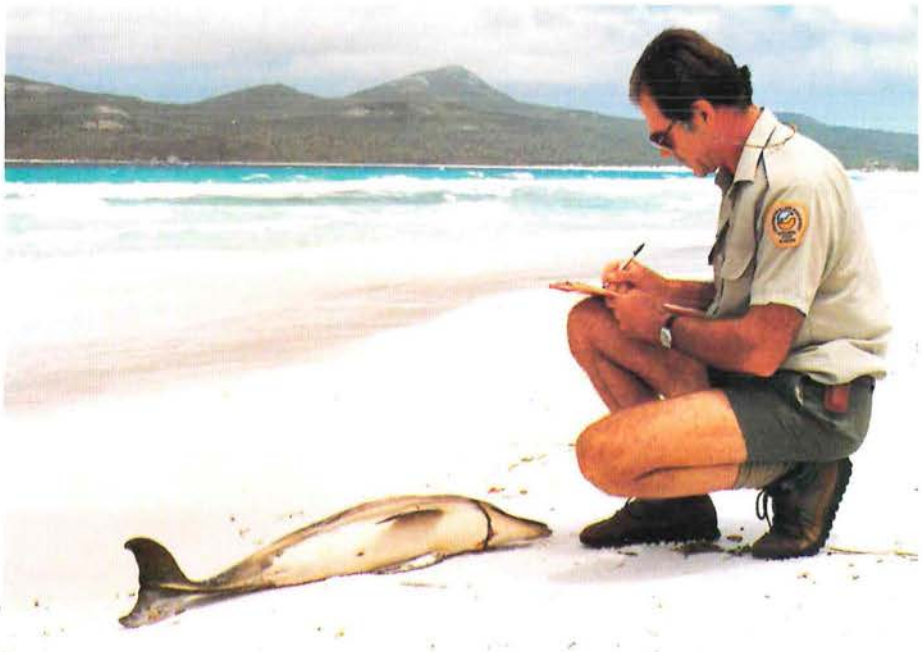
Late last year a female leopard seal (*Hydrurga leptonyx*) "hauled out" 10 kilometres north of Two Rocks. The vet who arrived to inspect the animal reported that it was dehydrated and had poor body condition. He recommended that the seal be taken to Atlantis Marine Park and placed on a course of antibiotics. Here it rapidly gained weight, consuming about 14 kilograms of fish each day. After about three and a half weeks it was back in peak condition and was released off Augusta to enable it to find the southern currents that would take it back to Antarctica.

Of course, not all attempts at rehabilitation are as successful as these, but even the failures are important; new methods are tested and vital insights gained. With every day an animal can be kept alive there is a greater chance that the next rehabilitation attempt may succeed.

Recently, an Australian sea-lion (*Neophoca cinerea*) was taken to Atlantis Marine Park to be nursed back to health. It did not respond well to treatment and tests revealed that it was riddled with a parasite similar to heartworm. This was the first time the disease had ever been found in a wild population of sea-lions and this has potentially enormous implications. But the discovery at least alerted CALM staff to the possibility that the disease may be found in wild populations. Research is now underway at Murdoch University to find out if this

Data on dead marine mammals is recorded for use in scientific research. Photo - Tony Tapper ▼

Photo previous page - Nick Gales



The baby pilot whale found near Lancelin was walked by volunteers for 24 hours a day to simulate the natural situation. In the ocean it would be held in the slipstream of its mother's body.
Photo - Gerhard Freudenthaller ◄

This sea-lion, known as Popeye, was gashed in the face by a boat propeller, but speedily recovered from an operation to remove his eye. He was later released near Geraldton.
Photo - Carolyn Thomson ▼

Murdoch University perform operations on sea-lions and other marine mammals. They provide their services and facilities free of charge.
Photo - Nick Gales ▼▼

is the case. The sea-lion in question did eventually improve under treatment and was released. However, it restranded and eventually died. The post-mortem showed it had severe arthritis.

In October 1989 a day-old pilot whale was stranded on the beach at Lancelin Bay. A wildlife officer assessed the calf's condition and, when the rest of the pod could not be located by helicopter, drove it to Atlantis Marine Park. There it was continuously walked and supported in a small pool and fed a cream and milk powder mixture. After a few days it began to refuse food and, five days after being stranded, it died of a bacterial infection.

The bid to keep the calf alive was unique - it was the first time anywhere in the world that there had been an attempt to rehabilitate a whale so young.

Most stranded marine mammals are dead before they are found. If it is practical, and the body is not too badly decomposed, an autopsy may be done by Murdoch University or one of a number of country vets to try to determine the cause of death. Other vital information is also obtained from these examinations. If an autopsy is impractical, wildlife officers record basic biological data and collect tissue samples used to analyse heavy metal and pesticide content.

Although most whales were rescued during the mass strandings in Augusta in 1986 and 1988, some animals died. Tissue samples and teeth were taken by Daryl Kitchener, a research scientist from the WA Museum. He has made some interesting findings. The tissue contained eight heavy metals, as well as pesticides. The teeth were sent to Japan to determine the age of the animals from which they were taken. So it should be possible to compare the accumulation rates of heavy metals in the whales with their age. This has not been done before anywhere in the world. Perhaps one day this research may even shed some light on why mass strandings occur.

Autopsies and other data have shown that a disturbing number of marine mammal deaths are caused by humans and their lifestyle. All too often they become entangled in marine plastics (*Landscope* Summer 1987), collide with boat propellers or drown in craypots. At least 35 per cent of the sea-lion deaths recorded by CALM over the last two years are known to be caused by humans.

If a marine mammmal is suffering and veterinary advice is that there is no doubt that it will die, a decision may be

Minister for Conservation and Land Management Ian Taylor and veterinarian Nick Gales release a rehabilitated sea-lion.
Photo - Peter Lambert ▲

IF YOU FIND STRANDED MAMMALS

Contact CALM immediately:

CHIEF WILDLIFE OFFICER
(09) 367 0429;

SUPERVISING WILDLIFE OFFICER
(09) 367 0339; or

NEAREST CALM OFFICE
(see government section of phone book).
After hours: (09) 448 1109 or (09) 401 8183.

Give as many details as possible, including:
- *description of animal (species if known)*
- *number and size*
- *exact location and weather conditions*
- *condition (whether dead or alive; any injuries)*

Remember, CALM wants to be informed of all strandings; even decomposing animals are valuable for research.

TO JOIN WESTWHALES:
Write to RMB 24, Manjimup 6255, or telephone Cecilia Aldridge (President) on (097) 561 084 or Andre Fulon (097) 721 327.

Scamperdown whales stranded at Boodjidup Beach, Margaret River.
Photo - Peter Lambert ▲

taken to euthanise it humanely. This is always done with veterinary guidance and is only considered in the interest of the animal.

The public plays a major role in marine mammal strandings and rescues. Many volunteers were involved in all three mass whale and dolphin strandings at Augusta. These people have now built up a considerable degree of expertise.

A group, Westwhales, was formed after the 1988 whale rescue to enable strandings to be dealt with more effectively. Westwhales members make a commitment to turn up to a stranding at short notice. About 60 committed people attended a meeting to ratify the Westwhales constitution earlier this year and regular workshops have been held in Augusta, Bunbury and at Atlantis Marine Park. Westwhales has prepared phone lists of volunteers, radio alerts and organised local groups in each area that can be mobilised in response to single or fairly small strandings.

During the mass striped dolphin stranding in January 1989 it was a considerable advantage for CALM to be able to call on a pool of experienced volunteers, who turned up with a wetsuit and other basic equipment such as hessian. CALM also asked Westwhales and Greenpeace to help when the newborn pilot whale was stranded in early October. The groups despatched members from as far away as Nannup to support the whale around the clock.

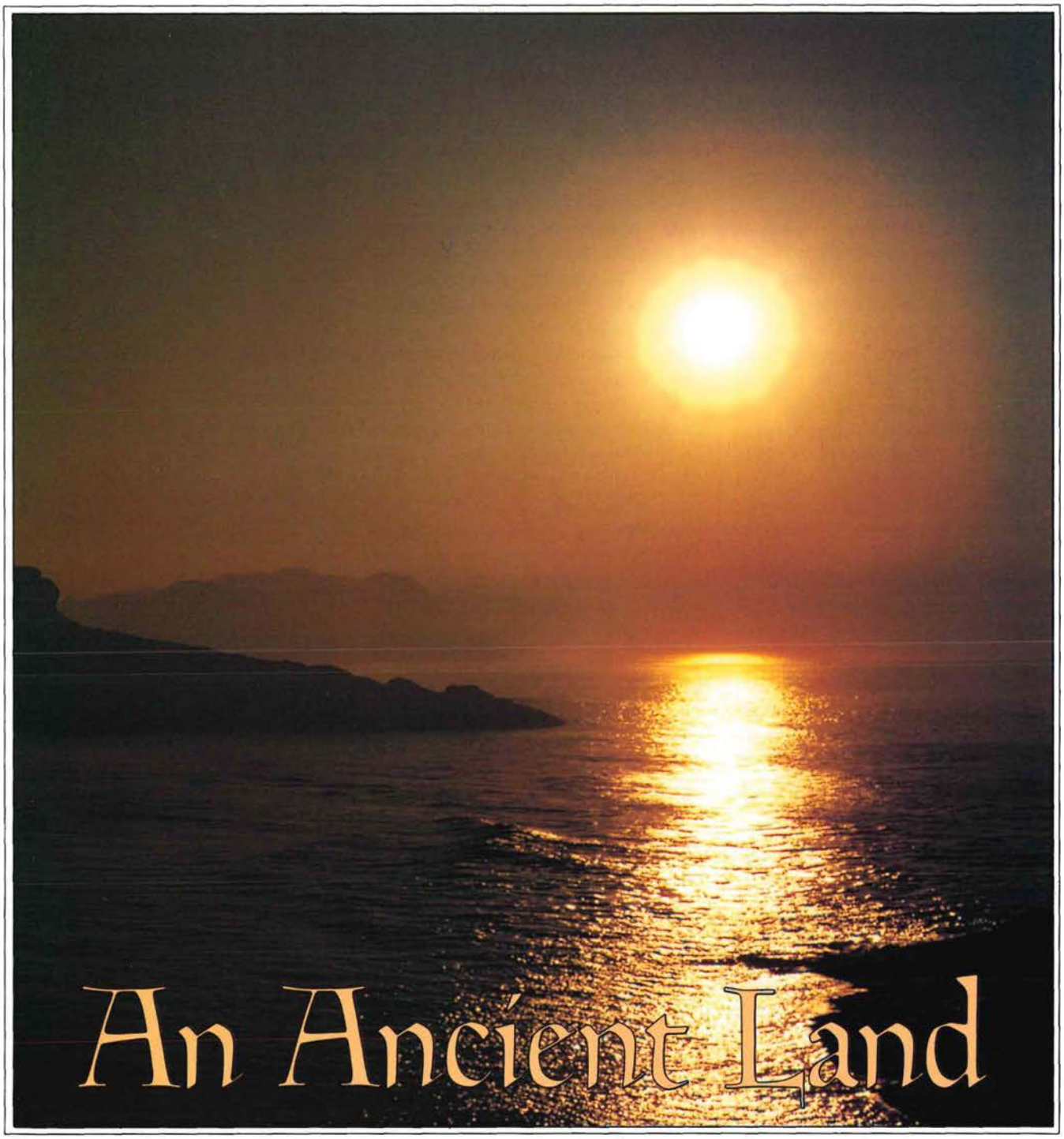
But of course you don't have to be a Westwhales member to help during a stranding. You may be walking along the beach early one morning and be the first person to stumble upon an animal that is clearly in distress. In such a case what do you do?

CALM must be notified immediately. You may be able to administer emergency first aid until help arrives. You should keep whales or dolphins cool and wet, especially the tail and flippers, and cover them with a wet cloth if it is hot. However, be careful to keep sand, water and cloth away from the blowhole. Seals or sea-lions can survive for long periods out of water, but people and dogs should be kept away to avoid distressing them. Animals returned to the ocean prematurely usually restrand, so never move them or push them back into the water until expert help arrives.

As public awareness of these animals develops and our isolated coastline becomes increasingly accessible, more and more strandings will be reported. The positive relationship that exists between CALM, Atlantis and the many other professional and voluntary groups involved in marine mammal strandings will certainly lead to great improvements in our ability to handle these events and lead to a great increase in our knowledge of these animals.⊡

NICK GALES, DOUG COUGHRAN AND CAROLYN THOMSON

Humpback whales, such as this one, are occasionally stranded on the beach, but they are so huge that very little can be done to help them. One that stranded recently at Wedge Island had to be euthanised.
Photo - Doug Coughran ◀



An Ancient Land

By Grant Wardell-Johnson and Vanessa Smith

Inlets and rivers, framed by towering karri and tingle forests; rugged coastline bordering the Southern Ocean; remote wilderness areas virtually untouched by humans. This is Walpole-Nornalup National Park, the southernmost national park in Western Australia.

AN Aboriginal tribe known as the Minang originally occupied the area from Albany north to the Stirling Range and west to the Shannon River and Broke Inlet. They hunted kangaroos and other animals; they built fish-traps in the estuaries and, presumably in search of weapon heads, quarried stone from the rocky cliffs. They called the area nornalup, meaning "place of the tiger snakes".

Snakes or not, this is a place of loveliness and immense variety. It surrounds two estuaries (the Walpole and Nornalup Inlets), and two major rivers meander through the changing landscape. Hidden sandy beaches fringe the coast. High cliffs of limestone and granite are backed by dunes, and the deposits of alluvial sands of the interdune plains. Inland, on the southern edge of the great plateau of Western Australia, granite hills and ridges rise up to 100 metres above the surrounding swampland.

THE TOUCH OF THE PAST

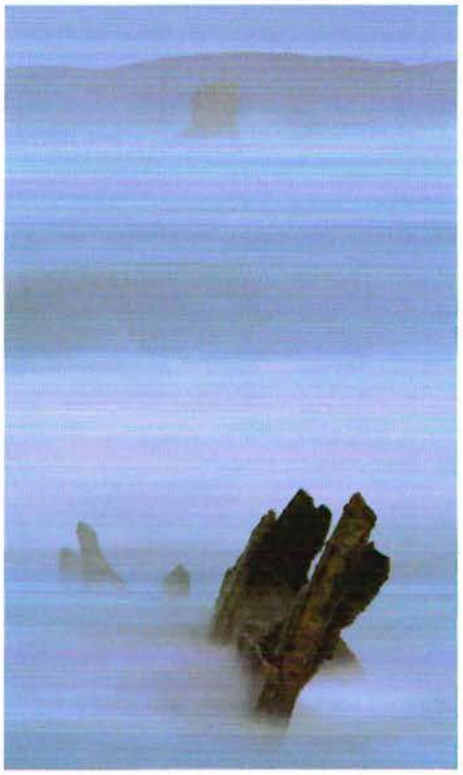
In 1627 the *Gulden Zeepard* (Golden Seahorse), a Dutch East India ship, sailed along the south coast and named Pt Nuyts after Pieter Nuyts, an official of the Dutch East India Company who was on board. Europeans took little interest in the region, however, until many centuries later. It was not until the 1850s that settlers from further inland began to drive cattle down to the coastal areas of the present National Park for summer grazing. Stock camps were established along the coast; part of one camp can still be found at Crystal Springs.

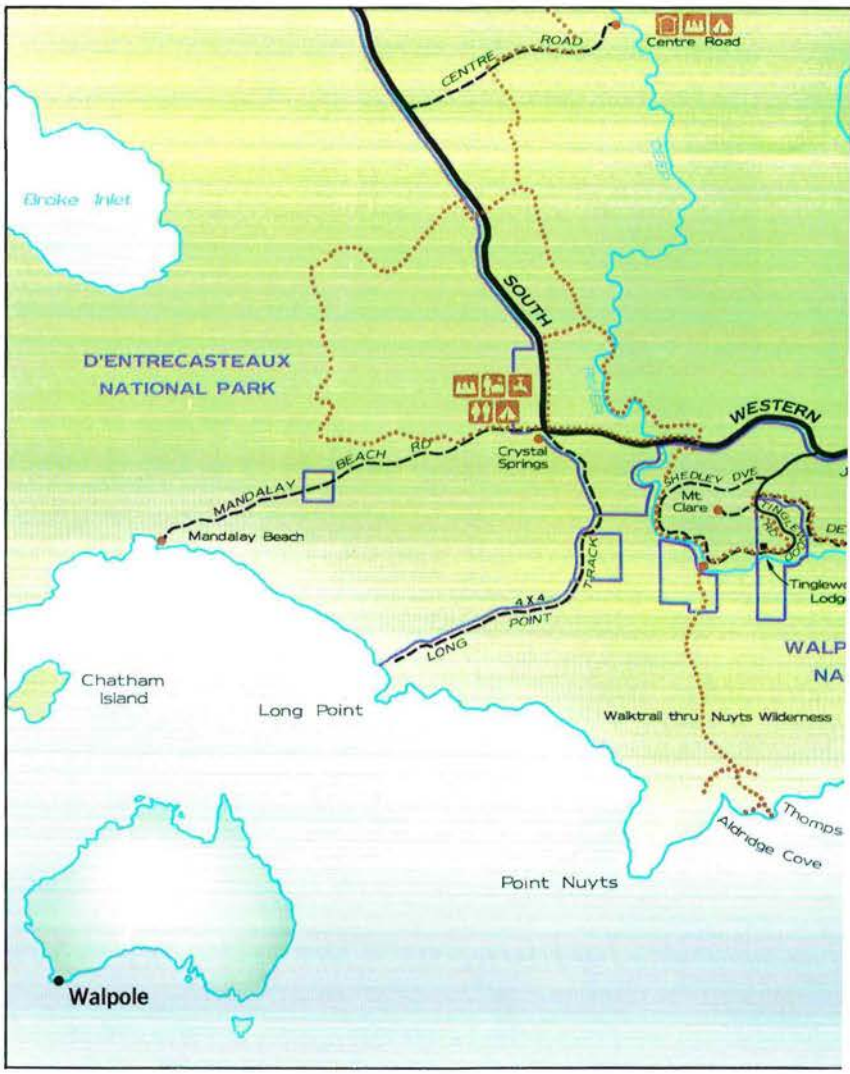
Permanent settlement began in 1910 when Frenchman Pierre Bellanger and his family took up land beside the Frankland River. The next year an English family, the Thompsons, settled at Deep River. The rest of the district was opened up for agriculture through land settlement schemes in 1924, 1927 and 1930.

Professor Ernest H. Wilson of Harvard University, who had seen many of the great forests of the world, visited the area in 1920 and remarked that "the scenery is just about as beautiful as you could have anywhere in the world... wonderful forest and river scenery, mountains, landscapes, seascapes, boating, fishing. The karri and tingle giants are the finest broad-leaved trees I have ever seen". He prevailed on Premier Sir James Mitchell to make 12 000 hectares of the Nornalup area a national park. It was declared as such in 1921.

This is an ancient land. Sixty-five million years ago, when Australia was part of the supercontinent Gondwana, the climate was warm and continuously wet. A number of invertebrate species found in the Park are relics from this era. Walpole-Nornalup National Park still has the wettest and least seasonal climate in the South-West. This accounts for the many unique and unusual plants and animals, particularly invertebrates.

The Park's remarkable variety of landforms and soils support a dramatic range of vegetation communities. Fifteen different plant communities, each with its own distinctive flora, have been identified. The narrow edges between shrubland communities and tall, open karri and tingle forest highlight the sharp boundaries between both the landform types and the communities. Study plots only 100 metres apart can include quite different groups of species.





The Mandalay, wrecked in 1911 off the Walpole coast, rises out of the sands every 10 years or so.
Photo - Kerry Cook ◄

Twisted sun orchid *(Thelymitra flexuosa)* grows in swampy ground of the lower South-West and flowers in October.
Photo - Grant Wardell-Johnson ▲

Newdegate Island at the mouth of the Deep River in Nornalup Inlet.
Photo - Cliff Winfield ►

The brilliantly coloured flowers of red-flowering gum *(Eucalyptus ficifolia)* vary from crimson to pink.
Photo - Geoffrey Rogerson ▲

ENDEMIC EUCALYPTS

Walpole is a special place for trees. Four species of eucalypts grow within a few kilometres of Walpole and nowhere else in the world.

The red tingle (*E. jacksonii*) is one of the largest trees in the world; some specimens have trunks measuring up to 20 metres in circumference. This tree is only found within 10 kilometres of the coast between the Deep River and Bow Bridge. The yellow tingle (*E. guilfoylei*) is more widely distributed and grows in a greater range of soil types. It occurs near Denmark, Mt Frankland and the Beardmore Ridge. Red and yellow tingle usually grow in mixed stands with karri (*Eucalyptus diversicolor*). Rate's tingle (*E. brevistylis*) is closely related to the red tingle but is even more restricted. Its main populations occur in the Mt Frankland National Park but there are two small outlying populations in the Walpole-Nornalup National Park, both near the South Coast Highway.

The karri/tingle forest is rich in birdlife, particularly those that nest in tree hollows formed by fungi, termites and fire. Although fire is a rare visitor to the tingle forest, the large fires that have occurred this century (for example in 1937 and 1951) have been intense because of the high buildup of fuels on the forest floor.

The red-flowering gum (*E. ficifolia*) is almost confined to the sandy interdune plains of the Walpole-Nornalup National Park. Small outlying populations also occur in the north of the Park and in Mt Frankland National Park. It is a well-known street tree throughout the world, because of its beautiful flowers, moderate size and attractive shape.

Research on these eucalypts suggests they were all once more widespread during wetter and more even climatic regimes, many thousands of years ago.

RARE PLANTS

More than 650 plant species are found in the Park. Largely because of its unique climate, the Park has a high number of rare and geographically restricted plant species. At least 50 plants, ranging from tall shrubs to ephemeral herbs, are still undescribed and many have been collected only here. An unnamed species in the potato family (only known from 20 plants in a single study plot), several unknown *Agonis* taxa, two daisies and tiny herbs such as *Monotaxis* sp. and *Amperea* sp. are found only in the Walpole-Nornalup National Park and remain undescribed.

The Park is one of the richest areas in Australia for orchids - there are at least 90 species. Herbaceous perennials such as orchids, lilies and irises are a dominant part of the flora. Annuals, such as daisies, and small shrubs are also abundant.

INSECTS BEWARE!

Three families of insectivorous plants grow in the Park's peaty swamps. Each has adapted its own means of catching prey. The Droseras, for example, have sticky leaves like fly paper. The bladderworts have the most complex system - a series of vacuum cleaners to draw in the prey, each equipped with valves to separate the prey from the debris. These minute traps lie just below the soil's surface. Bladderworts are also known as fairies' aprons because of their attractive flowers. The pitcher plant is found only in the lower South-West and is common in the peaty swamps of Walpole-Nornalup National Park. It is the only species in its family. Insects caught in its vase-like trap, a modified leaf-stem, are unable to escape because of its wax-like surface and inward-pointing hairs at its rim.

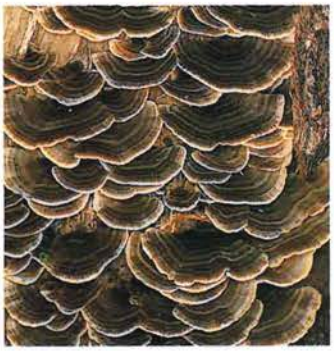
MANAGEMENT ISSUES

There have been many environmental changes in the area around Walpole-Nornalup National Park since European settlement. Nearby private property has been cleared for agriculture and cattle grazing has had an impact on coastal dune vegetation. Timber cutting and regeneration has occurred in the forests of the district over many decades. These changes have led to the introduction of predators such as the fox and cat, disease and weeds. The way the Park is managed can, however, minimise the impact of undesirable changes.

A draft management plan for the Park is scheduled to be released for public comment in 1990.

Red tingle tree; the word 'tingle' comes from an Aboriginal term and 'red' is for the almost purple colour of its timber.
Photo - Cliff Winfield ▲

The pitcher plant (*Cephalotus follicularis)* is found in peaty sites in the Park.
Photo - Grant Wardell-Johnson ▼



Walpole-Nornalup National Park is framed by inlets, limestone cliffs, hidden sandy beaches and granite headlands.
Photo - Cliff Winfield ▲▲

From left: bracket fungi on a dead tree; swamp sun orchid *(Thelymitra cucullata)*; a rare tail flower *(Anthocercis* sp.); and fungi growing on a rotting tingle log.
Photo - Grant Wardell-Johnson ▲

FLORA SURVEY

An extensive biological survey of Walpole-Nornalup National Park was conducted over three years (from 1985 to 1988) to specifically provide information for the management plan being developed for the Park. This is the most detailed survey ever carried out by the Department of Conservation and Land Management (CALM).

The study was designed to provide an understanding of plant communities and vulnerable species. Study plots in each community were marked and species within them recorded. Scientists returned each month to record the species in flower, heights of plants, vegetation density and fuels.

Vulnerable species and communities in need of special management attention were identified. These categories include species susceptible to dieback, and species with soft seeds and a long juvenile period which would make them vulnerable if fires were too frequent.

Species that dominate an ecosystem, those that fruit, flower or seed outside community peaks or those that produce copious flowers and nectar used by fauna may be extremely important to the community's continuation. Key species identified in the survey included the peppermint tree, holly-leaf banksia, oakleaf banksia, parrotbush and the dominant eucalypts.

DIEBACK DISEASE

Protection from dieback is critical. Because many key species are vulnerable, the disease could have a major impact on a number of plant communities. There are several areas in the Park infected by dieback, so restricting its spread to other areas will be a major priority. This will affect the design and location of tracks and roads, fire management and suppression, and any other activities that involve soil movement.

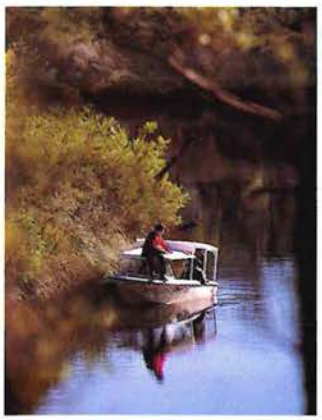
VALLEY OF THE GIANTS

The Valley of the Giants, a State forest named for the massive size of the red tingle trees, will soon be added to the Walpole-Nornalup National Park. The trees have huge buttresses and many are over 400 years old. Often, the huge trunk has been hollowed out by fire. A tree can survive this massive injury as the living part of the tree is just below the outer bark rather than the centre.

Ferns, mosses and colourful wildflowers grow in the dense jungle-like understorey. Countless birds, including the New Holland and White-naped Honeyeaters and noisy Purple-crowned Lorikeets, are abundant - particularly when the karri, tingle or Chorilaena is in flower.

Amid the giant trees one can also examine the smallest worlds. Tiny fruiting fungi in many shapes and colours carpet the forest floor and a huge array of insect life lives in the deep, moist litter layer. *Descolea maculata*, one of many species of fungi that help the larger plants take up nutrients (they are mycorrhizal) is a member of a genus of fungi mycorrhizal on southern beech, a species extinct in WA for many thousands of years.

Descolea maculata, one of hundreds of species of colourful fungi found in the moist forest understorey.
Photo - Grant Wardell-Johnson ▲



Boating on the Frankland River - an extremely popular and enjoyable recreational activity.
Photo - Robert Garvey ▶

RECREATION

While the Valley of the Giants is a big tourist drawcard, many other activities can also be enjoyed in the Park, including fishing, boating, yachting, canoeing, photography, sightseeing, nature study, pleasure driving, bushwalking and camping. Recent visitor surveys have shown that fifty-eight per cent of Park users are from interstate and overseas. The number of Park visitors has trebled over the past 10 years and numbers may double within five years. The goal is to plan for increased usage while maintaining the Park's wild and pristine qualities.

A comprehensive recreation plan is being devised for the Park. Intensive use will be restricted to specific areas, such as the Valley of the Giants, while keeping large areas free of any development or formal access. The suitability of present recreation sites for existing and increased future demand is being examined. The provision of a quality experience for the large numbers of short-term tourists is being examined, while guidelines will be needed to ensure adventure-based tours such as bushwalking, four wheel driving, canoeing and camping have a minimal impact. More bushwalking and camping opportunities may be provided. There will be improved access to the coast, but the number of coastal tracks may be reduced.

NUYTS WILDERNESS

In the south-western part of the Park about 5 000 hectares of near-pristine bushland has been set aside as a wilderness area for those seeking wild beauty and solitude. Access is by walking only; there are no interpretive signs, track markers or other facilities.

Nuyts Wilderness stretches from Deep River to the coast beside the Southern Ocean. The area contains high rock-capped hills, coastal dunes, deep forested gorges and a spectacular rugged coastline. Many plants and animals that occur here are found nowhere else in the world. As the area's popularity has grown, limits have had to be placed on numbers of people and nights for camping. These are measures necessary to maintain the wilderness experience. The management plan for the Park will address these issues and ensure that the many rare and vulnerable plants and animals in the area are also protected.

The preparation of this management plan has involved the highest level of public participation of any plan in Australia. Visitor surveys, workshops and the involvement of the Walpole-Nornalup National Park Association will help to ensure that the many conflicting demands do not impede the high conservation value of the Park.




From top left: Karri boronia *(Boronia gracilipes)*; southern brown bandicoot; bush cockroach on granite; and the rare finch, the Red-eared Firetail.
Photos - Grant Wardell-Johnson
Bandicoot photo - Jiri Lochman ▲▲

Pigmy possum dwarfed by a gum leaf. It hunts for insects at night.
Photo - Geoffrey Rogerson ▲

FAUNA CONSERVATION

Because of its relatively pristine state, its surrounding uncleared lands (including the adjacent Shannon-D'Entrecasteaux National Park), its mix of landform types and high and even rainfall, the Walpole-Nornalup National Park is important for fauna conservation.

Twenty-one species of native mammals, 109 bird species, 22 species of reptiles and 12 frog species live in the Park. One species of frog (*Geocrinia lutea*) is found only within 12 kilometres of Walpole and the short-nosed snake, square-nosed snake and crowned snake are confined to the lower South-West. The mud minnow, a species of fish, is found in peaty swamps that dry up over summer. It lies dormant in the mud during this time and reappears when winter returns.

The invertebrate fauna, although still relatively unknown, may yet prove to be the Park's most remarkable feature. The Park is an important refuge for species of invertebrates formerly more widespread in wetter climatic periods 65 million years ago, including many spiders, snails and the ancient *Peripatus*, which is a living link between worms and arthropods.

Because these organisms are restricted to the wet climate of the area, it is possible that they will be put at risk if major climate changes, such as those predicted under the greenhouse effect, were to occur.

RATS, POSSUMS AND BIRDS

The bush rat (*Rattus fuscipes*) is the most common mammal in the Park. There are also populations of the honey and pygmy possum, southern brown bandicoot, dunnart and phascogale. Many mammals have declined in the area during this century including the chuditch, ringtail and brush-tail possums, quokka and brush-tail wallaby; of these, only the quokka remains common in the Park. Predation by the introduced fox is considered to have been a major factor in the decline of these mammals.

Many bird species inhabit the Park's coastline, rivers, inlets, forest and heathland. Sites within the Park are included in the translocation program for the Noisy Scrub-bird, a species that has apparently become extinct in the area since European settlement. The only native finch found in the South-West, the Red-eared Firetail, a gazetted rare bird, is common in the karri/tingle forest and creeklines.

During the recent biological survey, animals were recorded every season. Pitfall traps were set for small mammals and reptiles and cage traps for medium size mammals such as bandicoots and possums.

Observers counted birds in 90 locations. The counts were carried out in all seasons over two years and provided important information on the Park's bird communities. Volunteers worked with CALM scientists on bird observation and survey work. One even helped provide a list of 100 species of fungi that serve as indicators of environmental change in the Park. The information collected by these people will be a great help in preparing the Park's management plan.

The Walpole-Nornalup National Park is home to many species and communities restricted to the southern tip of the State. The challenge for the future is to protect this unique area, its unusual plant and animal life and the feeling of a wild and pristine landscape. ⊡

Desert Bigfoot

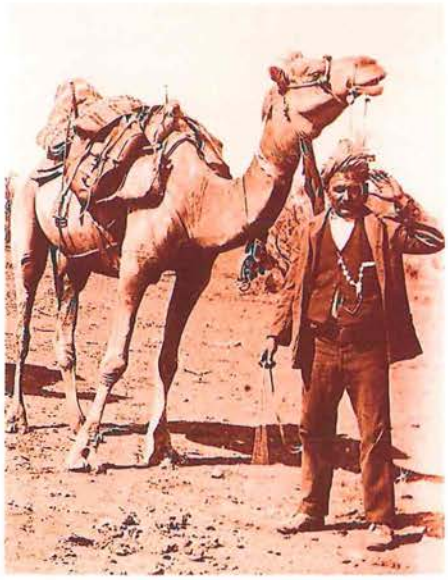
by
Andrew Burbidge

At the height of the goldrush late last century thousands of camels were imported into Western Australia. Breeding depots were established to increase their numbers further. When they were no longer needed for transport, many were released and became established in the wild.

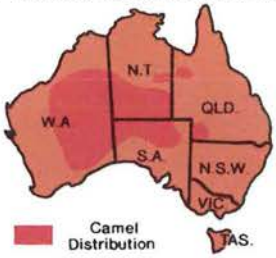
The first one-humped camels were introduced to Australia in 1840 but camels were not imported for use in desert travel until 1860, when they were shipped from India for the Burke and Wills expedition. It was gradually recognised that camels were much better pack and draught animals in arid areas than horses or bullocks and from the late 1860s to 1907 thousands were imported, together with many 'Afghan' camel drivers, who were actually from the drier parts of India. From 1894 to 1897, at the height of the goldrush, 6 600 camels were imported into Western Australia alone.

Camel-breeding 'depots' were set up by both private individuals and Governments. Government depots in WA included one at Londonderry, near Coolgardie, operated by the Mines Water Supply Department. Depots at Jigalong, Dromedary Hill (30 km east-north-east of Payne's Find) and Yalgoo were operated by the Agriculture Department to breed camels for use in vermin fence maintenance.

By the 1920s there were about 20 000 domesticated camels in Australia. They were an indispensable part of outback life until displaced by motor vehicles in the 1930s and 1940s. Today there are many more wild camels than there were domesticated ones earlier this century.



Camels were widely used as pack animals in arid parts of Australia.
Photo - Courtesy of Battye Library 5970P▲



The number of wild camels in Australia is not accurately known. In 1969 numbers were estimated at between 15 000 and 20 000 and a 1983 estimate put the number around 25 000. However, a 1984 aerial survey in the Northern Territory produced an estimate of 31 500 camels for the Territory alone, suggesting that there could be more than 100 000 in the whole country. This is likely to be conservative as, despite their size, camels blend into the landscape and are difficult to see from the air.

Camels occupy a variety of habitats in Australia, but are mainly found in the sandy deserts in the southern half of the Northern Territory, the northern half of South Australia and the extreme south-west corner of Queensland. In Western Australia they are found in the Great Sandy, Little Sandy, Gibson and Great Victoria Deserts, often spilling onto the Nullarbor Plain and into adjacent pastoral areas (especially in dry years) where they damage fences and artificial water points.

Australia is now the only place in the world where there are wild camels; the 15 to 20 million in other countries are all domesticated. Desert travellers in Australia often see signs of camels along roads and tracks; their large footprints and small, almost spherical droppings are everywhere.

Occasionally the animals are sighted, usually in small groups of four to 20. Some camels are road-hogs - they will run along a track in front of a vehicle, never moving from the wheel ruts, stopping when it stops and starting again when it starts. On a narrow track they are almost impossible to pass.

Camels blend into the landscape and are difficult to see from the air.
Photo - Cliff Winfield▲

The first feral camels in Australia were two abandoned by the Burke and Wills expedition.
Photo - Robert Garvey◀

Photos on opposite page:
Footprint - Andrew Burbidge
Camels - Cliff Winfield

DESERT ADAPTIONS

Camels are well-adapted to desert life. They have a low metabolic rate and slow water turnover, storing heat gained during the day and dissipating it at night. They don't begin to sweat until their body temperature rises above 38°C and their droppings contain little water. Their urine is only moderately concentrated, but it is produced slowly in times of water stress.

If drinking water is not available under hot conditions (about 40°C), a camel will lose about two per cent of its weight per day, but even when it has lost 25 per cent of its body weight, its blood volume has decreased by only 10 to 15 per cent. Camels can lose up to 30 per cent of their body water and still remain in good health.

To compensate for this water stress a dehydrated camel may drink 100 litres or more of water at one time. This causes a degree of dilution of the blood and other body fluids that cannot be tolerated by other animals: the red blood cells of the camel can swell to twice their normal size without rupturing. The hump stores fat that can provide a reserve food supply for up to six months. Some extra water is gained when the fat is metabolised.

Camels are gregarious and usually live in herds that range from a few animals to more than 100. A herd is usually led by an older female, but when males come into breeding condition a mature male will attempt to dominate a herd, becoming aggressive to other males.

The gestation period is between 360 and 380 days. The single calf weighs about 40 kg at birth and is suckled for more than a year. The interval between births is about 18 to 24 months. Camels become sexually mature at three years and continue to breed until they are about 20 years old. Their lifespan is about 30 years. A recent Northern Territory study has shown an increase rate of 12 to 15 per cent annually in undisturbed populations, allowing numbers to double every six years.

ONE HUMP OR TWO ?

The camel family, the Camelidae, are ruminants and part of the mammal order Artiodactyla (even-toed Ungulates). Other ruminants include giraffes, deer, cattle, buffalo, sheep, goats and antelope. Members of the camel family are usually separated from other ruminants into the suborder Tylopoda (meaning pad-footed) because they walk on pads instead of the sole of the hoof (the hoofs are reduced to claw-like toes projecting beyond the pad). The Camelidae also differ from other ruminants in not having horns or antlers. The oval shape of their red blood corpuscles makes them unique among mammals.

The Camelidae originated in North America (where they became extinct in prehistoric times) and spread to the south and west. In South America, wild members of the family are guanacos and vicuñas; the domesticated llama (used for meat and as a beast of burden) and alpaca (bred for its long, soft hair, used as wool) are descended from the guanaco.

Camels on a recently burnt area of sand on the Gibson Desert.
Photo - Andrew Burbidge ▲

Camels probably arrived in the Old World around two million years ago. In historical times the two-humped camel or bactrain (*Camelus bactrianus*) occurred in the wild only in the Gobi Desert, but was domesticated from Turkey to Manchuria. The original range of the wild one-humped camel or dromedary (*Camelus dromedarius*) is not known, but probably included Arabia (where there were wild camels in Roman times) and other parts of the Middle East. It is domesticated throughout north and east Africa, and from the Middle East to north-east India. Both the one-humped and two-humped camel were domesticated about 3 000 years ago.

Two main breeds of the one-humped camel are generally recognised - a slender riding form (the dromedary) and a heavier pack animal, but the breeds blend into each other. One-humped and two-humped camels may be forms of the same species, since crosses between the two are fertile.

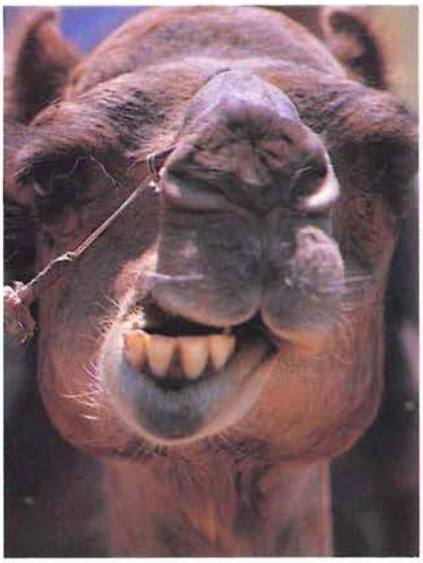
EFFECTS ON AUSTRALIAN PLANT AND ANIMALS

The camel's split upper lip enables it to browse selectively from tree branches, shrubs and groundcovers. It eats like a vacuum cleaner, sucking up leaves into its mouth. The diet includes a wide variety of plants, particularly those with high levels of moisture and salt, such as prostrate succulent plants.

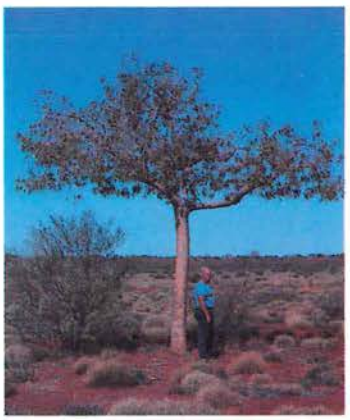
The impact of tens of thousands of half-tonne herbivores on Australian desert plants and animals is not yet fully known. One study has shown that feeding has little impact on plants unless camel densities are high (more than two per square kilometre). However, there is some evidence that selective grazing of palatable, uncommon species of plants such as desert kurrajong, quandong and pittosporum is gradually eliminating these species from the sandy deserts by preventing seedlings from establishing.

The greatest impact of camels is on desert waterholes. When Aborigines roamed the deserts they depended on many water points, mostly small rockholes and soaks (or "native wells"). The Aborigines kept these waterholes open and clean; rockholes were often covered with a slab of rock or a bundle of spinifex to reduce evaporation. A group of camels can empty a rockhole in minutes and this was a source of considerable friction between some of the early European travellers and Aborigines. Camels cannot dig for water like kangaroos and they collapse the walls of soaks.

The camel's upper lip is split and hairy - it is specially adapted for selective browsing.
Photo - Kerry Cook ▼

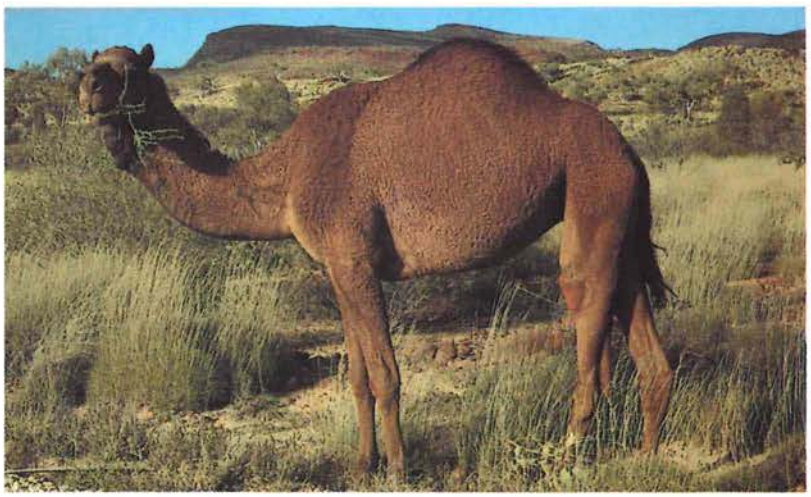


Camels often travel in groups of between four to twenty animals.
Photo - David Pearson ▲



A desert kurrajong (*Brachychiton gregorii*) browsed to camel height in the Great Victoria Desert.
Photo - Andrew Burbidge ▲

Feral camels destroy fences and compete with native animals for precious water supplies.
Photo - Neil Burrows ▼



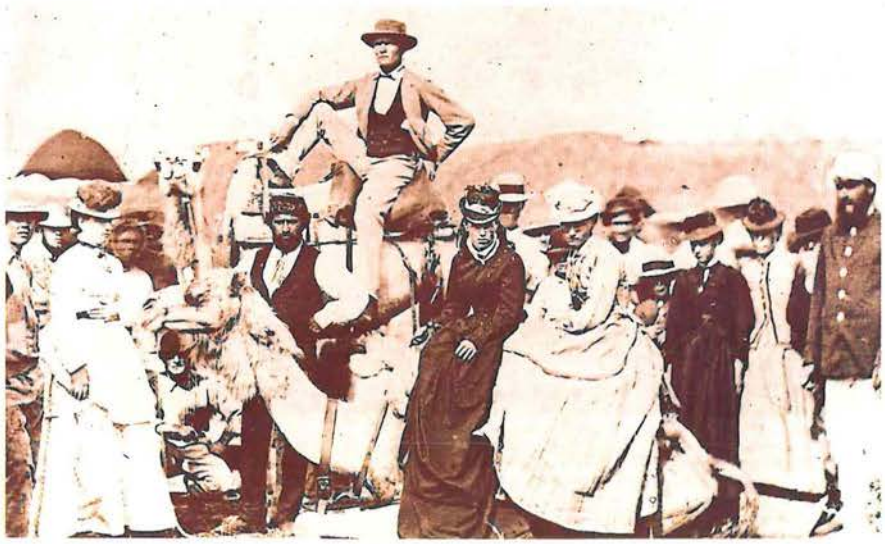
CAMELS AND AUSTRALIAN DESERT EXPLORATION

The first European to cross overland from South Australia to Western Australia was John Eyre in 1840-41. Hugging the coastline of the Great Australian Bight, he suffered incredible hardship, losing many of his horses, but managed to struggle into Albany. John Forrest made the return trip in 1870, again with horses, benefiting from supplies provided by a schooner at Esperance, Israelite Bay and Eucla.

The Burke and Wills expedition of 1860-61 was the first to use camels for exploration, having a mixture of camels and horses in their retinue. Peter Egerton Warburton was the first explorer to use camels as the only means of transport for desert exploration, when he crossed the Great Sandy Desert from east to west in 1873-4 *en route* from Alice Springs to the Pilbara. His party suffered extreme hardship and doubtless would have perished had horses been used.

Although John Forrest was able to cross a small part of the Gibson Desert from west to east with horses in 1874 while exploring from Geraldton to Alice Springs, he traversed mainly hilly country with many rockholes and travelled in a good season. Ernest Giles first tried to cross the central Gibson Desert from east to west with horses, also in 1874. He set off from the Rawlinson Range hoping to reach the headwaters of the Murchison River, but the horses failed before he had covered a fraction of the distance. His companion, Gibson, died in the desert that now bears his name and Giles only just escaped with his life. In 1875 Giles led an expedition in South Australia using both horses and camels. In the hot, dry conditions all the horses perished and the explorers might have died too if the camels had not survived a 350 km trek without drinking. Convinced that camels were the only means for desert exploration, Giles successfully crossed the Great Victoria Desert from east to west later in 1875 and returned eastwards across the northern Gibson Desert in 1876.

After this success many other explorers used camels for desert expeditions.



Camels brought west by Ernest Giles when he crossed the Great Victoria Desert in 1875.
Photo - Courtesy of WA Newspapers ▲

Camels may have contributed to the decline of seed-eating birds, such as this rare Princess Parrot.
Photo - Jiri Lochman ◀

The effect of camels on waterholes, combined with the lack of maintenance by today's Aborigines, has enormously reduced desert waters. This has a serious effect on some native animals, particularly seed-eating birds such as parrots, pigeons and finches. Camels may have contributed to the rarity of the Princess Parrot and the near-extinction of the Night Parrot, by eliminating sources of drinking water in arid areas.

The establishment of feral camels may not have been as damaging as the introduction of other northern hemisphere animals such as foxes, cats and rabbits; nevertheless, like most foreign intruders into natural ecosystems, camels are having a serious negative effect on Australian flora and fauna. More studies of the effects of camels are needed before their place in the desert web of life can be fully understood. ⊡

ENDANGERED!

THE "WALPOLE WAX"

Walpole wax (*Chamelaucium* sp.) is found in only a few habitats in the wilderness area of Walpole-Nornalup National Park. Here, it forms impressive displays of colour on coastal heathland from September to November.

Walpole wax is a shrub, related to the Geraldton wax, that grows to one or two metres tall. It is similar to a small pine tree in shape and produces thousands of small white or pink-tinged flowers in spring and early summer.

It is one of the thousands of Western Australian species without a formal scientific name. CALM botanists Neville Marchant and Greg Keighery have studied the *Chamelaucium* genus for a number of years and have located a number of populations of Walpole wax relatives on granite rocks near the south coast, from near Northcliffe to Two Peoples Bay.

They range from spindly shrubs with the same flower structure as the coastal Walpole wax to populations with variations in flower structure.

North of Mount Frankland there is a related species that is similar to Walpole wax, that was named in 1878 by well-known botanist Ferdinand von Mueller as *Darwinia forrestii*. The flowers of this rare species have a long style characteristic of other *Darwinia* species. However, it will soon be renamed because its other flower structures are those of the genus *Chamelaucium*.

For 30 years the Walpole wax was incorrectly known as Esperance wax and was widely cultivated, although its wild locality was unknown until quite recently. Because of the common name, it was assumed that the original plant from which the cultivated material had been propagated came from the Esperance area.

Then, about 10 years ago, Albany wildflower enthusiast Eileen Croxford told Neville Marchant that the pine-like species came from Walpole.

Taxonomic studies that will result in names for the new species and variants, as well as an understanding of relationships between them, are currently being undertaken at the Western Australian Herbarium.

NEVILLE MARCHANT


L I V I N G
L I M E S T O N E

Caves are subterranean fascinating worlds. Deep beneath the earth's surface there is life; bats and blind, colourless creatures known as troglodytes have adapted to a cave existence over eons. Ancient wall paintings or etchings are evidence of thousands of years of Aboriginal occupation. Today, tourists marvel at the well-lit 'developed' caves. Elsewhere, seasoned cavers squeeze through muddy cracks and wade chest-deep through icy water, hoping, perhaps, to discover a new passage or cave system.

by John Watson, Barbara York-Main and Bill Humphreys

WESTERN AUSTRALIA's oldest limestone caves are about 350 million years old. They lie in the Devonian Reefs in the Napier and Oscar Ranges of the Kimberley. Caves in Tertiary limestones (14-45 million years old) occur in the Cape Range National Park near Exmouth, and on the extensive Nullarbor Plain in the Eucla Basin. The Nullarbor caves may be small sinkholes or huge underground tunnels with lakes and submerged passages.

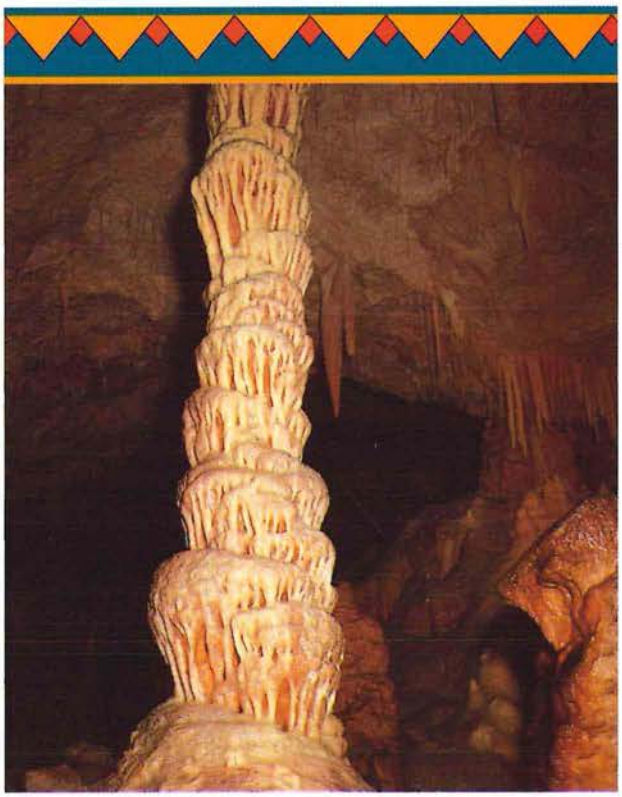
The most impressive formations (speleothems) are found in the youngest caves that have developed in the Pleistocene aeolian limestones (over 10 000 years old) fringing the South-West coast. The greatest concentrations of caves are in the Nambung National Park, around Yanchep and along the Leeuwin-Naturaliste ridge.

HOW DO CAVES FORM?

Caves are just one feature of a weathered limestone landscape ('karst') that formed along with underground streams, gorges and other features. Rain absorbs carbon dioxide from the air, and seeps through decaying vegetation in the soil surface, absorbing further acids. The weak acid solution dissolves the limestone, especially along cracks and other lines of weakness such as faults or old tree root channels.

Some caves were formed when underground lakes gradually dissolved the rock to create passages and chambers. Others were carved by underground streams and rivers. Occasionally they are formed from physical processes, such as the action of waves pounding coastal limestone.

Dissolved calcium carbonate or other minerals may create impressive formations, from minute helictites only a few millimetres long to huge pillars and flowstones weighing several tonnes. There are also stalactites, stalagmites, shawls, columns and straws.



Shawls at Yallingup Cave. Colour variations result from traces of minerals such as iron in the water.
Photo - Robin Morrison
Courtesy of *Reader's Digest* ◄

The common sheath-tail bat (*Taphozous georgianus*) roosts in deep caves and rock fissures in tropical and sub-tropical regions of Australia.
Photo - Jiri Lochman ▲

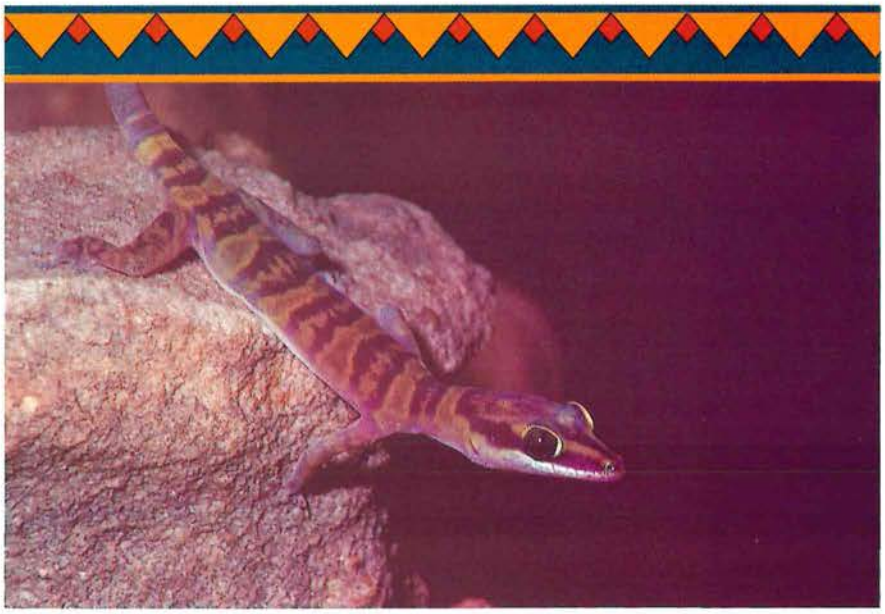
This large stalagmite flowstone was built up in sections from the floor of a cave in the Leeuwin-Naturaliste National Park.
Photo - Jiri Lochman ◄

CAVE FAUNA

Caves, with their relatively constant temperature and humidity, are ideal environments for some forms of wildlife. They are used by bats, specially adapted insects and water dwellers. Many contain bone deposits that may have been preserved for thousands of years.

In WA five main groups of caves harbour fauna - those of the Nullarbor (post-Miocene), the South-West and Jurien Bay areas (Pleistocene limestones), the Nambung area (also Pleistocene) north of Perth, and the North West Cape (Miocene). Each region has a distinctive fauna of a different relative age.

Vertebrate remains of the extinct marsupial lion, various rodents and small marsupials, the Tasmanian devil, thylacine, wombat and koala have all been found in caves of the South-West. They may have been carried into the caves from outside by predators such as owls (deposited as fragments in undigested pellets) or by floods. Occasionally animals may have accidentally stumbled into the caves or sought temporary shelter. Identifying and dating these remains, and the geological age of the sediments in which they are found, can show which animals were living around the caves at particular periods of time and indicate what sort of climate prevailed.



A velvet gecko (*Oedura kalumburu*) spends some time in caves.
Photo - Jiri Lochman ▲

Blind cave spider from the Cape Range area.
Photo - Derek Mead-Hunter ◄◄

The blind gudgeon (*Milyeringa veritas*) is a troglodyte, living in the water of caves and rock strata beneath Cape Range.
Photo - G Allen, WA Museum ◄

All cave systems have a particular suite of living invertebrates but none is entirely 'closed'. In Nullarbor caves bats are often the 'go-between', feeding outside the caves at night and roosting inside by day. Their droppings form the base of the food 'pyramid' for a whole suite of invertebrates from mites, cockroaches and beetles to predatory crickets, pseudoscorpions and spiders. The North-West cave invertebrates depend almost entirely on leaf litter that washes into the caves. In some deep caves, and in those with standing water, the food chain may start with insects that either fly into the caves or feed on organic matter in the water in their larval stages.

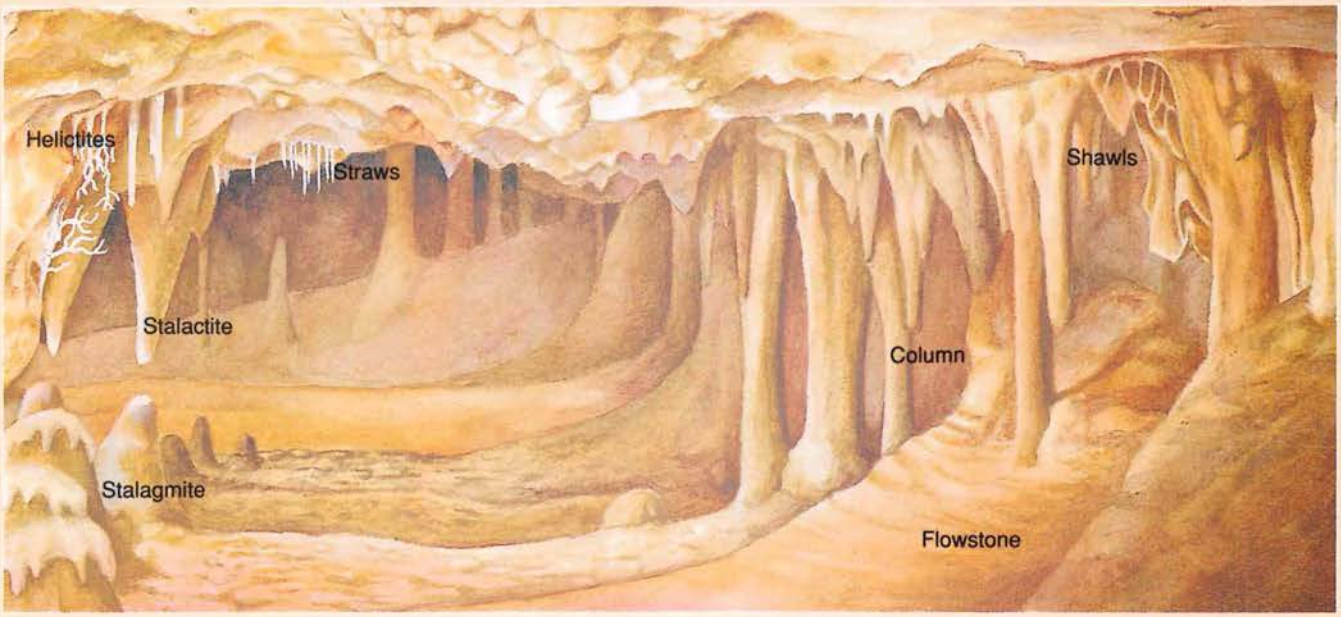
Invertebrates have adapted to cave existence; they often lose pigment, eyes and hairs. Depending on the ecology and degree of modification, invertebrates are classified as trogloxenes, troglophiles or troglobites. The last category are so modified that they can no longer exist in outside habitats.

Their relationships to species in other parts of the continent or regions of the world are fascinating. The vertebrate fossils of the relatively young caves of the South-West indicate that the forest was once much wetter and more lush, as it supported such animals as the Tasmanian devil (now found only in Tasmania). There must also have been a relatively well-forested corridor across the Nullarbor, or to the north, for such vertebrates to have been connected with their counterparts in the south-east. The 5000-year-old remains of a Tasmanian tiger, or thylacine, from a Nullarbor cave substantiate this theory. Fossils of small vertebrates from the Jurien Bay region indicate a dry period during the Pleistocene.

Whereas some of the vertebrates died out with the shrinking forests, some invertebrates managed to survive in smaller microhabitats or were able to change their lifestyle by retreating into caves. In the Nullarbor caves, for example, there is a blind mygalomorph spider (*Troglodiplura lowryi*) of the trapdoor and funnelweb group, a Gondwanaland relic of great significance. It has no near relatives in Australia and probably belongs to a group of primitive web-weaving genera otherwise found only in South America.

Some cave invertebrates have close taxonomic affinities with those other continents and New Zealand. The relationships are of ancient origin and some, such as that of the blind mygalomorph, are probably older than 65 million years. Thus our cave-living

CAVE FORMATIONS



DRIPSTONES form when water, saturated in carbon dioxide, drops from the roof and leaves behind a small amount of calcium carbonate. Gradually, each successive drop precipitates further layers of crystals, forming a stalactite. When drops of water fall on the same spot on the cave floor, the same thing happens, but the formation grows up from the floor and is called a stalagmite.

Each stalactite and stalagmite grows at a different rate, depending on the wetness and temperature of the cave, and the thickness of the limestone bed above it. Some stalactites grow an inch a year; others take one hundred years or so to grow that much. Often the stalagmites growing upward meet the stalactites growing down and form columns.

PORE DEPOSITS result when seepage through pores and cracks is too slow to form water droplets. Helictites - small irregular tubed growths - are the most common.

FLOWSTONES, including over-hanging shawls and canopies, frozen waterfalls and clusters of glistening nodules, are the bulkiest cave deposits. They are formed from films of calcite left by flowing water.

POOL DEPOSITS are level terraces at pool edges and the crust of crystal on the walls and bottoms of underground water pools.

Illustration - Ian Dickinson

invertebrate fauna is a living link with past faunas of adjacent surface areas and other Australian regions, with northern, tropical Australian rainforest habitats, and thence to South-East Asia and even Africa, and with South America.

WHERE TO SEE CAVES

All caves are different. Guided tours are provided to most of the caves open to the public.

CRYSTAL CAVE

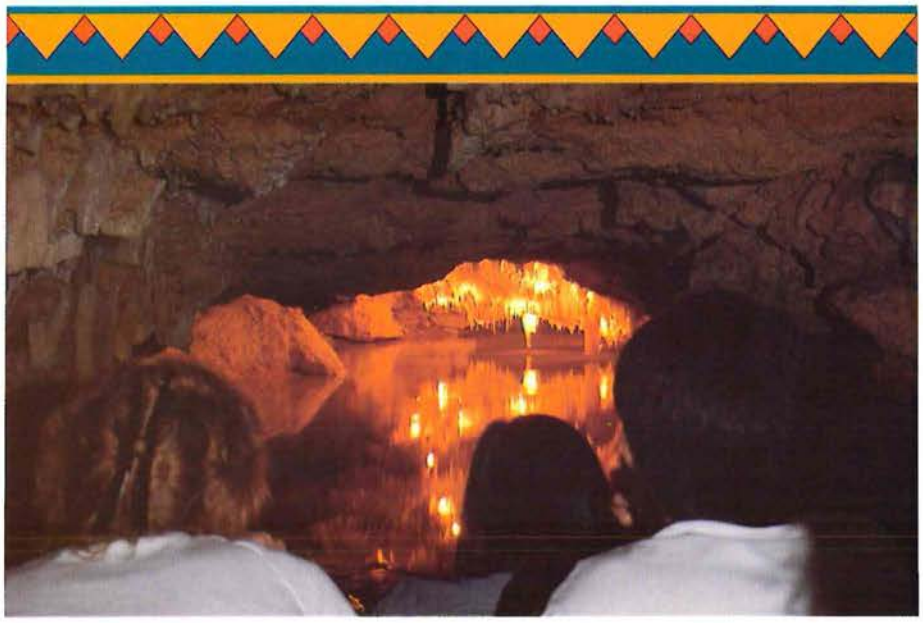
Crystal Cave in Yanchep National Park has fine examples of active stalactites and stalagmites, helictites, flowstone, shawls and other formations. There are beautiful reflections in the main grotto when it is wet. An underground stream occupies most of the floor in this section but the level of water varies with climatic conditions. Crystal Cave is a "stream cave" and has a horizontal, tubular shape caused by flowing groundwater removing the calcium carbonate.

Cave Systems in Western Australia

MAMMOTH CAVE

Mammoth Cave, about 21 kilometres south of Margaret River, is extremely large and has many long chambers and smaller passages. During winter a stream flows through it, creating reflections and giving the cave new life. The cave features stalactites, stalagmites and large columns where the two formations meet. A coloured shawl is prominent in one of the smaller chambers.

The WA Museum has located and removed several fossils left there by Aborigines who used the entrance cavern for shelter. The jawbone of an extinct marsupial about the size of a cow (*Zygomaturus trilobus*) is visible in the wall of this cavern.



An underground stream occupies most of the floor of Crystal Cave at Yanchep. Photo - Cliff Winfield ▲

Cave explorers need to be properly equipped and should be accompanied by other experienced people. Photo - Jiri Lochman ▼

Entry to the cave is from the eastern side and the exit is on the western side of Caves Road. A short bushwalk through the forest takes visitors back to their cars.

LAKE CAVE

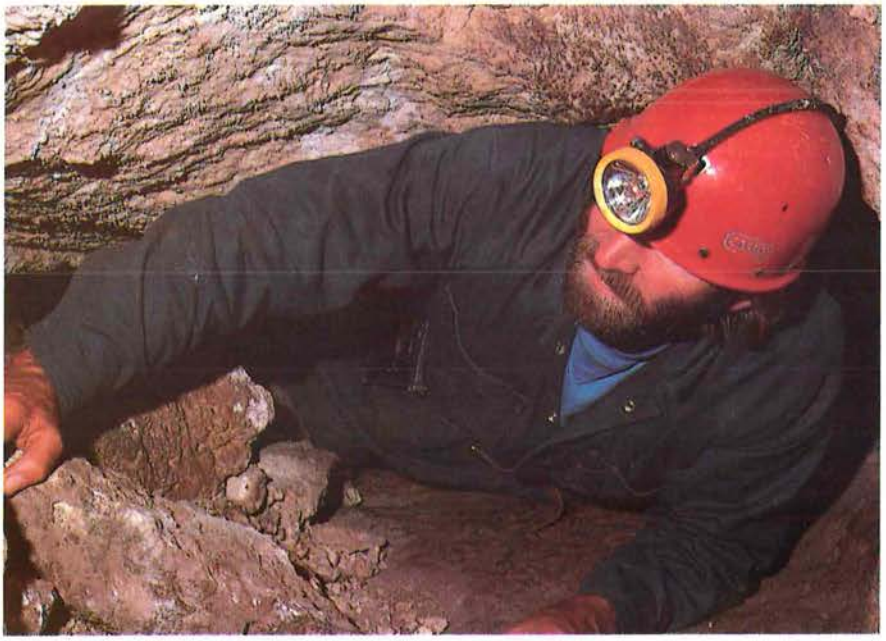
Lake Cave, located three kilometres south of Mammoth Cave, is the deepest and smallest of the tourist caves. A series of stairways and paths descend through a large "crater" (collapse doline) with huge karri trees growing from its depths. The lake never dries up and the path runs along its edge. It is heavily decorated with fragile white calcite straws, shawls, stalactites and stalagmites. A prominent feature is the Suspended Table, a large flat area of flowstone supported just above the lake from above by two large columns.

JEWEL CAVE

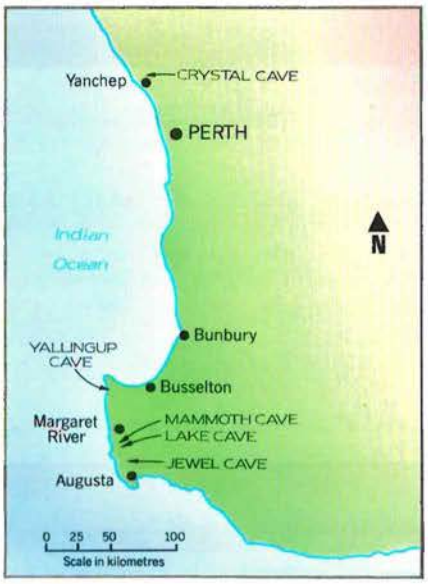
Jewel Cave, about 37 kilometres south of Margaret River and eight kilometres north of Augusta, is the largest and most recently-opened tourist cave; it was opened on Boxing Day 1959 (Lake and Mammoth Caves were opened in 1901-2). Entry is through a huge, spectacular cavern. The natural entrance, now closed, is a small solution pipe through which the first cave explorers were lowered.

The cave contains the longest straw in any tourist cave in the world (just over 5.9 metres). There is also a huge area of flowstone that looks like karri forest, and a stalagmite estimated to weigh 20 tonnes. The cave was named after a smaller section known as the Jewel Casket and its crystal formations.

Mammoth, Lake and Jewel Caves are open every day, except Christmas, for guided tours run by the Augusta-Margaret River Tourist Bureau.



Tourist Caves of the South-West



YALLINGUP CAVE

Yallingup Cave is renowned for its spectacular shawls. Visitors use a self-guiding circuit through the main chamber, which generally takes about an hour. The Green Chamber has recently been reopened to the public for the first time since 1904. Special guided adventure tours through some other parts of the cave are also available by appointment. Most of these areas are unlit but helmets and torches are provided.

TUNNEL CREEK

Tunnel Creek National Park, part of the Devonian Reef system in the Kimberley, is for the more adventurous. There is no guided tour available and visitors have to negotiate the 750 metre cave through the limestone of the Oscar Range by themselves.

The cave has an interesting history. Late last century, it was used as a retreat by the Aboriginal hero Jundamarra (known to Europeans as Pigeon) when

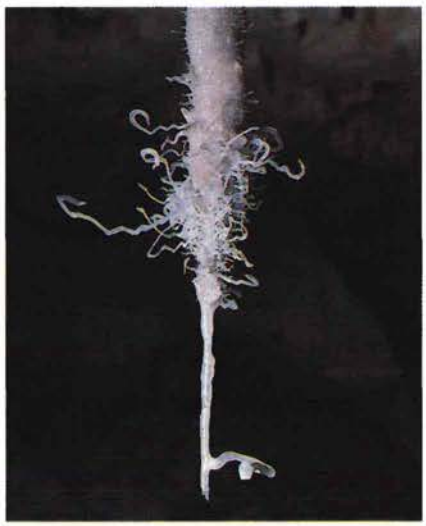
he and his followers waged guerrilla warfare on early Europeans who had settled his tribe's traditional land. Jundamarra called this the "Cave of Bats" - at least five species of bats live there.

CONSERVING CAVES

The two main caving groups in WA are members of the Australian Speleological Federation (ASF) and both accept newcomers. The clubs are actively involved in various research projects and new exploration throughout WA.

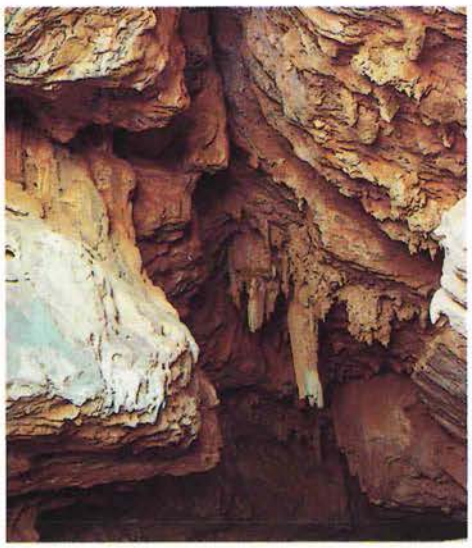
Caves need to be protected from obvious damage and more subtle influences such as surface land use; not just in the areas immediately above them but in the entire catchment area of any streams or drainage lines that enter them.

The effect of visitor pressure on the cave environment can be highly significant. Even the dirt on visitors' shoes and fluff or dust from clothing can, in time, build up on speleothems and spoil their appearance. Large numbers of visitors also increase the amount of carbon dioxide in the cave air. The high CO_2 levels affect the rate of formation of speleothems and the suitability of the cave environment for fauna.



Delicate helictites - experts are not really sure how they are formed.
Photo - Rob Klok ▲

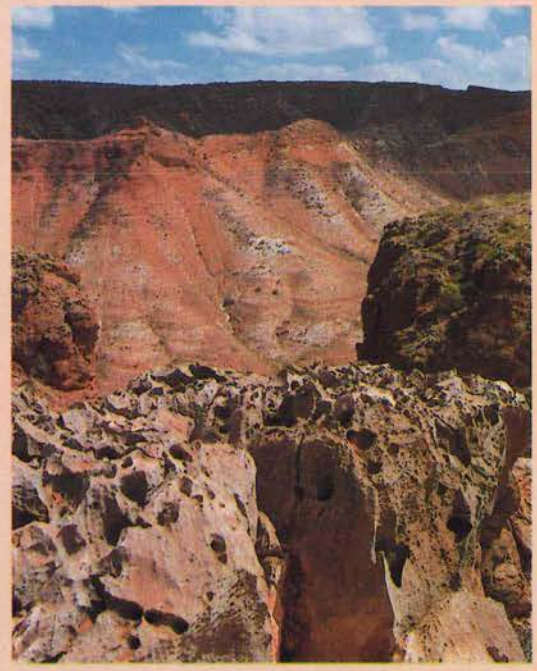
Blatant vandalism is the ultimate threat to cave speleothems. In a few moments a vandal can destroy something that took thousands of years to form. Most well-known caves in Australia have suffered some vandalism. Hopefully, more enlightenment now prevails.



These cave pearls were formed by calcite depositing and building up on grains of sand.
Photo - Norm Poulter ▲

Tunnel Creek cave runs beneath an ancient limestone barrier reef formed 350 million years ago.
Photo - Marie Lochman ◀

CAVES OF THE CAPE



The limestone of Cape Range is honeycombed with sinkholes and caves.
Photo - Michael Morcombe ▲

There are two groups of caves in the North-West Cape peninsula. The subterranean waters of the coastal limestone caves support blind shrimps, the gudgeon fish and the rare blind eel. The 200 or more caves in Cape Range are mostly vertical "wells" although only four contain water. These dry caves now have little life but contain important vertebrate remains, including those of a thylacine.

The more humid caves have a rich invertebrate fauna of cockroaches, millipedes, slaters and spiders. Species such as the micro-whip scorpions (not found in any other cave systems in the State) and pseudoscorpions indicate that the area was once covered by tropical rainforest.

These creatures depend on leaves washed into the caves by the unpredictable rainfall of Cape Range. Some caves flood after little rain while others require exceptional rain, flooding only every five years. So the food input comes in pulses, allowing the invertebrates to build up to very high numbers. The populations stop breeding as the cave dries and the organic matter is depleted, leaving small residual populations.

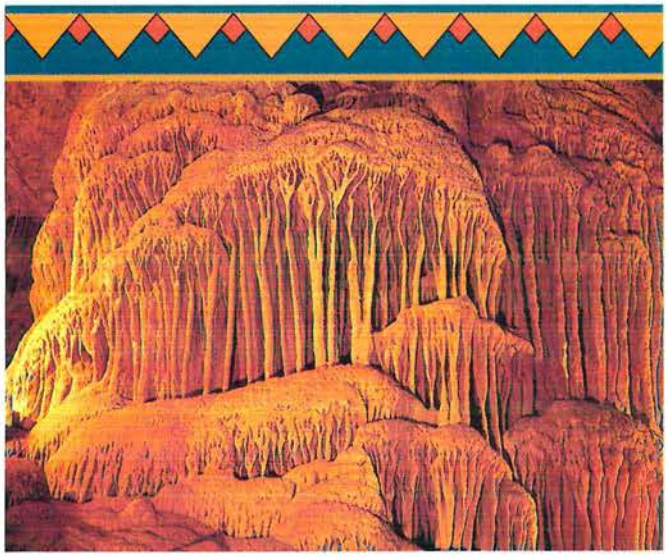
The deep gorges isolate populations between caves - providing a fascinating natural laboratory for studies of genetic differences.

CAVE MANAGEMENT

The first step in managing caves is to classify all known caves in terms of their values. Only then can the managing authority define the type of management and degree of protection needed for each cave.

This is fairly easy for recently-discovered caves and those where people have had minimal impact. Frequently, however, the damage has already been done. In some cases a decision may be made to 'let the cave go' and encourage use by large groups of inexperienced or recreational cavers. Existing tourist caves are a special case where there has been a degree of abuse on one hand but a degree of controlled access and management on the other.

The Working Group on Cave Protection and Management, convened by the EPA, addresses statewide issues such as cave classification, the need for cave legislation and cave management issues. It has representatives from the two major WA speleological groups, the WA Museum, the EPA and CALM.



This striking flowstone in Jewel Cave was formed from calcite left by flowing water.
Photo - Alex Bond ▲

CALM recently formed a Leeuwin-Naturaliste Cave Management Committee to protect caves in the Leeuwin-Naturaliste National Park from increasing pressure from amateur cavers and the general public. Speleologists, other local interests and CALM staff sit on the Committee.

At the national level, the ASF has strict guidelines and ethics for cavers and addresses issues such as cave protection, use and management. The ASF has acted as consultant to various State and Federal Government departments and, in Western Australia, has conducted studies on Yallingup Cave and the Nullarbor.

Cave management requires close consultation and assistance from all cave users. Most of the major cave systems of WA are located in CALM managed lands. The challenge is how to conserve and manage caves, their unique formations and their very special inhabitants. ⊡

Sections of this article are based upon John Watson's *Caves in Western Australia* (Dept of Conservation and Environment), Bulletin No 51, September 1978.

UNRAVELLING THE MYSTERIES OF

Verticordia

by Elizabeth George

For many years enthusiasts have been intrigued and fascinated by the beauty of *Verticordia*, commonly called feather flowers. Swiss botanist Augustin de Candolle described the genus in 1828 from specimens collected by Archibald Menzies (botanist on the Vancouver expedition aboard the Discovery) near Albany in 1791.

It is thought de Candolle named *Verticordia*, a genus of plants in the family Myrtaceae, for Venus, the Roman goddess of love and beauty whose sacred flower was the myrtle. Verticordia means "turner of hearts".

Pink and white forms of the same species *(Verticordia monodelpha)* growing in a private garden near Mandurah.
Photo - Elizabeth George ▲

Orange morrison *(Verticordia nitens)*, one of the best-known species of *Verticordia*, can grow to over two metres.
Photo - Michael Morcombe ▶

Previous page - Roe's feather flower *(Verticordia roei)* Photo - Jiri Lochman

MAGNIFICENT vistas of massed feather flowers signal the end of spring on the sandplains of southern Western Australia, especially near Wongan Hills, Lake King to Dumbleyung and the northern sandplains in the Murchison area and around Mount Lesueur. This proposed reserve contains 16 species of feather flowers.

Early summer brings drifts of the striking orange-yellow flowers of the orange morrison (*Verticordia nitens*) in the banksia woodlands of the Swan Coastal Plain, especially north of Gingin in Moore River National Park. This flower once commonly graced Perth homes around Christmas, being sold door-to-door like the spring-flowering brown boronia.

Despite their visibility, feather flowers have been poorly studied. George Bentham described 37 species in *Flora Australiensis* between 1863-1878, and only 16 species have been described since. The names of several have been misapplied and others have simply been lumped with the species that appeared closest.

All feather flowers are woody shrubs, but there is fascinating variation within almost all of the other features; including habitat, growth habit, foliage, flower structure, flowering times and duration of flowering. There is also wide variation within some species, subspecies and varieties, and sometimes even between plants within the same population. Feather flowers are found only in Australia and occur mainly in southern Western Australia with three species in northern Australia. One of these, *V. decussata*, appears to be confined to the Northern Territory.

Feather flowers vary from only a few centimetres high to large shrubs. Two of the tropical species, *V. cunninghamii* and *V. verticillata*, can be small trees up to seven metres high. The shrubby species can be erect or spreading, compact or open, slender or bushy. Most species are single-stemmed and killed by fire, but some have a lignotuber (swollen underground stem) and will regenerate after fire or physical damage to the plant.

A new subspecies of *Verticordia staminosa* growing in a granite outcrop.
Photo - Elizabeth George ◀◀◀

Verticordia endlicheriana resembles a yellow cauliflower.
Photo - Basil Smith ◀◀

Verticordia plumosa was the very first Verticordia species ever collected.
Photo - Steve Hopper ▼

The flowers are solitary, though they appear to be in heads or spikes. They vary from tiny to more than three centimetres wide and can be almost any colour except blue. Some are multi-coloured. Others change colour as they age; a signal to the pollinators, (which could be native bees, beetles and other insects) that the flowers are not producing pollen or nectar.

The flowers' sepals are divided into hairy, fringed or feathered lobes, hence the common name "feather flowers". The common name morrison, first given to the golden, summer-flowering *V. nitens* and later used for other species, honours William Morrison, a professional collector from the late 1830s, not Alexander Morrison (the first Government botanist) as is often assumed.

Because of the lack of research, attempting to positively identify specimens of verticordia has been difficult. More than 250 people, mostly *Verticordia* enthusiasts, spent 10 years from 1979 to 1989 helping to change this situation. They collected specimens of *Verticordia* from all over the State and gathered information about the distribution patterns and habitats of many species, including some that are rare and endangered. Some new species were discovered and several that had not been seen for many years were relocated. However, two species remain elusive. *V. carinata* was collected by James Drummond in the 1840s and has not been seen since; and *V. harveyi* was last collected in the 1950s.

The result was the *Verticordia* Reference Collection, now housed in the Community Reference Herbarium in CALM's WA Herbarium. It includes descriptions, more than 600 pressed specimens and photographs of most known species, subspecies and varieties and is available to anyone wishing to identify or study verticordia specimens.

Verticordia pennigera is sometimes covered in moths, which presumably gather the nectar.
Photo - Basil Smith▲▲

Verticordia nobilis has for many years been wrongly called *V. grandiflora*. This species occurs only on the sandplains north of Perth.
Photo - Elizabeth George▲

Botanists and CALM officers were among the many people who helped to compile the *Verticordia* Reference Collection.
Photo - Elizabeth George ◄

Painted feather flower *(Verticordia picta)*. There is a very large-flowered form that occurs only at Mt Lesueur.
Photo - Jiri Lochman▼

The styles of the rapier feather flower *(Verticordia mitchelliana)* are very short in the bud but they elongate overnight.
Photo - Jiri Lochman ▲

A book on *Verticordia* is also being written about the 98 species and 40 subspecies and varieties of *Verticordia* that are currently known. It will feature life-size watercolour paintings by Perth artist Margaret Pieroni. The paintings will be a valuable aid to identification.

Many *Verticordia* species and variants have potential for use in horticulture and floriculture, for their spectacular flowers, attractive foliage and habit. They are attractive to birds, insects and probably small marsupials. Some species have been grown for many years. A small number were even cultivated in England and probably in other parts of Europe during the second half of the last century and early this century, but proved to be difficult to establish and maintain.

Apart from Kings Park, where more than 25 species were grown during the 1960s and early 1970s, and the National Botanic Gardens in Canberra, most cultivation has been carried out by amateur enthusiasts and a small number of specialist nurseries. Feather flowers were considered too difficult to cultivate by most gardeners.

However, in the last few years commercial cultivation has escalated dramatically because of increased interest and demand for Australian flora by international flower markets.

Since 1979 a small group of dedicated enthusiasts in WA has been trying to cultivate all species of *Verticordia* and achieved remarkable results. They have proved that most species can be grown given suitable conditions, some more easily than others. Many have potential for gardens and landscaping. It is possible to have at least one *Verticordia* species - and usually more - in flower every month of the year.

Many species flower much longer in cultivation and with judicious pruning can be enticed into a second flowering. Most species respond well to regular pruning to maintain shape and encourage new growth and more prolific flowering, but whether this practice shortens plant life or productive life is not fully understood. Many cultivated species will set viable seed and self-sow.

All feather flowers appear to require good drainage, plenty of sunshine and air circulation, and some require protection from cold winds for successful cultivation. However, many more selection trials are needed to determine the best forms and more research is necessary to ascertain the specific requirements of species that are difficult to establish.

Since 1983 the Society for Growing Australian Plants (SGAP) *Verticordia* Study Group has been accumulating information from its members, who are distributed throughout Australia in a wide range of conditions. Research and breeding programs are being carried out by Government bodies and commercial growers.

The horticultural potential of *Verticordia* is substantial and, if it can be realised, future commercial picking from wild populations should cease to be necessary. ⊡

Verticordia oculata has the largest flowers of any species in the genus - they are over two centimetres across.
Illustration from a greeting card by Margaret Pieroni▲

SHOOTING FROM THE STARS

If we want to enjoy products made of wood, we have to find out just how much high-quality timber there is in our State forests and how quickly it grows. Then we need to estimate how much we should use. Amongst other things, forest measurement means knowing how tall a tree is, whether it's growing straight, what blemishes there are in the outer layers, what imperfections there may be in the heart of the wood, and so on.

But first we have to find our tree.

THERE'S a worn old image of the forester as an earthbound rustic, a bloke who sleeps on his axe amongst the tree-roots and sizes up his charges with a measuring tape. This quaint notion should have been put to rest two decades ago when, in 1972, the first magnificent LANDSAT photographs gave forest inventory a quantum leap forward. If the old image still lingers, recent developments within CALM ought to shatter it forever.

The very latest technology is being used by forest scientists to measure the amount of timber in the State's jarrah forests. Using a specially modified helicopter, forestry staff fly up and down pre-determined flight lines and photograph the forest below. Their equipment includes a computer that taps in to a precise satellite-based navigation system, known as a Global Positioning System (GPS).

ORBITING EYES

The helicopter's GPS receiver calculates its position on the earth's surface from a constellation of NAVSTAR satellites, launched by the US Defense Department. Signals are transmitted from the satellites, which orbit about 20 000 kilometres above the earth's surface. The

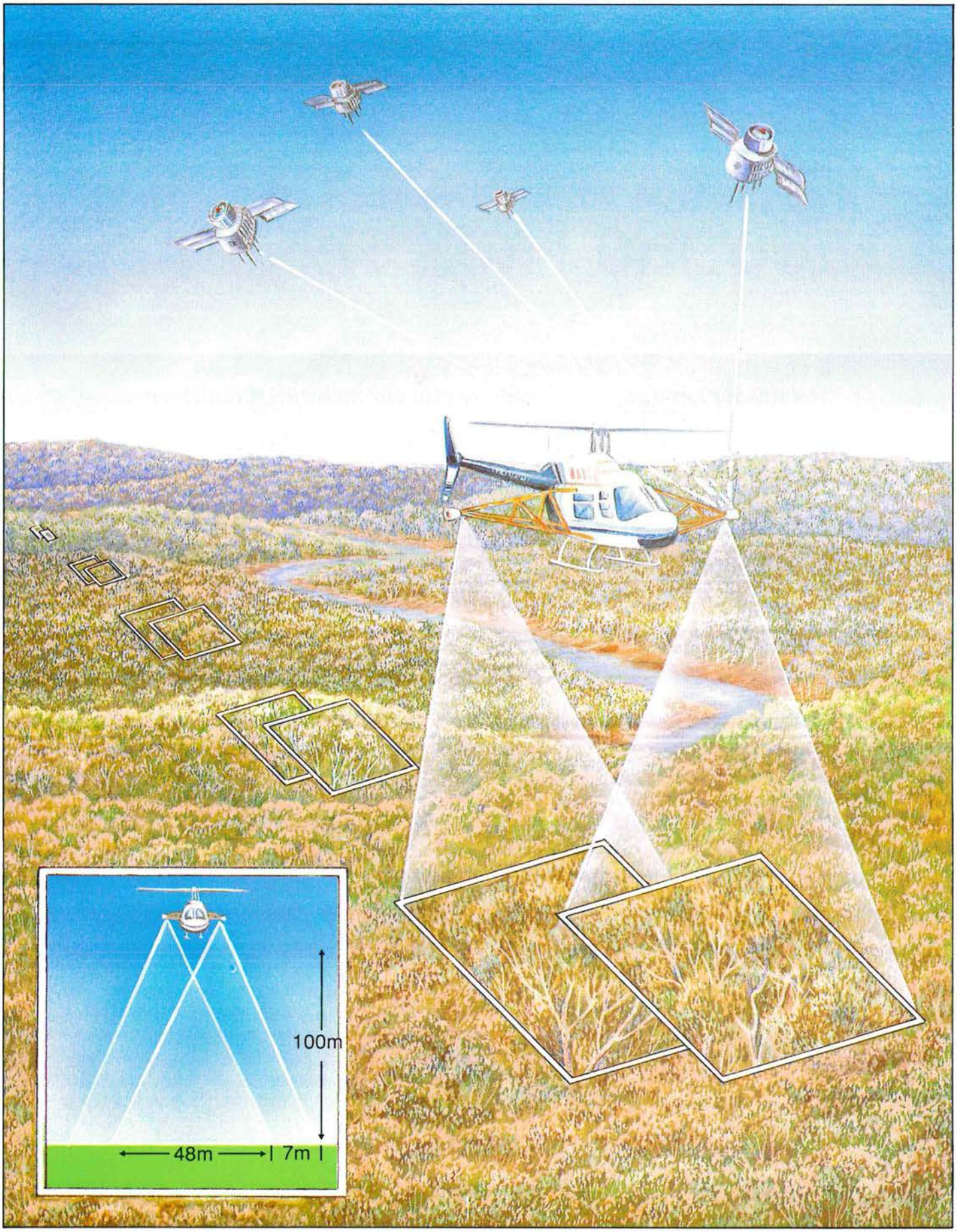
Technology ascends while the forest waits.
Photo - Jiri Lochman ▲

GPS unit in the helicopter receives the signals and fixes its position once every second by measuring the time each signal takes to reach the receiver.

At least four satellites must be visible above the horizon for observers to get a three-dimensional fix, and if the satellites are well distributed about the sky, the helicopter's position can be determined to within 25 metres. A full constellation of 18 satellites is needed for 24-hour coverage of the planet, but at present only seven are in orbit. As a result, a helicopter flying over Western Australia in the middle of the day can currently exploit the system only from November to February.

Large-scale stereo photographs are taken on a sample grid while the helicopter flies at a constant height of 100 metres. Two photo pairs are taken for each square kilometre of forest. Cameras are mounted on either side of the helicopter at each end of a 7.5 metre boom, and are aimed so that their images overlap at a spot 100 metres below - the 'plot'. The result is a regular sampling of the forest by a series of precisely positioned photographs, from which tree species can be identified and tree heights estimated.

Because of this technology, CALM foresters can find a plot a lot more easily than ever before - not only from the air, but on the ground. At the heart of the photography system is a laptop computer, connected ('interfaced') not only to the Global Positioning System, but also to a radar altimeter and the stereo camera control unit. Before a flight begins, the latitude and longitude of each of a series of parallel flight lines, spaced one kilometre apart, are read into the computer from a floppy disk, and are then transferred to the GPS unit. Through his GPS receiver, these coordinates enable the pilot to navigate accurately along the required



The helicopter flies at 100 m above the trees and takes a pair of photographs every 500 m. A GPS satellite navigation system is used to direct the helicopter along the correct line and to determine the exact location of each pair of photographs. ▲

INSET: The photographs are at a scale of 1:1000 and each covers an area 55 x 55 m^2. Any tree in the area where the photographs overlap can be measured stereoscopically.
Illustration - Yeon Hee Kim

Loading the camera in the starboard pod.
Photo - Jiri Lochman ▲

This article was written in consultation with staff of the Inventory branch and the Land Information branch of CALM.

flight paths. A map showing the position of the flight paths and the sequence of plots along them is used later to direct ground staff to the scene.

A FIX FROM THE STARS

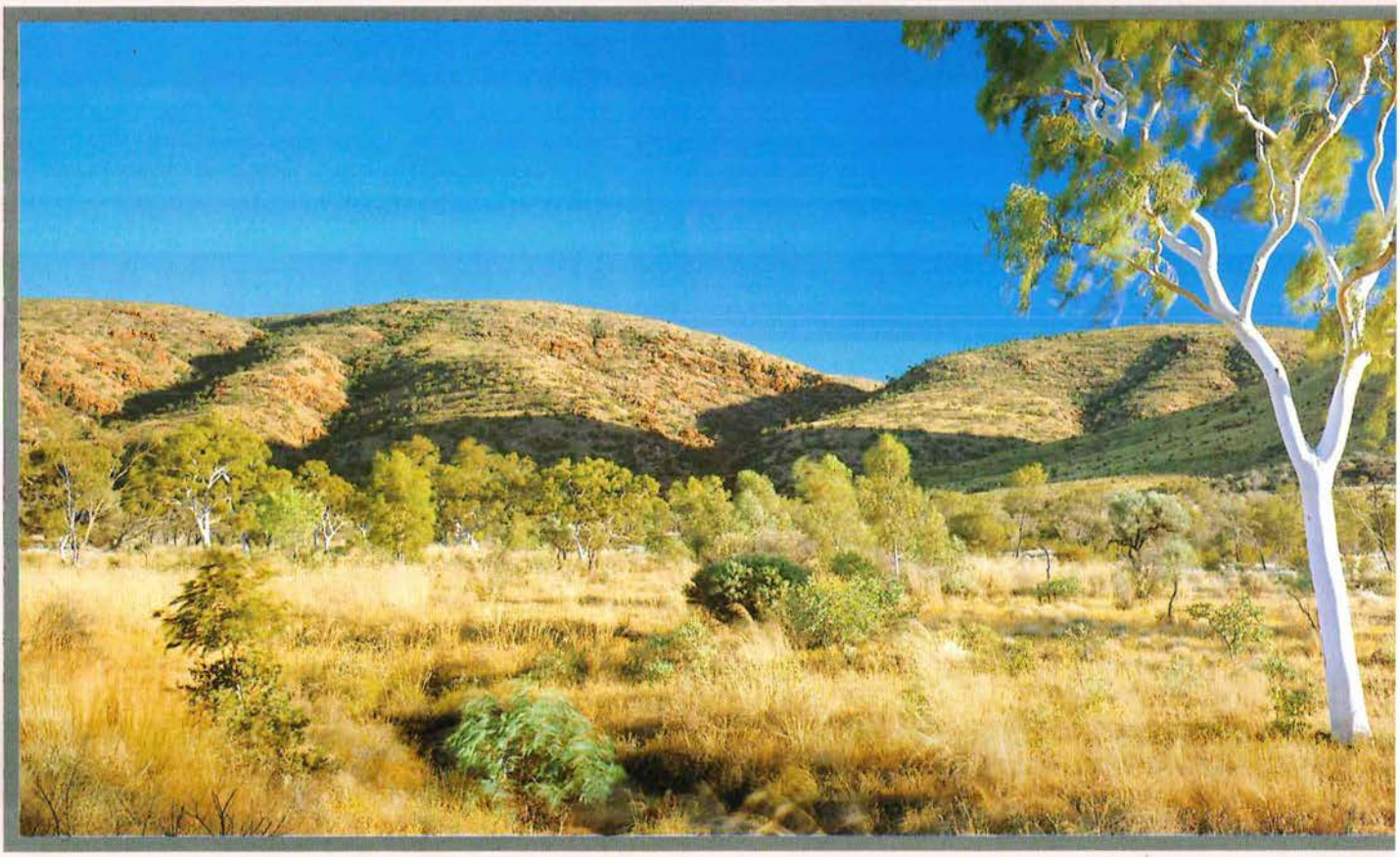
The computer gets its position once every second from the Global Positioning System, then sends a signal that triggers the cameras every 500 metres along the flight line. The computer knows from the GPS which satellites are sending the signals, and how accurate the positional fix is; it takes its altitude from the radar altimeter, and also generates a frame number for the photographs. All this information, plus the location coordinates, is written to a disk when each photograph is taken. The computer also displays information continuously to the cameraman, who can stop or pause the photography, or alter parameters if necessary.

While this is in progress, pilot and navigator are reading navigational information supplied by the Global Positioning System, displayed separately above the pilot's instrument panel. For each flight line, it displays the direction and distance to the destination point, the true direction of travel, the speed, and the amount of deviation to the right or left of the required line.

When the flight is over, the information written to disk is transferred to CALM's mainframe computer and translated into a map. Other staff can use this information to locate particular plots on the ground, after which they can measure any individual tree selected from each plot and assess the quality and potential use of its timber.

With the help of this and other new technology, foresters expect to complete the inventory of the jarrah forest by 1991. It will be the first time that such a detailed picture of the forest and its timber has become available. The information will be more than a huge help - it will be utterly essential to CALM's foresters in managing and conserving the State's forests well into the next century. ⊡

RAY BAILEY

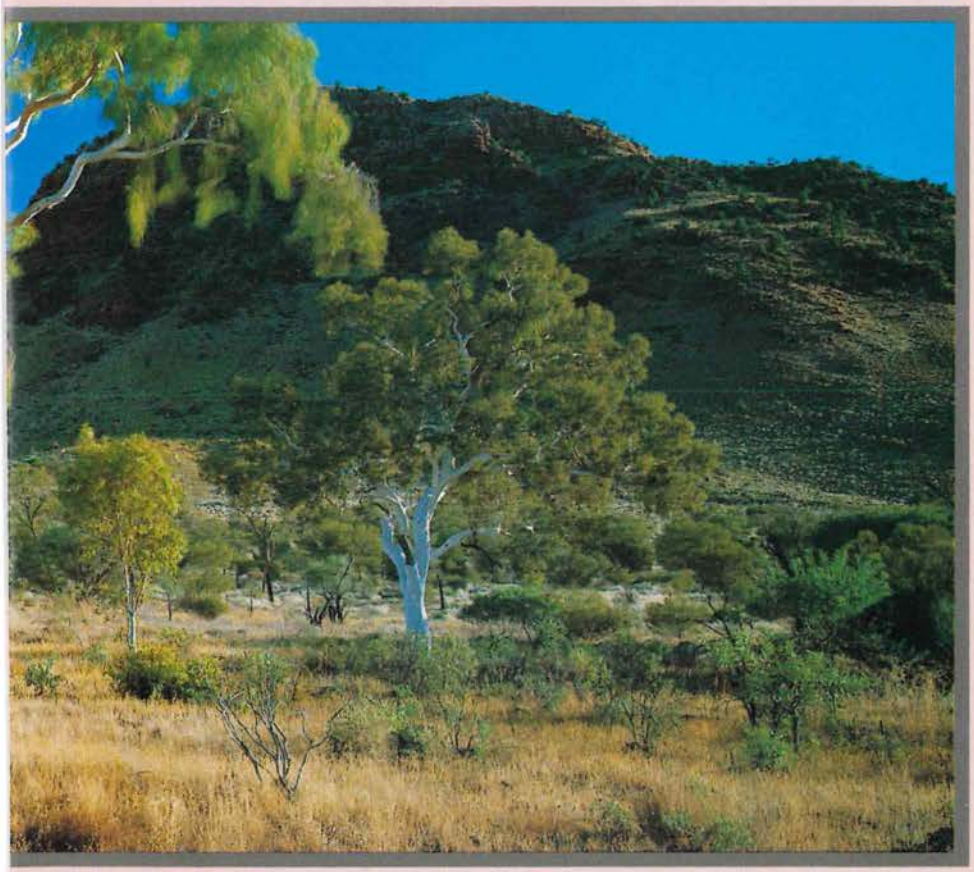


Western Australia *is a series of deserts bordered by the temperate or tropical fringe where most of us live.*

The vast desert *regions include the flat limestone plains of the Nullarbor and great salt lakes such as Lake Carnegie.*

There are *undulating plains of red sand dominated by spinifex or loamy soils dominated by wattle scrub, arid ranges of the Pilbara and central Australia and the sandstone ranges of the Great Sandy Desert and southern Kimberley.*

This harsh dry *land is largely unvisited by non-Aboriginal Australians. When rain comes, a rich and diverse assemblage of plants transform the landscape into a spectacular wildflower garden.*



An unusual yellow daisy *(Myriocephalus guerinae).* Photo - Jiri Lochman ◄◄◄

E. youngiana has the largest flowers of any eucalypt. Photo - Tony Start ◄◄

Heliotropium sp. is a widespread tropical desert genus. Photo - Tony Start ◄

Ghost gum at Gill Pinnacle in the far east; this area will be covered with colourful wildflowers with the coming of the rains. Photo - Robert Garvey ◄

Summer rains bring an abundance of grasses (over 100 species occur in these deserts) and winter rains promote the everlastings, vetches and mulla-mullas.

The rare event of summer rains followed immediately by winter rains synchronises the flowering of all the annuals and shrubs of the desert. The land is ablaze with pinks, mauves and yellows.

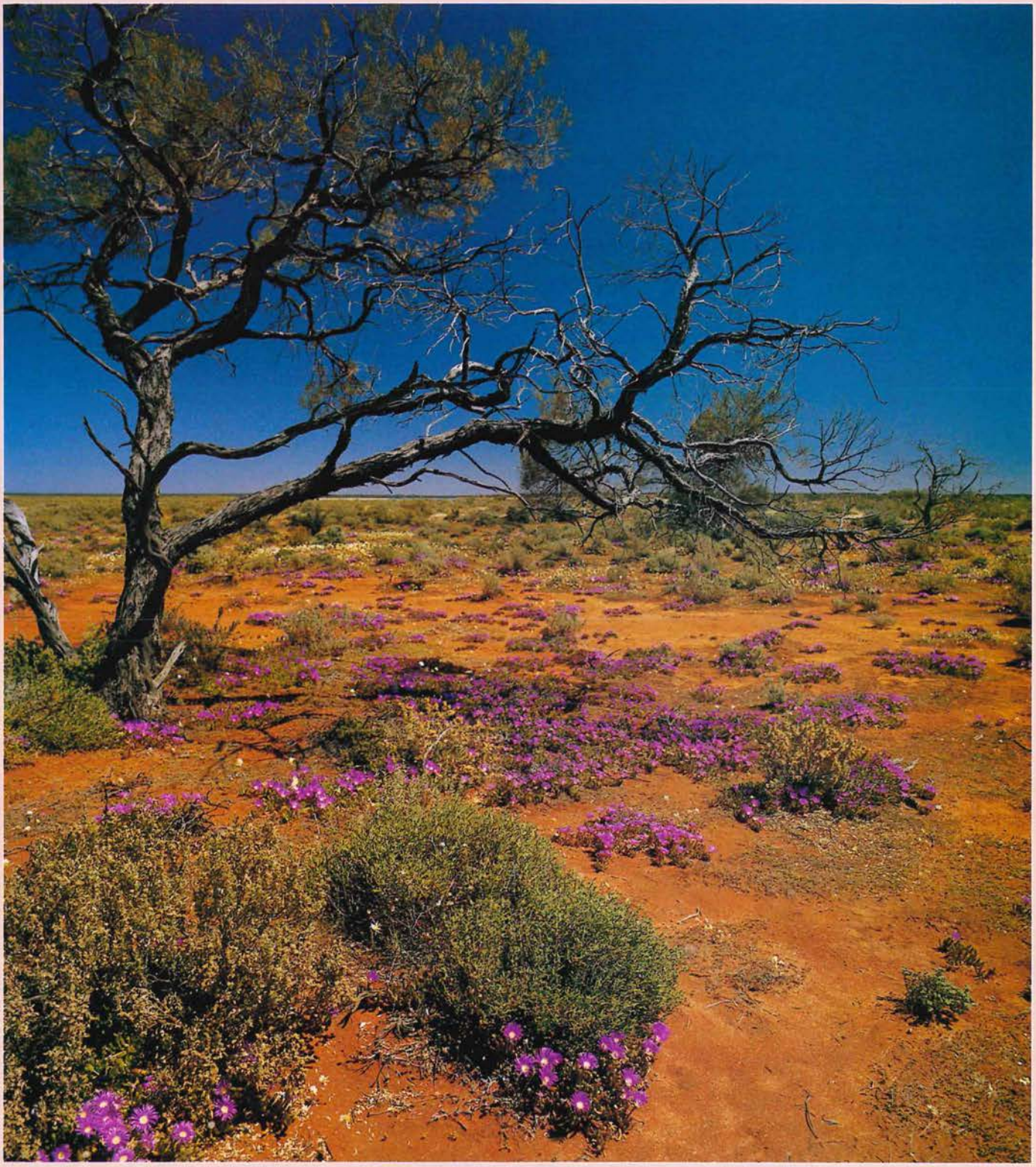
There are colourful poverty bushes (eremophilas), wattles and cassias, vetches (Swainsona, Sturt's desert pea), mulla mullas (Ptilotus), goodenias and daisies (everlastings and shrubby daisies).

Cut-leaf goodenia (*Goodenia pinnatifida*). Photo - Marie Lochman ◄

The Cape Range form of Sturt's desert pea (*Clianthus formosus*) lacks the black centre typical of this plant elsewhere. Photo - Robert Garvey ◄◄

Eremophila duttoni (right); mulla mulla (*Ptilotus exaltatus*) and pear-fruited mallee (*Eucalyptus pyriformis*). Photos - Michael Morcombe ▼▼

GREG KEIGHERY



Salt-tolerant pigface grows around the margins of Lake Moore, not far from Payne's Find.
Photo - Marie Lochman ▲

Starflower (*Calitrix carinata*). Members of this genus are widespread in desert and Wheatbelt areas.
Photo - Andrew Burbidge ◄◄

Many mammals and reptiles of the desert live in spinifex hummocks, while some birds eat the seeds.
Photo - Jiri Lochman ◄

BLAZING COMPUTERS

WILDFIRES are a major threat to human life and property and can affect wildlife. To make matters worse, bushfires move rapidly and a sudden change in conditions, such as wind direction, can have disastrous results. A Canadian, Judi Beck, is in Perth to help CALM's firefighters to predict the unpredictable - by using computers. Soon, updating a fire situation will be as easy as pressing a button.

A new Wildfire Incident Management System (WIMS) will soon make it possible to map fire behaviour from the forest onto a computer screen.

Firefighting (especially in forest country) is a major operation that requires a huge amount of information and planning.

To accurately predict the behaviour of a particular fire and plan strategies to counter it, firefighters need to know about fuels, weather, topography and the ignition point of the fire.

It is also essential to know what resources are available to fight the fire: information about fire crews (who they are and where they are positioned), vehicles and aircraft.

In Western Australian forests, an accurate fire-prediction technique already exists, but it must be worked out manually. As a result, it is very time-consuming and requires constant practice and expertise to implement. Although the manual system has been very successful in managing smaller fires, it is cumbersome when dealing with large complex fires or multiple fires in the same forest.

WIMS will enable fire controllers to simulate and map the potential spread of a fire and its intensity. The spread model rapidly integrates complex terrain, fuel and weather scenarios.

When a fire is located, firefighters can use the computer to build an accurate picture of the topography and fuels through which the fire is burning.

Different line colours and patterns will represent roads and creeks. Point features such as vehicles, heavy machinery, fire crews and aircraft will be depicted by symbols that can be moved around the screen.

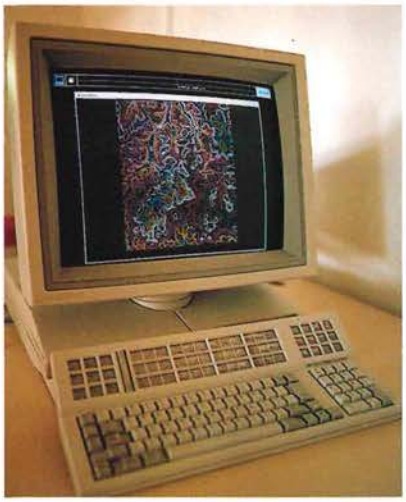
Each district has established fire gangs and crews that have been together for a whole season. The computer can store information about each individual and use it to show where they are positioned during the fire.

Users will be able to "zoom in" on part of the fire scenario to get further details. Who is in that vehicle? What is their radio call sign? A spot fire has jumped the road - which crew can get to it quickly?

And when a new shift of firefighters takes over, important local knowledge, situation summaries and resource details can be passed on through pictures and reports that can be interpreted readily and correctly.

The computer will make it easier to evaluate potential fire behaviour and take quick action to rectify any problems. For example: a wind change is expected some time between 1400 and 1600 hours; how will the fire behave if the wind change occurs at 1430 hours? Where will the fire be at 1500 hours and what if the change doesn't come until 1600 hours? Are there areas in which the fire behaviour may endanger the lives of firefighters?

If there are multiple fires, WIMS will help fire controllers maximise suppression efforts and minimise losses. During the Cyclone Alby emergency in 1978, 92 separate wildfires developed in State forest in a few hours. Under these circumstances, it is extremely difficult to consider all values at risk and to identify suppression priorities. WIMS can be used to simulate the growth of each fire over a specified time, and to compile statistics that summarise the potential losses, allowing



Terrain data such as slope, aspect and elevation, made available to WIMS by CALM's Land Information branch, can be processed and stored in the computer.
Photo - John Goodlad ▲

fire controllers to make effective decisions, based on as much relevant information as possible.

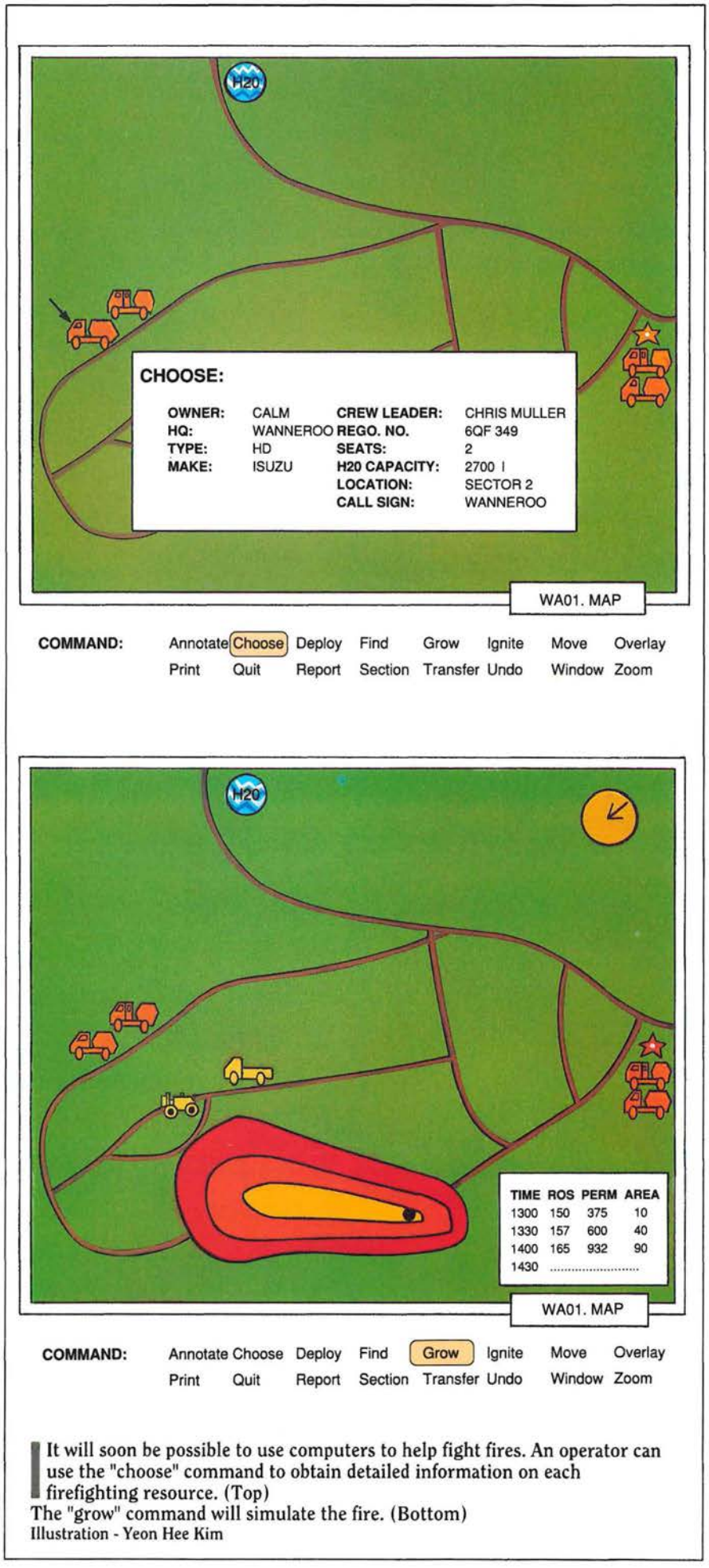
WIMS can also be used to help train fire controllers and fire bosses in wildfire management by allowing them to simulate fire situations and experiment with alternative strategies.

THE TASK HAS JUST BEGUN

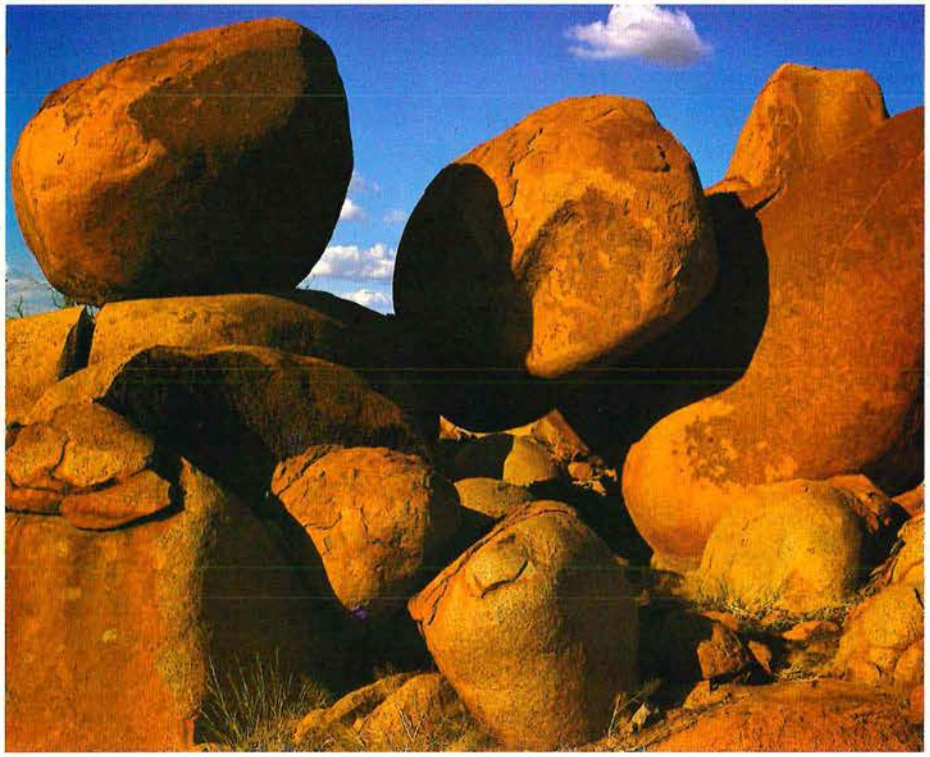
The first phase of developing WIMS began with the derivation of equations for the Forest Fire Behaviour Tables for Western Australia, developed many years ago by George Peet and Ric Sneeuwjagt. This fire behaviour prediction system is a manual, tabular system (the famous "little red book" used by CALM staff almost daily, each summer). Now that the equations are available (more than 75 rather ugly-looking mathematical relationships), the prediction system can be readily computerised.

The WIMS computer programs are still being designed, encoded, tested and refined. There is much to be done. Throughout this process, experienced firefighters will be asked to test components of the system and offer criticism and suggestions. Training programs will have to be developed and a system management group established. It's a lot of work, but the benefits will be worth it. ◘

Judi Beck is a PhD student at the Curtin University's School of Computing Science, on a CALM PhD research scholarship.



It will soon be possible to use computers to help fight fires. An operator can use the "choose" command to obtain detailed information on each firefighting resource. (Top)
The "grow" command will simulate the fire. (Bottom)
Illustration - Yeon Hee Kim



Rocks Of Ages

The gold prospectors who pushed their barrows through the mulga scrub a century ago had long walks between outcrops. The rocks that make up the old, weathered landmass of Western Australia are hidden from view over wide areas by their own debris and by sand, saltpans and vegetation. Geologist Geoffrey Shaw describes the processes that formed the State's rocks and land surface over billions of years.

WESTERN AUSTRALIA is made up of a complex arrangement of rock formations. This geological structure results from the interplay of many geological processes that have operated for billions of years and still operate today.

Throughout the State powerful forces have gradually warped, folded and fractured the crust's upper levels. Some fractures, called faults, may stretch several kilometres. In earthquakes, rocks adjoining them may move metres vertically or laterally. The Darling Fault, for example, may be traced for nearly 1000 km; near Perth it shows vertical movement of up to 10 km.

Erosion caused by rain, rivers, waves, wind and glaciers has worn away the land. Within the crust other processes such as the transformation and melting of rocks by heat and pressure have taken place. These processes are part of cycles of change that have been moulding and remoulding the outer "skin" of our planet. The cycles are thought to be powered by currents deep in the earth that cause continents to glide slowly about. Continental drift occurs when segments of crust are slowly forced down to great depths where they become heated and compressed. Metamorphism and intrusion of bodies of molten rock take place and belts of volcanoes and earthquake zones are formed. Great thicknesses of sedimentary rocks are deposited and over millions of years become folded and thrust up as mountains. When they are eventually worn down by erosion, their debris forms new generations of strata (layered rock).

Western Australia was once part of the supercontinent of Gondwana, which included Antarctica, Africa and India. Australia began to break away about 200 million years ago.

WHEN THE WORLD WAS YOUNG

The State's geological history begins in the Precambrian - the time that extended from the earth's formation until the Cambrian period some 600 million years ago. It consists of two eras - an older or Archaean, followed about 2.5 billion years ago by the Proterozoic. Precambrian rocks form about two-thirds of WA and contain most of the State's mineral resources. In the early Precambrian only the simplest life forms evolved and even the younger Precambrian rocks contain few traces of living things.

A Geological Survey team in the Goldfields in the early 1920s.
Photo - Courtesy of WA Geological Survey ▲

THE YILGARN CRATON

The rocks of the inland Murchison are among the oldest in Australia. Zircon crystals from rocky ridges such as Mount Narryer and Jack Hills are around 4.5 billion years old - the oldest minerals so far found in any part of the world. The Murchison rocks are part of the Yilgarn Craton, a vast, stable part of the earth's crust, dating from the Precambrian. It is built almost entirely of Archaean granites and gneisses and has been dry land for hundreds of millions of years. Much of it has been worn down, but, in Archaean times, mountains and volcanoes formed, and other enormous forces transformed and buckled rocks. These ancient rocks can be seen in the Darling Range; for example, at Mundaring Weir and Serpentine Dam. Many belts of volcanic and sedimentary rocks, known to goldminers as "greenstones", run through the Craton. They have yielded large quantities of gold, as at Kalgoorlie, Southern Cross and Cue.

THE PILBARA AND KIMBERLEY

The Pilbara Craton in the State's North-West is another vast, stable block of Archaean rocks. There, greenstone belts border huge granite intrusions. Striking views of these major structures are given by Landsat satellite images.

About 1.8 billion years ago the Yilgarn and Pilbara cratons slowly "drifted" and collided, rucking up massive thicknesses of late Precambrian sediments. Worn-down remnants of these great folded structures can now be seen in the Ashburton, Gascoyne and Hamersley regions (such as the Opthalmia Range).

In Marble Bar Gorge in the Pilbara, ancient volcanic lavas show the striking "pillow" form caused when lava cascades into the ocean (this can be seen happening today in Hawaii). The Pilbara's ancient sedimentary rocks contain many fossilised stromatolites - primitive colonial bacteria (cyanobacteria). Near the old mining centre of North Pole, some have been dated at 3.2 billion years - so far the earliest evidence of life on earth.

The Kimberley region in the far north has large expanses of Precambrian rocks, including the massive sandstones that form the Kimberley Plateau. Much is written about the Pleistocene Ice Age from which the world has recently emerged; but the Kimberley is one of the few places in the world with traces of glaciations that occurred in the late Precambrian. There, areas of hard bedrock show scouring and polishing caused by moving ice; extensive deposits of sand, clay and boulders represent fine debris and rocks dropped from floating ice sheets.

Coastal cliffs provide clear exposures of limestone rocks at Pt D'Entrecasteaux.
Photo - Kerry Cook

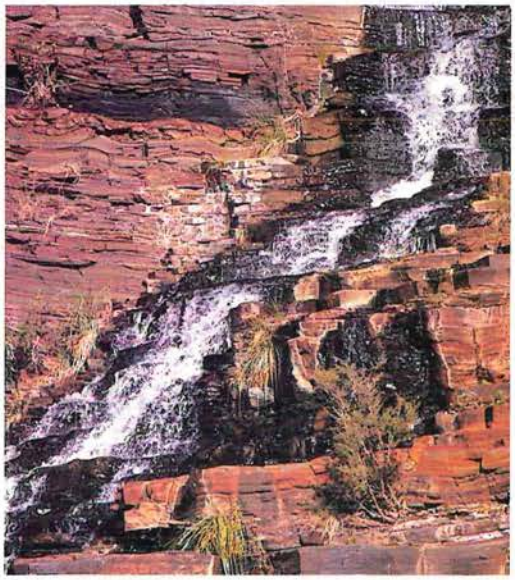
A HAMERSLEY PUZZLE

In the southern Pilbara, Archaean rocks vanish beneath later Precambrian rocks, including those from which the Hamersley Range has been carved. In the walls of the beautiful gorges of Hamersley Range National Park are layers of "banded iron formation". The formation consists of alternating thin layers (bands) of dark iron-rich rock and lighter silica-rich rock. Each dark band contains many "microbands" a few millimetres thick; geologists have been able to trace individual bands and microbands for tens, even hundreds of kilometres. It is thought that the sediments accumulated in an extensive, calm arm of the sea about 2.5 billion years ago. The surrounding land was low and arid and sluggish streams brought in only small amounts of fine-grained debris. As the seasons changed, there was alternating precipitation of iron-rich and silica-rich deposits which compacted to form the banded ironstone - the original source of the massive iron-ore deposits of the Pilbara.

THE PAST 600 MILLION YEARS

Phanerozoic time, which follows the Precambrian, spans about 600 million years and embraces three eras - the Palaeozoic, Mesozoic, and Cenozoic.

While Precambrian rocks show few traces of the many simple forms of life that must have existed then, many of the world's sedimentary rocks dating from the Phanerozoic are rich in fossils. The earliest contain only primitive marine creatures such as sponges and brachiopods, but later many more advanced invertebrate animals and land plants evolved. By about 350 million years ago fish, the earliest vertebrate animals, were abundant; they were followed by the amphibia, reptiles, birds and mammals.



Thin layers that make up the banded iron formation of Hamersley Range National Park have been traced for kilometres.
Photo - Elizabeth Paton ▲

THE LOCAL SCENE

Many fossil remains are preserved in rocks of Phanerozoic age in Western Australia. As well as many more familiar kinds of molluscs, echinoderms and crustacea, there are interesting extinct groups including graptolites, trilobites and ammonites. Silurian sandstones of the Murchison Gorge in the Kalbarri National Park reveal tracks made 400 million years ago by now-extinct eurypterids - fearsome predatory arthropods that grew to several metres in length. Early reptiles are represented by scattered bones of giant marine plesiosaurs and ichthyosaurs. Footprints of a huge carnivorous dinosaur are seen on Cretaceous sandstone beds near Broome and the bones of many extinct marsupial mammals have been found in late Cenozoic deposits in caves.

By the late Precambrian, WA had become a fairly stable part of the earth's crust. It was part of the vast supercontinent, Gondwana, which also included South America, Africa, India and Antarctica. The fairly quiet conditions continued throughout the Phanerozoic and no major mountain building occurred. Instead, the ancient Precambrian land surfaces were gradually lowered by weathering and erosion. These processes continue today.

Crustal movements that did occur were mainly large-scale warping of parts of the old land surface and sinking of crustal blocks, caused by stretching of the crust in the Mesozoic era as Gondwana

began to break up. The movements created broad depressions called "sedimentary basins" that were filled as they deepened. Ten such Phanerozoic basins lie beneath about 40 per cent of WA's land surface. Some have been intensively studied, as they contain the State's valuable resources of underground water, oil, gas and coal.

Sedimentary deposits several kilometres thick piled onto the floors of the deeper basins as they sank. Although most of these strata are hidden from view, they have been pierced and sampled by exploratory drillholes, sunk thousands of metres. Seismic and gravity surveys have also probed their depths.

MAJOR BASINS

The Perth Basin is a narrow trough about 1000 km long and up to 12 km deep, bounded to the east by the Darling Fault. Sunken Precambrian rocks form its floor and lowlands such as the Swan Coastal Plain occupy parts of its surface. The deep Carnarvon Basin contains most of the State's known oil and gas reserves, tapped at Barrow Island and the Rankin gas platform. The Canning Basin occupies a vast area north-east of the Pilbara, including parts of the southern Kimberley, and extends hundreds of kilometres offshore.

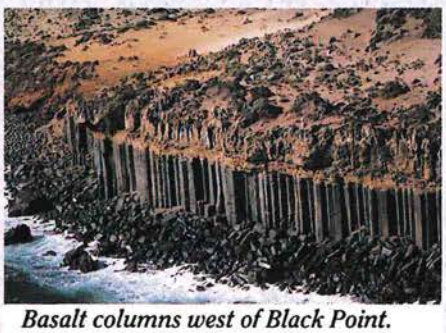
An early Cambrian trilobite (extinct marine arthropod) preserved in sedimentary rocks of the Ord River Region in the Kimberley.
Photo - Courtesy of the WA Museum ▲

Geological processes constantly change our land; waves tear at the Zuytdorp cliffs, south of Shark Bay.
Photo - Michael Morcombe ◀

ROCKS OF MANY KINDS

Rocks can be divided into three major groups - igneous, sedimentary and metamorphic.

IGNEOUS

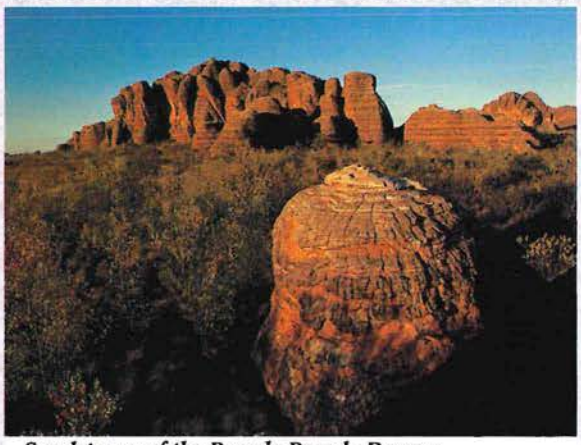


Basalt columns west of Black Point.
Photo - Jiri Lochman

Igneous rocks are formed from molten magma which rises from deep within the earth's crust. It may break through and pour out as volcanic rocks such as basalt or andesite, or cool slowly beneath the surface, forming bodies of intrusive igneous rocks such as granite, diorite or gabbro. Large bodies of granite and similar rocks are called batholiths, which may be exposed by erosion millions of years after they were formed.

SEDIMENTARY

Sedimentary rocks are formed by the accumulation of sediments such as sand, silt and mud on the sea-floor or in depressions on land. These sediments compact to form layers (strata) of sandstone, siltstone, shale, and other rock types. Limestone is sedimentary rock formed by accumulation of the skeletal remains of creatures such as molluscs and corals. Coal is a rock formed from plant remains.



Sandstones of the Bungle Bungle Ranges.
Photo - Jiri Lochman

METAMORPHIC

Metamorphic rocks, such as schist and gneiss, form when pre-existing rocks are subjected to great heat and pressure in the crust. Heat may come from the intrusion of igneous rock, or from deep burial; pressure is caused partly by major earth movements. During metamorphism, the mineral composition and appearance of rocks may be transformed. A soft shale may, for example, become a coarsely crystalline gneiss.

Coarsely crystalline gniess near Walpole.
Photo - John Myers

The small Collie and Wilga Basins contain the State's main coal reserves and coalmines. Their Permian coal seams, up to 13 metres thick, are the remains of swamp deposits and forests that existed about 275 million years ago. Fossil leaves and plant spores have been found in the coal-bearing strata, including those of *Glossopteris*, an extinct plant also found in other far-flung remnants of Gondwana. The basins also contain deposits formed during the great Permian glaciation of Gondwana, about 200 to 300 million years ago.

A coal seam exposed at Collie. Ancient swamp deposits and forests have been compressed by the weight of sediments accumulated above them.
Photo - Geoffrey Shaw ▲

The deposits provide many clues to the ages of the basins and to the marine and terrestrial conditions under which they were formed. For example, coarse sandstones and old delta beds are evidence of shallow-water deposition; thick, fine-grained mudstones indicate deeper water.

The evidence suggests that the major events that took place in WA during the Phanerozoic were direct responses to the prodigious forces associated with the gradual break-up of Gondwana. "Greater India" tore away first, from the western margin, beginning in the Jurassic period. In the south, Antarctica began to break free in the Cretaceous. There were widening rift valleys where the submerged continental shelf and slope now lie. These filled to form the present offshore basins and also extend onshore.

THE AGE OF ROCKS

When discussing the age of rock formations, geologists use two approaches. Today they can speak of the 'absolute age', which is the age in years, based on the rate of decay of radioactive elements found in rocks. More often, however, geologists use terms of 'comparative age', referring rocks to the internationally-used Geological Time-Scale. Fossils, the remains of animals and plants preserved in rocks, have been of critical importance in developing the Time-Scale. The earth's history is divided into major units called eras, the later of which are further divided into periods. WA has rocks from all eras and periods.

	ERAS	PERIODS	APPROX. AGE
PHANEROZOIC	CENOZOIC	Pleistocene Pliocene Miocene Oligocene Eocene Paleocene	65 million
	MESOZOIC	Cretaceous Jurassic Triassic	225 million
	PALAEOZOIC	Permian Carboniferous Devonian Silurian Ordovician Cambrian	600 million
PRECAMBRIAN	PROTEROZOIC		2500 million
	ARCHAEAN		4000+ million

Erosion has exposed pillars of harder limestone at the Pinnacles in Nambung National Park.
Photo - Marie Lochman

LANDSCAPES OF NOTE

Many of the State's interesting scenic features were shaped from rocks formed during the Phanerozoic. Ancient tropical Devonian barrier reefs wind across the countryside for hundreds of kilometres, forming the Napier and Oscar Ranges of the southern Kimberley. These 350 million-year-old reefs are built largely of colonial creatures such as stromatoporoids. Softer rocks that once surrounded the reef have been eroded away and it now stands boldly above the plains. Their structure can be seen in the walls of the gorges of Windjana National Park and Geikie Gorge National Park. The massive main reef, the rocks of the steeply inclined margin that faced the

ocean, and strata that accumulated in lagoons behind the reef are clearly visible. At a nearby cattle station ancient skeletons of Devonian armoured fish are preserved in sediments that surround the reefs.

The ranges of the Purnululu (Bungle Bungle) National Park of the east Kimberley consist of flat-lying, hard and weak layers of Devonian sandstone, broken by many vertical joint fractures. Erosion has eaten along the joints and selectively eroded the soft rock layers, creating a landscape that resembles gigantic piles of pancakes. On the beach at Bunbury steam bubbles and cooling cracks can still be seen in large areas of black basalt lava flows. They were poured out during the crustal rupturing that accompanied the breakup of Gondwana in the Cretaceous.

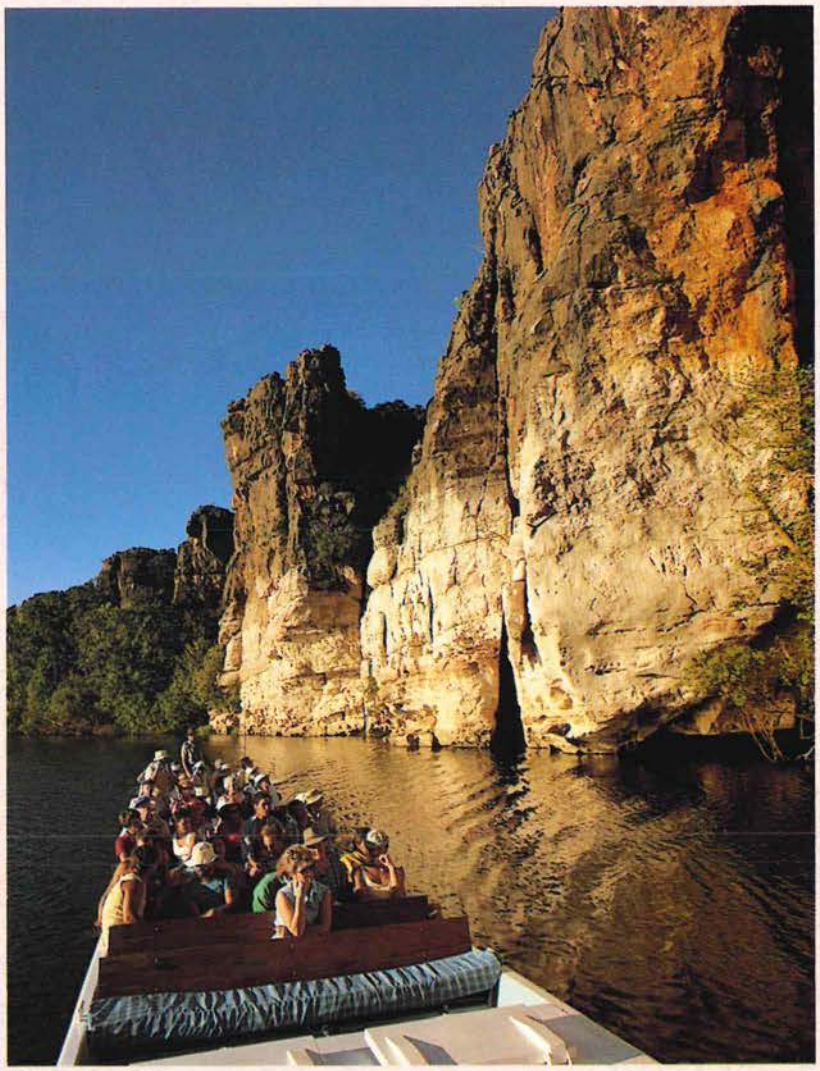
Basalt lava flows are the source of "blue-metal" used to make roads.
Photo - Geoffrey Shaw ▲

TOWARDS THE PRESENT

During the later part of the Phanerozoic there were major climatic changes. In the early Tertiary, Western Australia had a moist temperate to tropical climate under which the surface rocks were converted to a reddish crust known as laterite. In the Miocene and Pliocene the climate became more arid.

Our State has taken on its familiar form mainly over the past few millions of years. There were major glaciations in both hemispheres during the Pleistocene, but ice only lightly chiselled Australia's mountains.

Coastlines of all continents were, however, greatly affected by rises and falls of sea-level that accompanied the waxing and waning of vast ice sheets. At times of low sea-level, WA's continental shelf became dry land and ancestors of the Aboriginal people may have migrated to Australia along it. About 5000 years ago sea level was at its highest and coastal lowlands were submerged, as they may be again if polar ice caps melt.



Layers of fossils and the limestone construction of a Devonian tropical reef have been exposed at Geikie Gorge.
Photo - Jiri Lochman ▲

Many landscape features result from these climatic changes, including the extensive areas of desert sand ridges formed in an arid interglacial episode and the chains of saltpans that occupy valleys of vanished rivers.

WA's structure and landscape will continue to change: the powerful earthquakes that have struck the Wheatbelt in recent years are a reminder that the forces shaping our State are still at work. ◘

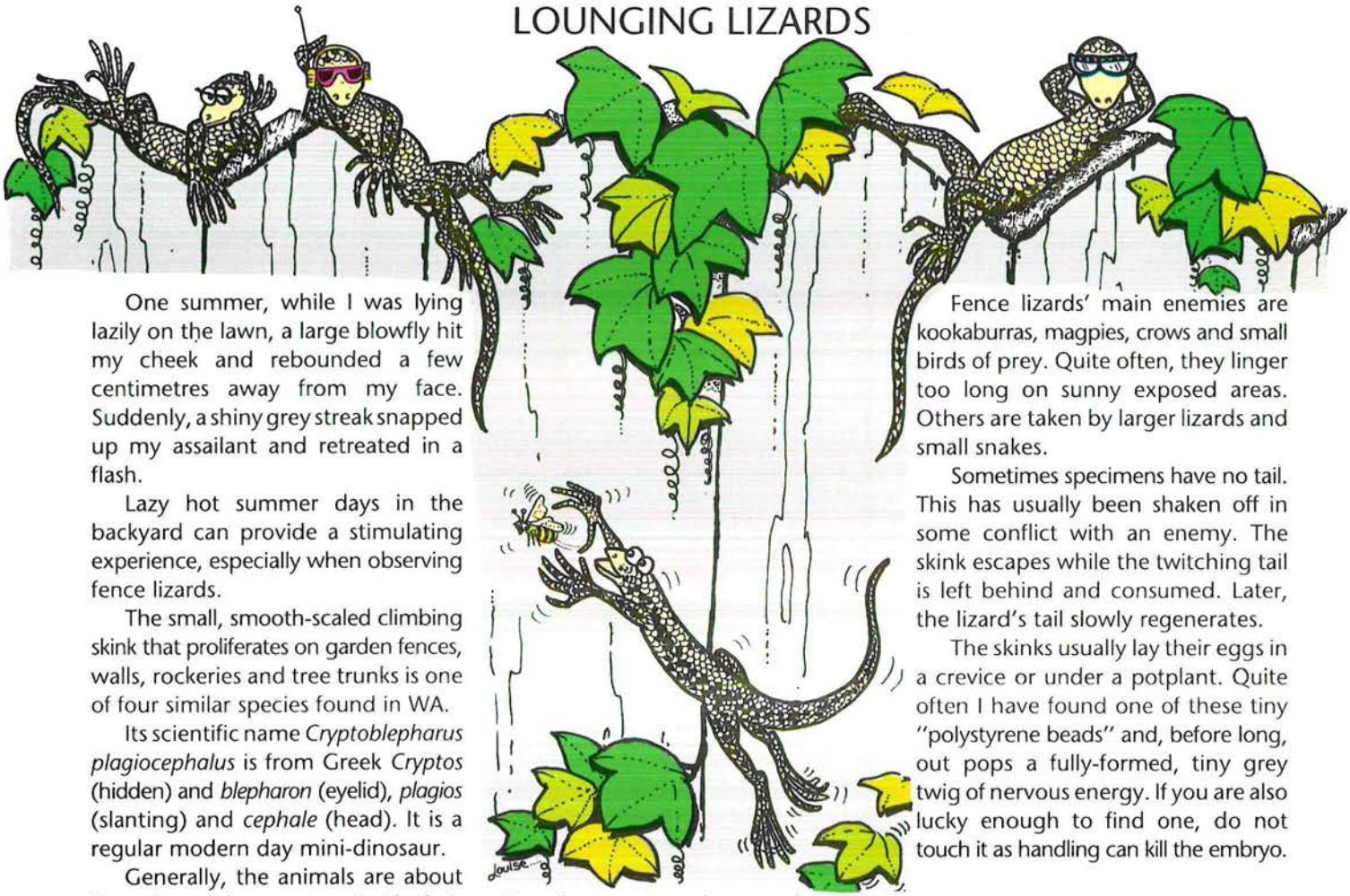
GEOLOGICAL SURVEY MAP

The Geological Survey of Western Australia (a branch of the Mines Department) has the main responsibility for State-wide mapping of geological formations and assessment of mineral resources. In 1988 the Survey marked 100 years' existence by issuing a special Centennial edition of the Geological Map of Western Australia (Scale 1:2,500,000). It shows the major groups of rocks (ages ranging to 3700 million years) that can be encountered throughout the State.

It is available from the Mines Department, 1st floor, Mineral House, 100 Plain St, Perth 6000. Also through agents in Kalgoorlie, Esperance Geraldton and Canberra.

URBAN ANTICS

LOUNGING LIZARDS



One summer, while I was lying lazily on the lawn, a large blowfly hit my cheek and rebounded a few centimetres away from my face. Suddenly, a shiny grey streak snapped up my assailant and retreated in a flash.

Lazy hot summer days in the backyard can provide a stimulating experience, especially when observing fence lizards.

The small, smooth-scaled climbing skink that proliferates on garden fences, walls, rockeries and tree trunks is one of four similar species found in WA.

Its scientific name *Cryptoblepharus plagiocephalus* is from Greek *Cryptos* (hidden) and *blepharon* (eyelid), *plagios* (slanting) and *cephale* (head). It is a regular modern day mini-dinosaur.

Generally, the animals are about 8 cm long when mature (with their tail intact). Their dark olive-grey scales are dotted with dark brown or black with a blackish side-stripe. A coppery coloured head is evident during the summer months.

With the onset of summer, fence lizards venture from their niches of winter dormancy to seek food, warmth and to mate.

The skinks are insectivorous and hunt their prey in every nook and cranny into which they can squeeze, or leap some 20 cm to devour a tasty insect.

Being cold-blooded, they often bask in the mid-morning sun on warm, flat surfaces.

In many ways they act like dogs; they will pounce on one another, locking jaws on any body part, and roll over and over for up to 10 minutes. Two beasts may chase each other across fences or walls then disappear into a crack or crevice.

Fence lizards are quite good swimmers and have been seen trying to escape from backyard swimming pools.

Inquisitiveness, thirst or attraction to insects on the pool surface often leads to their undoing. Young lizards, in particular, soon succumb to the cold water; their movement slows and if the surface tension is broken they drown.

It pays to check your pool regularly in summer as all types of reptiles can be caught, and become waterlogged or too cold to help themselves.

Simply place them on an exposed flat surface to obtain instant body heat and they will recover in a matter of minutes or seconds.

Fence lizards' main enemies are kookaburras, magpies, crows and small birds of prey. Quite often, they linger too long on sunny exposed areas. Others are taken by larger lizards and small snakes.

Sometimes specimens have no tail. This has usually been shaken off in some conflict with an enemy. The skink escapes while the twitching tail is left behind and consumed. Later, the lizard's tail slowly regenerates.

The skinks usually lay their eggs in a crevice or under a potplant. Quite often I have found one of these tiny "polystyrene beads" and, before long, out pops a fully-formed, tiny grey twig of nervous energy. If you are also lucky enough to find one, do not touch it as handling can kill the embryo.

JOHN HUNTER

Did you know ...

Lizards in the genus Cryptoblepharus *have five fingers and toes, each with a claw for efficient action on vertical surfaces.*

Most of the 150 species of skinks in WA throw their tails when in conflict. Regeneration is usually reflected by an abrupt change in colour pattern.

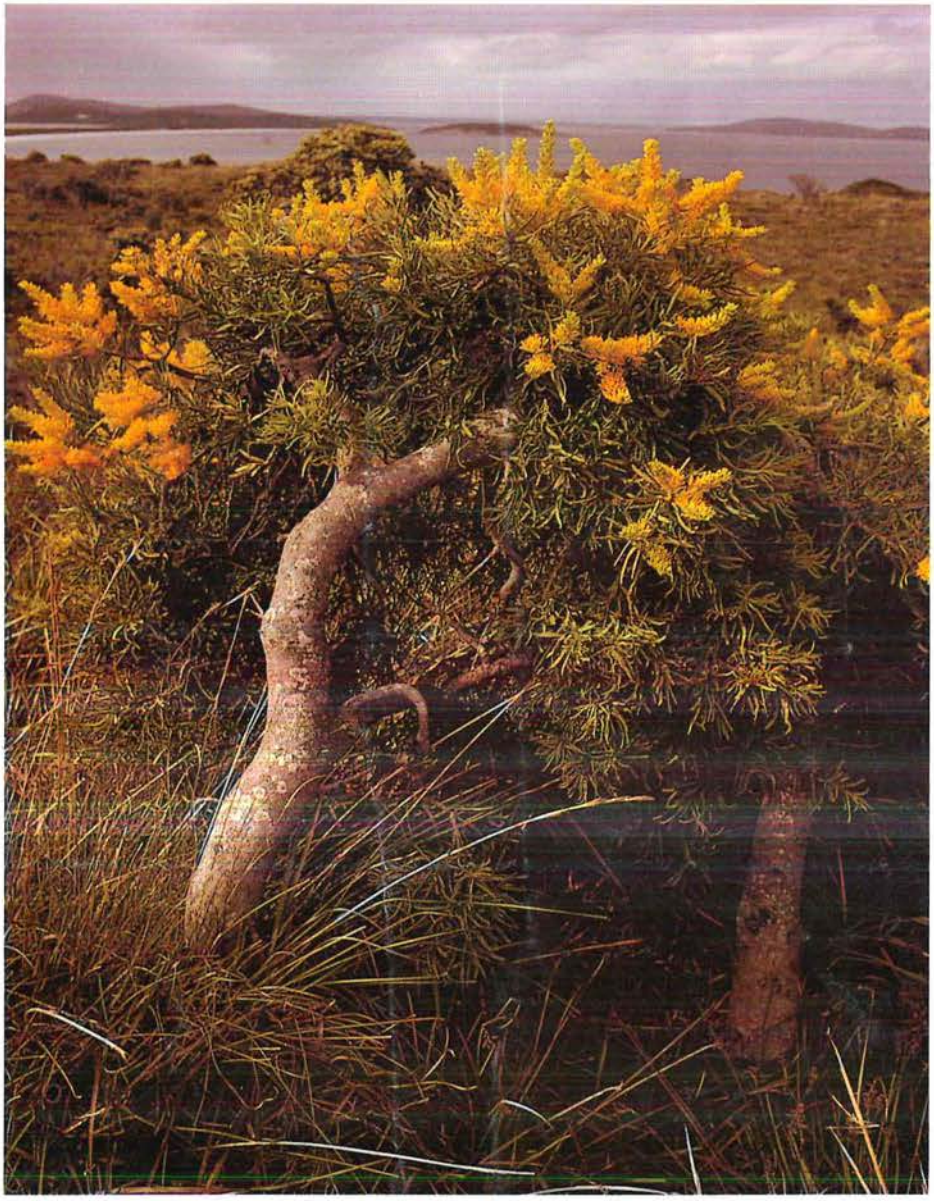
If you go looking for fence skink eggs beware, redback spiders inhabit similar locations in the same season and their egg sacs look similar.

It's a widely held, and popular belief that every Australian should have available to them the essentials of life, wherever they may be.
While Telecom Australia continues to provide even the remotest parts of Australia with telecommunications they are ever mindful of the impact on the environment and a dwindling reserve of resources.

Telecom Australia

Ad Link DDB TLA 2579

LOOKING BACK



THE FESTIVE LOOK

NUYTSIA FLORIBUNDA, THE WESTERN AUSTRALIAN CHRISTMAS TREE, MARKS THE APPROACH TO YULETIDE
PHOTO - WADE HUGHES