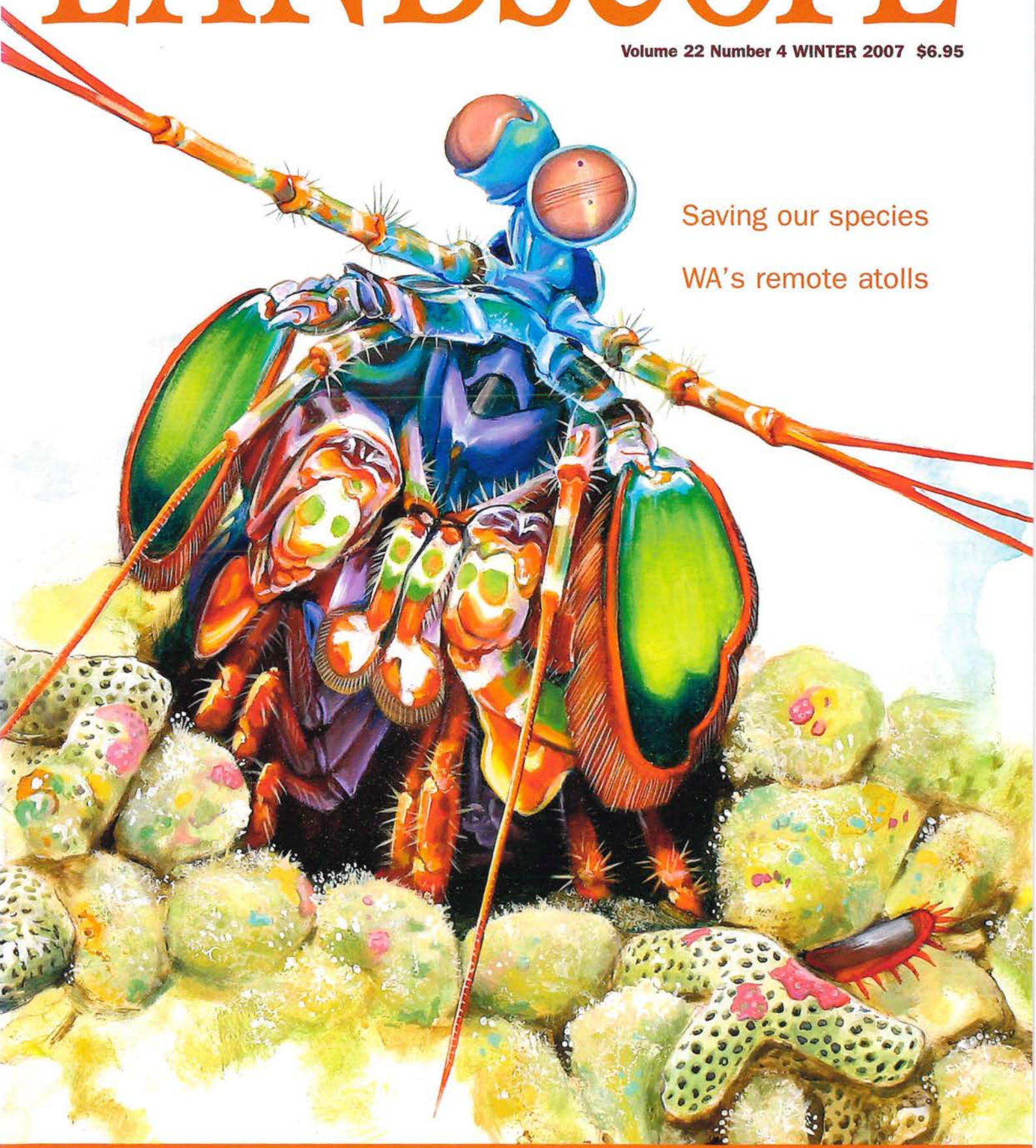
WA's conservation, parks and wildlife magazine

LANDSCOPE

Volume 22 Number 4 WINTER 2007 $6.95



Saving our species

WA's remote atolls

Tortoise battles extinction **Eucalypt health fluctuates** Island wildlife havens

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with *LANDSCOPE* magazine's *Western Australia 2008 Calendar*

Photo – David Bettini

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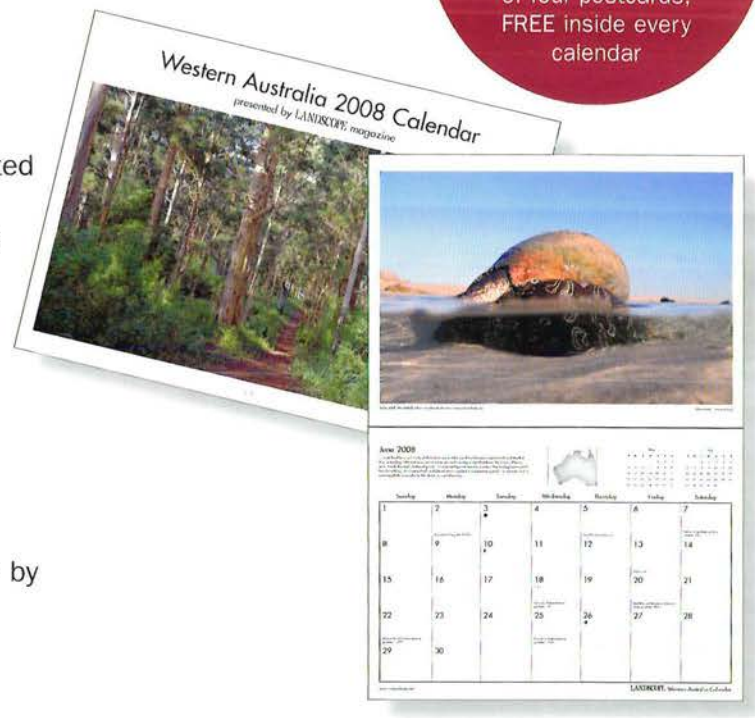

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    Bentley Delivery Centre, WA, 6983
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Department of Environment and Conservation
Our environment, our future


Linda Reinhold


Erik Veneklass

contributors

Linda Reinhold has worked with endangered animals for the Department of Environment and Conservation (DEC) for three years intermittently since 2001. In her away years, she has worked for both the freshwater and sea turtle programs for the Queensland Parks and Wildlife Service, and spent a year working on sea turtle conservation programs in the Caribbean. While working as the bat specialist for the Queensland Department of Natural Resources and Mines, she published *Key to the bat calls of south-east Queensland and north-east New South Wales*. She is DEC's Project Eden Ecologist, based in Shark Bay where she works with mammals and sea turtles.

editor's letter

From its first issue 22 years ago, *LANDSCOPE* magazine has been produced with the focus on Western Australia's conservation, parks and wildlife.

This issue is no exception, bringing together fascinating insights in to the research and initiatives that highlight the diversity of projects under way to protect and conserve our environment.

It is a privilege being part of the team developing the magazine and seeing the wide range of people and talents involved in the projects. Seeing the diversity of different people's work and the incredible range of their contributions—sometimes as part of their employment, sometimes as volunteers—is a fascinating part of working on each edition of *LANDSCOPE*.

Western Australia recently celebrated Volunteer Week and it is fitting that one of our articles this issue features the work of a passionate group of residents who banded together to rehabilitate the land around a brook that runs through part of the Perth hills region just east of the city. A clear vision, a careful plan and absolute determination matched by their passion and commitment have helped them achieve their goal.

Over the past 50 years since the rediscovery of the western swamp tortoise, many people have also been involved in work to bring the species back from the brink of extinction. Although there has been a great improvement in the tortoises' stature in the past 20 years, all of the work has yet to result in the reclassification from 'critically endangered'. Some of the factors that have made the task particularly difficult and the challenges ahead are outlined in this issue.

In contrast, the isolation of Bernier and Dorre islands at the north-western edge of the Shark Bay World Heritage Area and the fact that they are free from any introduced predator or herbivore species have helped the survival of a number of species. The article 'Bernier and Dorre: islands of marsupials, mice and men' takes a new look at the islands and the work of biologists and veterinary scientists who have been studying the populations of animals on them.

Further offshore, 'Life in isolated oases', provides an update on recent research on the remote north-west atolls on the edge of the continental shelf. The biodiversity of the atolls is still poorly known and the research provided scientists with the opportunity to make the first known collections for some groups of marine animals and plants.

Technology also has its part in conservation—and a group of innovative conservation managers has put it to good use in their bid for effective fox control. An article in this issue outlines their work in developing a special sausage bait for foxes, based on the salami manufacturing process. After successful trials, the bait is now being widely used for both agriculture and conservation purposes and is attracting interest from around Australia.

Kaye Verboon
Executive Editor

Erik Veneklaas is a Senior Lecturer in the School of Plant Biology of The University of Western Australia (UWA). He is fascinated by the diversity of Western Australian flora, particularly by the variety of their ecological and physiological adaptations. His research aims to increase our understanding of plants in order to achieve goals in nature conservation, land rehabilitation and sustainable plant production. Erik has been a member of the Wandoo Recovery Group since its inception and initiated and supervises UWA research on the impact of drought on wandoo.

Heather Taylor started work with DEC in 2003 after completing a Bachelor of Science degree at Murdoch University and DEC's graduate recruit program in May 2006. She has worked in a number of roles during this period, but mainly as the coastal and marine natural resource management facilitator for the rangelands, based out of the spectacular Pilbara Region. Through this role Heather has developed a passion for bridging the gap between communities and environmental managers to improve the sustainable use and conservation of Western Australia's land and oceans. She is now based at UWA with the Marine Futures project team—on secondment from DEC until mid-2008.

Leigh Sage is a Fire Operations Officer with DEC's Fire Management Services based in the Swan Coastal District. He has several years' experience working in the department's prescribed burning program and in wildfire suppression throughout WA's south-west. Leigh also has more than 12 years' experience as a botanist with a keen interest in the fire ecology of Australian flora and is currently the Western Australian specialist in the Goodeniaceae family.

Also contributing...

Katie Schoch, Liz Manning, Andrew Burbidge, Jessica Meeuwig, John Huisman, Sue Morrison, Mike Cantelo, Kevin Pollock, Roger Armstrong, John Stanley, Linda Stanley, Andrew Brown, Verna Costello, John Hunter, Nicky Marlow, John Asher, Rob Brazell, Samille Mitchell, Rachel Spencer, Amanda Thomas, Gerald Kuchling and Neil Thomas.


Heather Taylor

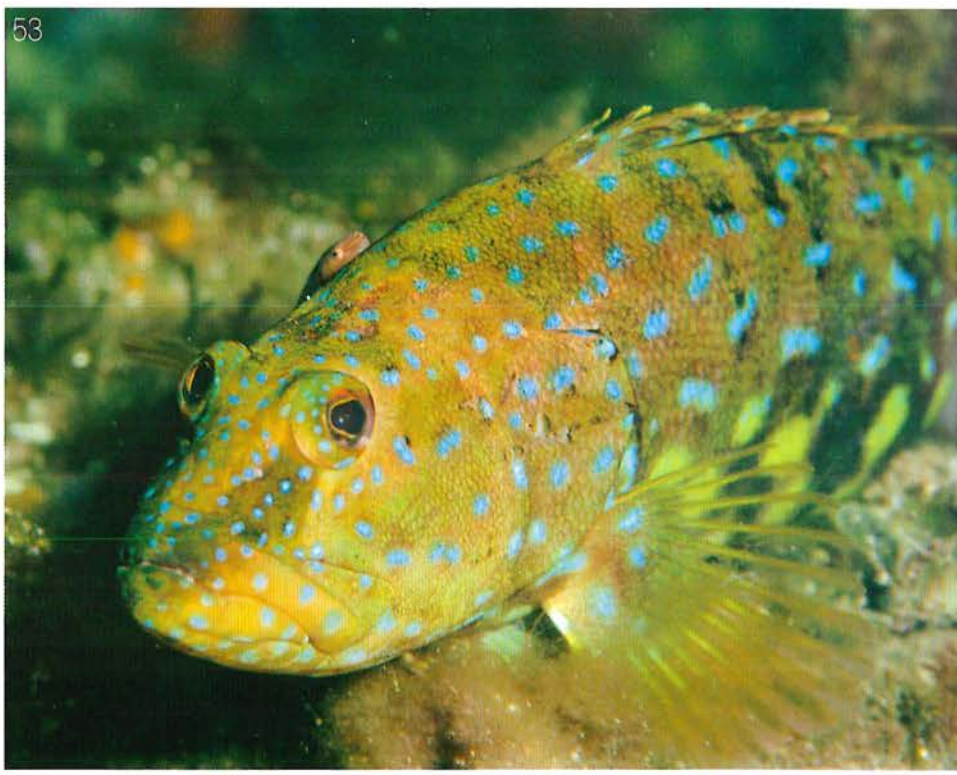

Leigh Sage

Cover illustration by Ian Dickinson
Mantis shrimps are usually found in shallow, intertidal areas, burrowing into sand or sheltering in rock or coral crevices Australia-wide. They are typically solitary and aggressive and feed mainly on small fish, other crustaceans and molluscs. They strike their prey with acceleration of up to 23 metres per second. The shock wave from the force can be enough to stun or even kill the prey.

Mantis shrimps are the only animals to have hyperspectral colour vision and are considered to have the most complex eyes in the animal kingdom. They can see ultraviolet, visible and infra-red light and different planes of polarised light. The shape of their eyes allows them to see things with three different parts of the eye at once.

Back cover photo Ann Storrie
Large sea fans (gorgonian coral) at the Rowley Shoals.

Features



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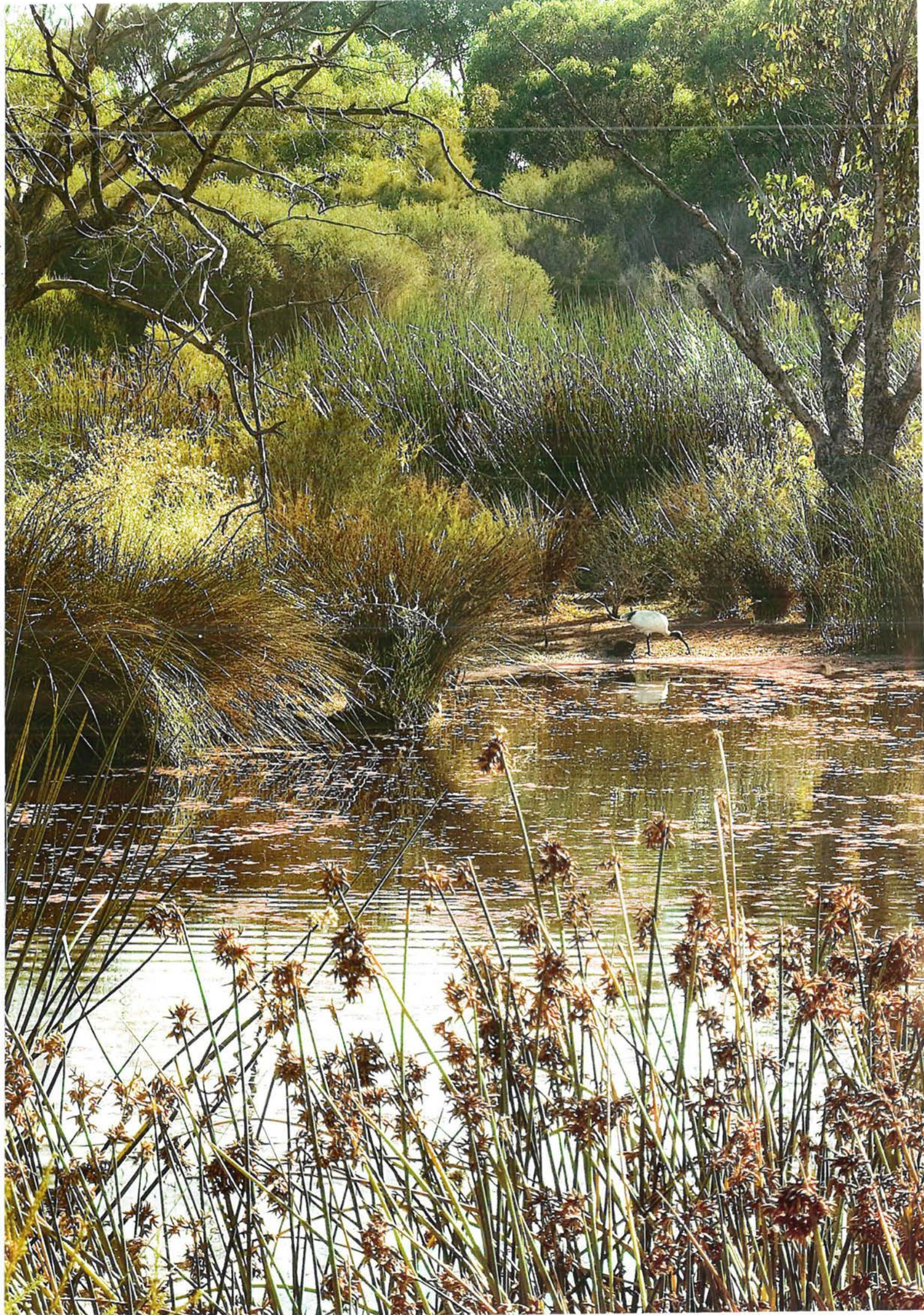
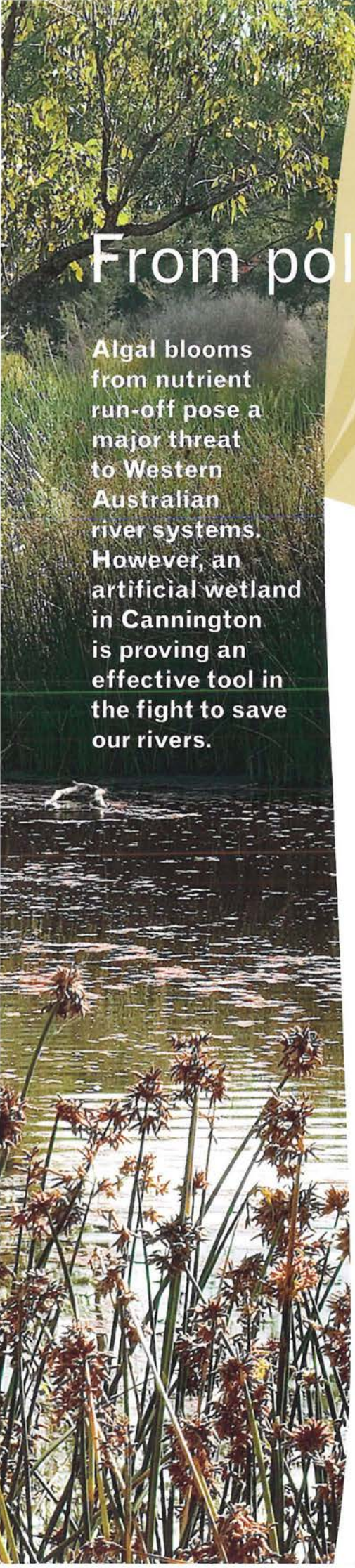
Department of Environment and Conservation
Our environment, our future





From polluted drain to healthy wetland

Algal blooms from nutrient run-off pose a major threat to Western Australian river systems. However, an artificial wetland in Cannington is proving an effective tool in the fight to save our rivers.

By Rachel Spencer and Amanda Thomas

The Swan–Canning river system, Western Australia's first official heritage icon, is a highly valued environmental, social and economic asset. However, since European settlement large sections of land surrounding Perth's rivers have been cleared and replaced with urban developments, industry and agriculture. Nutrient-rich run-off enters the river system through the drainage network, contributing to a decline in river health including regular algal blooms and seasonal fish kills.

Saving our rivers

In order to protect the environmental health of the Swan and Canning rivers by improving water quality, the Swan River Trust developed the Healthy Rivers Program. The program works towards reducing nutrients and other contaminants, minimising sediment loads entering the rivers, increasing oxygen levels and protecting and rehabilitating the river foreshores. The Healthy Rivers Program focuses on eight key areas, one of which is the Drainage Nutrient Intervention Program (DNIP).

DNIP sets the framework for onground works that strip nutrients from known nutrient-enriched drains before water is discharged into the rivers. Intervention works include the restoration of drains, re-establishment of tributary vegetation, wetland creation and the use of scientific products that remove nutrients.

The Liege Street Wetland in Cannington, 10 kilometres south-east of Perth city, is the DNIP's most significant project to date. It is a good example of how well-planned and constructed wetlands can tackle nutrients in a more natural way, provide ecological habitat and restore species diversity.

Creating an artificial wetland

Previously, three degraded drainage channels at the Liege Street site discharged high levels of nutrients directly into the Canning River, contributing to summer and autumn algal blooms. These drains were only a few metres wide, with little habitat, low water quality and limited aesthetic value. What little remnant vegetation remained was infested with weeds. Through the DNIP, the unsightly drains were converted into a diverse and attractive wetland, with the system acting as a filter to stop pollutants entering the Canning River.

The first step in creating the wetland was to install pollutant traps at each major drain outlet to trap floating litter. A bay was also constructed at the main inlet to collect, and allow removal of, sediment entering the wetland. A series of natural clay-lined ponds was then established to trap more sediment and improve aesthetics, while densely vegetated sumplands were created to filter nutrients. A weir at the wetland outlet was installed to recreate the floodplain and two internal weirs were added to enable water

Previous page
Main White ibis in restored habitat at Liege Street Wetland.
Photo – Alex Bond

Top Restored wetland.
Photo – Terrace Photographers

Left Birds like the mountain duck are returning to the restored Liege Street Wetland.
Photo – Amy Kimber

level manipulation. These steps created a system that removed nutrients and pollutants from water travelling through the wetland towards the Canning River. Islands were also added to the wetland, providing a refuge for nesting fauna from feral animal predation.

In addition, more than 70,000 native plants including 34 additional local native species were planted and weeds that were strangling native vegetation and destroying native fauna habitat were eradicated from the site. More than 144 volunteers contributed a total of about 76 days' work to help with the restoration works.

Now that the construction and planting stages of the project have been completed, education and monitoring strategies will be carried out. These will include the implementation of a visitor management plan and the installation of interpretative signage.

A new habitat

The development of the $700,000 Liege Street Wetland has been critical to restoring and protecting the Canning River and the bushland of the Canning River Regional Park. Preliminary monitoring shows the wetland has already reduced the amount of nitrogen and phosphorus flowing into the river waters by 33 and 45 per cent respectively. In addition, extensive planting has created 1.2 hectares of active wetland and 3.2 hectares of restored floodplain habitat.

Sightings of nesting turtles such as the oblong turtle (*Chelondina oblonga*) and evidence of increased bird life including the great egret (*Ardea alba*), purple swamphen (*Porphyrio porphyrio*) and the mountain duck (*Tadorna tadornoides*) demonstrate the environmental benefits of the project.

The project's success was recognised with two awards in 2006—a Western Australian Environment Award in the Bush, Lands and Waterways Category, and the National Award for Excellence in Stormwater Management from the Stormwater Industry Association.

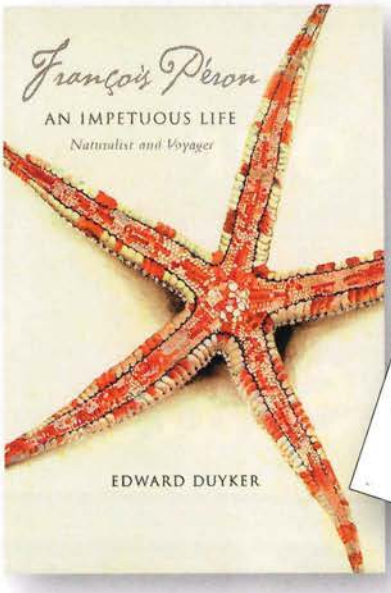
Rachel Spencer manages the Swan River Trust's Drainage Nutrient Intervention Program.

Amanda Thomas was an Environmental Officer with the Swan River Trust.

The Liege Street Wetland project was developed in partnership with the Swan River Trust, South East Regional Centre for Urban Landcare, Two Rivers Catchment Group, the Department of Environment and Conservation, the City of Canning and the Water Corporation.

For more information on the project contact the Swan River Trust on (08) 9278 0900.

bookmarks by Verna Costello

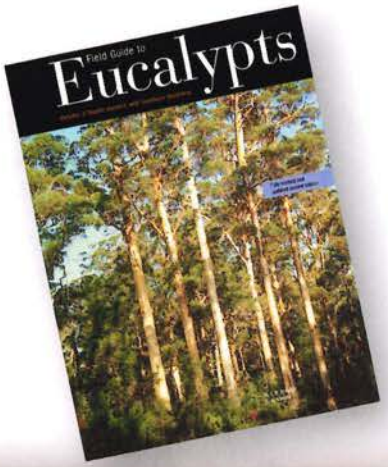


François Péron: An Impetuous Life

Author: Edward Duyker
Publisher: The Miegunyah Press
349 pages, hard cover
ISBN 0-522-85260-2
RRP $59.95

This well-researched book offers intriguing insights into François Péron, one of the most celebrated collectors of Australian animals, especially marine invertebrates. In 1801 he sailed to Australia aboard the *Géographe* as part of the French scientific expedition led by Nicolas Baudin. Due to death and desertion, Péron was one of only three of 23 scientists to complete the voyage. On three occasions (all occurring in WA) Péron failed to return to the ship by the required time only to do so in a pitiful state. Baudin described him as "the most thoughtless and most wanting in foresight of everyone on boat".

Péron outlived Baudin and wrote the first volume of the expedition's official history, with virtually no mention of Baudin by name. Péron's early death from tuberculosis in 1810, at just 35, prevented him from describing the zoological discoveries from the expedition which represented about 2500 new species!



Field Guide to Eucalypts Volume 2 South-western & Southern Australia

Authors: MIH Brooker and DA Kleinig
Publisher: Blooming Books
436 pages, hard cover, 1500 colour photos
ISBN: 1 876473 28 2
RRP: $130.00

The eucalypt is the world's most important hardwood plantation species and of great importance in landscaping.

The genus *Eucalyptus* includes more than 700 species and more than 360 are described in this volume. The text is supported by about 1500 colour plates to help the reader identify the different species

Ian Brooker is a world authority on *Eucalyptus* taxonomy and has discovered many new eucalypt species. He has more than 30 years' experience as a botanist and has been widely published. David Kleinig is a photographer and expert in identifying eucalypts through his work in seed collection with CSIRO.

ANZANG Nature and Landscape Photographer of the Year The Third Collection

Editor: Stuart Miller
Publisher: Nature and Technical Publications for ANZANG Nature Pty Ltd
83 pages, soft cover, full colour
ISBN: 0 9580642 2 9
RRP: $25.00

It would be difficult to match the superb quality of photographs to be found in this book. They are shown under nine categories: Animal Behaviour, Animal Portrait, Botanical Subjects, Underwater, Wilderness Landscape, Threatened Animals or Plants, Black and White, Interpretive Photography and Junior Photography.

Among the photographs that may well stop many readers in their tracks are those depicting some spectacular insects up close.

Saving our Species, Saving our State

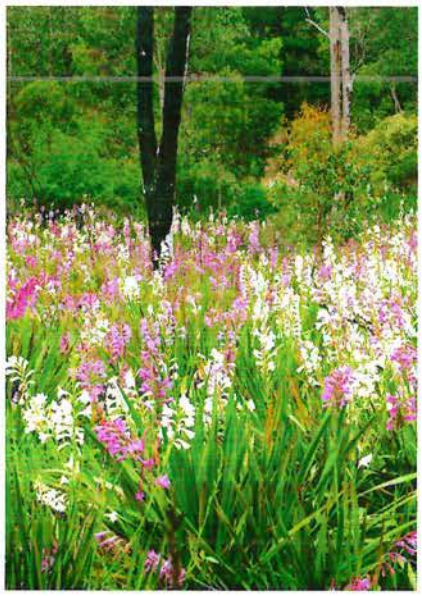
A two-year, $15 million biodiversity conservation initiative will enhance ongoing conservation work and boost immediate efforts to protect the unique biodiversity of Western Australia.

By Katie Schoch

Western Australia is internationally recognised for the diversity of its flora and fauna. Our State has eight of Australia's 15 national biodiversity hotspots and the south-west of WA is the country's only internationally recognised terrestrial hotspot for biodiversity, one of just 34 world-wide.

This unique biodiversity provides extensive benefits to WA, from helping maintain the quality of the atmosphere and regulating the climate to providing economic benefits through tourism.

Although we depend on it for our quality of life, the impacts of years of human activity mean there are now grave risks to this biodiversity. The recently released State of the Environment report into the condition of the environment in WA found that threats to the State's biodiversity were among the highest priority environmental issues of our time. As such, the Department of Environment and Conservation (DEC) has drafted a 100-year biodiversity conservation strategy for WA, with the aim of recovering and conserving the State's biodiversity within 100 years.



Biodiversity in Western Australia

Biodiversity refers to the variety of all life forms—the different plants, animals, fungi and micro-organisms, the genes they contain, and the ecosystems they form. With an area of 2.5 million square kilometres and a coastline that stretches 13,500 kilometres, WA's biodiversity is among the richest in the world. It includes 11,500 named species of vascular plants, an estimated 226 species of mammals, more than 600 species of birds, an estimated 560 species of reptiles and 73 named species of freshwater fish.

Alarmingly, 11 mammal species and 14 plant species are already presumed extinct and 204 native animal species and 378 native plant species are formally listed as threatened. As well as this, 66 of the State's ecological communities are also considered threatened.

Saving our species

Enhancing ongoing efforts to protect WA's unique plants, animals and ecosystems is the focus of *Saving our Species*, a WA State Government initiative providing $15 million towards strategic biodiversity conservation projects over the 2006–2007 and 2007–2008 financial years.

Saving our Species projects are targeting the key areas of *Phytophthora* dieback, invasive animal control, environmental weed control, cane toad control, the recovery of threatened species and ecological communities and biological survey and research.

The initiative is supporting the recurring programs of DEC and other agencies by providing an injection of short-term, strategic and focused investment to address critical biodiversity conservation priorities in the State.

These priorities include weeds and pest animal species that can be eradicated or reduced to a level where recurrent programs can maintain effective control, the protection and recovery of high-value biodiversity assets under threat, filling important gaps in scientific knowledge and

Previous page
Main Juvenile woylie.
Photo – Sabrina Trocini/DEC
Inset Research scientist Tania Jackson working on a flora translocation project.
Photo – Katie Schoch
Background Ant on a parrot bush.
Photo – Keith Claymore

Above The introduced weed watsonia competes with native flora species.
Photo – Dennis Sarson/Lochman Transparencies

Left Swamp starflower.
Photo – Andrew Brown

research, and meeting 'good neighbour' commitments that aim to strengthen partnerships between DEC and landowners whose properties join DEC-managed lands.

Saving our Species is about being proactive in biodiversity conservation, taking action now to prevent further problems and the need for a far greater level of expenditure in the future if the problems were left unchecked.

In this way we can help ensure that all Western Australians, as well as visitors to the State, have the opportunity to appreciate our flora and fauna and their diverse habitats, both now and in the future.

Phytophthora dieback: the 'biological bulldozer'

There are more than 50 species of *Phytophthora* (pronounced fy-tof-thora), but the species that causes the most severe and widespread damage to native plants in WA is *P. cinnamomi*. *P. cinnamomi* (the pathogen that causes *Phytophthora* dieback) is an introduced water mould that attacks plants and causes root rot, which kills the plant by limiting or stopping the uptake of water and nutrients.

In the south-west of WA about 40 per cent of the region's flowering plant species are susceptible to *Phytophthora* infection. Fitzgerald River National Park, located 180 kilometres north-east of Albany, is known for its floral diversity, degree of endemism and large number of mammal species including the critically endangered western ground parrot and the endangered dibbler. Unfortunately the park has a serious infestation of *Phytophthora*, introduced in this area in the 1970s by earth-moving equipment constructing an illegal access track, now known as Bell Track.

The Bell Track infestation has led to almost total collapse of the overstorey vegetation and the loss of most understorey species over a 265-hectare area. At present the infestation is confined within a discrete micro-catchment. If the infection was to escape into the adjoining catchments, control of the infestation would become an impossible task, with an area of about 30,000 hectares being immediately exposed to potential infestation. The long-term consequences for Fitzgerald River National Park could be devastating.

Above Projects are under way to prevent the spread of the dieback causing pathogen *Phytophthora cinnamomi*. *Photo – Marie Lochman*

The goal of the Bell Track *Saving our Species* project is to hold the disease front within the current micro-catchment. The affected area will be fenced to prevent the spread of the pathogen by humans and native and feral animals, and a range of approaches are also being tested to contain the disease.

In other *Saving our Species Phytophthora* dieback projects, strategic and operational mapping and risk-assessment modelling are being carried out to identify where on-ground measures can be taken to protect and manage areas of high conservation value by preventing the introduction and spread of the pathogen.

Invasive animal control

A 2004 report into the impact of invasive animals in Australia found the economic costs of control to be at least $370 million each year. The cost of tackling the damage they cause to the nation's environment and biodiversity was estimated at $345 million annually. This totalled more than $700 million without even including their significant social impact, which was unable to be quantified.

In WA, invasive animals, including feral pigs, camels, wild dogs, donkeys, feral goats, cats, foxes and birds such as starlings and rainbow lorikeets, impact on native species by predation, competition for food and shelter, habitat destruction and by spreading diseases and pathogens.

Saving our Species is targeting pest animal species in key areas where there are known impacts and where it is feasible to eradicate or significantly reduce populations to protect biodiversity values. To date, more than 6000 pest animals have been removed through *Saving our Species* projects State-wide and more than 106 kilometres of fencing have been installed.

Under the *Saving our Species* initiative, feral goat control operations have been undertaken in Kennedy Range, Cape Range, Kalbarri and Francois Peron national parks. Feral goats have severe grazing impacts in these parks, causing soil erosion and preventing regeneration, fouling waterholes and acting as a vector for weeds.

Top left Projects are under way to slow the advancement of the common starling into WA.
Photo – Jiri Lochman

Left Feral goat.
Photo – Geoff Taylor/Lochman Transparencies

Top Black-flanked rock wallabies are threatened by feral animal invasion.

Above Cane toad.
Photos – Jiri Lochman

Feral goats are also a threat to the protection and recovery of threatened species, significantly impacting on native animals through habitat destruction and direct displacement, and competition for food and shelter. In Kalbarri National Park, feral goats have been linked to the recent disappearance of the vulnerable black-flanked rock wallaby (*Petrogale lateralis*).

The control program has significantly reduced goat numbers in these parks. While eradicating feral goats is an impossible task, the objective of the program is to reduce and maintain goat numbers to a level that enables the protection and recovery of the natural ecosystems.

Other invasive animal control projects under *Saving our Species* include wild dog control in the rangelands and parts of the eastern Wheatbelt; pig control on the Darling Scarp and Swan Coastal Plain and in the forests around Manjimup and Lake Muir; a camel survey in Rudall River National Park and control of introduced bird species in the metropolitan area and around Albany and Denmark.

Environmental weed control

Environmental weeds present a serious threat to WA's biodiversity because they compete with native species for resources, are often aggressive colonisers and will displace native plant populations, particularly following ground disturbance. Some weed species, such as the tamarix, have effects that are toxic (allelopathic) to surrounding native plants. Weeds will also alter the natural fire regime and can be toxic to native grazing species.

In WA, there are an estimated 1350 species of environmental weeds, of which 34 are a high priority for eradication under the 1999 Environmental Weed Strategy for WA. *Saving our Species* is targeting 40 weed species in an initial 18 projects. A number of these projects are attempting to eradicate entire weed populations at a local scale. Other projects will achieve a 'knock down' of weed populations to enable control under recurrent programs and the long-term recovery of native species.

Since the implementation of *Saving our Species* mid last year, State-wide control work has been undertaken on 47 species of weeds across more than 6000 hectares of DEC-managed land, metropolitan regional parks, and pastoral leasehold land.

The environmental weed control projects have provided DEC with the opportunity to work with private leaseholders, community groups and other agencies, in line with its Good Neighbour Policy to achieve eradication or control outcomes.

Saving our Species has also helped raise awareness of weed species around WA and has resulted in previously unknown weed populations being reported to DEC.

Saving our Species weed control projects are targeting asparagus fern (*Asparagus scandens*) in Denmark, Albany, Augusta and Margaret River, *Moraea fugax* at nature reserves west of York, watsonia at Chittering Lakes Nature Reserve east of Bindoon, neem (*Azadirachta indica*) in Kununurra, succulents and other weed species on the south coast, date palms (*Phoenix dactylifera*) in Pilbara wetlands, athel pine (*Tamarix aphylla*) at Lake Boonderoo on Kanandah Station, prickly acacia (*Acacia nilotica*) in the Durack River in the Kimberley and cactus (*Cylindropuntia fulgida*) on pastoral land at Quobba Station, north of Carnarvon.

Cane toad control

Cane toads were introduced into Australia to control beetles that were destroying sugar cane crops. Unfortunately they failed to control the cane beetles and became major pests themselves. Having now invaded the Northern Territory, Queensland and parts of New South Wales, cane toads are approaching WA, and DEC estimates they could reach the border by 2012.

The cane toad, nominated as among 100 of the world's worst invasive species, will consume almost any living thing that it can fit into its mouth and as a predator is a threat to many small native species. It is toxic in all stages of its lifecycle from egg to adult, and native species that predate on the cane toad are also at risk. Should the cane toad enter WA, the impact on biodiversity is likely to be significant across the Kimberley.

Funds from *Saving our Species* are supplementing ongoing efforts of the WA Cane Toad Initiative, launched by the State Government in 2004 to slow down the advancement of cane toads into WA. All field work so far has been conducted in the Northern Territory, where the Cane Toad Initiative team has covered more than 100,000 kilometres in the course of its work controlling toads through strategic trapping and also by hand.

Since the introduction of *Saving our Species* last year, the WA Cane Toad Initiative has acquired a sniffer dog, Nifty, who has been trained to detect cane toads. Nifty is currently being used in the field to assist in identifying cane toad habitat and at the WA/NT border checkpoint to inspect vehicles and deliveries of produce for the presence of cane toads.

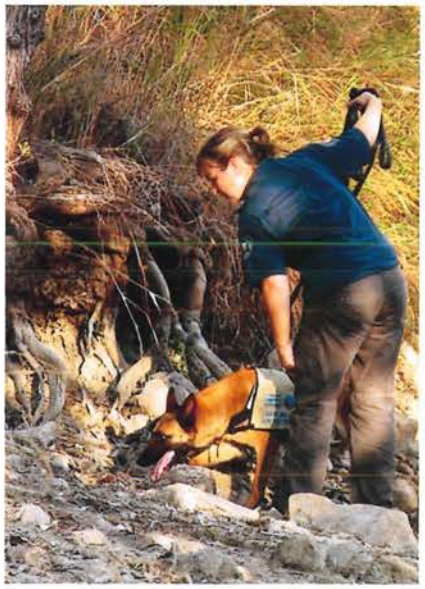
Efforts by the State Government, together with enthusiastic and committed community groups, represent the first time an Australian State or Territory has taken pre-emptive action against toads before they reach its border.

Threatened species and ecological communities

Not only is *Saving our Species* targeting introduced species that need to be controlled and eradicated, the initiative also aims to significantly advance the recovery and conservation of WA's threatened species and ecological communities.

It supports activities that are carried out under recovery plans, for individual threatened species and ecological communities and management plans, which cover the entire threatened flora in a DEC region or district.

One species being supported is Gilbert's potoroo (*Potorous gilbertii*), the world's most endangered marsupial, with less than 40 animals known in one natural population near Albany and a small translocated group on nearby Bald Island. Since the inception of *Saving our Species*, scientists have



Right Nifty the sniffer dog is trained to detect cane toads.
Photo – Errol Kruger/DEC

Below Weed eradication at a Bush Forever site.
Photo – Brian Inglis/DEC

Left Juvenile Gilbert's potoroo.
Photo – Tim Button

released three potoroos onto Bald Island in two separate releases.

They have also conducted five monitoring trips to the island to track the translocated group. On their most recent monitoring trip they discovered that the first independent island-born young was now fostering a pouch young herself. The monitoring trip previous to this had discovered the second independent island-born young, the first potoroo conceived on the island. As well as indicating that potoroos are capable of breeding on the island and that the island can sustain a new population, the early success of this project gives reason to hope that the Gilbert's potoroo might one day be a more secure species.

Flora translocations are also being carried out under *Saving our Species* to bring six of the State's critically endangered plant species back from the brink of extinction. Current populations of the species, originating from the Wheatbelt, Midwest, south coast and Perth metropolitan area, have been threatened by frequent fires, clearing of habitat, weeds and in some cases soil salinity and prolonged waterlogging.

The species have now all been propagated and will be transferred to new secure locations. Successful translocation will ensure the survival of these species and will help conserve the unique biodiversity assets of each region.

Other threatened species and ecological community projects include ecological assessment of a high biodiversity hotspot in Badgingarra, assessment and protection of biodiversity assets of the Nullarbor karst, monitoring of ecosystem health on Bernier and Dorre islands (see 'Bernier and Dorre: islands of marsupials, mice and men' on page 46) in the Shark Bay World Heritage Area and conservation work on several Bush Forever sites, which have been identified as regionally significant bushland to be retained and protected forever. So far more than 80 tonnes of rubbish have been removed from these sites.

Biological survey and research

Saving our Species is investing in important biological surveys and research that will provide the knowledge necessary for future biodiversity conservation planning and actions.

Taxonomists at DEC's WA Herbarium, in collaboration with botanists from around Australia, are in the process of describing and naming more than 50 new plant species, many of which have conservation priority or are under threat from mining activities. Providing scientific descriptions of these plants will allow their conservation status to be assessed and will ultimately help identify appropriate areas to be protected.

Saving our Species is also funding partnership projects between DEC and CSIRO to study interactions between fire and biodiversity in the Kimberley and Wheatbelt regions.

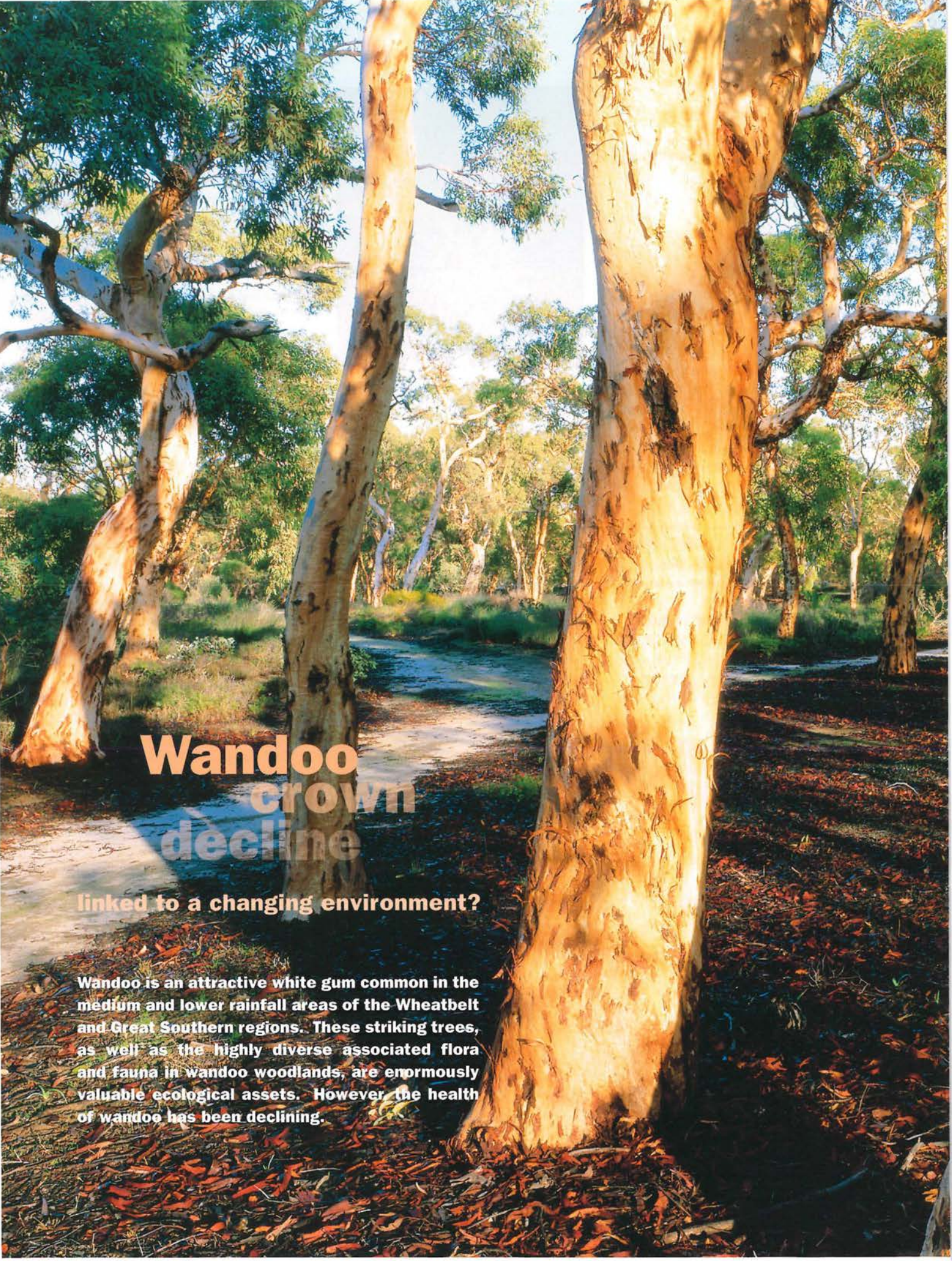
As well as this, FloraBase, DEC's online plant identification website, and NatureMap, DEC's interactive biodiversity information website, are being upgraded and improved with funding from *Saving our Species*.

Biodiversity and the future

Although there is no short-term cure for biodiversity loss, *Saving our Species* is a critical part of the overall long-term plan to restore and protect WA's biodiversity assets for the future. It is hoped that by increasing immediate efforts to protect WA's unique biodiversity, DEC, the State Government, community groups and other agencies can help have a long-term, lasting effect on biodiversity conservation in WA.

If you would like to find out more about *Saving our Species* and WA's biodiversity, or to access FloraBase or NatureMap, visit DEC's NatureBase website at www.naturebase.net.

Katie Schoch has joined DEC to take on the new role of *Saving our Species* Communications Project Officer. She can be contacted on (08) 6467 5149 or by email (katie.schoch@dec.wa.gov.au).



Wandoo crown decline

linked to a changing environment?

Wandoo is an attractive white gum common in the medium and lower rainfall areas of the Wheatbelt and Great Southern regions. These striking trees, as well as the highly diverse associated flora and fauna in wandoo woodlands, are enormously valuable ecological assets. However the health of wandoo has been declining.

By Erik Veneklaas and Liz Manning

Wandoo (*Eucalyptus wandoo*) is one of several prominent tree species under severe stress in south-western Australia. Others include tuart (*E. gomphocephala*), flooded gum (*E. rudis*) and marri (*Corymbia calophylla*). These cases of decline may have common causes. There have been several changes in the environment, varying from widespread clearing and related effects on local climate and hydrology, to impacts of fire management, commercial use of ecosystems, spread of introduced animals and the presence of pollutants and agrochemicals. Also, in the south-west, rainfall has been declining for two to three decades. Given the significance of water in this region, any reduction is likely to have a considerable impact on ecosystems. It may not be a coincidence that trees like wandoo, which dominate the ecosystems they occur in, are the first species that are affected.

Wandoo's ecological value

Wandoo is endemic to Western Australia and provides an important habitat for wildlife. It is regarded as a keystone species for an entire ecosystem

type. A myriad of insects and other invertebrates inhabit the trees' bark and foliage, attracting insectivorous birds. Flowers produce abundant nectar, a source of food for birds and insects. Many animal species such as the red-tailed phascogale, brushtail possum, several bat species and a variety of birds including the rufous tree creeper, regent parrot, Carnaby's cockatoo and barn owl use hollows in the branches and the trunk of trees. Hollow logs on the ground provide homes for numbats, chuditch, echidnas, carpet pythons, Gould's monitors, western bearded dragons and other reptile species.

However, extensive clearing for agriculture has diminished and fragmented the distribution of wandoo, leading to a severe loss of habitat for wildlife. This is seen in the dramatic reduction in the number of available nesting and feeding trees for species such as Carnaby's cockatoo. Remaining nesting and feeding areas are threatened by salinity, waterlogging, grazing, firewood collection and changes in fire management. The long-term survival of species such as Carnaby's cockatoo is closely linked to the survival of its habitat and the retention of nesting and feeding trees such as wandoo.

What is wandoo crown decline?

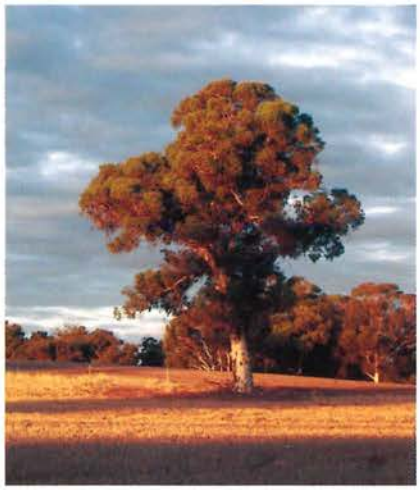
Wandoo crown decline is characterised by browning and the death of portions of the upper and outer foliage of the tree, a symptom known as 'flagging'. Epicormic shoots (new foliage) sprout along the trunk and lower limbs to replace the dead twigs and foliage. But this growth may also die, resulting in progressive loss of the tree crown and sometimes the death of the tree. The decline process can eventually stabilise and the tree may recover as epicormic growth replaces the lost canopy. Wandoo crown decline has been observed in many areas across wandoo's natural range since the mid 1980s.

In contrast, healthy wandoo trees have well-developed crowns, abundant blossoms and clean trunks. Intact wandoo woodlands comprise large, old trees with scattered clumps of younger trees where regeneration has occurred on ashbeds from fires. The woodlands support a healthy and diverse associated flora and fauna community.

Previous page
Main Wandoo woodland.
Photo – David Bettini

Above Wandoo flowers and buds.
Photo – Jiri Lochman

Left Carnaby's cockatoos use wandoo hollows to nest.
Photo – Birds Australia



Top left A Gould's monitor on a wandoo stump at York.

Above left Clearing for agriculture has diminished wandoo's distribution through the Wheatbelt.
Photos – Liz Manning

Above A declining stand of wandoo.
Photo – Allan Wills

Possible causes of decline

Drought stress and insect and fungal attack all appear plausible causes of wandoo crown decline, but it is probably the combination of these and other factors that explain the current decline. There is no conclusive evidence that trees are succumbing to drought stress directly and, while the evidence for the involvement of insect borers and fungi is strong, it is not clear why these organisms have rather suddenly become a problem.

Why is it so difficult to identify a cause? Health problems in trees can prove difficult to identify for a number of reasons. Firstly, changes in trees take a long time to manifest themselves—trees are big and able to resist some stresses for a long time. Moreover, patterns in tree health within a woodland or region can be confusing because some trees are more resistant than others, and growing conditions can be quite different even for neighbouring trees. Furthermore, interpreting tree health is complex because many ecological factors act upon trees. Even if only one factor is ultimately responsible for a tree health problem, many other factors interact and are involved in the stress and response of the tree. Unfortunately, the ecology of wandoo woodlands is poorly known and not always easy to investigate.

Wandoo woodlands have been subject to many changes over the past century including clearing, exploitation, altered fire regimes, invasive animals, plants and diseases. Wandoo crown decline, however, had not been noticed on a large scale until the mid 1980s. This coincided with the start of an extraordinary decrease in average annual rainfall.

Wandoo is declining in locations with widely different management and conservation status including sites with minimal intervention. This supports the idea that the cause must be sought in a regional change rather than a factor that acts locally.

Drought stress may be one of these regional factors. Unfortunately, it is not always easy to diagnose drought stress in trees in our region, because symptoms of drought are often not clearly visible. Moreover, many species have a high level of tolerance to seasonal drought. Nevertheless, trees do experience bad years and careful observation shows they grow less and are more susceptible to pests and diseases during long dry periods. This illustrates the complexity of tree responses—trees may suffer and even succumb to insect pests or root diseases, not necessarily because a

new pest arrives in the woodland, but because the resistance of the trees is weakened. Evidence is accumulating that pest and disease organisms have a key role in the damage observed in wandoo crowns. Accurate and comprehensive information is important in understanding decline syndromes, such as where and when crown decline is occurring.

Based on our current knowledge of declining rainfall and on the visible symptoms of crown decline (flagging), the research is now focusing on clarifying the interrelationships between changes in the environment, and the presence and impacts of insects and fungi.

Wandoo's water requirements

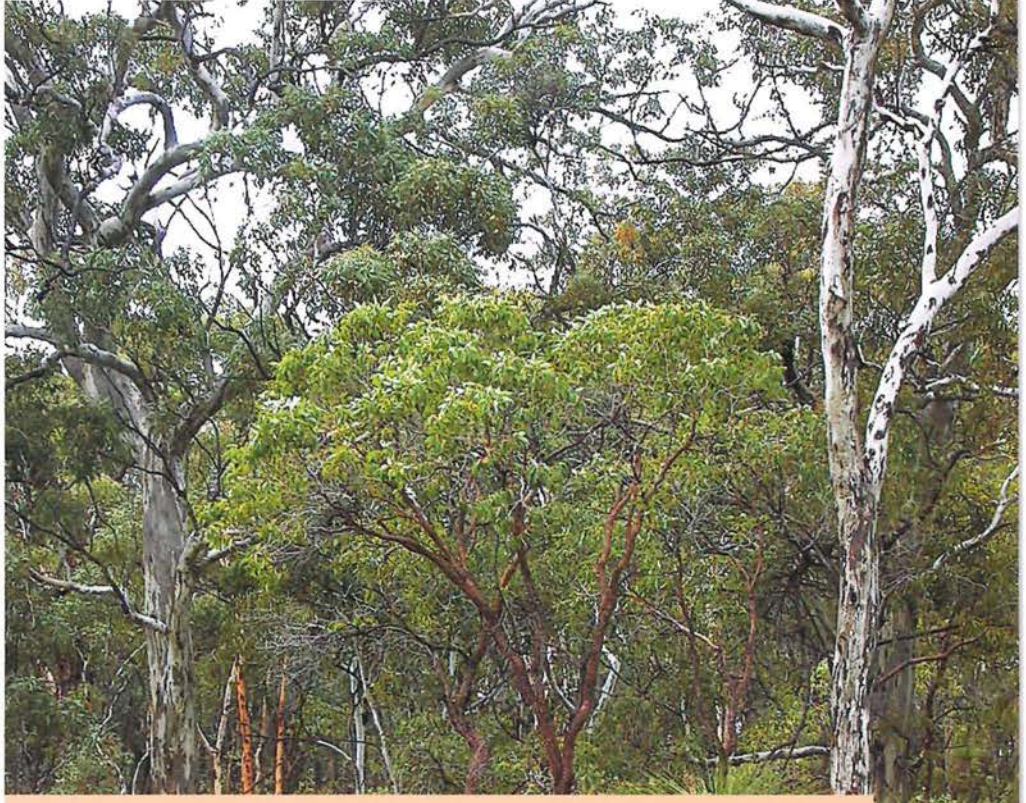
We know that trees need water and, therefore, where rain is the only source of water, a reduction in rainfall must have some consequences for tree vigour and health. But why would this have a greater impact on wandoo than on other species—wouldn't this apply to all trees? Could it be possible that wandoo suffers more than other trees that grow in the same region, or even in the same woodland? New studies carried out by The University of Western Australia's (UWA) School of Plant Biology provide insight into how trees experience drought in their environment and what the consequences of drought might be.

State-of-the-art equipment is used to measure the amount of water flowing through vessels in the sapwood, from the roots to the crowns. This flow is driven by suction, created by transpiring leaves. The more water a leaf loses and the less it is replenished by water from the roots, the stronger the suction becomes. The stronger the suction, the easier it is to access water from relatively

Above left Wandoo and powderbark (*E. accedens*) can occur together and have very similar appearance and ecology.
Photo – Liz Manning

Left Wandoo stands out with its mottled bark.
Photo – Hans Lambers

Above This giant wandoo has a girth measuring nearly 5.2 metres and could be more than 450 years old.
Photo – Liz Manning



Above right Intact wandoo woodlands support a diverse and healthy understorey.
Photo – Hans Lambers

How can you help?

The Wandoo Recovery Group (WRG) coordinates government and community-based actions to implement community awareness programs and help secure funds. It promotes, supports and coordinates research into wandoo decline and recovery.

The group organises wandoo crown assessment surveys with community groups to collect information and monitor changes in the health of wandoo. All interested groups are encouraged to get involved.

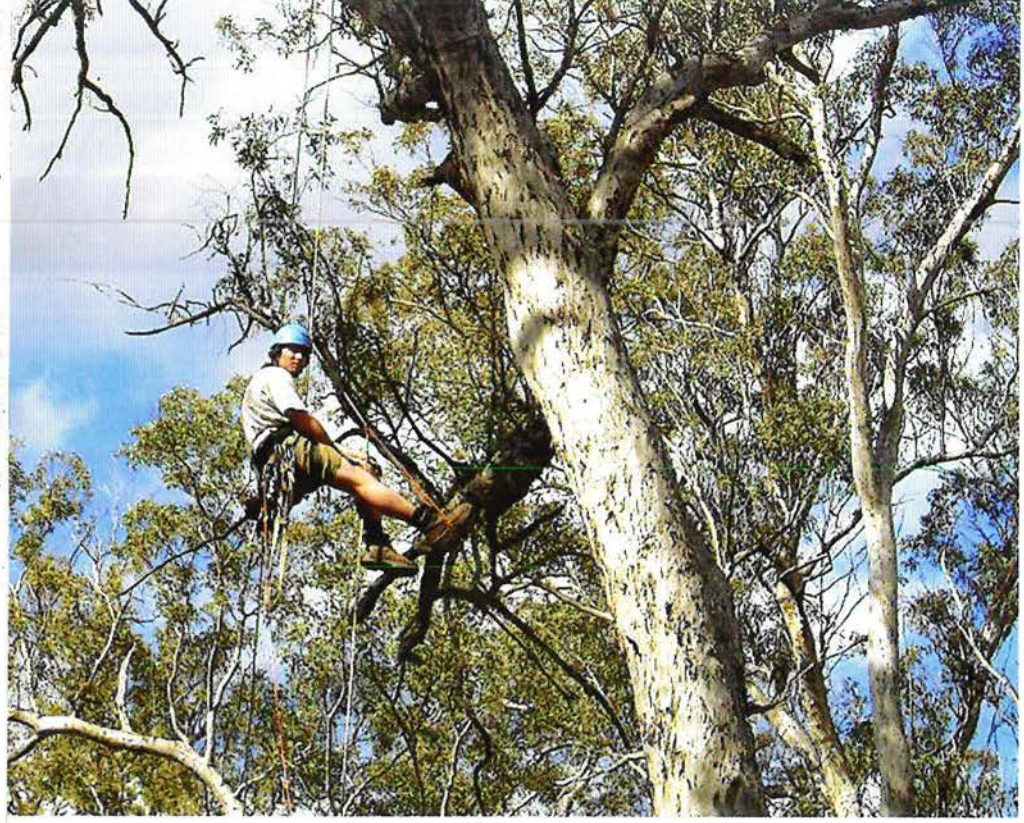
A historical review of wandoo health and the changes to woodlands is planned for the future. The research will provide vital information on whether the current decline is unique or periodic. Community members with knowledge about wandoo health, particularly before the 1970s, are invited to share this information with the WRG.

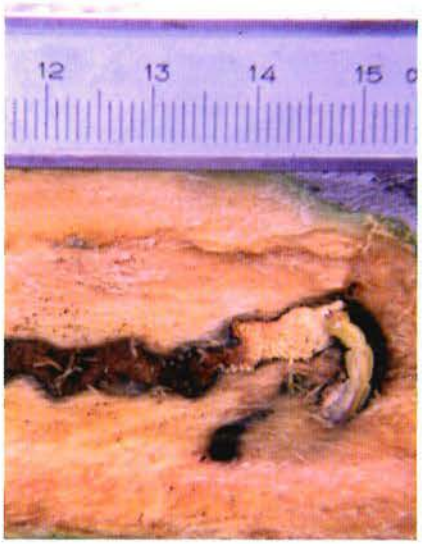
For more information on the activities of the group, and how you can help, contact the WRG Executive Officer Liz Manning. Contact details are on page 22.

dry soils. However, when the suction becomes too strong the water columns in vessels may break, rendering the transport system ineffective and whole twigs or branches may dry out.

Plants control the water status of their leaves by closing and opening pores in their leaves through which vapour diffuses to the air. Knowing the diversity of plant types and environments in nature, it is no surprise that different species use this control mechanism in different ways. For example, control is much tighter in species that are adapted to low and unpredictable rainfall, because if they left their leaf pores open for too long they would run out of water quite quickly.

The interesting results for a mixed eucalypt woodland show large differences in the water use patterns of wandoo and other eucalypts growing at the same location. As soils dry out over summer, jarrah and marri reduce their water use by closing the pores in their leaves, especially during the hot afternoons, but wandoo keeps them open and continues to use large amounts of water. While leaf dehydration in jarrah and marri is moderate, wandoo trees typically lose up to 35 per cent of the moisture held in their leaves on summer days. This dehydration leads to suction in wandoo vessels that are one-and-a-half to two times as strong as those in jarrah and marri. Perhaps one would not expect such a 'careless' water use behaviour in a species that often grows in lower-rainfall regions than jarrah and marri. But this may just be the right strategy for wandoo in its natural habitat. Wandoo usually grows in places where, in summer, most of the stored soil water is held tightly in clays. This water can only be obtained by species that develop and can withstand large 'suctions' such as wandoo. For these trees, this tightly-bound water represents a considerable volume of water that does not require a conservative use—except, perhaps, during long-term droughts when suctions needed to extract this water may become critically strong. Soils have indeed dried out considerably over the past decades, and groundwater level and stream flow have declined in all catchments. There could be a direct link between the low water level of the dams of the Darling Range and the condition of the woodlands in the catchments feeding them.





Above Ryan Hooper from UWA installs insect traps in the canopy of a wandoo tree.
Photo – Heather Monteiro

Top right Scientists use probes to measure the flow of sap in trees.
Photo – Pieter Poot

Right Type 1 borer (larvae) burrowing beneath the branch surface.
Photo – Ryan Hooper

Insects and fungi damage

A research project being conducted by UWA's School of Earth and Geographical Sciences addresses the hypothesis that insects and pathogens have become more prevalent and damaging in recent years, due to changes in climate and subsequent alterations to landscape and site factors. Trees examined by UWA researchers showed that dying branches are invariably associated with damage by wood-boring insects and decay-causing fungi. The borer burrows beneath the branch surface, forming galleries within the branch tissue. It appears that the borers do not themselves cause enough damage to explain branch death, but their tunnelling provides the fungi with access to the wood. The fungi cause decay (lesions) in the branch tissue surrounding the corridor. These lesions resemble a narrow scar meandering down the length of the branch that follows the borer corridors beneath the surface. The fungi decompose the wood to such an extent that it loses its capacity to supply the foliage with water, and leaves dry out and bleach, causing the typical flagging—isolated branches with dead foliage among seemingly healthy foliage. Most of the observed damage to date has been attributed to a specific insect known as 'Type 1 borer', which is thought to be a native jewel beetle.

Although the few years of research have produced some important clues about wandoo crown decline, considerably more work needs to be done before the causes and the solutions to the problem are identified and understood. Research at UWA will increasingly focus on the complex interactions between environmental change and the threats posed by insects and fungi.

Evidence of a changing environment

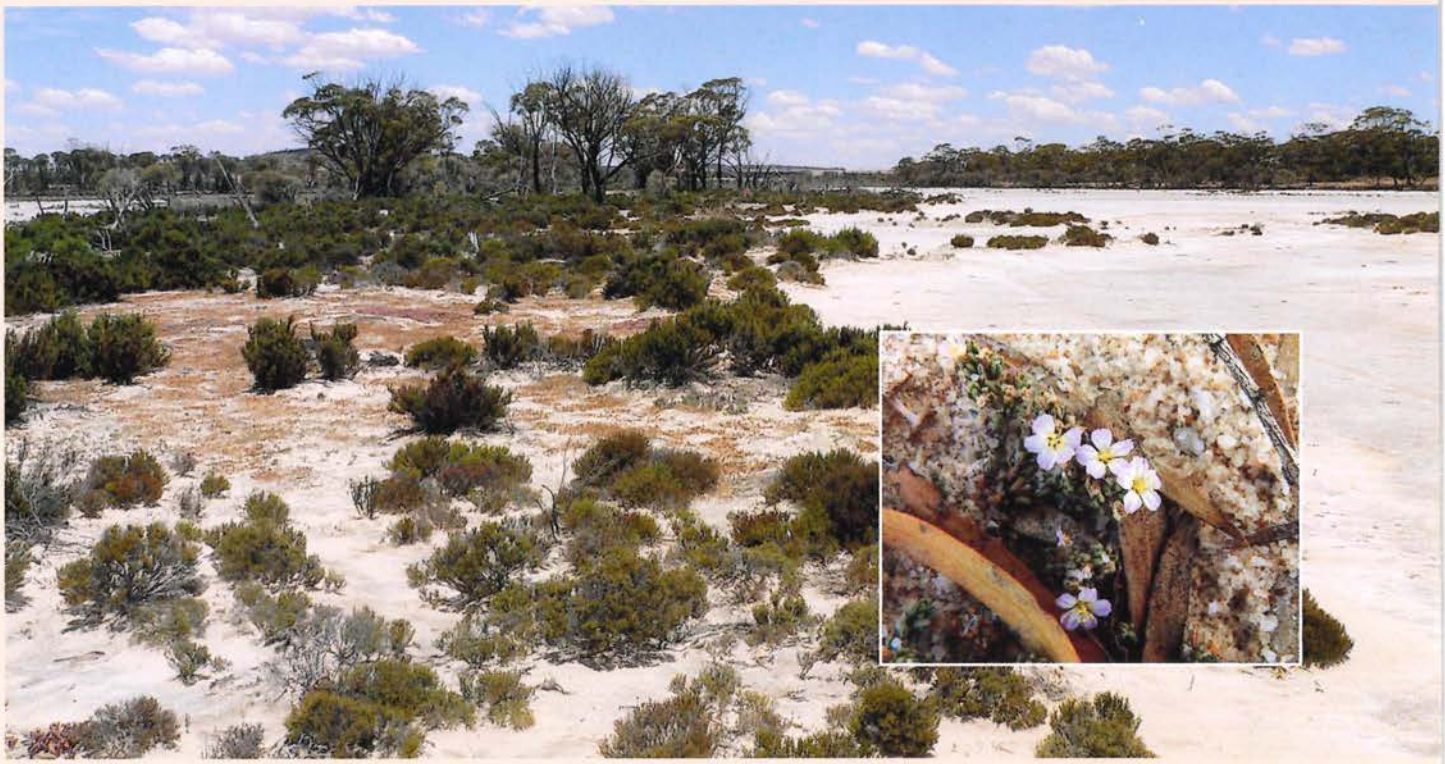
Understanding the decline of wandoo could be considered a test case of our ability to comprehend the complex impact of environmental changes, and in particular climate change. The south-west of Australia harbours a very important part of the world's species diversity, and climate models predict that this region will be subject to substantial change. This poses some big questions. Will plants and animals just tolerate these changes? Will their health suffer? Will their populations migrate to more favourable places, if there are any? What will happen to important ecological interactions, such as pollination, seed dispersal and pest control when plant and animal communities change? Shifts in species interactions may have consequences that we are not yet able to predict. Conservation biologists in the State are facing this challenge and increasing their research effort to safeguard WA's biodiversity.

Erik Veneklaas is a Senior Lecturer in The University of Western Australia's (UWA's) School of Plant Biology. He has been a member of the Wandoo Recovery Group since its inception, and initiated and supervises UWA research on the impact of drought on wandoo. Erik can be contacted on (08) 6488 3584 or by email (evenekla@cyllene.uwa.edu.au).

Liz Manning is the Executive Officer of the Wandoo Recovery Group. She can be contacted on 0427 441 482 or by email (lizmanning@bigpond.com).

The authors would like to thank Pieter Poot and Peter White for their input into this article.

endangered by Andrew Brown



Drummond's frankenia

Frankenia is a widespread genus of plants named by Linnaeus in 1753 in honour of Johann Franke, professor of botany and anatomy at Uppsala University, Sweden. *Frankenia* plants are small shrubs or herbs and are found in a variety of habitats such as coastal cliffs, dry creek beds and the margins of saline areas. Two species of *Frankenia* are listed as rare flora in Western Australia with Drummond's frankenia (*Frankenia parvula*) being the rarer.

Drummond's frankenia is a low, spreading shrub growing 50 to 80 centimetres across, with creeping stems, short, upright branches and tiny leaves to three millimetres long. The attractive pale pink flowers to 12 millimetres across, appear between October and March and may be solitary or in heads of two or three. The flowers have a mixture of spreading bristly hairs and short flat-lying hairs above but are hairless below and feature six or seven stamens and a style which has three branches.

The species was first collected in the Mt Stirling and Mt Caroline areas by James Drummond in 1847. It was then thought to be extinct until rediscovered near Cunderdin and Yellowdine during botanical surveys in 2000–2001. Further collections were made near Kellerberrin and Kwyolin.

Habitat is white to brown sand over sandy clay on the edge of rises around the high water mark of drainage channels or, more rarely, across the pan of seasonal lakes. Broad-scale clearing of native bushland for agriculture has removed much of the species' former habitat and remaining areas are subject to changes to hydrology, resulting in rising salinity and water logging. One population is also being grazed by rabbits.

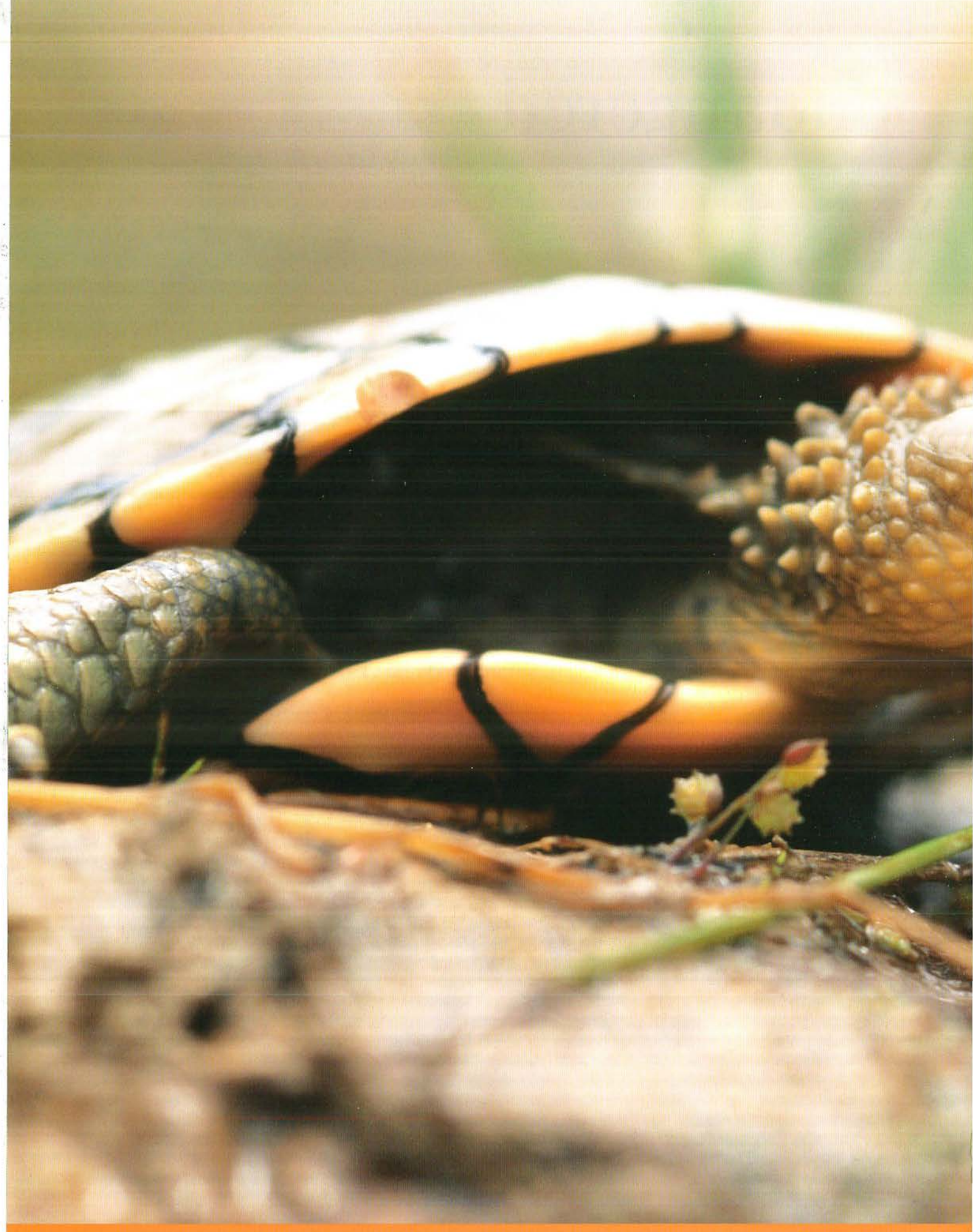
Frankenia parvula is declared as rare flora under the Western Australian *Wildlife Conservation Act 1950* and currently meets criteria for Endangered (EN) because of its limited area of occupancy and a continuing decline in the quality of its habitat. The species is also listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Private property containing one population of the species has been dedicated as a conservation block through WWF-Australia's Woodland Watch Program and as a *Land for Wildlife* site. The area containing this population was fenced in January 2007 as part of the Avon Catchment Council's *Back from the Edge* project.

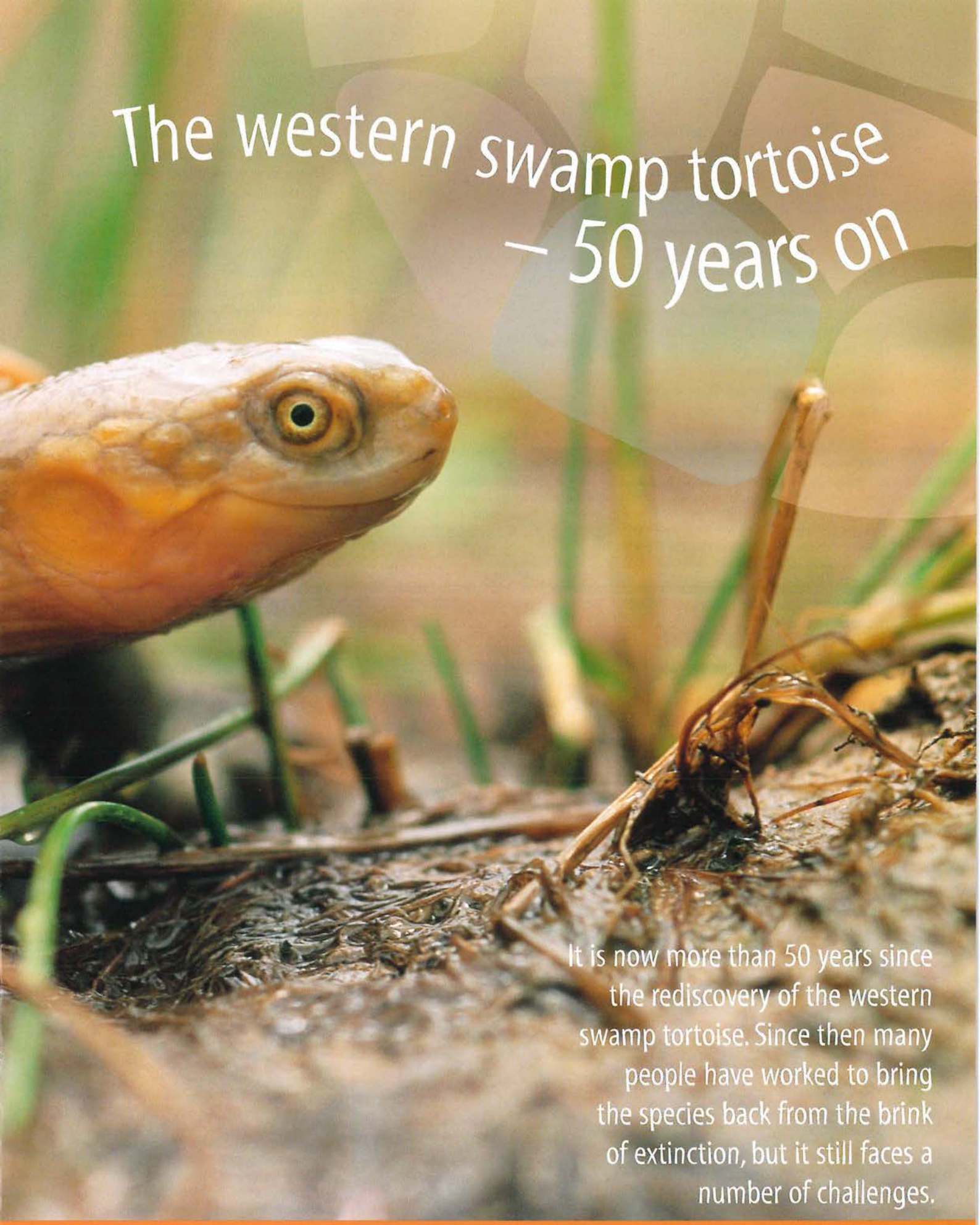
An interim recovery plan is being prepared for the species and recovery actions include more surveys, monitoring, rabbit control, seed collection and seed storage in DEC's Threatened Flora Seed Centre.

It is possible that there are more populations of *Frankenia parvula* in the central Wheatbelt. If you think that you have found this species, please advise DEC.

Photos by Wendy Johnston (main) and Andrew Brown (inset)



The western swamp tortoise – 50 years on



It is now more than 50 years since the rediscovery of the western swamp tortoise. Since then many people have worked to bring the species back from the brink of extinction, but it still faces a number of challenges.

By Andrew Burbidge and Gerald Kuchling

The 1953 rediscovery of the western swamp tortoise (*Pseudemydura umbrina)* close to Perth triggered an increase in public interest in nature conservation in Western Australia. Interest in the species has remained high and governments, conservation agencies, scientists, companies, societies and individuals have supported the necessary scientific research and on-ground conservation work. But all this work has yet to result in the species being reclassified from 'critically endangered' to 'endangered' or a lower category of threat. Why?

Threats to the western swamp tortoise

The conservation of critically endangered plants and animals is rarely easy. In the case of the western swamp tortoise there are several factors that have made the task particularly difficult. Firstly, the tortoises' biology prevents a rapid increase in numbers, even if conditions were ideal. They grow slowly and maturity is not reached until they are about 10 to 15 years of age. Females lay only one clutch of three to five eggs yearly, while other Australian freshwater turtles may lay several clutches each of more than 10 eggs. And in years with limited food due to low rainfall, the western swamp tortoise may lay no eggs at all. Eggs are laid from late October to early December and hatchlings emerge the following May or June. Being very small (about 25 millimetres long and weighing only three to five grams), the hatchlings are susceptible to predation.

Secondly, the species has a very small geographic range. All records come from a narrow strip of the Swan Coastal Plain, just west of the Darling Range from Pearce south to Perth Airport. The Swan Valley was the first part of WA developed for intensive agriculture and by the 1950s most had been cleared, urbanised or mined for clay. That trend continues today.

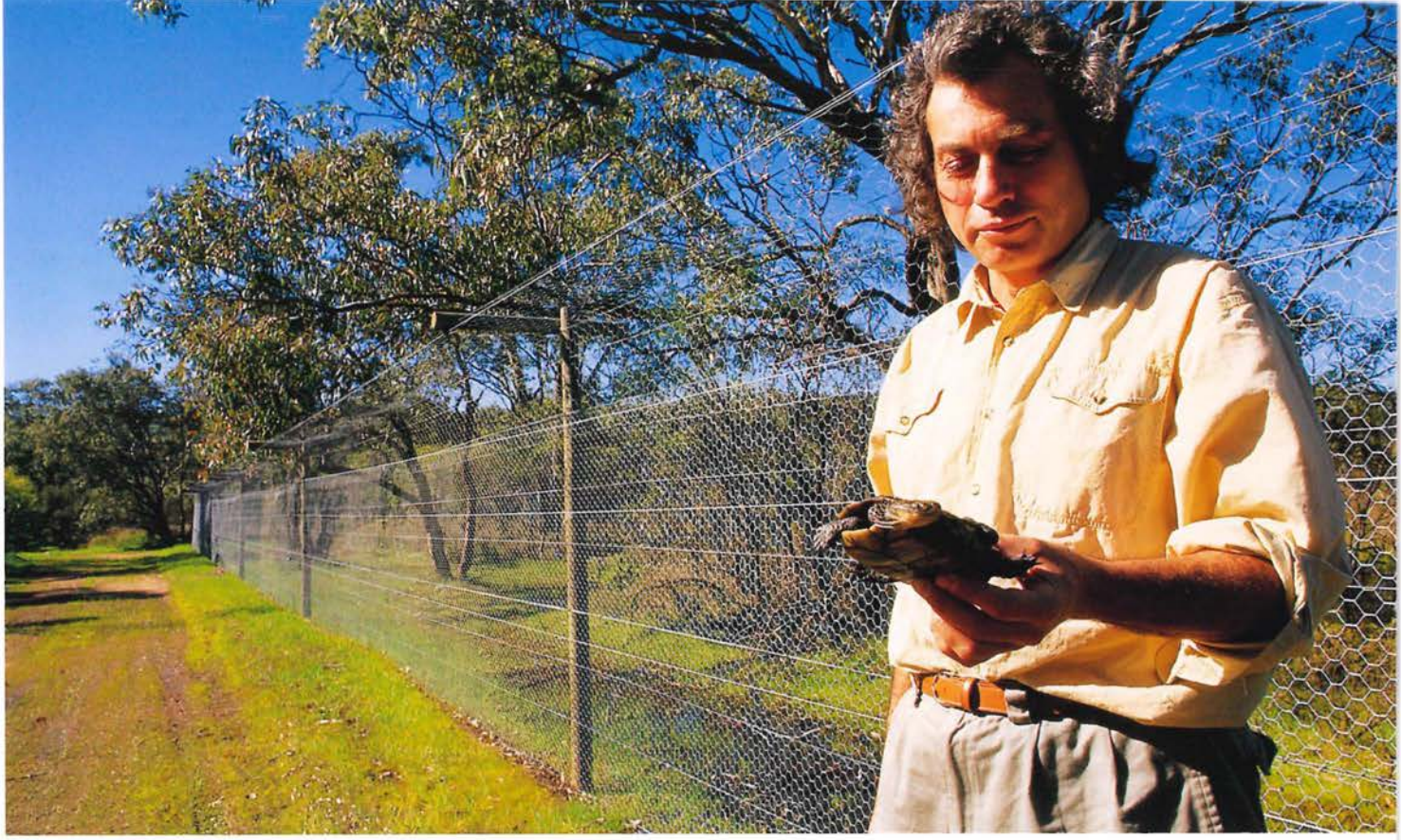
In 1962, two small nature reserves—Ellen Brook and Twin Swamps—were declared to protect the tortoises' habitat. Both have since been enlarged by the purchase of adjacent areas, but both remain very small in terms of the tortoises' requirements. Some good-quality habitat remains adjacent to one of the reserves and negotiations to acquire it are underway. Urbanisation is creeping ever closer and the Environmental Protection Authority has developed an environmental protection policy on the tortoise to limit development in surrounding areas. This was an important step in protecting the tortoises' habitat, but caused antagonism from some nearby landowners who were hoping to get permission to subdivide their land.

Climate change looms as the third major challenge facing the western swamp tortoise. Winter rainfall has already declined significantly in Perth and it is predicted that this trend will continue. Western swamp tortoises live in temporary swamps that have standing water from around June to November in most years. During the winter and spring, they feed on aquatic invertebrates and grow and lay down fat for the coming summer. Adult females need plenty of food for egg development. The clay-based swamps at Ellen Brook Nature Reserve in Upper Swan fill even in dry winters such as that of 2006, but the sand over

Previous page
Main A western swamp tortoise.
Photo – Jiri Lochman

Above A western swamp tortoise in a puddle at Ellen Brook Nature Reserve adjacent to Great Northern Highway.

Left Captive-bred western swamp tortoises.
Photos – Gerald Kuchling



Above Gerald Kuchling holds a western swamp tortoise next to the predator-proof fence in Ellen Brook Nature Reserve.
Photo – Jiri Lochman

clay swamps at Twin Swamps Nature Reserve in Warbrook has been greatly affected by Perth's increasingly dry winters. A bore was drilled in 1994 so water could be pumped into one of the swamps in dry years. Recently the winter rains have been so low that it has had to be used almost every winter and spring. In some years, the only one of the six major swamps at Twin Swamps Nature Reserve with water in it has been the one that is being augmented with groundwater. Because of increasing concern about the ability of Twin Swamps Nature Reserve to maintain a viable western swamp tortoise population, the Department of Environment and Conservation (DEC) recently called in hydrological consultants to advise on surface and groundwater management.

Predation is the fourth major factor affecting the species' recovery. As hatchlings, western swamp tortoises are easily predated by large waterbirds such as herons, as well as by goannas. Recently, predation of juveniles by ravens (*Corvus coronoides*), which have become more numerous in metropolitan Perth, has been recorded. Introduced laughing kookaburras (*Dacelo gigas*) may be an added threat.

European red foxes (*Vulpes vulpes*) are a well-known threat to many of our native animals. Foxes prey on tortoises during the winter and spring, but it is

Left Large waterbirds, including the white-necked heron, predate on western swamp tortoise hatchlings.
Photo – Ken Stepnell/DEC

during the summer, when the tortoises aestivate (sleep) while the swamps are dry, that they are most susceptible. Aestivation sites vary—at Ellen Brook Nature Reserve they are usually in naturally occurring tunnels in the clay soil but at Twin Swamps Nature Reserve they are often on the surface under leaf litter. In the mid-1960s there were more than 200 western swamp tortoises at Twin Swamps, but by the late 1980s there were less than five and, while declining rainfall had some effect, fox predation is thought to have been the major cause of the fall in numbers. To prevent this unnatural predation, both nature reserves now have fox-proof fences around them. Introduced black rats (*Rattus rattus*) also predate western swamp tortoises, especially juveniles, and rat control is now a necessary management activity.

Recovery efforts

Planning for recovery began decades ago and was first formalised in a recovery plan published in 1990 (see 'What the tortoise taught us', *LANDSCOPE*, Winter 1991). Two later versions have been published with the next one, for 2008-2013, in preparation. A recovery team, comprising scientists and managers from DEC, Perth Zoo, The University of Western Australia (UWA), WWF-Australia and The Friends of the Western Swamp Tortoise, coordinates the implementation of the recovery plan. Gerald Kuchling is employed part-time through UWA as the team's Chief Investigator.

Habitat management is critical. Wanneroo-based DEC staff intensively manage all three nature reserves where the species now occurs. They build and maintain fox-proof fences, bait for foxes, cats and rats, manage fires, liaise with neighbours and rehabilitate degraded habitat. Their work is often

Left Gerald Kuchling and Andrew Burbidge at the official release of captive bred tortoises at Twin Swamps Nature Reserve, which attracted significant media attention.
Photo – Jiri Lochman

Below left Members of The Friends of the Western Swamp Tortoise group releasing tortoises.
Photo – Gerald Kuchling

aided by volunteers from The Friends of the Western Swamp Tortoise, who are also involved in education and information dissemination.

Because of the slow reproductive rate and high natural juvenile mortality, captive breeding has been very important to produce animals that can be translocated to develop self-sustaining wild populations. Some tortoises were taken into captivity in the 1950s and some breeding occurred, but few of the young tortoises survived to adulthood. In 1987 a captive breeding project was developed at Perth Zoo under the guidance of Gerald Kuchling. Over succeeding years, better husbandry, improved facilities and the dedication of staff have led to captive breeding becoming almost routine with 40 or more hatchlings being added to the colony each year. The growing season in captivity is longer than in the wild and three years after hatching most young tortoises have grown to more than 100 grams, the size at which the recovery team considers them large enough to be released.

Early in the captive breeding program, the tortoises were translocated to Twin Swamps Nature Reserve, to augment the very small surviving wild population. Some of these tortoises have now attained reproductive size and some females are known to have developed eggs, but no hatchlings have yet been found.

In species conservation you should not have 'all your eggs in one basket'. Only one small nature reserve, Ellen Brook, seems to have a secure, viable western swamp tortoise population. The recovery team's aim is to have four or five. If the Twin Swamps Nature Reserve population becomes self-sustaining, that would be two. In 2000 a very valuable area of bush was purchased and added to Mogumber Nature Reserve, 100 kilometres north of Perth. The new area includes three clay-based swamps that the recovery team considered to be suitable western swamp tortoise habitats. Concerns that regional groundwater changes might cause the swamps to become saline have been investigated and seem unfounded. Introductions of the tortoises to Mogumber started in 2000, but have not gone entirely to plan. In December 2002, a very hot wildfire swept through the reserve, killing all the western swamp tortoises aestivating under vegetation on the surface. Most animals sheltering underground, including three tortoises in artificial tunnels installed to provide aestivating habitat, survived. However, as there was now no shade or shelter, these tortoises were returned to Perth Zoo. Introductions got underway again the following winter, but a further set back in 2006, when extreme drought meant that there was no water in any of the swamps, prevented the programmed release that year. Whether the 2006 drought will lead to lower survival remains to be seen.

Two other prospective translocation sites are being investigated. The first is within one of Perth Airport's conservation zones and the recovery team continues to negotiate with the airport's owners, Westralia Airports Corporation, to gain access to this land. The other is within Moore River Nature Reserve, 85 kilometres north of Perth, where hydrological and other investigations are underway to properly

Right Western swamp tortoise.
Photo – Jiri Lochman

evaluate this area. The recovery team is now looking for suitable areas south of Perth.

From critically endangered to endangered?

The western swamp tortoise currently meets the World Conservation Union (IUCN) Red List criteria 'A2' and 'D' for critically endangered species (see www.redlist.org). To qualify for 'endangered' under criterion D, there must have been more than 50 adult tortoises in the wild for five years. At the end of 2006, population estimates suggested that there were still fewer than 50 adult animals in the wild, but that the number was slowly increasing. If all goes well, wild adult numbers could pass 50 within five years. Criterion A2 is more difficult. It is defined as:

> "Reduction in population size based on an observed, estimated, inferred or suspected population size reduction of ≥80% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible..."

In the case of the western swamp tortoise, the causes of population reduction are fairly well understood, but they have not ceased and some, such as habitat loss and climate change, may not be reversible. So, how long is three generations? The IUCN Red List criteria define generation length as the average age of parents of newborn individuals in the population. Reproductively active adult western swamp tortoises may be from 12 to 100 years old and the average age of parents is thought to be around 30 to 40 years. So three generations is about 100 years.

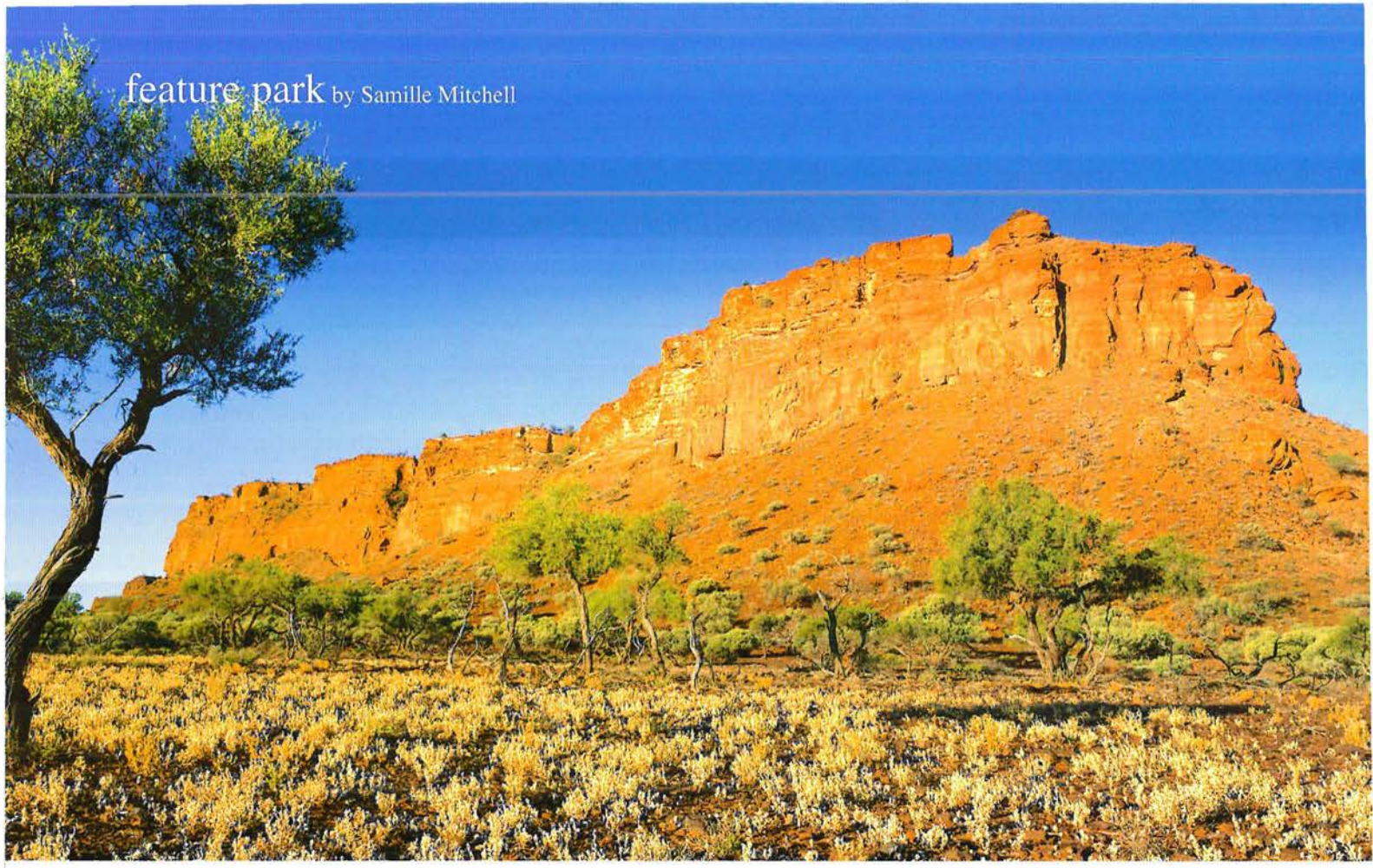
We don't know how many western swamp tortoises there were 100 years ago, but we do have population estimates from the early 1960s when there were probably more than 300 individuals within Twin Swamps and Ellen Brook nature reserves, plus an unknown number outside. We know that in the 1960s, western swamp tortoises still occurred near Midland, at Perth Airport, near Caversham and near Pearce, so it is likely that they also occurred at other localities between these points and that 100 years ago there were many more of the tortoises alive than in 1960. If we assume that 100 years ago there were 1000 western swamp tortoises, for the decline to be less than 80 per cent in the past 100 years, there must now be more than 200 tortoises in the wild. Currently, we think there are between 150 and 200, but most of these are sub-adult. Because of the uncertainty about criterion A2, the recovery team is concentrating on criterion D and once we know that there have been more than 50 adults in the wild for more than five years, we will seek to have the species upgraded from critically endangered to endangered.

The western swamp tortoise is a classic example of a long-lived, but slow-reproducing species, with highly specialised habitat requirements. Scientists and land managers often find the conservation of such species, when faced with habitat loss, predation and other threats, very difficult and slow to bring back from the edge of extinction. The tortoises' status has improved considerably during the past 20 years, but there are still many challenges for it and us to face and overcome.

Dr Andrew Burbidge is a Research Fellow with the Department of Environment and Conservation and a Consultant Conservation Biologist. He was chair of the Western Swamp Tortoise Recovery Team for many years. He can be contacted on (08) 9405 5103 or by email (andrew.burbidge@dec.wa.gov.au).

Dr Gerald Kuchling is a Research Fellow with The University of Western Australia's School of Animal Biology and is the Western Swamp Tortoise Recovery Team's Chief Investigator. He can be contacted by email (kuchling@cyllene.uwa.edu.au).

The recovery team acknowledges Natural Heritage Trust funding towards implementation of the recovery plan.



Kennedy Range National Park

With its soaring cliffs, golden hues and remote location, the Kennedy Range National Park exudes a feeling of wilderness. Improved road access from Carnarvon means this still untamed park is set to increase in popularity.

Above Kennedy Range.
Photo – David Bettini

Opposite page
Far right above Wedge-tailed eagle.
Far right Weathered patterns on cliff face.
Photos – Jiri Lochman

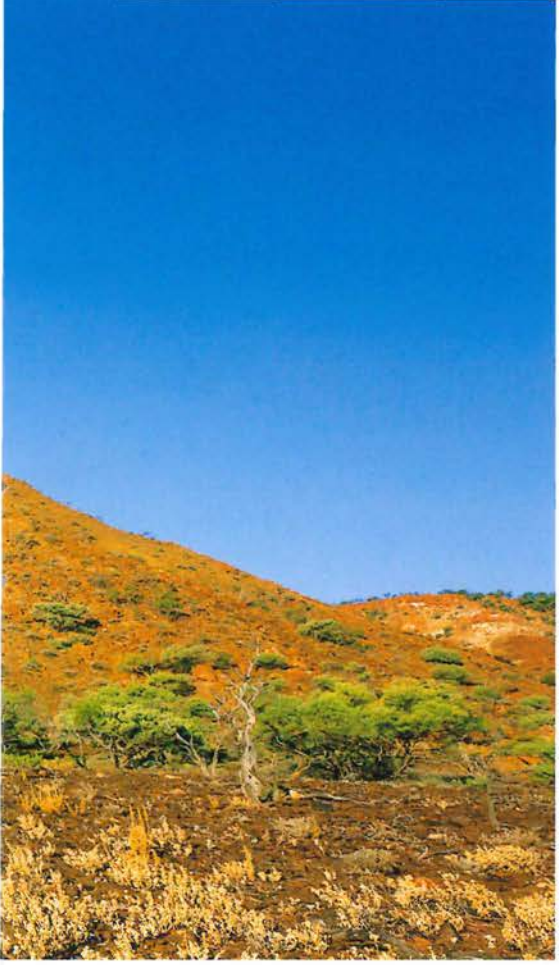
The Kennedy Range National Park boasts 141,660 hectares of Gascoyne wilderness. The towering walls of the range form the centerpiece of the park—a golden mesa stretching some 80 kilometres in a north-south direction. It is the enchanting beauty of this mesa, its craggy crevices and sheer cliff face, that lures visitors. But despite the growing popularity, the park retains a feeling of being untouched. Spend a night here camped under the stars, watch a solitary wedge-tailed eagle soar above or delight in the showing of seasonal wildflowers, and you are bound to sense the beauty of untamed wilderness.

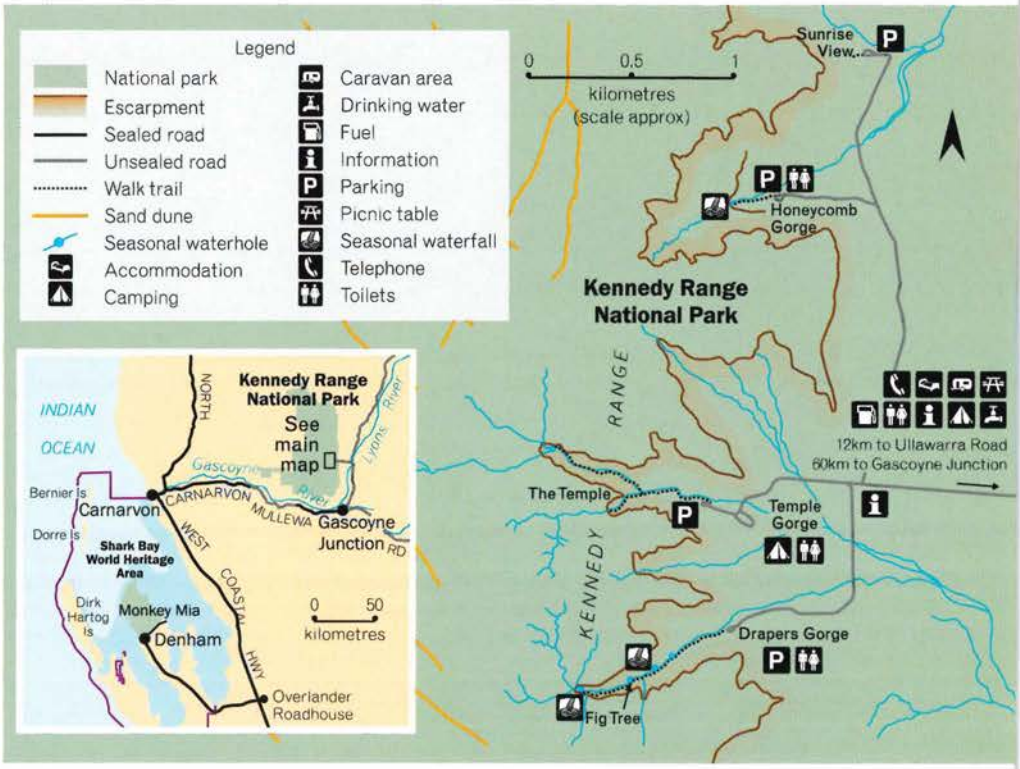
Natural attributes

The Kennedy Range National Park features an ancient landscape, sculpted by the hands of time to form a giant mesa. This mesa rose from an ancient seabed as the surrounding landscape eroded over the millennia. The erosion has left a series of spectacular cliff faces, rising up to 100 metres above the surrounding Lyons River plain.

The ancient nature of the rocks is evident in the many fossils visable today. Visitors may be lucky enough to see marine fossils in the range's sandstone strata and fossilised plant specimens too. Some of these plant specimens represent the earliest known occurrence of banksias in Australia.

Today the park supports more than 400 native plant species, of which at least 80 are annual wildflowers. After good winter rains, the park bursts





into spectacular blooms of arid flora species like mulla mulla (*Ptilotus*), poverty bushes (*Eremophila*) and fan flowers (*Scaevola* and *Goodenia*), which are particularly beautiful set against the rugged backdrop of the range. The top of the range features a series of red sand dunes, vegetated with spinifex, wattle, mallee and other small shrubs.

Visitors to the park may also spot some of its wildlife. The park is home to 33 reptile species, 103 bird species and 20 species of native mammal, including nine bats.

Feral goats are prolific and are the subject of Department of Environment and Conservation (DEC) control programs. A *Saving our Species* project in February 2007 resulted in the removal of more than 1800 goats from the park (see also 'Saving our Species, Saving our State' on page 10).

Enjoying the Kennedy's beauty

Visitors to the Kennedy Range can access the eastern, and arguably most spectacular, side of the range. Journey about 45 kilometres north of Gascoyne Junction on a gravel road and turn west into the national park. There is a basic campground at Temple Gorge, with walk trails, sealed vault toilet and basic information. Visitors can also access day use sites at Drapers Gorge, Honeycomb Gorge and Sunrise View.

During the winter months, visitors may also encounter campground hosts —volunteers who camp in the national park, and assist DEC with management and welcoming visitors.

Kennedy Range future

While the Kennedy Range National Park is growing in popularity, its visitor numbers are light compared with more easily accessible areas. However, with work on the sealing of Mullewa Road between Carnarvon and Gascoyne Junction nearing completion, visitation is expected to increase. DEC is currently finalising a management plan to guide development in the future. The plan outlines longer-term proposals to develop visitor facilities on the western side of the range. While less dramatic than the eastern battlement, the western gorges feature shady river gums and springs and opportunities for camping and exploration.

Opportunities to better experience the top of the range and further explore its beauty are also identified in the plan, offering visitors still more ways to experience the park's rugged beauty.

park facts

Where is it? 170km east of Carnarvon and 60km north of Gascoyne Junction.

Total area 141,660 hectares. Another 177,377 hectares was purchased in 2000–2001 to add to the park. This land is currently classed unallocated Crown land, rather than national park, while it awaits reclassification.

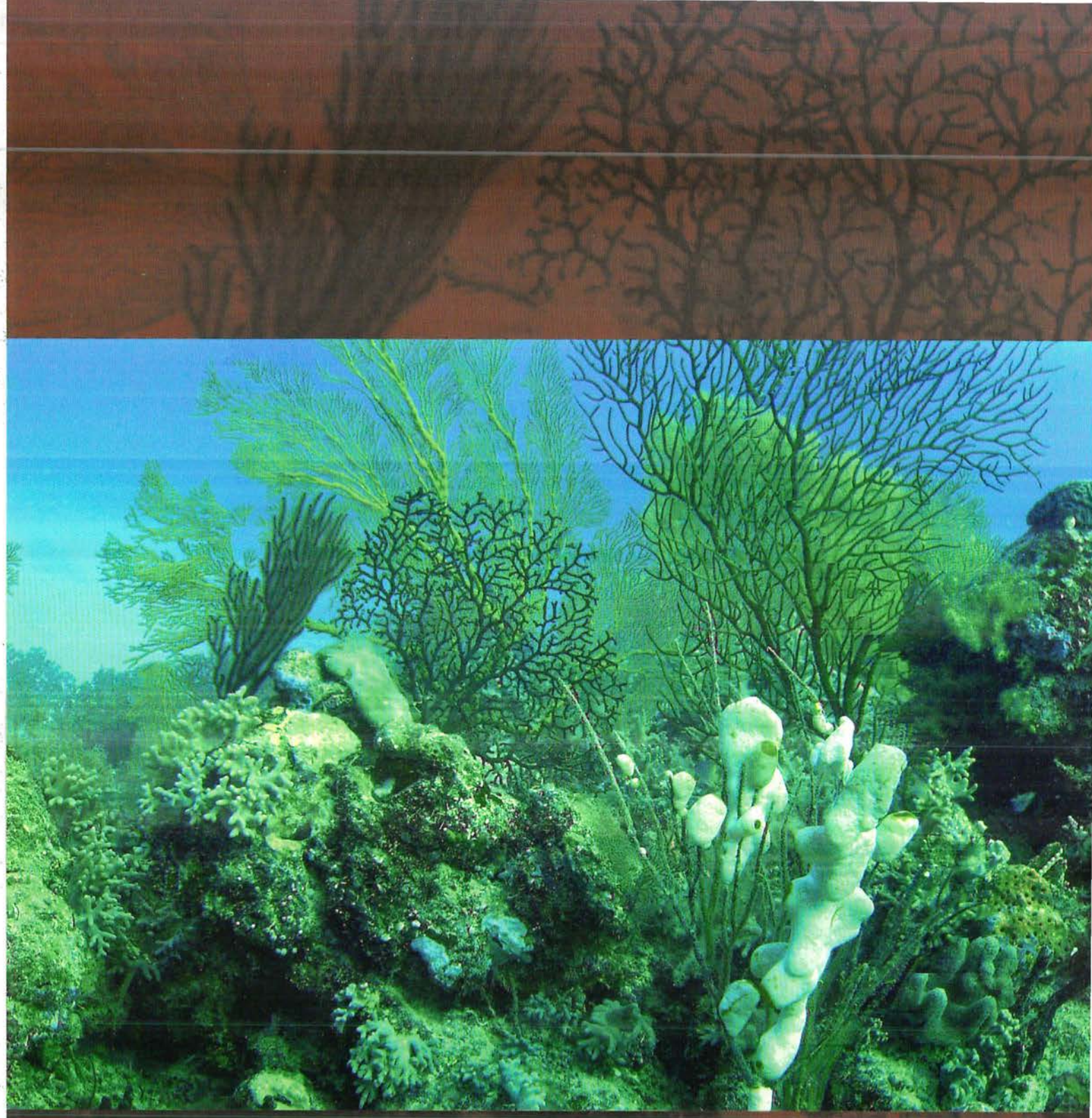
Naming The range was named in honour of a Governor of Western Australia, Arthur Edward Kennedy, after explorer Francis Thomas led an expedition to the Gascoyne in 1858.

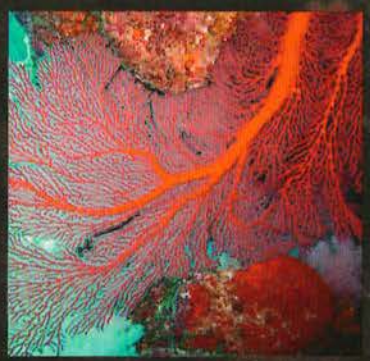
What to do Hiking, wildlife watching, wildflower viewing, photography and camping.

Must see sights Temple Gorge, Drapers Gorge, Honeycomb Gorge and Sunrise View.

Facilities Camping area, sealed vault toilets.

Nearest DEC office Carnarvon, 211 Robinson St, Carnarvon. Phone (08) 9941 3754.





Life in isolated oases

Western Australia's shelf-edge atolls

A major biological survey of Western Australia's remote offshore atolls has revealed a diverse assemblage of more than 1500 species of marine plants and animals, with many not previously recorded in the State and several new to science.

by John Huisman and Sue Morrison

Western Australia's remote north-west offshore atolls lie on the edge of the continental shelf in deep, clear oceanic waters far from the mainland. The biodiversity of these atolls is still poorly known to scientists. Such remote places are always of great interest to biologists, as their isolation often leads to the development of unusual communities. The interplay of environmental conditions such as large-scale current systems and local climate all affect these communities, the former largely dictating what species might make the journey, the latter what might survive in the new home. Once a species is established, isolation from the source population may eventually lead to the evolution of new species, endemic to that location.

Research in such remote places is expensive. So, when Woodside Energy Limited agreed to sponsor a WA Museum survey of Mermaid Reef Marine National Nature Reserve (in the Rowley Shoals), Scott Reef and Seringapatam Reef, the news was received with much excitement. The aim of the survey in September 2006 was to document the presence, distribution and, where possible, the abundance of the major groups of marine animals and plants. Specialist marine scientists were invited to survey and study seaweeds, seagrasses,

sponges, corals, crustaceans, molluscs, echinoderms and fish. For some groups, such as fish and corals, this was a chance to revisit and update earlier surveys. For others, such as marine plants and sponges, it was an opportunity to make the first known collections.

In the past, marine scientists and researchers from the WA Museum, Department of Environment and Conservation (DEC), Australian Institute of Marine Sciences (AIMS) and CSIRO have made visits to the northern atolls to study their habitats and ecology.

Left on the shelf

The three most southerly shelf atolls, located north-west of Broome, are known collectively as the Rowley Shoals. From south to north, they are Imperieuse Reef, Clerke Reef (both in the DEC-managed Rowley Shoals Marine Park, first declared in 1990 and extended four-fold in 2004) and Mermaid Reef, a Marine National Nature Reserve under Commonwealth legislation. Regarded as Australia's best examples of shelf-edge atolls, the Rowley Shoals provide some of the best diving and nature-based tourism found in WA.

Scott and Seringapatam reefs lie more than 300 kilometres north-west of Cape Leveque and rise steeply some 400 to 500 metres from the sea floor. Scott Reef is comprised of South Scott Reef, a large crescent-shaped formation, and North Scott Reef, with a roughly circular shape. They are substantial structures with a combined area (including the lagoons) of some

Previous page
Main Gorgonians, soft corals and sponges at Scott Reef.
Insets Colourful gorgonian coral; false clownfish and its anemone home; sunset over Scott Reef.

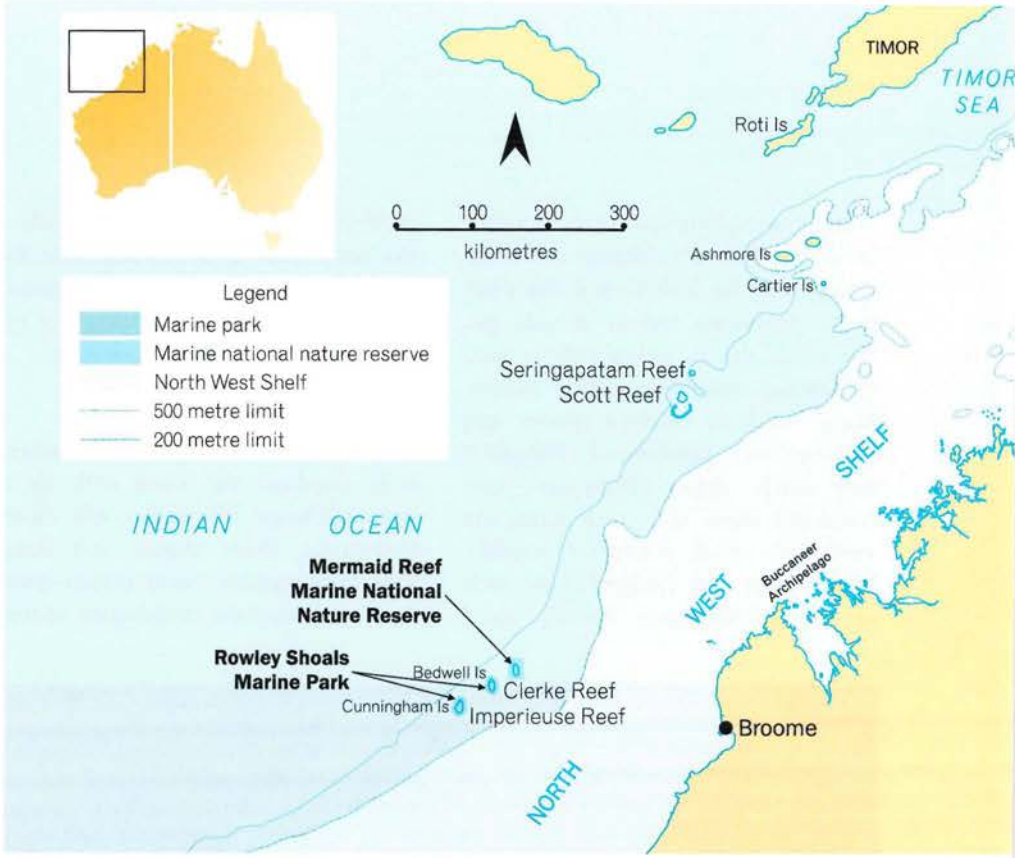
Above Researchers survey the vast expanse of Seringapatam Reef at low tide, with the brown seaweed spiny tops in the foreground.

Below left Smith's weed.
Below The green seaweed *Halimeda* sometimes forms luxuriant meadows.
Photos – John Huisman

250 square kilometres. Seringapatam Reef, 23 kilometres north of North Scott Reef, is a smaller circular reef with an area of 55 square kilometres.

Scott Reef has also been of interest to marine scientists for less positive reasons. In 1998 it suffered a severe bout of coral bleaching caused by unusually warm sea temperatures. Coral bleaching occurs when the living tissue of the coral loses its pigmented symbiotic algal cells, which often kills the coral but leaves its white skeleton behind. AIMS scientists reported that about 80 per cent of Scott Reef's coral cover was lost in this 1998 event. In 2004, the reef bore the full brunt of Cyclone Fay. Three hundred kilometre per hour winds uprooted coral colonies and tore huge reef boulders up to five metres in diameter from the reef's edge. AIMS scientists are monitoring the reef's slow recovery from this double blow of rare events.

The Rowley Shoals, Scott Reef and Seringapatam Reef lie on the very edge of Australia's continental shelf. Around 15 million years ago the shelf probably formed the shore of the mainland, which was fringed by a reef. The atolls were possibly once reefs surrounding former headlands. As a result of changes in sea level and other geological processes (probably related to the collision of the Australian and Asian continental blocks), these subsided into the sea, slowly enough for the fringing coral reefs to be maintained. As a result, the reefs built up from the sea floor like high turrets, each enclosing a shallow lagoon. The growth of similar reefs along the shelf was not sufficient to keep pace with subsidence and there are a number of drowned reefs along the shelf, including one south of Imperieuse Reef.



Above Purple anthias at Scott Reef.
Photo – John Huisman

Marine plants

None of these atolls had ever been systematically surveyed for marine plants, so the expedition provided a great opportunity for seaweed expert John Huisman to make new discoveries. Each species was photographed and representative specimens collected and preserved for DEC's WA Herbarium, where they will form an important part of the State's marine plant collection. More than 100 species of seaweeds and three species of seagrasses have so far been recorded, but the list will no doubt grow once the smaller, cryptic species, mostly growing on the larger seaweeds, are examined in detail. It is the first time many of these species have been found in WA waters, although they have been recorded from tropical reefs in Indonesia and the Philippines.

The marine plants come in all manner of shapes and sizes. Some, such as encrusting coralline algae, are extremely important in consolidating reef crests and therefore play a major role in reef ecology. Others inhabit the gaps in reefs, presumably as a refuge from the many grazing, herbivorous animals. Others dominate rocky sections of the reef flat, with the brown seaweed spiny tops (*Turbinaria ornata*) almost completely covering parts of Seringapatam Reef. There are plants that grow only in the sandy, mobile sediments of the lagoon. Some, such as lobed halimeda (*Halimeda macroloba*) and grey-green udotea (*Udotea glaucescens*), form massive, sand-binding holdfasts to help keep them in place. These plants are also calcified, providing an unusual defence against herbivorous fish that is not just due to their crunchy texture. When calcified green seaweeds are

crushed, as might happen in the stomach of a parrotfish, the calcium carbonate would combine with acids in the plant tissue, producing carbon dioxide gas. For a fish, this is undoubtedly a very unpleasant experience! Other marine plants—such as *Caulerpa* species and the seagrasses paddleweed (*Halophila*) and turtle grass (*Thalassia*)—have horizontal stems that creep across the sand and attach wherever possible. Some plants defy categorisation, such as the mucilaginous Smith's weed (*Gibsmithia hawaiiensis*), with its jelly-like body growing from a firm stalk. In many cases, the evolutionary pressures that led to the unusual appearance of these plants can only be guessed at.

Fish

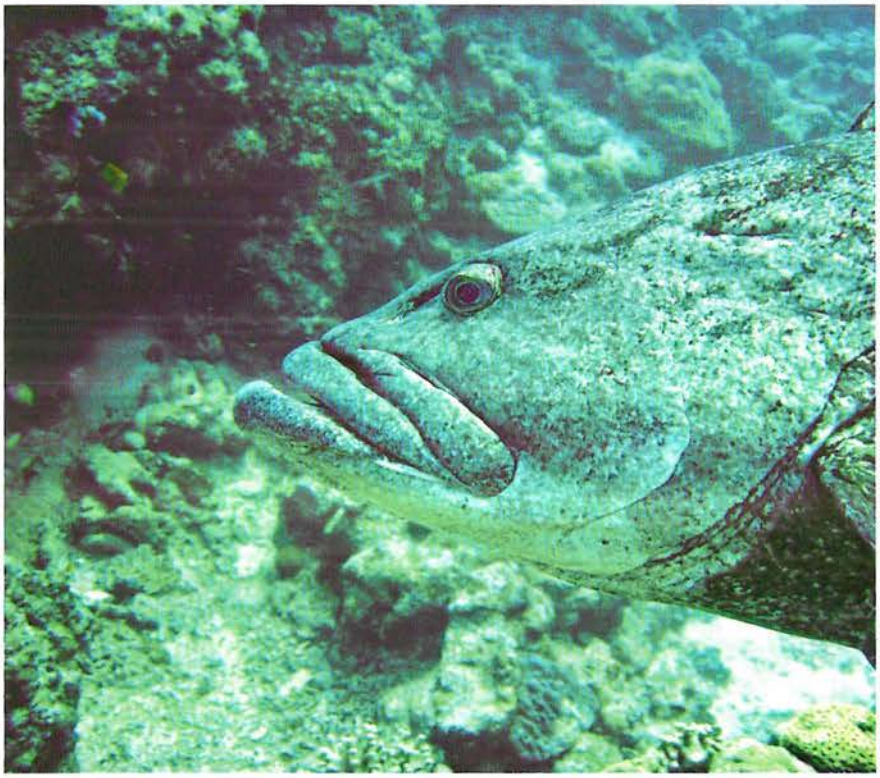
The reef fish of the north-western atolls overload the senses with their stunning range of colours and sheer abundance. Body shapes and sizes vary from gigantic, solid potato cods hanging around the deeper parts of the outer reef, to squadrons of triggerfish and surgeonfish cruising along the outer reef perimeter. Elongated painted moray eels slither in and out of crevices in the intertidal reef flats and dainty damselfish school around the corals in the lagoons. Tiny, slender whip gobies shelter between the polyps of sea-whips on the outer reef.

Fish experts Glenn Moore and Sue Morrison recorded 433 species of fish during the surveys, representing 59 families. Their diversity tended to increase towards the more northerly atolls, with 290 species recorded at Mermaid Reef and 376 species at Scott and Seringapatam reefs, which agrees with the results of earlier surveys. Typically, the outer reef habitats had a greater diversity of fish species than the lagoons. The most abundant and diverse fish families recorded from all reefs were the damselfish, wrasse, surgeonfish, triggerfish, butterflyfish, rock cod and goatfish.

The fish fauna at these atolls has more in common with fish communities of clear-water reefs in Indonesia than with those of the more turbid coastal reefs of north-western Australia. According to Barry Hutchins of the WA Museum, around 36 per cent of the fish species occurring at these atolls are not recorded from coastal reefs of WA. Scott and Seringapatam reefs are likely to be important 'stepping stones' for fish dispersal between Indonesia and the Rowley Shoals, and possibly regions further south.

Molluscs

Many molluscs are cryptic, nocturnal and/or mobile, so are difficult to observe. WA Museum mollusc experts Clay Bryce and Corey Whisson recorded 373 mollusc species at the atolls. As with the fish, these species have a greater affinity with mollusc communities of the Indonesian Archipelago than with those of coastal waters of north-western Australia. Of



Above left The Rowley Shoals are famed for their large potato cod.

Left The spectacular tiger cowrie.
Photos – John Huisman

Top Barrel sponge.

Above A delicate comb jelly (*Ctenophora*).
Photos – John Huisman

Above right Porcelain crab on an anemone at the Rowley Shoals.
Photo – Ann Storrie

particular interest are the depleted populations of giant clams (*Tridacna* species) at Scott and Seringapatam reefs where, under a Memorandum of Understanding, traditional fishers from Indonesia may harvest limited quantities.

Corals

Reef-building hard corals are the essential 'building blocks' of these north-western atolls. They also provide complex structures in which other marine life live or take shelter and form a food source for many species. Both the physical structure of the atolls and the health of associated marine life therefore depend on the health and diversity of the hard corals.

Being sedentary animals, corals are in some ways easier to record than mobile species but they are often difficult to identify. Although corals have been well documented during earlier surveys, coral biologist David McKinney recorded new distribution records for 23 species at Mermaid Reef and 18 species at Scott/Seringapatam reefs, plus a new record for the region—finger coral (*Montipora digitata*)—and one new record for WA—Moluccan mushroom coral (*Fungia moluccensis*).

A total of 273 hard coral species from 14 families were recorded. When combined with historical records, this brings the overall total recorded for the region to 291 species. Most coral species found in the atolls are widespread Indo–Pacific species with clear affinities with coral assemblages of Ashmore Reef and Indonesian provinces to the north.

Sponges

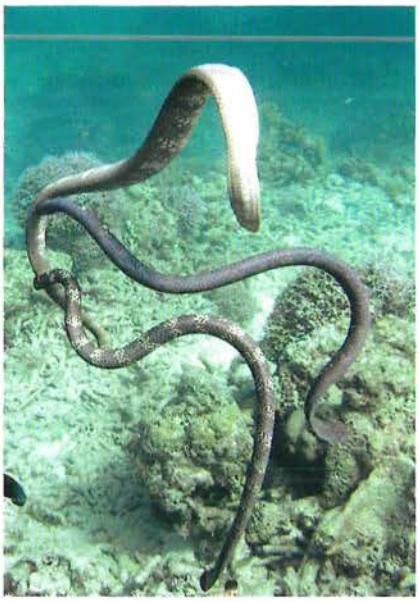
Identifying sponges can be difficult, as some species are extremely variable in shape and colour. To make matters worse, most species need to be examined under a microscope before they can be identified. This made it necessary for sponge expert Jane Fromont to collect samples, for later study, from every sponge she saw during this survey that she believed may belong to a different species.

The sponges of Mermaid, Scott and Seringapatam reefs were documented for the first time in this survey. A total of 137 species from 36 families were recorded. In contrast to fish and corals, most of the sponge species were rare, supporting indications that many species are endemic (only found in one region). These limited distributions are probably due to their short-lived larval stages, which means the larvae cannot travel very far, restricting their dispersal.

Crustaceans

Crustaceans are particularly difficult to observe because most species are cryptic, many are nocturnal, most can move quickly, and some live hidden within or on the surface of other animals, algae or the seabed. Collecting and identifying crustaceans was therefore very time consuming and required the input of two researchers, Melissa Titelius and Christine Hass.

The crustacean fauna of the north-western atolls was poorly known and Mermaid Reef had not been surveyed at all. This survey documented 153



Above The orange marble sea star (*Fromia monilis*).

Above right Courting olive sea snakes. Two males vie for the attention of a female (top snake).
Photos – John Huisman

species of crustaceans, including an amazing 98 new records for the region plus two new species. The most diverse families at these reefs were the black-fingered crabs, coral crabs, spider crabs, hermit crabs and swimming crabs.

Stars of the sea

Echinoderms—sea stars, brittle stars, feather stars, sea urchins and sea cucumbers—were not thoroughly surveyed as there was no specialist available. However, a new species of sea star was discovered at South Scott Reef. The limited results indicate that sea cucumber populations at Scott and Seringapatam reefs may have suffered from habitat degradation (after severe cyclones and possibly ongoing global warming) and fishing pressures (they are a favoured food in parts of Asia) from Indonesian fishers. This degradation could detrimentally affect the reef ecology.

Habitat descriptions

A video method devised by AIMS was used to document the habitat at each site. Video recordings were taken by Peter Morrison and later analysed to determine the percentage cover of each of 15 habitat types (corals, rock, algae, sponges and so on). The images provide a permanent record of each habitat and can be compared with those from similar surveys in the future.

The results showed distinct differences between the lagoon and outer reef habitats, largely related to the level of wave action. The outer reefs generally supported more robust and encrusting coral species, while fragile coral species inhabited the lagoons.

More to uncover

The diversity recorded in this survey is undoubtedly an underestimate, as many nocturnal species, species that live in holes or crevices in the reef or under the sand, small cryptic plants and animals and wary pelagic species will not have been observed. Whole groups, such as the worms and soft corals, were not recorded due to the unavailability of specialists during the field work. Even some clearly visible species will have been missed because it was impossible to survey a sufficient number of sites to be sure of documenting all species in the time available. It must also be remembered that all such surveys are just a 'snapshot' in time—there are often seasonal variations in numbers and species possibly related to breeding times and movement, variations due to currents, storms and cyclones, plus the effects of human impacts through fishing and tourism. It is important to use a survey method repeatable in regular monitoring programs to establish an understanding of such complex and changeable ecosystems.

Such surveys are extremely important. Despite their remoteness, the reefs are of increasing commercial interest, as they sit upon a huge gas reservoir that could potentially generate billions of dollars in revenue. It is therefore imperative that detailed surveys of the region are undertaken to ensure adequate protection of this delicate ecosystem.

John Huisman is a contract seaweed specialist at the WA Herbarium and a research fellow at Murdoch University. He is an international expert on seaweeds, having studied WA's marine plants for more than 20 years and written several books on marine plants in various parts of the world.

Sue Morrison of the WA Museum has coauthored the DEC books *The Marine Life of Ningaloo Marine Park and Coral Bay*, *Wonders of Western Waters*, *Beneath Busselton Jetty* and *The Turquoise Coast*. She is a regular contributor to *LANDSCOPE* and can be contacted on (08) 9212 3743.

The authors would like to thank their many co-expeditioners, who are named in the text, and Woodside Energy Limited for its financial support.

Taking the **bait**

A new sausage bait developed by innovative conservation managers is helping our native mammals to recover from the impact of introduced foxes.

by John Asher, Nicky Marlow, and Rob Brazell

Over the past 100 years 11 species of native mammal in Western Australia have gone extinct. A further five species have disappeared from the mainland but remain on a few offshore islands, and 29 species remain on the mainland but have declined significantly.

In the 1980s scientists from the Department of Environment and Conservation (DEC) (the then Department of Conservation and Land Management) conducted research that showed effective fox control could result in an increase in the abundance and distribution of several native mammalian species.

Western Shield

DEC initiated a broad-scale aerial fox control and research program called Operation Foxglove in 1994. This program involved baiting almost 570,000 hectares of the northern jarrah forest with poisoned dried meat baits for fox control. This project was so successful that in 1996 it was expanded and the *Western Shield* fauna recovery program was launched. The *Western Shield* baiting program extends from Esperance in the south-east to Karratha in the north. It includes national parks and forests of the south-west, numerous Wheatbelt reserves, and encompasses an area of nearly 3.6 million hectares. As a result of these successful fox control programs the woylie (*Bettongia penicillata ogilbyi*) was removed from the WA and national threatened species lists in 1996 and the tammar wallaby (*Macropus eugenii derbianus*) and quenda (*Isoodon obesulus fusciventer*) were removed from the WA threatened species list in 1998.

When the program first began, fox control was achieved by using baits made from chunks of fresh meat that were injected with sodium fluoroacetate (1080) and dried to 40 per cent of their original weight. The amount of 1080 was reduced to three milligrams in 2001. Fox baits are delivered from the air at an intensity of one bait to every 20 hectares (five baits per square kilometre), up to six times a year. Smaller reserves are ground baited every month. The toxin used in the baits (1080) occurs naturally in the WA environment in the *Gastrolobium* genus of plants. Native animals in WA have evolved a strong tolerance to 1080 while introduced animals, such as the fox and cat, are highly sensitive to it and succumb easily.

The dried meat baits have been manufactured by the Department of Agriculture and Food for many years and were the basis of success for the *Western Shield* program. However, the cost and difficulty in obtaining suitably cut chunks of meat to produce fox baits and the labour intensive bait-production process led DEC to look for alternatives. The *Western Shield* program uses around 750,000 fox baits a year and a continuing, reliable supply of cheap baits is essential for its success.

Pro-bait

In 1998 innovative staff at DEC's newly established bait-production research facility at Harvey, with advice from the small-goods processing

Previous page
Main Foxes are targeted with Pro-bait.
Photo – Jay Sarson/Lochman Transparencies
Inset Dave Hawkes in the Harvey sausage-making factory.
Photo – Rob Brazell/DEC

Above Quenda.
Photo – Ann Storrie

Left The tammar wallaby is vulnerable to fox predation.
Photo – Jiri Lochman

Left Baits containing 1080 are dropped from planes.
Photo – John Asher/DEC

Below left Prepared Pro-baits on pallets.
Photo – Rob Brazell/DEC

Below right Pro-bait sausages are more uniform in shape and size than dried meat baits.
Photo – John Asher/DEC

industry, developed a sausage bait ('Pro-bait') for foxes, based on the salami manufacturing process. Staff also developed an automatic injection system for the computerised sausage-making machine enabling a fast, accurate dose of 1080 to be injected into every sausage. The advantages of Pro-bait over the existing dried meat bait include the automated process, large production runs and minimal wastage. Moreover, the product's uniform shape and size allows improved packaging efficiency, reduced transport and storage costs and automated bait-laying procedures. Pro-bait is a cheap fox bait that can be used for both agriculture and conservation purposes and there are commercial opportunities for the State to sell it elsewhere in Australia.

Pro-bait was registered for use in WA by the Australian Pesticides and Veterinary Medicines Authority in 2002. In 2004 trials were conducted in WA's Midwest in which the uptake of the dried meat fox bait and Pro-bait were compared. There was no significant difference between the two baits with both having an excellent uptake by foxes of about 87 per cent.

Although native animals are highly tolerant to 1080, due to their small body weight, some species might succumb if they managed to consume a bait. Pro-baits were specially formulated to be too large and too hard for most native species to eat. The dentition and jaw size of our native fauna is such that most of them will have difficulty consuming large dried meat baits. However, to be doubly sure, captive trials were undertaken on 14 native species including brush-tailed phascogales, chuditch, brushtail possums, woylies and bandicoots. Only chuditch and phascogales ate sufficient bait material to be at risk so field trials were undertaken to ensure they were not affected by operational baiting campaigns. Although both did consume baits, or parts of baits, they didn't die as a result. Significantly, the study was undertaken at a time when recently born chuditch were dispersing and growing.

In 2005 DEC approved the broad-scale use of Pro-bait for the *Western Shield* program with the aim of fully replacing the dried meat fox bait. The Harvey bait production research facility was expanded to enable the manufacture of sufficient Pro-bait for the entire *Western Shield* program. This expansion will also assist the Department of Agriculture and Food with supplies of wild dog sausage baits for the pastoral industry that are based on Pro-bait technology.

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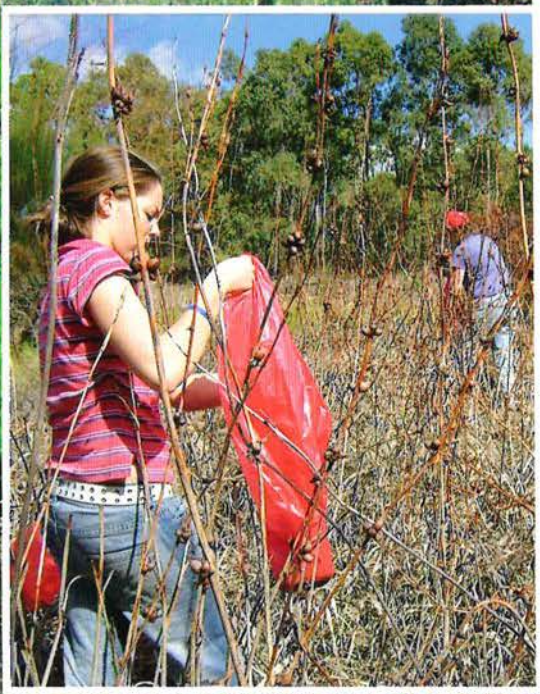
Rob Brazell is the Harvey Bait Factory Manager, based in DEC's Wellington District.



Volunteers make a difference

With invasive weeds appearing and habitat destruction occurring on their doorsteps, a passionate group of Perth hills residents decided enough was enough. They banded together, threw their hearts and souls into a rehabilitation effort and have restored much of the Piesse Brook valley to its former state.

By John and Linda Stanley

Previous page
Main Piesse Brook.
Photo – Alex Graham/Sallyanne Cousans Photography
Inset Friends of Piesse Brook collecting watsonia.
Photo – Linda Stanley

Above WA Christmas tree blossoms.
Photo – Sallyanne Cousans Photography

The Piesse Brook runs through a valley in the Perth hills to the east of Kalamunda. Orchards and residential properties surround the brook upstream before it runs through Kalamunda Shire reserve and the Kalamunda National Park into the Helena River. The brook is an important part of the Helena River Catchment that serves Perth with its water supply via the Mundaring Weir reservoir.

Ten years ago the habitat in the national park and reserve in the Piesse Brook valley was heavily infested with introduced plant species including watsonia, cotton bush (*Gomphocarpus physocarpus*), giant reed (*Arundo donax*), blackberries (*Rubus laudatus*) and pampas grass (*Cortaderia selloana*). The natural habitat in the valley had been destroyed.

Today, however, the picture is different.

Restoring Piesse Brook

In 2000, a handful of Piesse Brook locals, aware of the continued degradation of the wildlife habitat taking place on their doorstep, formed the Friends of Piesse Brook group. Their bold plan was to clean up the Piesse Brook valley and restore its natural habitat. Their target area comprised the banks of the brook from the entrance of Kalamunda National Park in Schipp Road, to where the brook entered the Helena River—a stretch of five kilometres.

The group's first challenge was to convince other local residents that the project was achievable. A plan was developed where weed eradication and revegetation would take place in stages over eight years. A street barbecue was organised, the plan was outlined, discussions took place and a committee was formed. The committee, led by group founder Linda Stanley, then approached the Shire of Kalamunda and the Department of Environment and Conservation (DEC) for advice and help.

What was at stake?

Piesse Brook valley is a flora-rich region home to an unusually diverse mix of eucalypts. The various soil types and changing topography of the valley harbour species including jarrah (*Eucalyptus marginata*), marri (*Corymbia calophylla*), WA flooded gum (*Eucalyptus rudis*), wandoo, (*Eucalyptus wandoo*) and WA blackbutt (*Eucalyptus patens*). In addition, there is WA sheoak (*Allocasuarina fraseriana*), WA Christmas tree (*Nuytsia floribunda*), the four-sided sedge (*Lepidosperma tetraquetrum*) and the snottygobble (*Persoonia elliptica*).

Fauna in the valley includes the brushtail possum, southern brown bandicoot, echidna and grey kangaroo while bird life features the Carnaby's cockatoo, red-tailed black-cockatoo, red eared fire tailed finch, red-capped parrot, red wattlebird, Port Lincoln parrot, boobook owl and many more.

The survival of these species was at risk of being compromised if something was not done in the valley to remove the invasive weeds that had destroyed the natural habitat. The main problem was watsonia, a bulb native to South Africa that was introduced to Western Australia as an ornamental garden plant. The plant had taken over native vegetation in most of the valley, choking out the native understorey and creating a monoculture. Watsonia multiplies at an alarming rate. Two varieties of watsonia occur at Piesse Brook. *Watsonia meriana* var. *meriana* produces seeds and *W. meriana* var. *bulbifera* is sterile but produces stem-borne vegetative reproductive organs referred to as 'bulbils'. One plant produces an average of 15 cormils around its main corm as well as an average of 15 bulbils along its flower stem. That means that each year one plant can reproduce itself by a factor of 30. As such, a single plant can transform to 30 plants in a year, 900 plants in two years, 27,000 in three years, 810,000 in four years and 24,300,000 in just five years.

Tackling the weed invasion

The technique used in Piesse Brook to bring the devastating watsonia weed under control involved dividing the working area into manageable segments to be targeted each year. Each segment had to be worked on as a primary zone in year one and then continue to be managed each following year. It was crucial to make sure that each zone was of a manageable size for the group to handle. The work plan began with the group going out during bud and

Above Collecting rubbish from Piesse Brook.
Photo – Linda Stanley

Above right Watsonia weed was introduced from South Africa.
Photo – Dennis Sarson/Lochman Transparencies

flowering periods to cut off the buds and flowers to prevent further seeding. Next, a contractor was employed to spray the foliage in September during the bud stage and before the flowers bloomed. The contractor used the frog-friendly variety of the chemical Roundup BioActive. The group then went into the selected working area and removed any seed corms that had survived to make sure they didn't seed any further.

The next growing season, the group returned to the previous year's working area and spot treated plants that had survived. The maintenance of each zone was important as the work progressed through the valley. In addition, the group progressed to the next working area needing primary control.

Near the water course, the stream was clogged with what is commonly known as bamboo. This species, introduced to Australia as an ornamental plant, is in fact giant reed, a form of tall grass, and not a true bamboo. The challenge with giant reed was different—to tackle this weed, the group had to cut down tall clumps of grass and then spray with poison. Each year there is a little regrowth that again needs to be cut and sprayed until control is achieved. The good news is that once the main plant has been controlled there is hardly any problem with regrowth. What regrowth does come through can be killed off within three years of using this control method.

Blackberry from Europe was introduced into the Perth hills as a fruiting plant to remind new arrivals of home. However, the plant is well suited to the hills climate and quickly spread from gardens into the surrounding bush at an alarming rate. Friends of Piesse Brook controlled the spread of blackberry by spraying in summer with Trounce and then undertaking touch-up spraying using Roundup BioActive. Once sprayed, the plants needed to be checked each year and re-treated where necessary to control and prevent regrowth.

Once the main spraying has occurred, the work of the group intensifies. The bare soil is an ideal propagation area and the seeds of watsonia that have been dormant for years come to life and need to be controlled with a vigilant spray program.

Other weeds such as the large-leaved plantain (*Plantago major*) from Europe also enjoy the new environment. This is a plant that was probably introduced into the State by accident when early nursery owners brought in exotic plants.

Another weed that emerges is cotton bush. This can be controlled by hand weeding before it starts to flower. If left until after flowering, the problem can intensify.

The use of chemicals

Using chemicals in the bush to control weeds caused concern for some residents who felt the problem should be tackled in a more natural way. Although one can agree with the principle of hand weeding noxious weeds in the valley, hand weeding a five-kilometre stretch of bush extending 30 metres wide was a task that none of the group was prepared to take on. They would have been fighting a losing battle as the weeds would have proliferated faster than they could be pulled. Plus, with hand weeding some bulbils would have been left in the ground and would have continued to multiply at a rapid rate.

The replanting effort

The part of the rehabilitation process that most people seem to enjoy is the planting stage. Native plants were purchased from the Shire of Kalamunda and provided by DEC. They were grown from local seed to ensure the natural stock of the valley was maintained. Planting first took place in winter 2001, two years after Friends of Piesse Brook cleared the land of weeds. Since then, some 15,000 seedlings have been planted. The group organised a Bushland Care Day where locals were invited to join in a planting day and a barbecue lunch. Together they planted tubes of more than 20 plant species including devil's pin (*Hovea pungens*), coral vine (*Kennedia coccinea*),

Left This juvenile red wattlebird is one of the species that occurs at Piesse Brook. *Photo – Sallyanne Cousans*

Below left Rocky Pool, Piesse Brook. *Photo – Alex Graham/Sallyanne Cousans Photograhy*

two-leaf hakea (*Hakea trifurcata*) and prickly bitter-pea (*Daviesia horrida*). The Bushland Care Day was made as much fun as possible with novelty ideas introduced by the group to keep the day light and entertaining.

However, the real challenge was keeping the young seedlings alive during the hot summer months of the first two growing seasons. Many early plantings were lost due to lack of watering during summer. As a result, the group sought and obtained funding to set up a water tank and trailer that could be towed behind a vehicle. Two members of the group took on the arduous task of watering the seedlings throughout summer. Such watering increased the survival rate of the young plants enormously.

The group is now in the last stages of clearing weeds at the point where the Piesse Brook flows into the Helena River. The initial objectives of the Friends of Piesse Brook have now been met, but the maintenance carries on. If maintenance is not carried out for a year, this can result in months if not years of weeding out new weed seedlings. This in turn could result in a huge loss in motivation for members.

Future plans

The group has been criticised for starting its work midstream in the national park as opposed to further upstream where weed growth begins on private properties. Some argued it would have been better to tackle the weed at its source before seeds were brought downstream in the flow of the river. However, the group felt it would be too big an ask to start on private property to solve the problem in the national park without any track record.

The example the group has since created in the national park has shown what can be done and this year the group has started work on private land upstream with the help of private landholders. A meeting was held in early 2006 to show private landholders with properties along the Piesse Brook what had been and could be achieved. To the group's surprise and delight, all but one resident attended the meeting and they agreed to start a weed clean-up program in which the group is involved. This meeting made the original objective of cleaning the brook of weeds from its source an achievable goal.

Friends of Piesse Brook continues to meet on the second Sunday of every month from April to November to work on the project. During the summer months, the bush is left to nature while the group enjoys the rewards of its hard work.

If you're interested in developing a friends group then our advice is to start now. Have a vision, sketch out a basic business plan, talk to your local shire and DEC about your goals, then just do it and enjoy the experience. Remember, it only takes a couple of people to make a big difference.

Linda Stanley is the instigator and secretary of Friends of Piesse Brook. She has a background in business development and is a keen gardener and conservationist.

John Stanley is a qualified horticulturist and consultant and speaker to horticultural and retail businesses around the world. He is a member of the Friends of Piesse Brook.

For more information on the Friends of Piesse Brook visit www.friendsofpiessebrook.org.au.

Bernier and Dorre:

islands of marsupials, mice and men

Located some 50 kilometres west of Carnarvon, Bernier and Dorre islands are two of the most important refuges for some of Australia's most endangered mammals.

by Linda Reinhold and Neil Thomas

Bernier and Dorre islands are part of an old sand dune system at the north-western edge of the Shark Bay World Heritage area (see map on page 31). When the sea level rose 8000 years ago, these areas were marooned, forming two natural arks where the island inhabitants went about their existence, blissfully unaware that thousands of years later their cousins on the mainland would be driven to extinction. Of Australia's 26 species of threatened terrestrial mammals, five reside on these two reserves. This can be attributed to their isolation and the fact that they are free of any introduced predator or herbivore species. Between them, the islands cover less than 100 square kilometres. At many places, the islands are less than a kilometre wide, but reach just over three kilometres at their widest point.

The islands are home to the last naturally occurring wild populations of western barred bandicoots or marl (*Perameles bougainville*), banded hare-wallabies or merrnine (*Lagostrophus fasciatus*) and rufous hare-wallabies or mala (*Lagorchestes hirsutus*). Shark Bay mice or djoongari (*Pseudomys fieldi*) are found only on Bernier. Burrowing bettongs or boodie (*Bettongia lesueur*), ash grey mice (*Pseudomys albocinereus*) and water rats (*Hydromys chrysogaster*) also inhabit the islands, but are found elsewhere.

It is envisaged that once feral cats are eradicated from Shark Bay's Dirk Hartog Island, these species will be reintroduced to that island, aiding in their long-term conservation. The Peron Captive Breeding Centre, which is part of the Department of Environment and Conservation's (DEC's) Project Eden program, and the Return to Dryandra Field Breeding Facility are breeding the two hare-wallabies and the boodie for this purpose (see 'Return to Eden', *LANDSCOPE*, Autumn 1995 and 'Return to Dryandra', *LANDSCOPE*, Winter 2001). Previous reintroductions of hare-wallabies to Dirk Hartog Island and Peron Peninsula failed, predominantly due to feral cat predation, making the refuge status of Bernier and Dorre islands and the two captive breeding facilities even more crucial.

Because the islands had not been thoroughly surveyed for mammals since CSIRO expeditions of 1988–1989 and 1991–1992, DEC was keen to find out how the populations were faring on what is quite possibly Australia's most important threatened mammal nature reserve. So, last August, a team of biologists and veterinary scientists from DEC and Murdoch University made the voyage from Denham to the islands with funding from DEC's *Saving our Species* program (see 'Saving our Species, Saving our State' on page 10).

For two weeks, the boat crew ferried the research team back and forth from the charter vessel to the islands—day and night. They journeyed to the islands in the afternoon to place wooden stakes and reflective tape to mark transects for that night's spotlighting. Carrying bundles of stakes and later spotlighting batteries, they made their way across spinifex, through bushes and over sand dunes in search of the islands' threatened inhabitants. They

Previous page
Main Dorre Island (bottom) and Bernier Island (top).
Photo – David Bettini
Inset Banded hare-wallaby.
Photo – Linda Reinhold/DEC

Left Boodie.
Photo – Jiri Lochman

Above Dwarf bearded dragon (*Pogona minor*).
Photo – Michael Mathieson/DEC

Right Dorre island.

Below right Ash grey mouse.
Photos – Linda Reinhold/DEC

criss-crossed the islands spotlighting from sunset until midnight, walking back and forth with old and new technology in hand—a compass and GPS. At sunrise, they were back on the islands to check traps.

Spotlighting and trapping

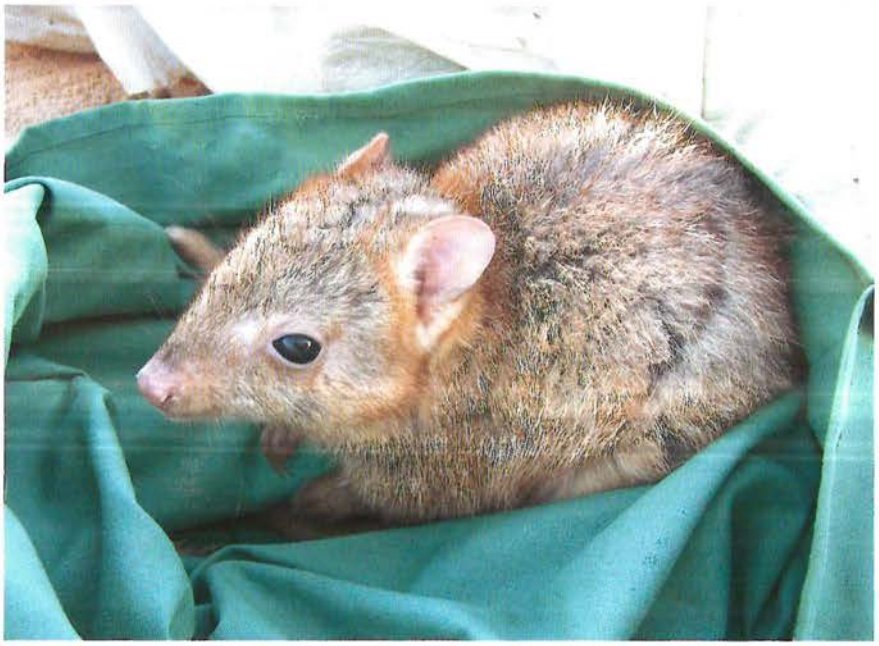
Going ashore after sunset, the team found the transects marked out earlier that afternoon. In two or three teams, they traversed the island, back and forth, walking at a steady three kilometres an hour. Lines were set by the distant glint of another piece of reflective tape atop the next hill, as the spotlight moved over the varied terrain, constantly scanning for the slightest sign of life in the form of a furry rump, eyeshine or a hopping movement. The main quarry was boodies, merrnine and mala. The team saw marl less often and on rare occasions a djoongari or ash grey mouse would be caught in the beam of the spotlight. Once they sighted a water rat—a species that uses the islands' beaches to fossick.

Where practical, the team duplicated the methodologies of the previous CSIRO expeditions. They could then calculate how many animals were seen per kilometre of transect, roughly comparable to the earlier surveys. The 1988–1989 trips were undertaken at the end of a drought, and the 1991–1992 trips after a period of good rainfall. For all species counted, numbers had increased on the second survey. In 2006, the team saw a greater number of boodies. Densities of the two hare-wallabies were less than in 1991–1992, but much the same as in 1988–1989. Sightings of marl were similar to 1991–1992.

The number of hare-wallabies is estimated by spotlighting, boodies can be counted by spotlighting and trapping, but marl, djoongari and ash grey mice must be trapped to accurately assess their population sizes, as they are not sighted frequently enough in the spotlight surveys to conduct statistical analyses.

The team set out cage and Elliott traps as another way to measure abundance, especially for the smaller species. Trapping also enabled the team to check the animals' health and provided an opportunity for the scientists to see these rare animals up close after glimpsing them in the spotlight.

Each species had a very different temperament. Boodies were always full of spirit, sometimes having rolled several traps over before finally getting caught in one. While, at the other extreme,



Left Murdoch University vets Mark Bennett and Lucy Woolford took swabs from marl to test for viruses.
Photo – Michael Mathieson/DEC

Below left Boodie.
Photo – Linda Reinhold/DEC

ash grey mice were very placid, and would usually sit on a researcher's hand for a while before deciding to hop off and amble away when they were being released. Djoongari were somewhere in between—a big furry handful, easy-going, but not averse to trying to get a bite in if given the chance. The marl took it all quite well, unaware of the part they were playing in representing their species for such important research.

Veterinary research

Two veterinary PhD candidates from Murdoch University joined the expedition to examine marl for a papillomatosis and carcinomatosis (wart and skin cancer) syndrome that has been hindering captive breeding efforts in some mainland populations (see 'Western barred bandicoot: warts and all', *LANDSCOPE*, Spring 2003). Marl affected by this disease develop multiple, wart-like lesions of the haired skin, conjunctiva, oral cavity and pouch. With time these lesions often undergo malignant transformations to form large squamous cell carcinomas (malignant cancer). Involvement of the feet, eyes and the mouth leads to problems with walking, vision and eating. Affected animals often die due to secondary complications and are euthanased to prevent suffering.

Researchers at Murdoch University have recently detected a virus similar to papillomavirus in association with this disease. On the two islands, the team caught 22 marl for examination. During the veterinary examinations, the bandicoots' skin was swabbed in order to test for the presence of this virus. Marl showing wart-like skin lesions and testing positive for the virus were detected on Bernier Island. No signs of the disease were seen on Dorre Island and all Dorre marl swabbed negatively for the virus. These findings are consistent with previous expeditions that have found this disease on Bernier but not Dorre Island. However, this was the first expedition in which disease findings could be supported by testing for the presence of the virus. As with all trapping sites, the team cleaned each trap and hessian bag with viral disinfectant between the islands to stop the transfer of infectious material between populations.

Animal life

Although the team was focused on the land-based mammals, it was hard not to notice some of the larger marine visitors. Humpback whales passed by every day, splashing and slapping as if vying for attention. A highlight was the sighting of a tiger shark that slowly cruised around near the anchorage. These creatures seem a lot less menacing when swimming slowly in a pool-like bay, taking a long time to hone in on a smell, tasting and nudging potential food rather than attacking. Their apparently gentle behaviour challenged their reputation as a fearsome predator.

Of the native animals handled, several stood out as particularly interesting. Take boodies for example. Not quite the peaceful herbivores they appear, boodies have been known to attack other animals that are caught inside traps. There have also been reports of them digging into turtle nests on the beaches. Despite their feisty nature, boodies were no match for cats and foxes and became extinct

Above Researchers travelled to and from the islands by boat and were sometimes accompanied by marine animals such as a tiger shark.
Photo – Colleen Sims/DEC

Left Lock hospitals were used between 1908 and 1918.
Photo – Courtesy of the Battye Library

on Dirk Hartog Island in the 1920s, and on the mainland in the early 1960s. Boodies also occur on Barrow and Boodie islands, and have been successfully reintroduced to Heirisson Prong (part of a CSIRO reintroduction project), Faure Island (part of an Australian Wildlife Conservancy reintroduction project, see 'Return to Faure', *LANDSCOPE*, Autumn 2007) and the Arid Recovery Project in South Australia.

After foxes, feral cats and domestic stock wiped them out from the mainland more than 100 years ago, djoongari persisted only on Bernier Island. From here they have been translocated to Doole Island, Heirisson Prong, North West Island (Montebello group) and Faure Island. The latter two of these translocations have so far been successful. The Doole Island translocation failed, probably due to goanna predation, while the Heirisson Prong failure was attributed to feral cat predation.

Discovery and devastation

Dirk Hartog discovered Bernier and Dorre islands in 1616 but Dorre Island (or 'Dor Eyland', meaning dry or barren island) wasn't surveyed and named until Dutch sailor Willem de Vlamingh visited it in 1697. Bernier Island was named after the astronomer on Nicholas Baudin's French scientific expedition of 1801–1803.

In 1874, pioneer Julius Brockman camped on the southern end of Dorre Island and documented a devastating fire.

> "The Island was high with spinifex which had never been burnt and we were maybe the first people that had ever landed on it. There were thousands of wallaby. The wind was blowing a gale from the south and when I lighted a fire to camp, it swept the Island bare for twenty-two miles."

The next day he sailed to the north end of Dorre.

> "I walked about the Island, which was now bare as a sandpatch and what were not burnt of the animals would have no food except seaweed until rain fell again."

Fires due to human presence again burnt much of Dorre Island in both 1908 and 1973.

Sandalwood cutters worked on Bernier Island in 1896. Sheep were also grazed on Bernier for about 10 years at the turn of the twentieth century. Goats, possibly released with the closure of the Lock Hospital (see 'The Lock hospitals' below), were finally eradicated from the island in 1984 by the then Department of Fisheries and Wildlife. Today the shifting sand dunes found on the island can be partly attributed to over grazing by the goats.

The Lock hospitals

From 1908 to 1918 the islands were the site of a Lock Hospital for the treatment of venereal and other diseases in Aboriginal people. Men were sent to Bernier Island while women went to Dorre. About 200 patients are estimated to have died on the islands.

Above Bernier Island.
Photo – Linda Reinhold/DEC

Daisy Bates describes her visit in her book *The Passing of the Aborigines*:

> "Dorre and Bernier Islands: there is not, in all my sad sojourn among the last sad people of the primitive Australian race, a memory one half so tragic or so harrowing, or a name that conjures up such a deplorable picture of misery and horror unalleviated, as these two grim and barren islands off the West Australian coast that for a period, mercifully brief, were the tombs off the living dead. When I landed on Bernier Island in November 1910 there were only fifteen men left alive, but I counted thirty-eight graves. There were seventy-seven women on Dorre Island, many of them bed-ridden. I dared not count the graves there."

Remnants of the hospital sites can still be found on the two islands. In 1986 they were registered as protected areas under Australia's *Aboriginal Heritage Act 1972*. The islands' cultural heritage significance was also recognised with their inclusion on the Register of National Estate in 1987.

Protection

In 1907 Dorre Island was declared a reserve for native game. This protected fauna from 'wanton destruction' but did not protect their habitat. Cabinet rejected a request from the Natural History Society of Western Australia that either island be set aside as a flora and fauna reserve.

In 1919, Bernier Island was also declared a reserve for native game. Both the Keeper of Biology at the Western Australian Museum and the Royal Society of Western Australia requested that cats and firearms be prohibited, but these requests were refused.

In 1957 a comprehensive survey of the islands was finally undertaken. The survey team, comprising some of the most eminent biologists of the time, stated:

> "... they (the islands) are of paramount importance to anyone who is conscious of the need for the permanent preservation of areas of natural land which clearly illustrate the state of Australia before the advent of the white man and his introductions".

The islands were then gazetted as A Class Nature Reserves for the conservation of fauna.

There are certainly no cats or firearms allowed on the islands today. Due to the high nature conservation values of this reserve, camping is not allowed on either island. This restriction aims to minimise the islands' greatest threats, which are the possibility of wildfire and the accidental introduction of invasive species.

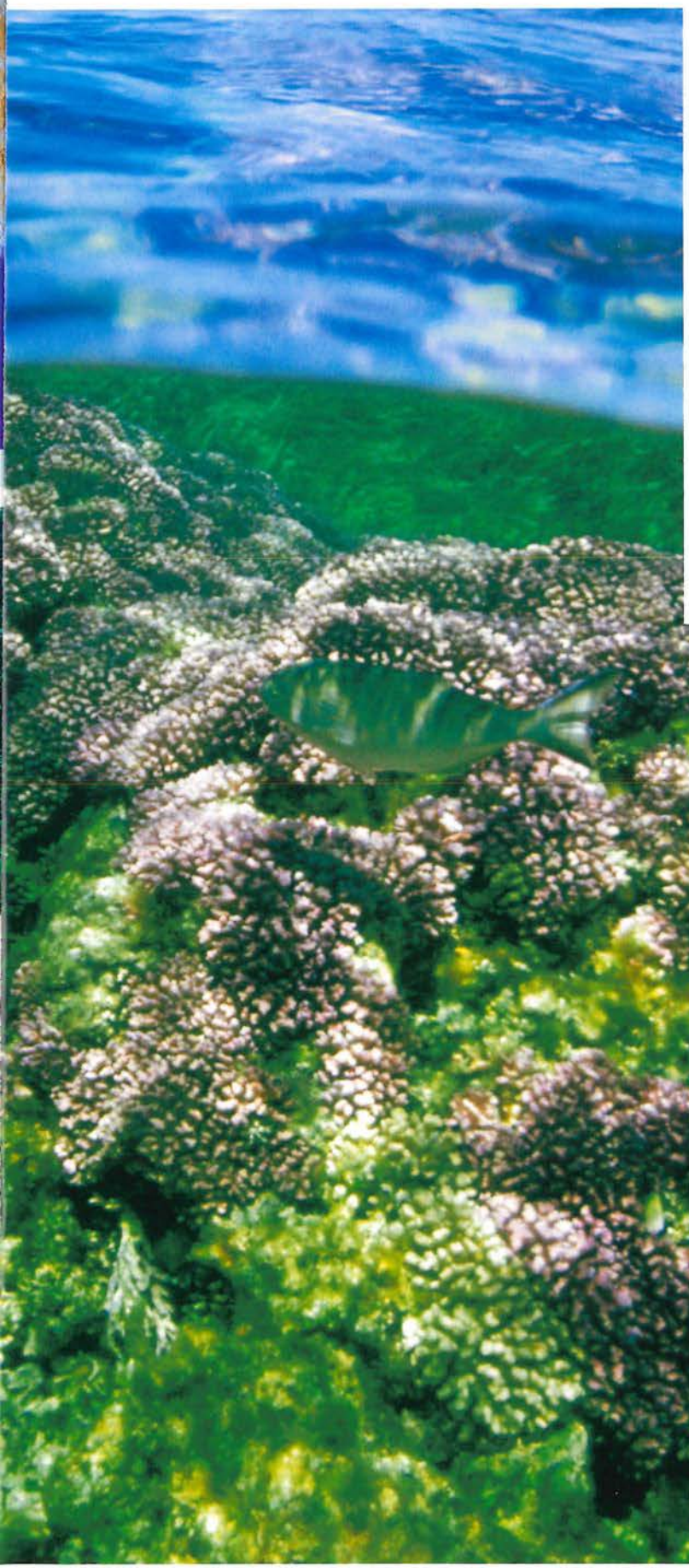
What of the future? Comprehensive data is needed to be able to detect population trends, so DEC plans to survey the mammals on the islands at least every couple of years in the long term, subject to funding. Fluctuations in numbers could possibly be attributed to rainfall but only further surveys will aid in determining this. Over many years, trends due to any threatening processes over and above the background of natural fluctuations may be seen.

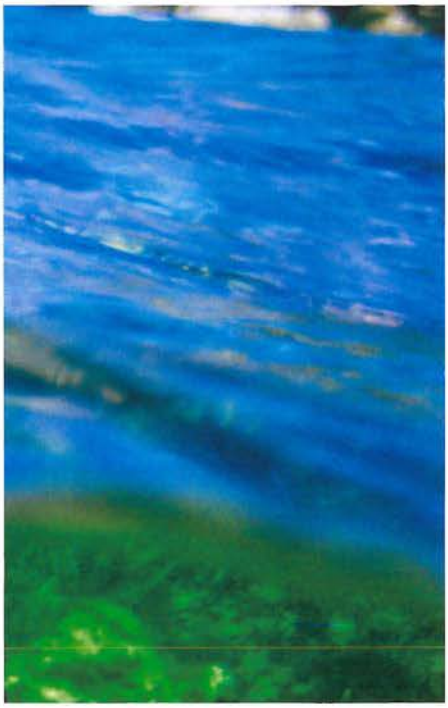
Linda Reinhold is DEC's Project Eden Ecologist. She is responsible for trapping and tracking animals on Peron Peninsula and the islands of Shark Bay. She also travels the globe working on sea turtle conservation programs. Linda can be contacted on (08) 9948 1208 or by email (linda.reinhold@dec.wa.gov.au).

Neil Thomas is a Principal Technical Officer based at DEC's Wildlife Research Centre in Woodvale. He has been visiting the islands since 1986 to study the ecology of the marl. He also has extensive knowledge of other WA native mammal fauna and introduced pest species. Neil can be contacted on (08) 9405 5119 or by email (neil.thomas@dec.wa.gov.au).

The authors thank Lucy Woolford, Mark Bennett and other researchers from Murdoch University's School of Veterinary and Biomedical Sciences for their help in writing this article. Thanks also to Stephanie Pfenningwerth for her input.

Marine Futures:
pulling back the blue curtain



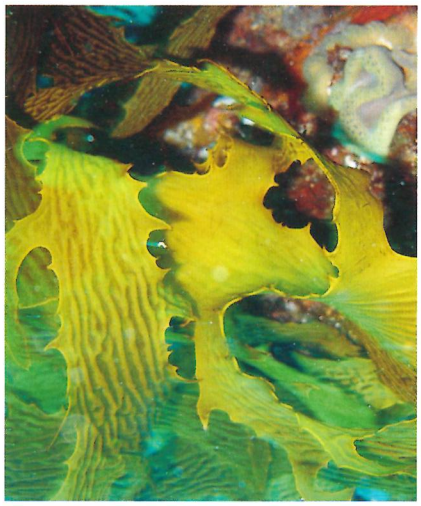


An ambitious, ground-breaking and collaborative project in Western Australia has started to reveal some 'treasures' beneath our ocean's surface. Our hidden ocean floor is being mapped in exquisite detail as part of a $4.2 million project—**Securing WA's Marine Futures**—a major marine investment in WA, funded through the Natural Heritage Trust.

by Heather Taylor and Jessica Meeuwig

Our use of the marine environment is increasing rapidly. The 'sea change' phenomena means that more and more people are moving to the coast and either earning their living from the sea or pursuing recreational interests on or near it. We need to establish baseline information on the state of our marine environment so we can monitor how it changes over time and make sure that we manage for those changes.

Although we have a reasonable amount of knowledge about some marine species, particularly those of commercial and recreational interest, our knowledge of many other species as well as their interactions with the habitats they call home is still fairly limited. 'Marine Futures' is mapping the ocean floor to put many of these pieces together. In doing so, it is building a comprehensive picture of the relationships between marine habitats and the plants and animals associated with them. New video footage collected through the project shows grey nurse sharks, which are listed as threatened, associated with deep water wrecks off Rottnest Island and camera work at Cape Naturaliste is allowing the team to measure the relative abundance of a range of key species such as snapper.



The Marine Futures team, led by The University of Western Australia (UWA) and comprising representatives from WA's five coastal natural resource management councils, State Government agencies and surveying company Fugro, is helping to establish baseline information by producing state-of-the-art, detailed habitat maps of priority areas covering more than 1400 square kilometres of Western Australia's south-west marine environment. The maps will also have detailed layers describing the biodiversity values and human uses at the sites.

Information from the project will also be invaluable in other planning processes such as the State Government's regional marine planning process (see 'Oceans of opportunity for our south coast', *LANDSCOPE*, Autumn 2007). It will also help with planning for new marine conservation reserves and fisheries management.

The information gathered through Marine Futures will increase our understanding of WA's marine environment and provide some great tools for planning processes that will allow managers, stakeholders and the community to make informed decisions about what areas, and exactly how much of them, they want to protect and manage for future generations.

Mapping the sea floor

In the project's first 12 months, bathymetric maps—showing the contours and the texture of the sea floor—have been produced for eight sites, extending from the Houtman Abrolhos Islands offshore from Geraldton to Middle Island in the Recherche Archipelago near Esperance. The complexity of habitats under the Indian and Southern oceans is amazing and the project is uncovering lumps and bumps that are both uncharted and unknown in terms of the organisms associated with them.

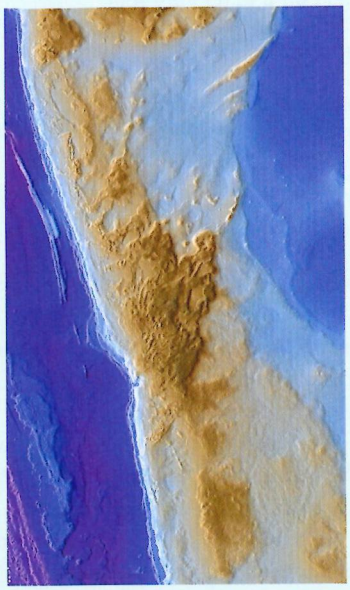
Now we can start answering questions such as how much of these representative areas are composed of reef, seagrass or sponge gardens? Where are these habitats? What animals are living in them and how abundant are these animals? Answers to these questions allow us to make better decisions about how we are going to manage these resources, whether it be by setting up marine conservation reserves, planning a sub-sea pipeline or determining how many fish we

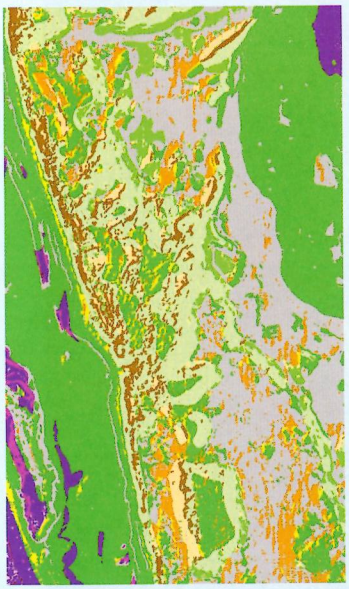
Previous page
Main Pocillopora Reef at Rottnest Island.
Photo – Peter and Margy Nicholas/ Lochman Transparencies
Insets from top Underwater baited camera; sea squirts; western blue devil.

Above Common kelp.

Left Sponges at Jurien Bay Marine Park.
Photos – Heather Taylor

Developing habitat maps in Jurien Bay Marine Park (west)





The bathymetric data is synthesised with the analysed towed video information to produce full coverage habitat maps.

Legend

- None modelled wih confidence
- Macroalgae
- Rhodoliths
- Algae + Rhodoliths
- Seagrass
- Seagrass + Algae
- Seagrass + Rhodoliths
- Seagrass + Rhodoliths + Algae
- Sessile invertebrates
- Sessile + Algae
- Sessile + Rhodoliths
- Sessile + Rhodoliths + Algae

Left The *Macedon*, a historic shipwreck on Rottnest Island's Kingston Reef. *Photo – Eva Boogaard/Lochman Transparencies*

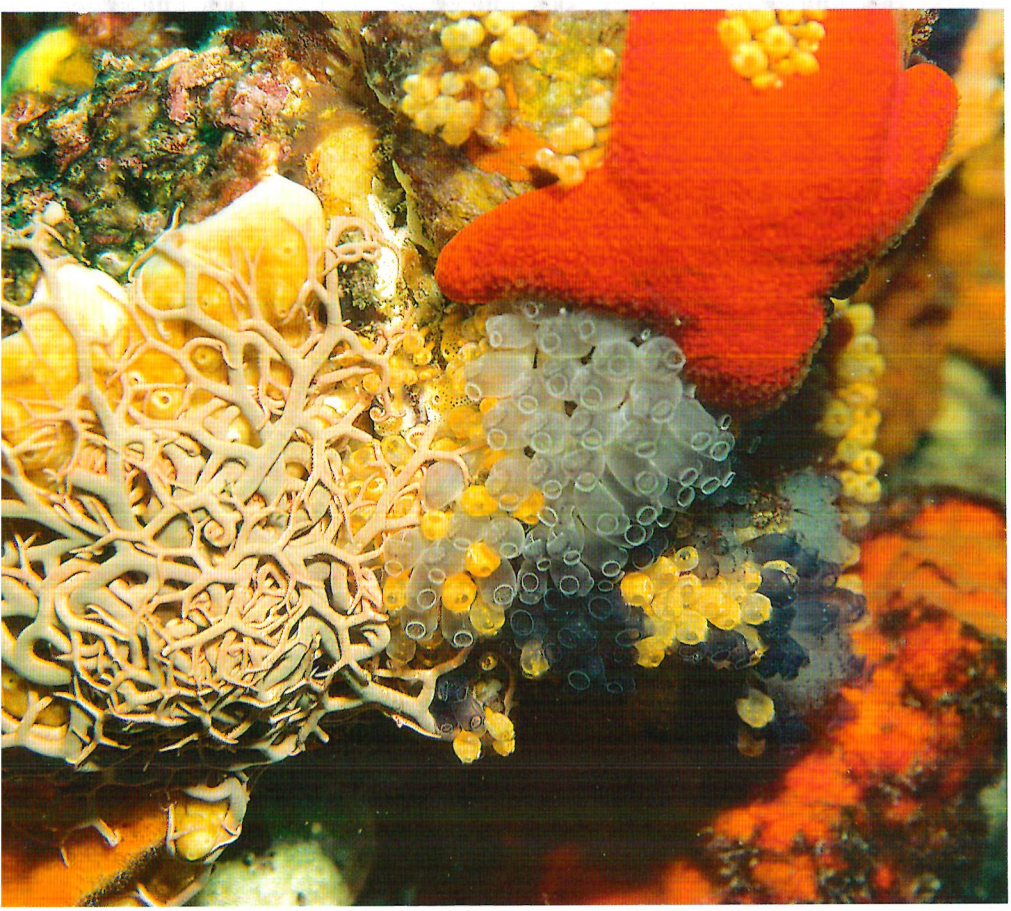
can sustainably harvest. By taking a snapshot of the state of our marine environment in 2007, we will also be able to monitor for change and ask ourselves whether these changes are acceptable for the long term.

The Marine Futures project comprises three teams—habitat mapping, biodiversity and human use. Team members from UWA and the international survey company Fugro have been developing the internationally cutting edge mapping techniques. This habitat mapping team develops the 'base layer' of information in the project. This process involves hydroacoustic surveys, underwater video surveys and habitat modelling.

During the hydroacoustic surveys, a multi-beam sonar device is attached to the hull of the survey vessel. This enables data to be collected from depths ranging from 10 metres to deeper than 120 metres. The ship works 24 hours a day, seven days a week, weather and logistics permitting. The vessel moves back and forth in a grid, just like mowing a lawn, sending acoustic signals to the seabed. When these signals come back to the ship, they are used to generate a full coverage, highly accurate map that reveals the depth and the 'texture'—whether soft or hard—of the bottom.

Following the hydroacoustic surveys, the team tows an underwater video camera across major structures that can be seen on the maps of depth and texture. So far, more than 200 hours of video footage has been collected. The final step is to develop the maps by relating the images from the video to the hydroacoustic data. Detailed habitat maps showing the distribution of sponge gardens, macroalgal reefs and seagrass meadows have been developed for around 800 square kilometres at both the Rottnest and Capes sites.

The patterns in marine habitats are, however, just the beginning of the details unveiled by the mapping activities. The ancient shoreline beyond Rottnest Island can be traced along its meandering path, submerged for 18,000 years. As mapping continues to the north, we can also trace this ancient shoreline offshore from Jurien (within the magnificent Jurien Bay Marine Park). Myriad vessels can also be seen resting in the area known as the Ships' Graveyard off Fremantle, with details down to the direction in which the wrecks are lying. Some of these shipwrecks were previously unknown to the WA Maritime Museum.



Left Colourful invertebrates vie for space on a temperate reef.
Photo – Eva Boogaard/Lochman Transparencies

Below left A cuttlefish.
Photo – Heather Taylor

Sampling biodiversity

The biodiversity team builds on the habitat maps by surveying the distribution and abundance of plants and animals at each site. This team has a broad array of expertise in marine biodiversity, with members drawn from the WA Museum, the Department of Fisheries and UWA.

As part of the process to develop the biodiversity sampling plan, Marine Futures held a workshop to get input from top marine scientists in Australia. The biodiversity team began work in the field last summer using a wide range of camera-based and diver-based techniques to collect data on fish, invertebrates, seagrass and larger seaweeds. The camera footage is particularly exciting: as well as capturing data on the types and numbers of fish, it depicts amazing behaviour such as deep water octopuses wrestling with small sharks!

Identifying patterns of human use

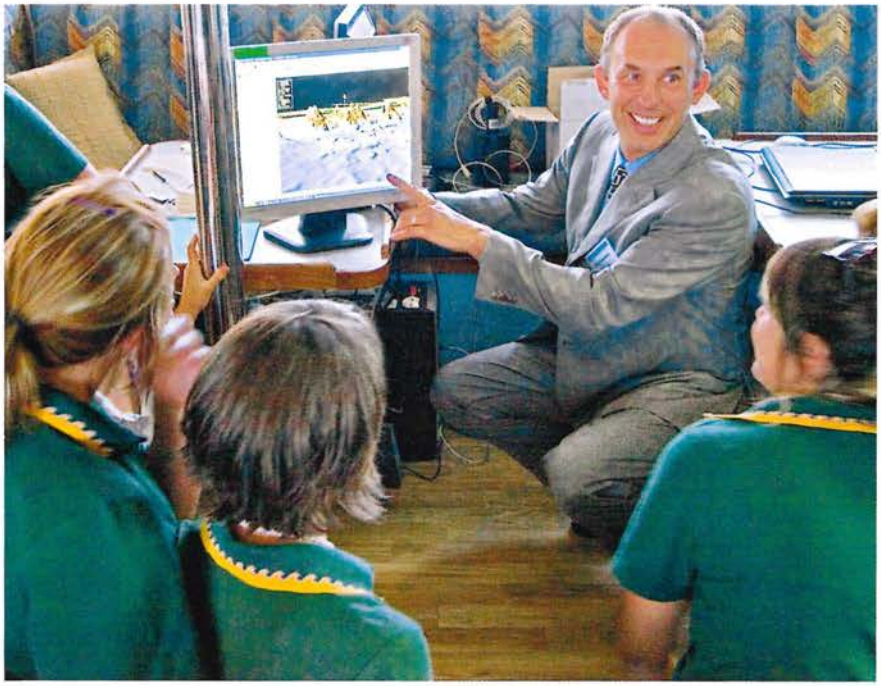
Marine Futures also aims to help us understand if and how our marine environment is changing as a result of human activities. Through a targeted interview program and spatial reviews on the patterns of human uses over time at each site, a human use team is providing critical information to illustrate patterns of human activity and help identify 'drivers of change' in the marine environment. This team has interviewed more than 60 people who either earn their living from or enjoy recreational activities on the ocean.

Combined, the outputs from the three teams are enabling us to identify marine indicators that tell us what's out there and how things are changing. This information is supporting regional Natural Resource Management Councils in establishing targets to maintain the quality of their marine environment.

Knitting together the three strands within Marine Futures is an education program to increase community awareness and capacity for marine resource management. The program includes events such as regional 'ports of call'. These ports of call are an opportunity for the community to come on board the survey vessel, the *Kimberley Quest*, to find out more about the project. To date, ports of call have been held in Busselton, Fremantle, Geraldton, Jurien, Esperance and Albany. The ports of call have been an excellent opportunity for the public to glimpse what lies beneath the ocean surface of their marine environments.

Capes

Information so far uncovered by Marine Futures is already proving useful for marine park planning. In September 2006, an indicative management plan for the Geographe Bay/Leeuwin-Naturaliste/Flinders Bay ('Capes') Marine Park was released by the Minister for the Environment for a three-month public comment period. Marine Futures mapping at Cape Naturaliste/Geographe Bay includes areas proposed as both sanctuary zones



Above Fugro's Marine Futures Operations Manager Paul Kennedy with an Albany school group.
Photo – Heather Taylor

Right Blue groper.
Photo – Eva Boogaard/Lochman Transparencies

and general use zones. It is hoped that the detailed information on the habitats found within both types of zones may assist the State Government in finalising the Capes marine park, which should hopefully be established in late 2007 or early 2008.

The project is also providing valuable information on the plants and animals found in the proposed marine park, including the relative abundance of species such as jewfish and blue groper, which are targeted by recreational fishers, enjoyed by divers and are important from a conservation point of view. The baselines it establishes will assist in monitoring any changes in the marine environment and help to determine if or how the area responds to the new management. In this way, the information can be used for both planning and ongoing monitoring and evaluation, using the biodiversity indicators developed through Marine Futures.

Where next?

Marine Futures has now completed the hydroacoustic surveys at the Houtman Abrolhos Islands, Jurien Bay (including Jurien Bay Marine Park), Rottnest Island, Albany, offshore from Fitzgerald River National Park, Two Peoples Bay and Broke Inlet, and eastern Esperance. These sites were selected in collaboration with resource managers and key stakeholders. Towed video work on the south coast is ongoing and biodiversity sampling has occurred across all eight sites.

Marine Futures is an ambitious project, representing the largest investment in marine resource management by the Natural Heritage Trust to date. Its success is flowing from the partnerships underpinning the project. These partnerships span the five regional catchment councils (Northern Agricultural, Swan, South West, Avon and Rangelands) as well as the South Coast Regional Initiative Planning Team, State Government agencies (Department of Environment and Conservation, Department of Fisheries, Department for Planning and Infrastructure and the WA Museum), and the Department of the Environment and Water Resources, Fugro and UWA.

The strong collaboration will help ensure the outcomes from Marine Futures are useful to both marine resource users and managers.

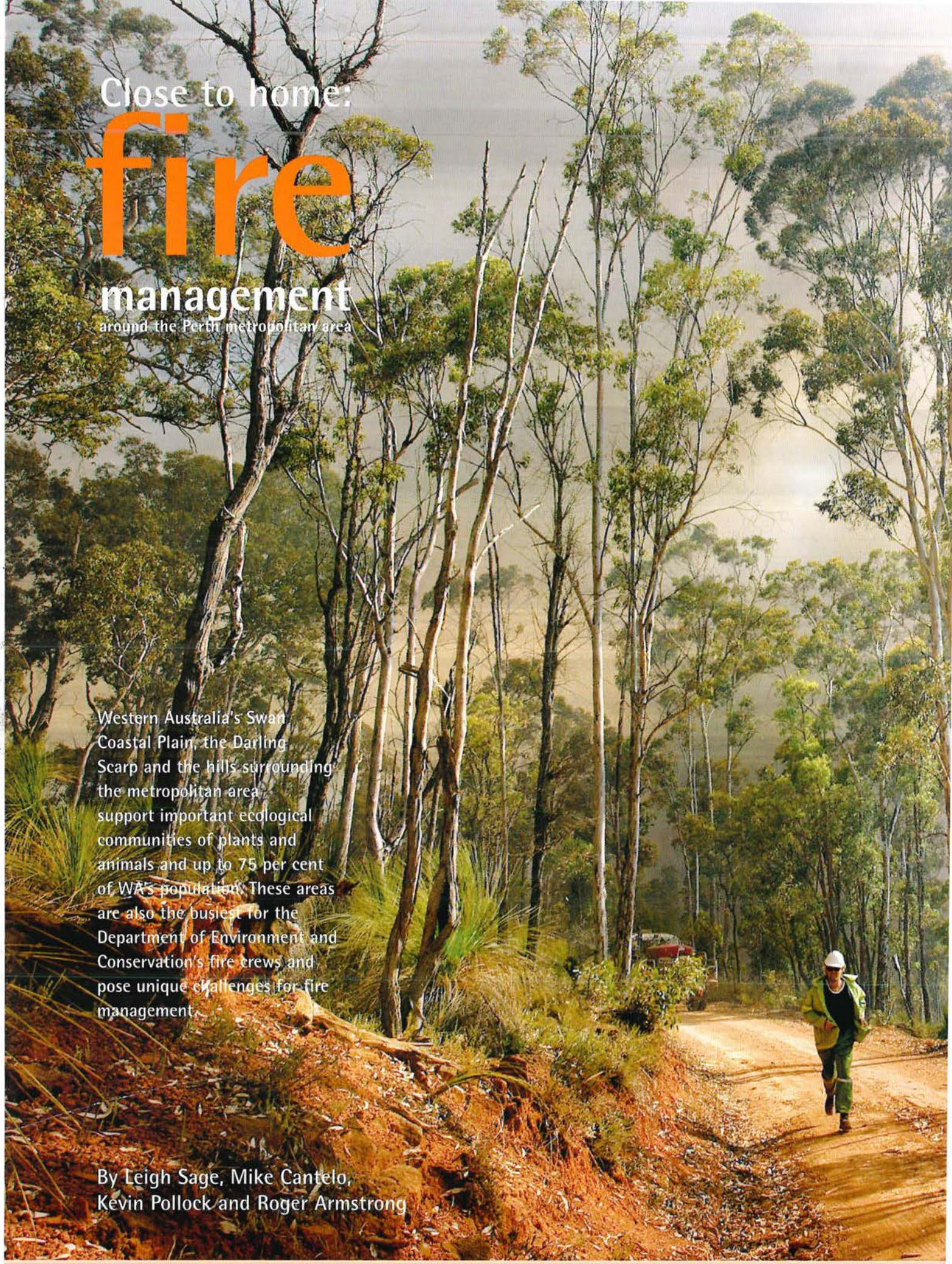
For more information on the project visit www.marinefutures.com.au or email marinefutures@uwa.edu.au.

Heather Taylor is the Communications Coordinator for Marine Futures, having been seconded to this role from the Department of Environment and Conservation. She can be contacted on 6488 5800 or by email (heather.taylor@uwa.edu.au).

Dr Jessica Meeuwig is the Marine Futures Project Manager and can be contacted on 6488 1464 or by email (jessica.meeuwig@uwa.edu.au).

The project is funded by the Natural Heritage Trust, an initiative of the Australian Government in partnership with the Western Australian Government.

Close to home: fire management around the Perth metropolitan area



Western Australia's Swan Coastal Plain, the Darling Scarp and the hills surrounding the metropolitan area support important ecological communities of plants and animals and up to 75 per cent of WA's population. These areas are also the busiest for the Department of Environment and Conservation's fire crews and pose unique challenges for fire management.

By Leigh Sage, Mike Cantelo, Kevin Pollock and Roger Armstrong

Fire is an environmental factor, which together with climate, landform and soils, has operated over millions of years to shape the biodiversity of Australia. Bushfires in the ecosystems of Western Australia's Swan Coastal Plain are not new but the implications for people are profound. This area, which stretches from Jurien Bay in the north to Bunbury in the south and east to the Darling Scarp, covers many land uses and tenures which, combined with continuing urban sprawl and the impact of climate change, are increasing the risk of bushfires having devastating effects on the metropolitan area.

The Department of Environment and Conservation (DEC) is responsible for fire management and wildfire suppression on the lands it manages outside the metropolitan fire district. Responsibility for lands within the metropolitan fire district rests with the Fire and Emergency Services Authority (FESA). DEC's fire management work is often carried out in association with FESA, the Forest Products Commission, volunteer fire crews and other emergency services. DEC fire crews combat several hundred blazes in the south-west during the summer bushfire season and spend the rest of the year preparing through prescribed burning, strategic planning, training, equipment maintenance, firebreak upgrades and water point construction. DEC also assists in combating wildfires on private property and other unallocated Crown land in a combined approach with local bushfire brigades, shires and FESA.

Fighting fires around the metropolitan area

The Swan Coastal Plain, the Darling Scarp and the hills surrounding the Perth metropolitan area support a large variety of vegetation types from coastal dunes and sandplains to banskia, eucalypt woodlands, tall forests and wetlands. This area has been extensively cleared as Perth's population has grown. Within this urban precinct a number of areas are set aside for conservation as national and regional parks, nature reserves and State forest. These unique ecosystems, and the precious plant and animal populations they contain, can present challenges to fire managers as they are often interspersed among assets such as houses, farms and industry.

Opposite page
Main Fire suppression in the Perth hills. *Photo – Leigh Sage*

Above Smoke engulfed Perth skies during the Perth hills fires of 2005. *Photo – Emma Rose*

The warmer temperatures and decreased rainfall of the past decade have rapidly reduced water tables, in turn causing many of the wetlands on the Swan Coastal Plain to completely dry out over summer. This has resulted in the peat layers of wetlands burning in wildfires—layers which would have otherwise been inundated and therefore protected from fire in the past. Peat fires are very difficult to suppress and often only extinguish after heavy winter rains. Other environmental factors that need to be considered in fire management in this area of high biodiversity include the protection of threatened flora, threatened ecological communities and native animals as well as preventing the spread of dieback disease.

The concentration of people and valuable assets such housing, power lines, transport corridors, tree plantations and biodiversity values such as wetlands requires that all wildfires be detected quickly and responded to rapidly. A rapid and aggressive initial attack is undertaken using fire trucks and earth-moving machinery, supported by fixed-wing aerial water bombers and Helitaks to put out fires and keep them as small as possible.

One of the assets often under threat on the Swan Coastal Plain is the pine plantation north of Perth. This plantation covers 25,000 hectares from Gnangarra in the south to Yanchep in the north, and is subject to a large concentration of bushfires, with the majority deliberately lit. Very high fuel loads due to needle bed accumulation and harvesting in the plantation and the high susceptibility of pine trees to being killed by fire means that fires in the area can have devastating impacts. On days of extreme bushfire danger, DEC fire crews and machinery are strategically positioned throughout the plantation so fires can be reached quickly to minimise their size and impact.

Plan of attack

Wildfires in the plantation and other areas of the Swan Coastal Plain, the Darling Scarp and the hills surrounding Perth, are aggressively attacked by DEC fire crews on the ground, supported from the air by water bombers. The bombers provide an essential and effective initial attack in fighting wildfires in the relatively flat, low terrain, particularly in the heathlands along the coast and open banksia-dominated woodlands inland.

Able to carry more than 3200 litres of water, the bombers aid in dampening the fire ahead of crews and machinery. They are also vital in protecting high value assets, such as houses. While the bombers do not put the fire out, they provide the ground crews with extra time by slowing its rate of spread. They can also begin work on the fire while ground crews are on their way. The pilots receive direction from crews on the ground and in the air about where to drop their water loads to aid in their effectiveness.

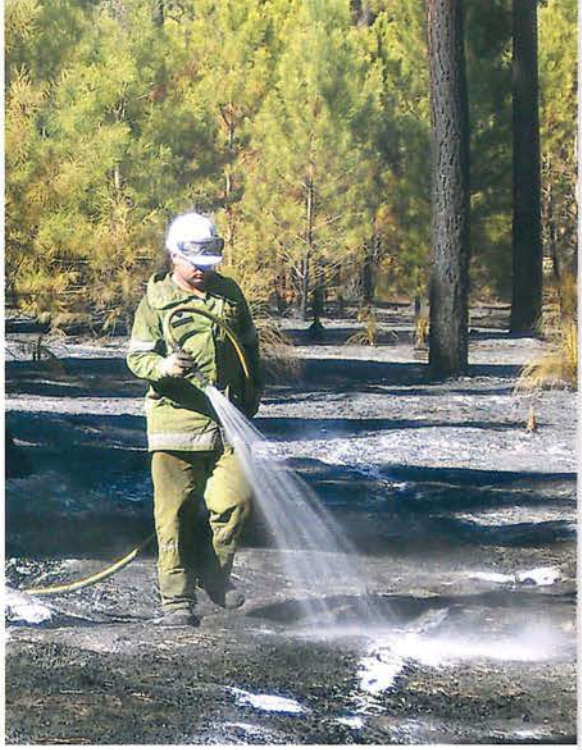
DEC has a large fleet of fire trucks, purpose equipped four-wheel drive vehicles, heavy earth-moving machinery, communications equipment and supporting aircraft at its disposal to fight and manage wildfires in its 'Swan Region' management area and other parts of the south-west. DEC also has a network of spotter towers and surveillance aircraft, which operate throughout the bushfire season to detect fires. Spotter aircraft operate out of Dwellingup and cover the entire northern jarrah forest area from Bindoon to Dwellingup. Four towers are used in the outer Perth area at Pinjar, Walyunga, Caraban and Bickley with the latter two only operational on extreme fire days. Depending on seasonal conditions, the towers are manned from October to May each year. In the event of a fire, spotters at the towers take bearings to accurately fix a fire's location and give an indication of its behaviour and size. Fire crews and water bombers can then be quickly and effectively activated.

DEC has a large force of permanent and seasonal firefighters who hone their summer bushfire skills during autumn and spring prescribed burning. DEC also draws on the experience and skills of its other staff from areas such as communications, information technology and mapping during large and complicated 'campaign' fires such as the Perth hills and Yanchep National Park fires of January 2005 and the fire in January 2007 that threatened the towns of Dwellingup, Pinjarra and Waroona. It is not uncommon for several hundred people to be involved in managing a campaign fire. Many people are not directly involved in fighting the flames but provide essential support to those who are. In recognition of their expertise and experience, DEC fire crews and managers also take part in regular deployments to fires in the USA and the eastern states of Australia. In 2006 a contingent from DEC helped with fires in the USA and also assisted with the extreme Victorian fires of 2006–2007.

Putting out the flames is only the first part of the role of the crews at a fire. Mopping up or 'blacking out' to make a wildfire area safe for the public to return can take several days and is particularly important in areas with high population and recreational values, such as around the metropolitan area. Public roads and walk trails are often closed for several days while experienced fire crews check the entire length of the fire and mark trees that are at risk of falling or dropping limbs or have fires in them that need to be extinguished with water. The track or road is only re-opened to public traffic when this task has been completed. Yanchep National Park, located

Below left Water bombers play a vital role in protecting assets.

Below DEC has a large force of permanent and seasonal firefighters. *Photos – Leigh Sage*



Above left A view of Perth from one of the State's spotter towers.
Photo – Owen Donovan

Above Post-fire recovery is an important role of fire crews.
Photo – Leigh Sage

55 kilometres north of Perth, was closed for more than a week after a wildfire in January 2005 burnt through more than half of the park. Many large tuart trees (*Eucalyptus gomphocephala*) had their trunks burnt almost all the way through and posed a risk to park staff and visitors. It was during this fire that a DEC national park ranger was seriously injured by a falling branch from a tuart tree. Fire crews and park staff worked for several days to re-open walk trails, tourist caves and roads through the park after the fire had been contained and mopped up.

Post-wildfire rehabilitation, including revegetation of constructed fire breaks, weed control and repairing fences, is also carried out after major wildfire events. This work is essential in areas that contain environmentally sensitive sites such as wetlands or lakes that would otherwise take many years to recover.

Preparing

A major factor in wildfire suppression is preparing for the season ahead. Prescribed burning plays a crucial role in protecting the community from large wildfires and our native forests and woodlands from the impacts of intense wildfires. Prescribed burning reduces the amount of 'fuel' or combustible material including leaf litter and pine needles and consequently reduces the intensity of wildfires. Areas burnt by prescribed burning also provide low-fuel buffers that slow the rate of spread. DEC undertakes a prescribed burning program of around 200,000 hectares each year in native vegetation and in plantations in the south-west.

Extreme summer wildfires can often result in high plant mortality. However, mild intensity prescribed burns will result in litter and debris being burnt away with little crown or canopy scorch or death. Burning in the many different vegetation types often requires a different approach each time. The banksia-dominated woodlands of the Swan Coastal Plain tend to burn faster because wind moves easily through the lower tree canopy. Fires in this ecosystem tend to result in a high death rate of plants.

Prescribed burning in DEC's Swan Region is often completed by fire crews who light the bush by hand. However, aircraft are sometimes used if burning is carried out over a large area. Aerial ignition is used primarily in the Perth hills where the vegetation is dominated by jarrah forest and where road access is limited.

DEC also undertakes prescribed burning in plantations in conjunction with the Forest Products Commission. This involves burning off pine tops remaining after harvesting and the pine needle bed every few years, during the wetter months when the ground moisture is higher, so the burn is mild and the pine trees are not affected.

With the aim of protecting life and property, as well as maintaining biodiversity, DEC fire crews face daily challenges. In highly populated areas such the Swan Coastal Plain, the Darling Scarp and the hills surrounding the Perth metropolitan area crews face additional challenges because of urbanisation and the continued expansion of Perth's population. Away from the metropolitan area they have the task of tackling large wildfires in remote areas. Every major fire presents an opportunity to demonstrate and continue to develop skills and expertise in firefighting.

Leigh Sage is the Department of Environment and Conservation's Swan Coastal District Fire Operations Officer. He can be contacted on 9405 0709 or by email (leigh.sage@dec.wa.gov.au).

Mike Cantelo is DEC's Swan Coastal District Fire Coordinator based in Wanneroo.

Kevin Pollock is DEC's Perth Hills District Fire Coordinator based in Mundaring.

Roger Armstrong is DEC's Senior Fire Planning Officer with Fire Management Services based in Bunbury.

urban antics by John Hunter

The *hîb*

They stood like a cohort of ancient Assyrians, but it wasn't the sheen on their spears that was startling, but rather the metallic purple, green–bronze reflection of the evening sun on their gloss-black wing and back feathers.

Ibis of the black and white, straw-necked variety were again prowling the playground parks among the affluent dwellings of Perth's City Beach not 300 metres from a hostile habitat of barren sand and pounding surf.

For some two years now the birds have made themselves conspicuous among very tolerant ground foraging groups of magpies, crows, galahs and wagtails. If I didn't know better, it appears as though the smaller species all wait for the long-legged interlopers to land and then join in a united front on whatever grubs or insects they can flush from the longer grasses of some parks.

The straw-necked ibis (*Threskiornis spinicollis*) is a large wading waterbird with a naked black head, long downcurved black bill and yellow throat plumes. It stands about 60 centimetres high and while usually found in farmlands and across dry plains and grasslands, is not common to inner suburban playgrounds. It was quite entertaining this summer, therefore, to see human mothers franticly ushering their toddlers away from what appeared to be 'long billed vultures of unknown intentions'.

While highly nomadic, straw-necked ibis normally inhabit the margins of lagoons and swamps and other inundated wetlands. They nest colonially, sometimes with cormorants, in wooded south-western wetlands between Busselton and Carnamah and occasionally in the southern Pilbara and southern Gascoyne areas. They have a penchant for feeding on terrestrial invertebrates, especially grasshoppers and locusts, which has endowed them with the title of 'the farmer's friend'. The birds have been also known to take frogs, lizards, small snakes, molluscs, centipedes and cockroaches.

Over the long dry summers of the past two years, small groups of ibis have apparently 'discovered' early morning and evening delicacies amid the grasses of our local urban playing fields. They are an exciting addition to the wildlife of our suburbs as nothing else quite resembles their image, plodding gait and group foraging techniques.

It would be a fair assumption that the extensive new wetland ponds, fairway reticulation and forest habitat in the Wembley Golf Precinct now provide a perfect oasis for the night roosting and summer day loafing of many terrestrial and waterbird species. As the precinct is only a few kilometres west and north of the Herdsman Lake Regional Park wetlands and Perry Lakes, it has probably become an important link to the extensive green belt parks of suburban City Beach. On the other hand, it could simply be just another irruption of ibis, which happens from time to time when perfect conditions for breeding occur and results in many birds appearing in new and unusual places.

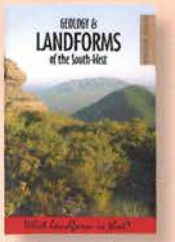
Once the bird was rarely, if ever, seen in the Perth area, yet its image (although that of a different species) appeared regularly in the Egyptian hieroglyphics in our school history books. Ibis are special creatures—there is something about them, something mysterious, something sacred,

DID YOU KNOW?

- In 1958, young tagged birds from the Gingin area dispersed some 800km north, to the east of Carnarvon, in just a few weeks and have since indicated their nomadic preference to head northwards and coastally after fledging.
- In flight over long distances the birds tend to prefer to fly in 'V' formation and at times individuals can be seen soaring in thermals.
- The word 'ibis' is from Greek, which was originally borrowed from the ancient Egyptian *hîb*.

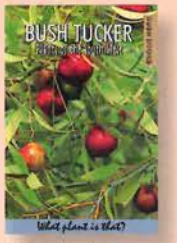
Bush Books...

Explore Western Australia's plants, animals and special features with this series of interesting and informative pocket-sized guides. Packed with information set out with simple scientific accuracy and full-colour photographs, these books are a fantastic reference and the perfect companion for any trip or outing.



Geology and Landforms of the South-West

Waterbirds of the South-West wetlands



Bush Tucker Plants of the South-West

Beachcombing Perth and South-West beaches

Marine Plants of the Perth Region

Orchids of the South-West

Common Trees of the South-West Forests

Common Wildflowers of the South-West Forests

Wildflowers of the South Coast

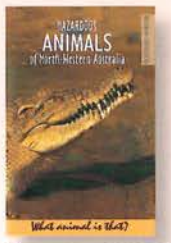
Wildflowers of the Stirling Range

Fungi of the South-West Forests

Mammals of the South-West

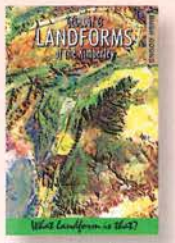
Common Birds of the South-West Forests

Mammals of North-Western Australia

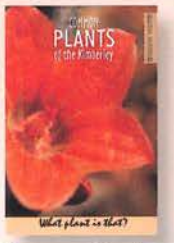


Hazardous Animals of North-Western Australia

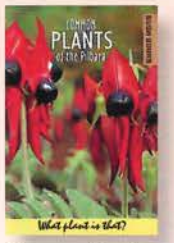
Common Birds of the Kimberley



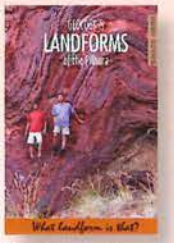
Geology and Landforms of the Kimberley



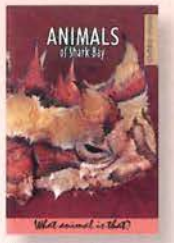
Common Plants of the Kimberley



Common Plants of the Pilbara

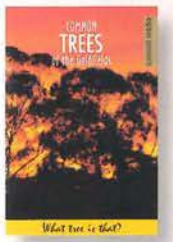


Geology and Landforms of the Pilbara



Animals of Shark Bay

Wildflowers of Shark Bay

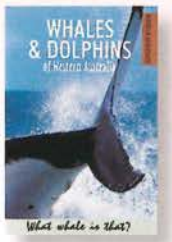


Common Trees of the Goldfields

Common Wildflowers of the Mid-West

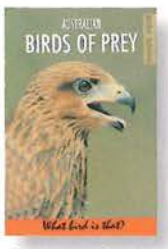
Threatened Wildflowers of the Mid-West

Wildflowers of Dryandra Woodland



Whales and Dolphins of Western Australia

Threatened and Rare Birds of Western Australia



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