WA's conservation, parks and wildlife magazine

LANDSCOPE

Volume 22 Number 2 SUMMER 2006–2007 $6.95

Marine park proposed for Walpole–Nornalup

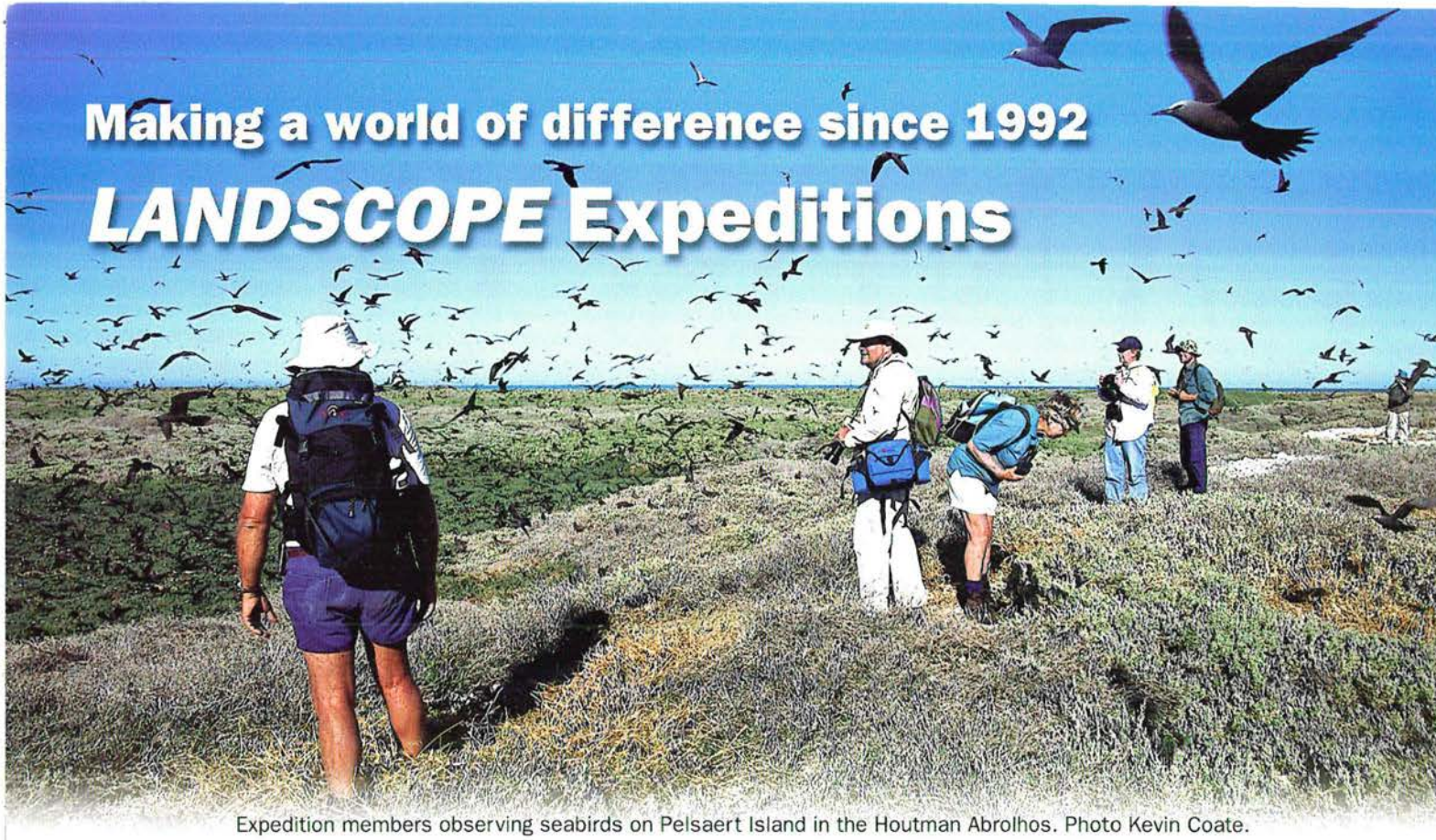
Black swans on the Swan

War on weeds

Mundaring National Park **Climate change** Putting the sting on feral bees

Making a world of difference since 1992

LANDSCOPE Expeditions



Expedition members observing seabirds on Pelsaert Island in the Houtman Abrolhos. Photo Kevin Coate.

Loggerhead Turtles of Dirk Hartog Island, Shark Bay World Heritage Area

(a) 8 – 15 January 2007 (b) 15 – 22 January 2007

The sandy beaches of Turtle Bay, at the northern end of Dirk Hartog Island, are key nesting sites for the endangered loggerhead turtle. Expedition members will have the opportunity to observe egg laying and help tag female loggerheads that nest at night on Dirk Hartog Island at the peak of the summer season.

Moon over the Murchison – Astronomical and Botanical Explorations at Mount Singleton

20 – 26 May 2007

Join astronomers from the Perth Observatory at Ninghan Station conducting astronomical experiments and viewing the night skies through portable telescopes. By day, search the region for rare and endangered flora with DEC scientists and learn about the fascinating environmental and cultural history of the area.

Desert Tracks – Plants and Animals of the Canning Stock Route

13 – 24 August 2007

Join a scientific discovery of a part of one of Australia's most remote and historic desert tracks. Expedition members will discover local fauna, record native flora, map fire scars and search for evidence of introduced predators while experiencing the magnificence of the Australian desert. Tag-alongs are welcome on this expedition.

Awash with Colour – The Art of the Flower Hunters

10 – 19 September 2007

Discover the art of botanical painting with Philippa Nikulinsky at Woolgorong, a former pastoral lease in the Murchison region that is being managed by DEC for its conservation values. Expeditioners will also assist in establishing baseline data for the spectacular wildflowers of the Murchison region of Western Australia.

Sanctuaries of the Sea – Wildlife of the Montebello Islands

1 – 8 October 2007

The Montebello Islands are home to many native animals, severely affected by introduced predators which arrived at the turn of the century. DEC has removed these threats to allow the recovery of native species. Join scientists in searching for boodies, mala, golden bandicoots and Shark Bay mice and discover the history of these magnificent marine sanctuaries.

Magenta Magic – Exploring the Biodiversity of Great Southern Nature Reserves

5 – 15 November 2007

Lake Magenta Nature Reserve is an important habitat for a number of native animals and threatened flora species. The success of DEC's *Western Shield* program has seen the return of chuditch, brushtail possums, Mitchell's hopping-mice, red-tailed phascogales, reptiles and frogs. Expeditioners will record animal species, monitor introduced predators and search for rare and threatened flora.

Seabirds and Shipwrecks – Exploring the Houtman Abrolhos Archipelago

11 – 18 December 2007

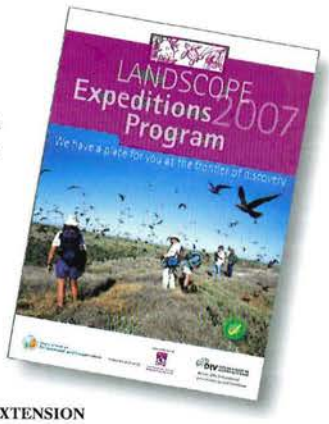
The Houtman Abrolhos Islands off the mid-west coast of Western Australia support the most species-rich assemblage of seabirds in the Indian Ocean. Lying in the path of the warm Leeuwin Current, the islands and the surrounding waters form a unique marine area where tropical and temperate sea life meet. Join an expedition to these islands to record seabird, shorebird and bush bird species at the peak of the breeding season.

Send for your copy of the *LANDSCOPE* Expeditions 2007 brochure:

call (08) 6488 2433
fax (08) 6488 1066
email extension@uwa.edu.au

or write to *LANDSCOPE* Expeditions
The University of Western Australia
35 Stirling Highway
Crawley, Western Australia 6009

or visit www.naturebase.net



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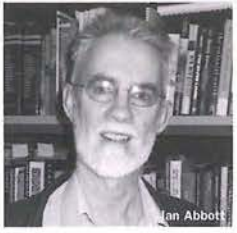
Kate Brown


Ian Abbott

contributors

Kate Brown has worked as the Bushland Management Advisor with the Department of Environment and Conservation's (DEC's) Urban Nature Program for the last two years, and she is involved in working with various land managers to develop appropriate techniques for the protection and restoration of regionally significant bushlands on the Swan Coastal Plain. Before that she spent five years working for The Environmental Weeds Action Network on a series of bushlands across the Swan Coastal Plain developing techniques and strategies for managing environmental weeds. This work culminated in a series of publications including *Bushland Weeds; a practical guide to their management*.

editor's letter

Not so many years ago, seaweed was almost unheard of as a food choice for Western Australians. How times have changed! These days, it's a popular option—from the ubiquitous platters of sushi offered at functions to tasty seaweed crackers and biscuits.

This edition of *LANDSCOPE* takes a new look at seaweeds and their increasing role as valuable 'vegetables from the sea'. A part of the Japanese and Chinese diets for centuries, today seaweeds are used by people around the world for food, stock feed, medicine and fertilisers as well as providing raw materials used in food processing and industrial processes. Western Australia's coast supports more than 1000 different seaweed species with many similar to the 30 or so species regularly used as food in other countries. 'Vegetables from the sea' provides a fascinating insight into the unusual, and potentially lucrative, range of tasty treats found along our coastline.

The marine environment is also the focus of an article on the magnificent Walpole and Nornalup inlets on the south coast of the State. Proposals to make the area a marine park would protect the plants and animals and the wilderness character of the area, while allowing visitors to continue to fish, tour and holiday on and around the inlets. The inlets, which experience marine-like conditions for most of the year, are more biologically diverse than most estuarine systems in south-western Australia.

Staying south of Perth, we head inland to the Stirling Range National Park where conservation strategies are being implemented to protect the threatened flora in one of WA's rare mountain environments. The mountains are effectively islands, providing a wide range of habitats in an otherwise flat landscape. The high peaks in the area and the diverse microclimates, soils and topography attract visitors ranging from rock climbers and bushwalkers to biologists and naturalists.

The focus switches to Perth and the Swan River in an article on WA's iconic black swans. Concern that they had moved away from the river led to studies and action to attract them back. We are now seeing some results from a range of projects to conserve and create habitats on the Swan River for them.

There is also good news in other articles with positive results from the initiatives to counter the growing problem of weeds affecting conservation lands and other areas, and some promising research into controlling feral bees.

With the growing international awareness and increasing public debate about climate change, this edition of *LANDSCOPE* brings the focus right to our doorstep, discussing how it is already affecting WA and what we can do about it. The article highlights the need to understand the role of climate in ecosystem composition and functioning so that we can better prepare for the impacts of future climate change.

The value of good information, research and better understanding is a common theme throughout the magazine. I hope you find it an interesting and enjoyable read.

Kaye Verboon
Executive Editor

Ian Abbott, a public servant scientist since 1979, has studied the ecology of trees, soil fauna and birds, particularly in response to fire and logging in jarrah forest. Ian published his first scientific paper in 1970 and has since published more than 180 papers. Before 1979, Ian worked on plant and bird ecology on many islands, including Tasmania and those in Bass Strait, the Galápagos, and WA. Recent interests include understanding the role of epizootic disease in causing extinctions of many mammal species in WA during the period 1875–1925, and synthesising a vast amount of historical information relevant to explaining the process of decline and extinction of bird and mammal species in WA, and the way Nyoongars used fire in south-west WA.

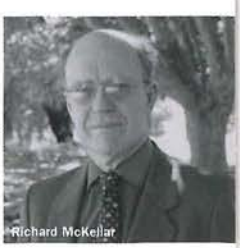
Rhianna King has been working with DEC for nearly five years in the Programs and Publications section developing and producing various products that communicate to a range of audiences. She is also an editor of *LANDSCOPE* magazine and has written several articles. Before that she completed a Bachelor of Arts (Mass Communication) from Curtin University. She enjoys discovering more about the natural environment through her work, reading, travelling and reading about travelling.

Richard McKellar has worked on climate change policy for DEC and its predecessors since 2000. His current professional interests include both climate science and the potential impacts of climate change on ecosystems and other conservation reserve values. These interests involve integrating two entirely different types of complexity and uncertainty to generate useful and effective response activities to protect WA's environment.

also contributing . . .

John Huisman, Anne Cochrane, Sarah Barrett, Carolyn Thomson-Dans, Jessie Cochrane, Greg Keighery, Michael Phillips, Jacqueline Hay, Mary-Anne Clunies-Ross, Liz Moore, Verna Costello and John Hunter.

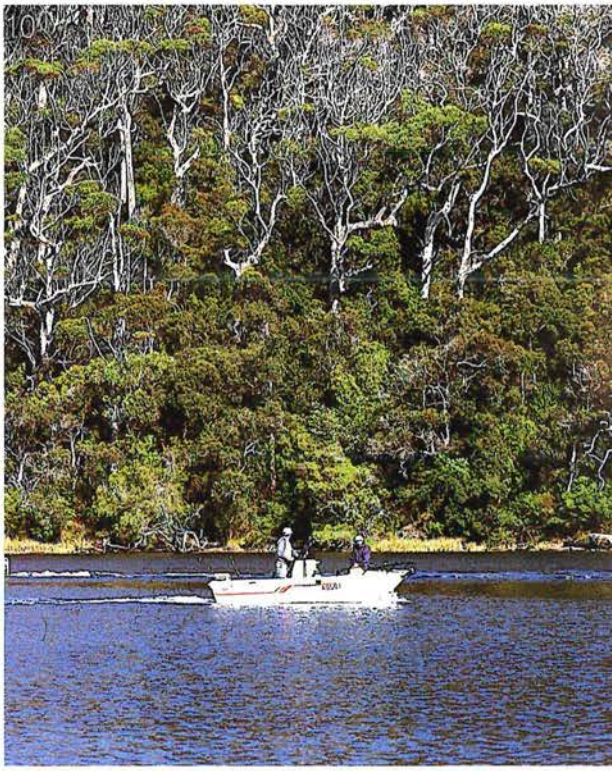

Rhianna King


Richard McKellar

Features

Cover illustration by Philippa Nikulinsky
The Australian pelican (*Pelecanus conspicillatus*) is easily recognised by its bold black-and-white markings, blue legs, enormous bill with pink pouch, and yellow eye-rings. During courtship, the pouch becomes bright red, blue and orange. The pouch is used mainly as a 'scoopnet' for catching small fish and shrimps, rarely for carrying them, and is also used for catching rain. Australian pelicans are common throughout most of Australia and inhabit fresh and saltwater lakes and estuaries, rivers, swamps and sea shores. They are an especially visible feature of the Walpole and Nornalup inlets.

Back cover photo Brett Dennis/Lochman Transparencies
The proposed Walpole and Nornalup inlets marine park.



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Regulars

Publishing credits
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Phone (08) 9334 0481 or (08) 9334 0437.
Prepress and printing Advance Press, Western Australia.

© ISSN 0815-4465

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Visit NatureBase at www.naturebase.net

Published by the Department of Environment and Conservation, 17 Dick Perry Avenue, Kensington, Western Australia.

Department of Environment and Conservation

Capturing places and spaces

As well as being important conservation areas, Western Australia's parks and protected areas play a crucial role in providing opportunities for people to experience the natural environment. Amateur photographers are invited to enter a new photographic competition on protected areas to communicate what parks and protected areas mean to them.

by Jessie Cochrane

Opposite page
Main Granite coastline near Castle Rock in Geographe Bay.
Photo – Brett Dennis/Lochman Transparencies

Above WA's south-west is Australia's only internationally recognised terrestrial biodiversity hotspot.
Photo – Ken Stepnell/DEC

Western Australia's national parks and other terrestrial and marine protected areas are set aside because of their scenic, cultural or biological values and for the role they play in protecting plant and animal communities. In WA, these areas equate to more than 26 million hectares of lands and waters, which are managed by the Department of Environment and Conservation (DEC). They promote a sense of wellbeing, not only for people who visit our parks but even for those who may only drive through them or gain comfort from just knowing they are there. In our busy and sometimes stressful lives, natural areas provide a space in which we can rest and recover, and from which inspiration can arise.

Revaluing our parks and protected areas

A partnership of the Conservation Commission, Marine Parks and Reserves Authority, the Department of Environment and Conservation, Conservation Council of Western Australia and the Forum Advocating Cultural and Eco-tourism (FACET) is culminating in a national forum, 'Parks and Protected Areas: A Sense of Place, for all People, for all Time' in Fremantle in September 2007 (see box on page 8).

The forum will focus attention on the significance and value of the protected area network, of which national parks and marine parks are the cornerstone. The intended outcome of the forum is to raise public awareness and support for a secure, publicly owned and publicly managed network of protected areas, particularly in WA. The forum will emphasise the value of the protected area network for biodiversity conservation, public recreation and tourism and hence its economic and social value to the community.

Competition

To promote the value of WA's national parks and other terrestrial and marine protected areas, the conference organisers invite *LANDSCOPE* readers to enter an amateur nature photography competition. The competition has the theme of parks and protected areas. Entrants are asked to capture the value and meaning of these precious areas and share their own unique experience of a park or protected area through their photographs.

The competition has two junior categories and three open categories: primary school (for entrants 12 years and under); secondary school (for entrants between 13 and 18 years); seascape; landscape; and wildlife (flora and fauna).

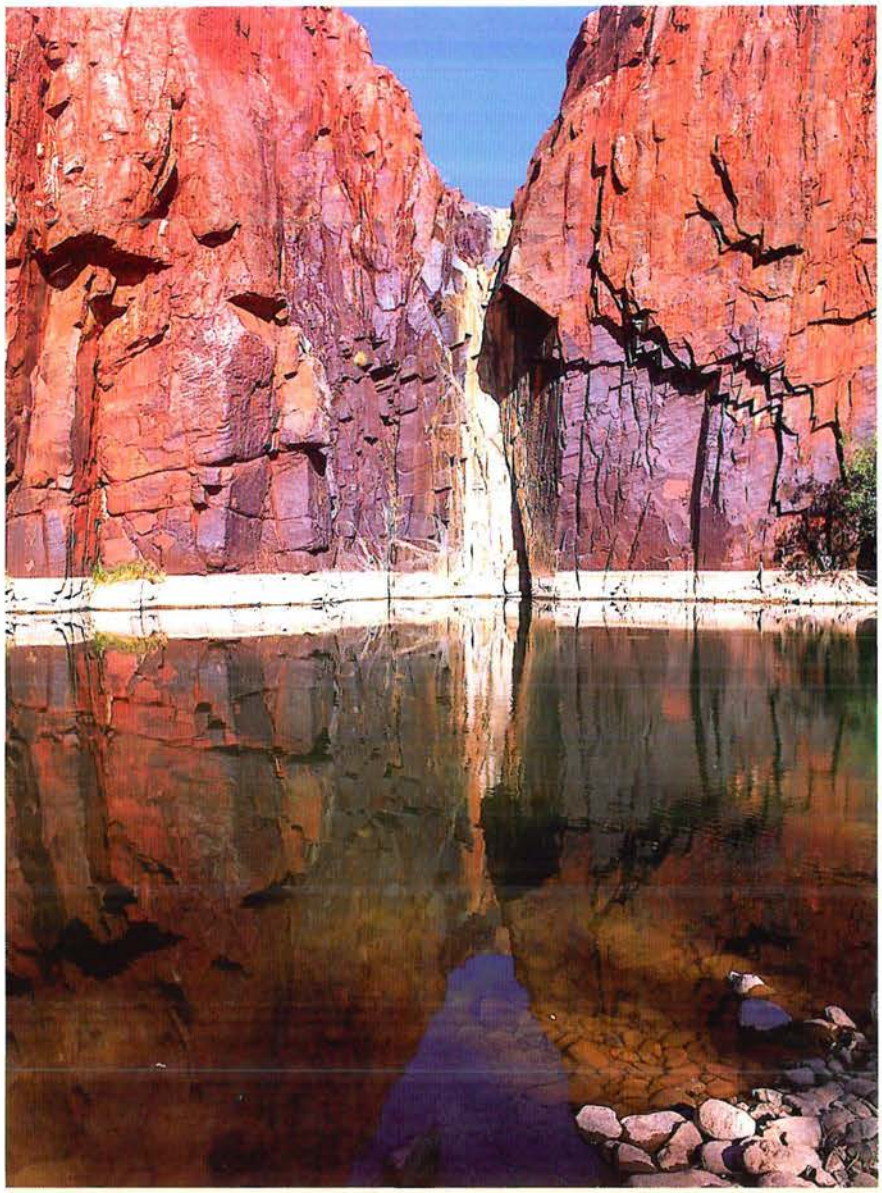
Photographs must be in colour and taken in a park or protected area in WA. Entries must be submitted as prints by 1 August 2007. Send entries with your full contact details and the category you're entering to *LANDSCOPE*

magazine, Parks and Protected Areas Photographic Competition, Locked Bag 29, Bentley Delivery Centre, WA, 6983. Entries must clearly indicate where the photo was taken and should include a 50 (or less) word explanation about what you believe the value of our parks and protected areas is and what they mean to you.

The entries will be judged by a panel from the 'Parks and Protected Areas: A Sense of Place, for all People, for all Time' national forum. The entries of all finalists will be displayed and the winners announced at the forum.

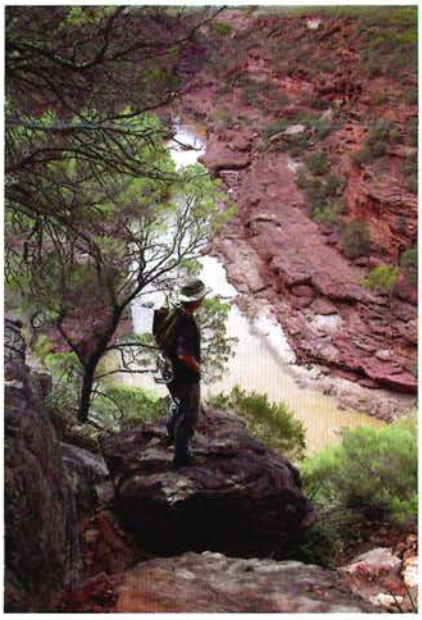
Prizes

The winner of each category will receive photographic equipment valued at $500 donated by Portside Duty Free and Retail of High Street in Fremantle. An overall winner across the five categories will receive a place on a *LANDSCOPE* Expedition giving them a once-in-a-lifetime opportunity to take part in a study and research project on an expedition in 2008 in a remote location in WA. A people's choice winner voted by the forum's attendees will also be awarded.



Above right Python Pool at Millstream–Chichester National Park.
Photo – David Bettini

Below The gorges of Kalbarri National Park.
Photo – Brent Johnson



Parks and Protected Areas: A Sense of Place, for all People, for all Time

Western Australia's national parks and other terrestrial and marine protected areas (for example, marine parks and marine and terrestrial nature reserves) represent our shared contribution to living with, caring for and valuing our natural and cultural diversity. The natural and cultural values found within our national parks and protected areas are of global significance and merit conservation and interpretation for that reason alone. Equally, though, these areas provide locations where people from many and varied backgrounds, both Indigenous people and other Australians, can meet and work together with a common purpose. In this way, parks and protected areas provide social values that reach beyond their immediate boundaries to provide bridges and overcome barriers. At least that is our hope and vision.

To fulfil that hope and deliver on that vision requires that we revalue our parks and protected areas, and define an agenda for action that has meaning for all who care for these areas, to guide all in their own programs and actions.

You are invited to take part in defining this agenda by attending a national forum to be held from 23–25 September 2007, in the port city of Fremantle with the theme 'A Sense of Place, for all People, for all Time'.

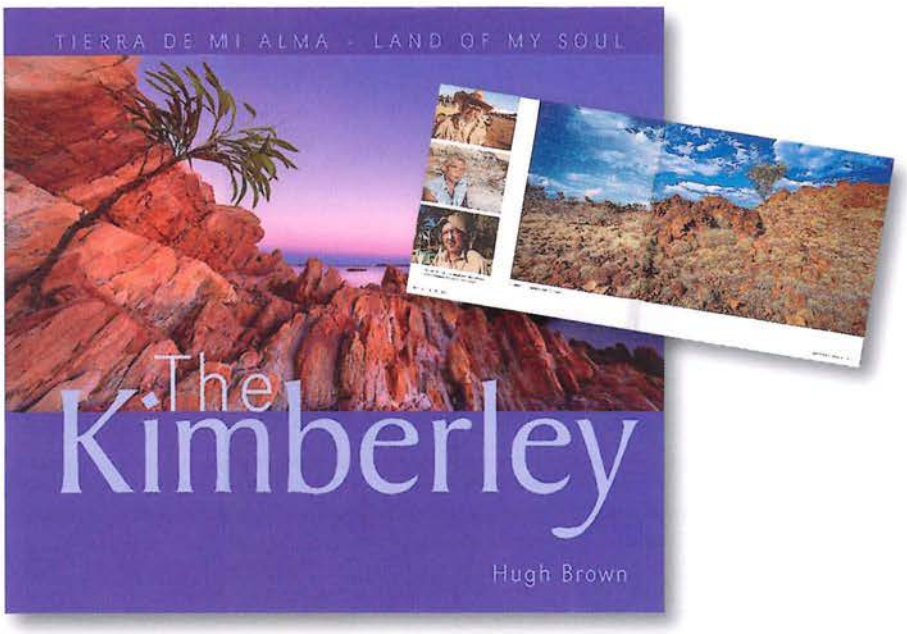
For more information contact the organisers, Promaco Conventions Pty Ltd by phone (08) 9332 2900, fax (08) 9332 2911 or via email (promaco@promaco.com.au).

Jessie Cochrane is the Community Liaison Officer for the Conservation Council of WA. She can be contacted on (08) 9420 7266 or by email (clo@conservationwa.asn.au).

bookmarks by Verna Costello

The Kimberley

Author: Hugh Brown
Publisher: Fanfaronades of Thunder Pty Ltd
168 pages, hard cover, full colour
ISBN: 0 9752054 2 0
RRP: $79.95



The subheading of this book is 'Tierra de mi alma – land of my soul' and, indeed, Hugh Brown has put his heart and soul into this inspirational book. It contains some of the most dramatic photography I have ever seen of the scenic grandeur for which the Kimberle y is well known. Much of it is taken from the air and so presents views that most visitors and coffee table connoisseurs will never get to see.

The text, too, is equally entertaining, well researched and insightful, with many historical and personal anecdotes, such as crossing 100-metre waterfalls and losing $7000 in camera gear in floodwaters. If you love the Kimberley region and beautiful photography then this book is definitely one for you.

Gascoyne Murchison Outback Pathways

Author: Samille Mitchell
Publisher: Mid-West Development Corporation
174 pages, soft cover, full colour
ISBN: 0 646 46256 3
RRP: $29.95

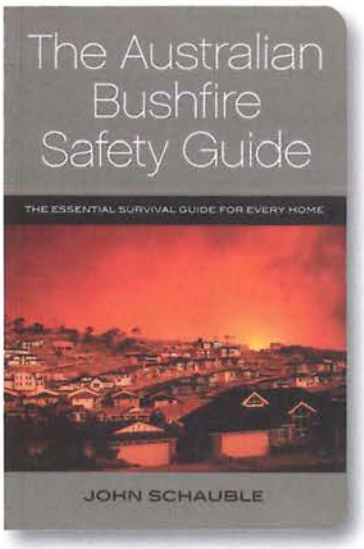
This is an invitation to 'Come and explore the real Western Australian outback – steeped in history, rich in stories'. We might add that the book is also lavishly supported by superb photographs.

The pathways referred to in the title are the Miners and the Wool-Wagon pathways, and the Kingsford-Smith Mail Run. They include the areas traversed by local Aboriginal people, and the book looks at the history, flora, fauna and geology of each pathway. There is an outback pathways map and information on links to other self-drive adventures and a safe outback pathways experience.

The Australian Bushfire Safety Guide:

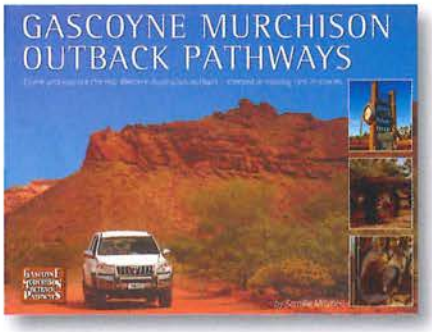
the essential survival guide for every home

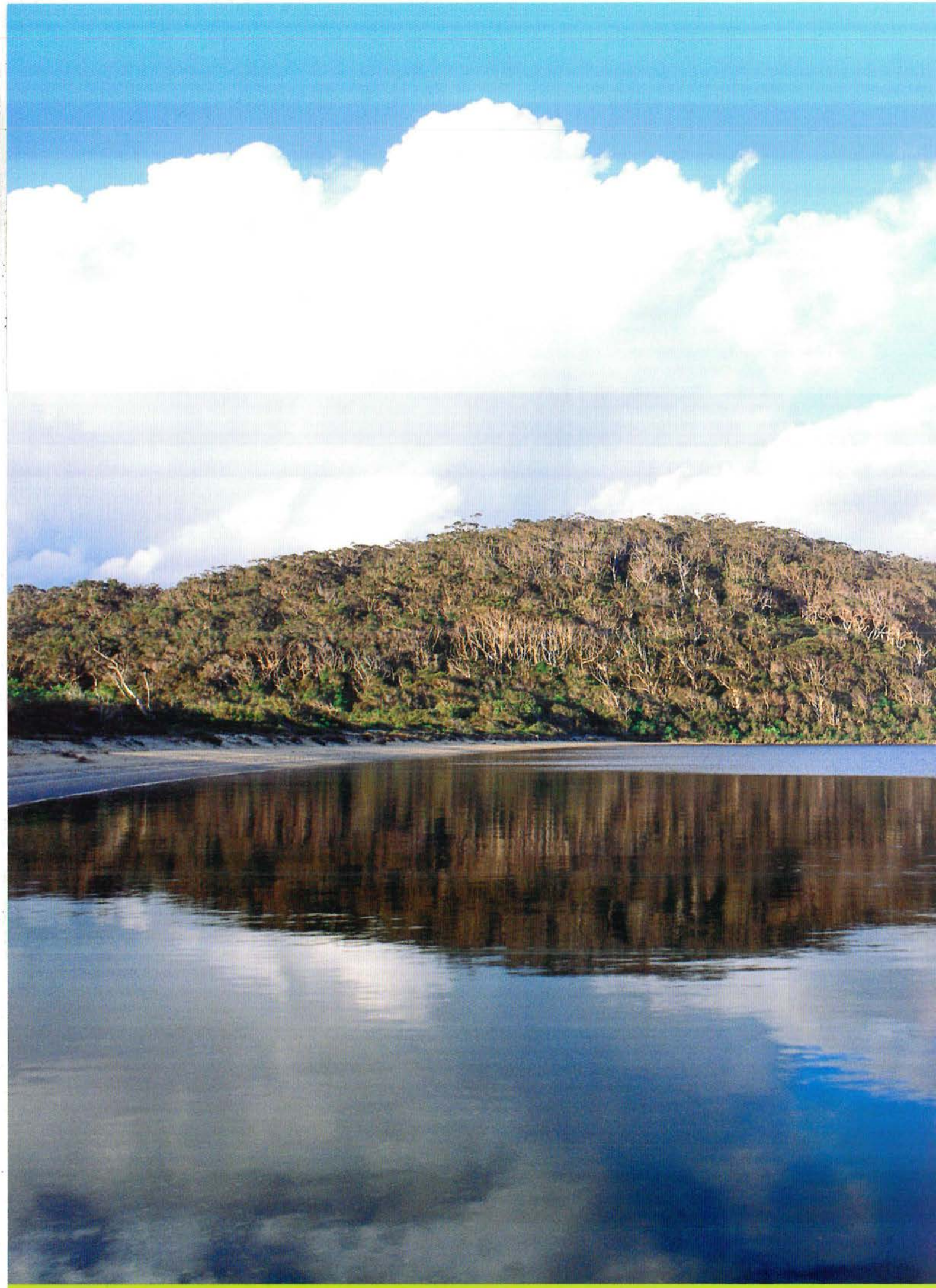
Author: John Schauble
Publisher: HarperCollinsPublishers
208 pages, soft cover, full colour
ISBN: 0 7322 7884 8
RRP: $19.95

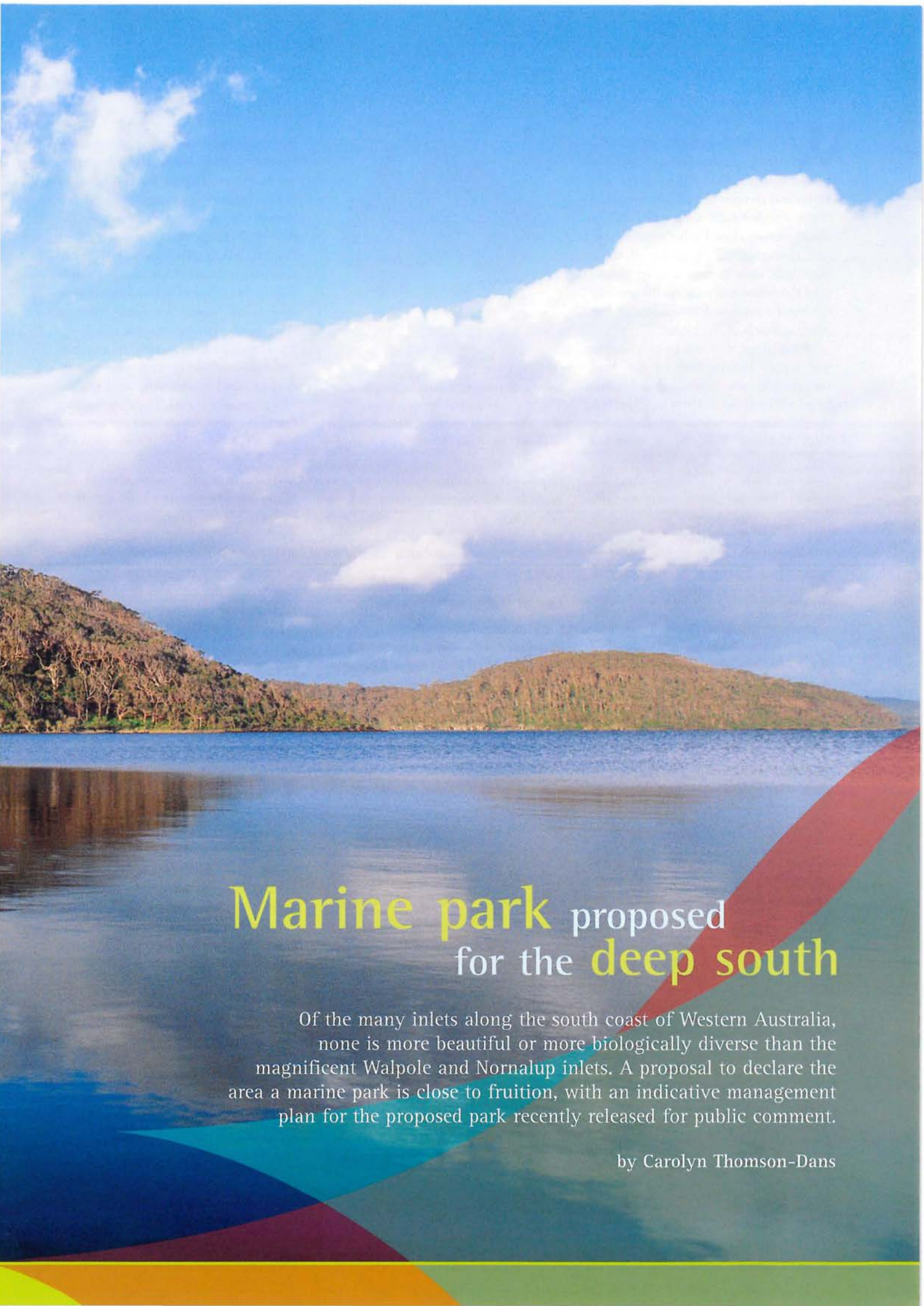


With predictions this will be a worse than normal bushfire season in Western Australia, it is more important than ever that home and business owners in bushfire-prone areas act to protect their properties from fire. The message of this handy, informative guide is that you can reduce the risk of your house being burnt down or damaged by fire. But you need to know what to do and when.

It provides information about fire behaviour, making your home and property fire-safe, travelling during the bushfire season, defending your personal safety, insurance, first-aid and animal care. It is a good source of information for all Western Australians, not just those who live in the bush.







Marine park proposed for the deep south

Of the many inlets along the south coast of Western Australia, none is more beautiful or more biologically diverse than the magnificent Walpole and Nornalup inlets. A proposal to declare the area a marine park is close to fruition, with an indicative management plan for the proposed park recently released for public comment.

by Carolyn Thomson-Dans

When William Nairne Clark and his party rowed into Nornalup Inlet—and then up the Deep and Frankland rivers—in 1841, he recorded 'lofty wooded hills, with tall eucalypt trees growing close to the water's edge, and crowning the summits of these high hills, thus casting a deep gloom over the water and making the scenery the most romantic I ever witnessed in other quarters of the globe'.

Early steps were taken to preserve this scenic beauty. Part of the land surrounding the Nornalup Inlet has been reserved since 1910 in what was at one time known as the Nornalup Inlet National Park (later extended and renamed Walpole-Nornalup National Park in 1972) and the inlet system has not been commercially fished for several decades. The relatively undisturbed state of the inlet system no doubt contributes to the excellent recreational fishing opportunities that still abound in the estuary.

The State government established a working group in 1986 to identify representative and unique areas of WA's estuarine and marine waters for consideration as part of a statewide system of marine conservation reserves. The Walpole and Nornalup inlet system was identified by the ensuing report, released in June 1994, as a distinct coastal type with high conservation values. It recommended that the Walpole and Nornalup inlets and the tidal parts of the Frankland, Deep and Walpole rivers be made a marine conservation reserve 'as a matter of high priority'.

Lay of the land

The Walpole and Nornalup inlets lie about 450 kilometres south of Perth on WA's south coast. The town of Walpole is adjacent to the shallow (approximately one metre deep) 100-hectare Walpole Inlet, which is fed by the freshwater Walpole River. The larger (1300-hectare) and deeper (up to five metres) Nornalup Inlet is fed by the freshwater Deep River and the saltier Frankland River. The Deep and Walpole rivers have forested catchments, while 54 per cent of the Frankland headwaters have been cleared for farms, making the run-off water somewhat saline.

The estuaries are joined by a natural one-kilometre-long and two-metre-deep channel, bordered by steep granite hills and rocky shores. These are known locally as 'The Knolls' and are covered with dense karri forest. Other channels have been dredged to allow boats to navigate from the town jetty to the ocean bar. Because the inlet mouth is protected from prevailing winds and swell by an adjacent rocky headland, and due to the high rate of water discharge into the system from the three rivers, the estuaries form the only permanently open estuarine system in the south-west. As a result, the Walpole and Nornalup inlets experience marine-like conditions for most of the year and are more biologically diverse than most estuarine systems in south-western Australia.

The Deep River of the Sealers

One of the Indigenous tribes that nomadically used the Walpole and Nornalup area was known as the Minang. Remains of rock fish traps can still be found in the inlets. Indigenous people also made spears from young Warren River cedar (*Agonis juniperina*) growing on the shores of the inlets. These people called the area Nor-Nor-Nup, the 'place of the Norne' (black snake). Both dugites and tiger snakes are common around the edges of the inlets.

Even before Albany was established in 1826, sealers, including some ex-

Previous page
Main Nornalup Inlet with 'The Knolls' in the background.
Photo – Alex Bond

Left The mouth of Nornalup Inlet is permanently open to the ocean.
Photo – David Bettini

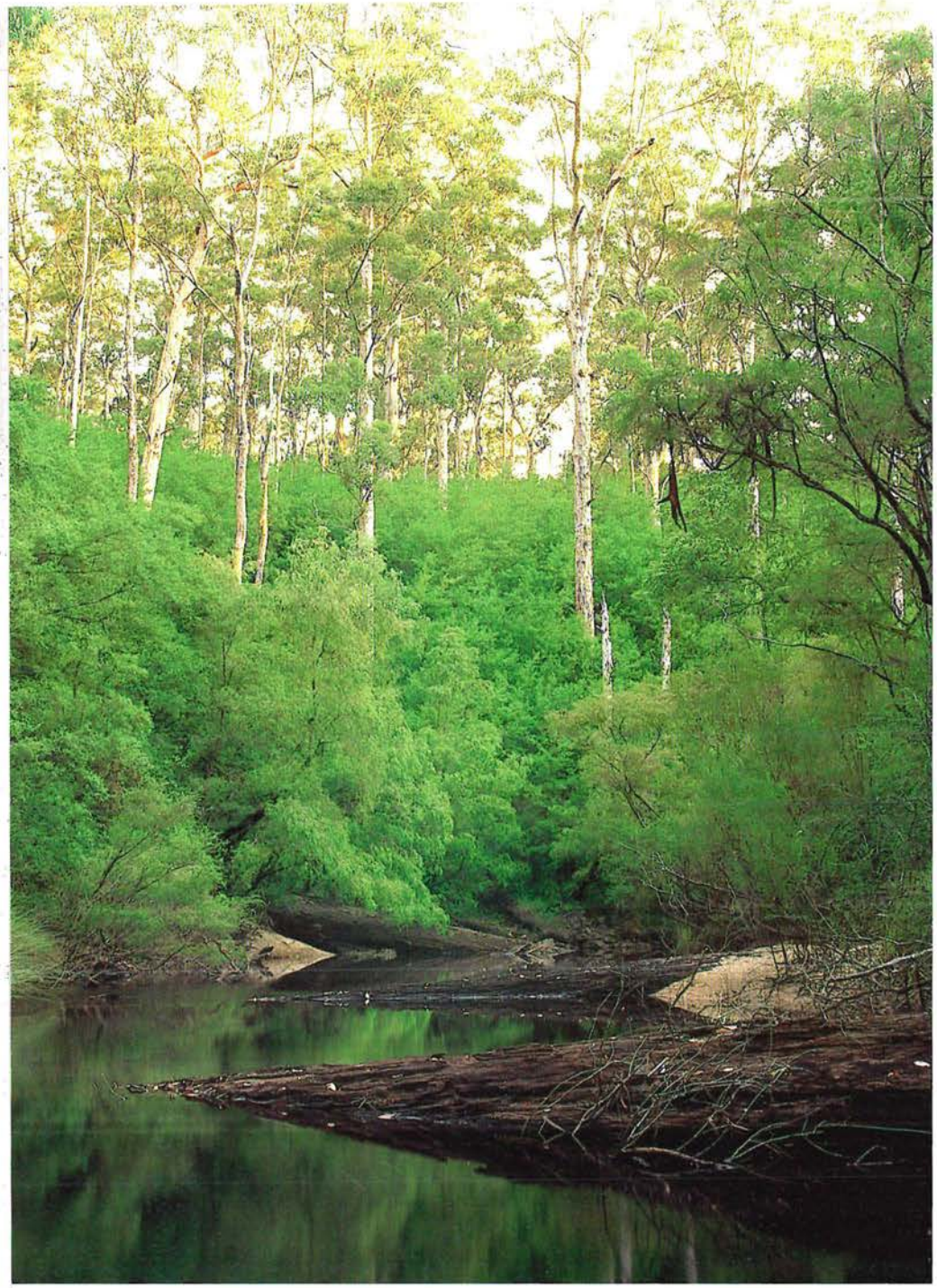
Left Members of the Muir family on an outing on Nornalup Inlet.
Photo – Courtesy of Alison Muir

convicts from Van Diemans Land (Tasmania), also used the area. Sealers Cove in Nornalup Inlet was probably one of their base camps and a sealer named Isaac is recorded as having lived on nearby Saddle Island with an Aboriginal woman in 1830. Using small boats, they systematically hunted New Zealand fur-seals, whose thick pelts achieved prices of 15 shillings apiece at King George Sound in 1842. The sealers provided French and American whalers with fresh kangaroo meat and local knowledge in return for biscuits, flour and salt pork.

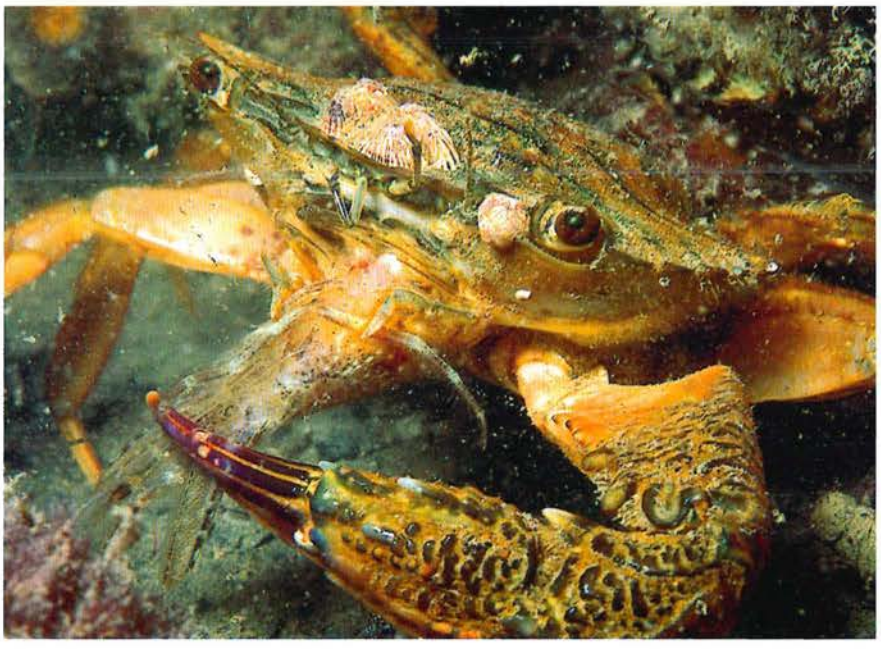
Captain Thomas Bannister and his party skirted the inlet in 1831 when they strayed off route while travelling overland from the Swan River Colony to Albany. Bannister's reports brought William Preston and his party to explore the Walpole-Nornalup area in 1831, followed by surveyor Alfred Hillman and his party in 1833. In February and May 1841, William Nairne Clark and his party rowed into Nornalup seeking 'the Deep River of the Sealers', as it had become known in local lore. Preston and Nairne Clark, in particular, were deeply impressed with the area's scenic grandeur, the friendliness of its Indigenous inhabitants, the abundance of fish in the inlets and the magnificent stands of timber.

Newdegate Island, at the delta of the Deep River, is known locally as Snake Island. In 1845, a group of Englishmen, led by Dr Henry Landor, set up an ill-fated camp on the island. They planned to catch and salt fish for export and to graze cattle and horses. Within a year the venture failed. Two circular fireplaces covered with undergrowth are all that remain of it today.

The first successful settlement of the area began in 1909 when Frenchman Pierre Bellanger and his family took up land beside the Frankland River. The Bellangers also established a tourist attraction in the area, the Nornalup Park Homestead, which provided accommodation, fine food and entertainment in the form of picnics and fishing trips on the river and inlet. In 1911, Frank Skinner Thompson and family settled on the Deep River and established a farm, and later a guest house in 1923 which was very popular with holidaymakers from Perth. In 1926, Tom Swarbrick was granted land at Rest Point, on the western shore of the inlet. A sawmill was established and an eight-bedroom guest house was up and running by 1928. The rest of the district was opened up for settlement through the disastrous Group Settlement Schemes in 1924 and 1927.



Left Tall karri forest along the Deep River, one of the last totally forested river catchments in the south-west.
Photo – Brett Dennis/Lochman Transparencies



Below left A blue swimmer crab eats a shrimp.
Photo – Ann Storrie

Biological diversity

Surrounded by undulating hills and majestic forests, the tranquil waters of the Walpole and Nornalup inlets support seagrasses, algae, a diverse array of shellfish and other animals living in the estuary floor, both marine and estuarine fish species and a variety of waterbirds, seabirds and shorebirds. Marine worms are abundant throughout the estuary and a number of small aquatic snail species can be found in the fringing rushes. Typical estuarine bivalves such as mussels and trough shells are found near the entrance to the Frankland River. Some prawn species, the blue swimmer crab and mud burrowing crab are also found in the inlets.

The open inlet mouth, the mixing of fresh and salt waters, river deltas and two large inlets result in diverse marine habitats and a great range of fish species. Black bream, whiting, trevally, herring, juvenile Western Australian salmon and even pink snapper are just a few of at least 40 fish species that have been recorded here, including larger fish such as sharks, which are uncommon in other estuaries. The smooth hammerhead shark, southern shovelnose ray, black stingray, eagle ray and gummy shark have all been found in the Walpole and Nornalup inlets. Eagle rays and gummy sharks have been particularly abundant, though gummy sharks are confined to the outer basin of the Nornalup Inlet where salinity is the highest.

A fish with an interesting lifestyle, the pouched lamprey (*Geotria australis*), occurs in its larval stages in the Deep and Walpole rivers, burrowing into the shaded organically-enriched riverbeds for more than four years, before migrating to the ocean via the two inlets. Among the most primitive of living fish, lampreys have a jawless

Above Misty dawn and karri trees on Nornalup Inlet.
Photo – Brett Dennis/Lochman Transparencies

Right Visitors enjoy fishing and camping along the shores of the Walpole and Nornalup inlets. There will be no recreational fishing restrictions in the proposed marine park.
Photo – Tourism WA

mouth that is modified to form a circular suction disc, and have a skeleton of cartilage rather than bone.

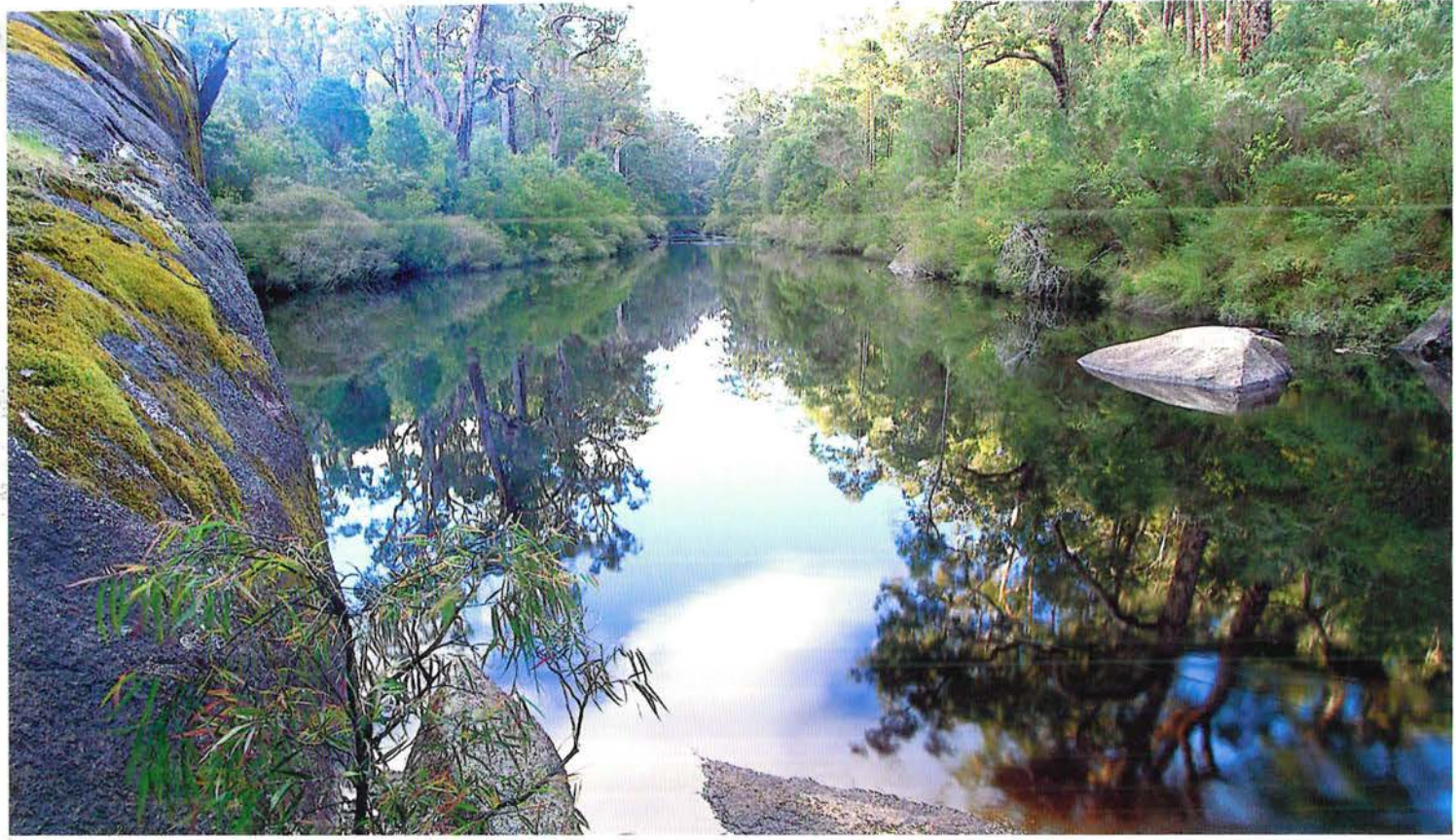
Black swans, ducks, swamphens, moorhens, grebes, coots, cormorants, herons, egrets, Australian pelicans, whimbrels, ibises, sandpipers, stints, oystercatchers and plovers—among other birds—all use the proposed marine park. Gulls and terns are abundant in the area, and shearwaters, gannets and albatrosses may also be observed. Ospreys and white-bellied sea-eagles ply the inlet waters for fish. These large predatory birds are major attractions for nature-based tourism in the inlet system. Migratory shorebirds utilise the tidal delta flats.

Recreation

The natural, wildlife and scenic qualities of the inlets provide a wealth of opportunities for nature-based tourism, canoeing, boating, water sports, nature appreciation and recreational fishing. A major attraction of the inlet system to visitors is the perception of 'wilderness' that can be experienced, particularly in parts of the Nornalup Inlet and the Frankland and Deep rivers.

Management of the proposed marine park will focus on research, monitoring, education and interpretation, and public participation programs. Such programs will allow managers and scientists to gain a better understanding of the estuarine ecosystem, and to assess and manage the impacts of human activities in the area.

The plan, when implemented, will conserve the Walpole and Nornalup inlet system to the approximate limits of tidal influence in the Frankland, Deep and Walpole rivers. The environmental condition of estuaries is closely linked to the condition of surrounding catchments and tributary waterways. The proximity of the adjacent Walpole-Nornalup National Park provides an exceptional opportunity to manage the interconnected terrestrial and



Above Tidal areas of the Deep River will be included in the marine park.
Photo – Brett Dennis/Lochman Transparencies

Below Great crested grebe.
Photo – Jiri Lochman

aquatic ecosystems as a single unit, so the indicative management plan is integrated with the draft management plan for the Walpole Wilderness Area and adjacent parks and reserves.

The indicative management plan proposes to protect the plants and animals and the wilderness character of the area, while allowing visitors to continue to fish, tour and holiday on and around the inlets. It is envisaged that economic benefits of sustainable management of the inlets will flow to the Walpole community. It is important to ensure the local community feels ownership of the inlets, participates in managing the area, and feels confident in their long-term protection.

Vision splendid

The indicative management plan is based on input from a community-based focus group formed in 2003 to assist the former Department of Conservation and Land Managment (now part of the Department of Environment and Conservation) to guide the conservation and management of the proposed Walpole and Nornalup inlets marine park.

The release of the indicative management plan in August 2006 was just one of a raft of recent major marine conservation initiatives. The plan's release was closely followed by the release of an indicative management plan for the proposed Geographe Bay/Leeuwin-Naturaliste/Hardy Inlet marine park. It is anticipated that a final management plan for the Shoalwater Islands Marine Park will be released in early 2007, followed by the final management plan for the proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area.

The Recherche Archipelago, a 200-kilometre-long smattering of more than 300 islands off the coast of Esperance (see 'Researching the Recherche', *LANDSCOPE*, Winter 2003), will be the next area considered for marine reservation, a process that will be undertaken in parallel with a regional marine planning process for the entire south coast of the State.

Western Australia is blessed with a remarkable and unique marine environment. We have a special responsibility to protect and conserve this wonderful marine heritage. A comprehensive, adequate and representative marine reserve system will form a 'string of pearls' (see 'Vision Splendid', *LANDSCOPE*, Spring 2003) gracing our coast. The value of such a marine reserve system will appreciate in years to come, as areas in other parts of the world are affected by ever-increasing population pressures and industrial development. Managed properly, our marine reserves will allow future generations of Western Australians to reap the aesthetic, recreational and economic benefits such a system can confer.

Carolyn Thomson-Dans is a long-time editor and contributor to *LANDSCOPE* and has written and edited numerous departmental publications. She has a special interest in the marine environment. She can be contacted on (08) 9389 8644 or by email (carolyn.thomson-dans@dec.wa.gov.au).

Many thanks to Gary Muir, Lee and Geoff Fernie, Peter Bidwell and Leanne Thompson for their input into the article.

endangered by Kellie Mantle

Burrowing crayfish

Burrowing crayfish (*Engaewa* species) are enigmatic crustaceans found only in seasonally inundated freshwater swamps and seepages in the highest rainfall areas of south-western Australia. They hide in extensive underground burrow systems that connect to the water table, providing refuge in drier months.

Burrowing crayfish are small, up to five centimetres, and have reduced eyes, antennae and tail. Their claws, built for digging, are disproportionately large and strikingly coloured—usually vivid purple but some are a dazzling cobalt blue.

Burrowing crayfish were first discovered in the late 1950s and there are now five recognised *Engaewa* species. Three of these are threatened. The Walpole burrowing crayfish (*Engaewa walpolea*) is vulnerable, the Dunsborough burrowing crayfish (*E. reducta*) is endangered and the Margaret River burrowing crayfish (*E. pseudoreducta*) is critically endangered, with only one known population.

The Dunsborough and Margaret River burrowing crayfish both occur in the Capes region and both are severely threatened due to the removal and drastic alteration of critical habitat for farming, agroforestry and viticulture. Compaction of soil by livestock and changes in hydrology due to the creation of large dams for irrigation, drainage works and the establishment of bluegum hardwood plantations are all impacting on their survival.

Almost nothing is known of the ecology of the burrowing crayfish and they are difficult subjects to find, let alone study. A PhD student from Edith Cowan University is taking on the challenge to investigate aspects of burrowing crayfish distribution and life history, including the burrow structure, reproduction and population dynamics. DNA analyses will also be conducted to help understand the biogeographical relationship of WA's burrowing crayfish and confirm whether there are any more undiscovered species hiding in those dark burrows.

The information will be crucial for future management of the threatened burrowing crayfish species. In the interim the Department of Environment and Conservation, with funding from the State government's program of biodiversity conservation initiatives, will endeavour to establish stock-proof fencing around critical habitat restricted to private property and prepare a draft recovery plan. The three threatened burrowing crayfish species will also be nominated for listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act (1999)*, which will greatly increase the chances of the recovery actions receiving Natural Resources Management funding.

Photos by Kellie Mantle and Kelly Rogerson

'Mundaring National Park'

'Mundaring National Park' covers both sides of a valley created by the Helena River below Mundaring Weir and Lake C Y O'Connor.

Above Wildflowers at 'Mundaring National Park'.
Photo – Rob Olver

Facing Page
Above right top Lookout on Weir View Walk in 'Mundaring National Park'.
Photo – Michael Phillips
Above right Fred Jacoby Park is home to a heritage-listed oak tree—believed to be the oldest in WA. The specially-designed boardwalk is popular for picnics and photos.
Photo – Ron D'Raine
Far right Helena River in 'Mundaring National Park'.
Photo – Michael Phillips

The 4500-hectare park lies less than an hour's drive east of Perth in the Darling Range. It was officially gazetted in November 2004 under the State government's *Protecting Our Old Growth Forests* policy but the name 'Mundaring National Park' remains unofficial.

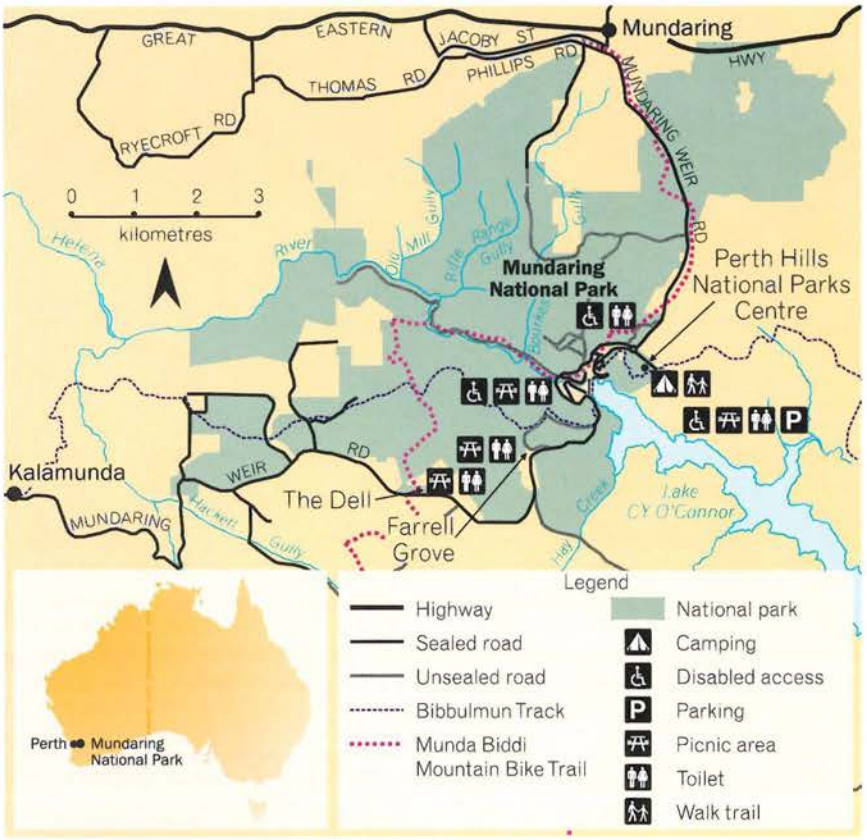
The park's natural values become obvious during late winter and spring, when colourful wildflower species appear among the jarrah forest, woodlands and granite outcrops. Recreation sites within the park include The Dell, Forsyth's Mill, Gungin Gully, North Ledge, Pimelia and Grevillea Mycumbene. The most popular, however, is Fred Jacoby Park on Mundaring Weir Road.

Fred Jacoby Park

The history of Fred Jacoby Park dates back to the 1870s when the Darling Range was first being settled. Before the turn of the century, Fred Jacoby Park was a vineyard owned by W. Jecks. Mr Jecks is thought to be responsible for planting the large English oak tree (*Quercus robur*) in about 1870.

When Jecks died in 1896, brothers Matheison and Fred Jacoby bought the property and named it 'Portagabra'. In 1904, Fred Jacoby became the sole owner and began to develop an orchard, growing vegetables and daffodils. He then built the Goldfields Weir Hotel (now the Mundaring Weir Hotel). Fred Jacoby died in 1955 and his daughter, Elfreda Devenish, presented Portagabra to the people of Western Australia, to be managed by the Forests Department.

Between 1956 and 1958, the property was developed as a golf course and many arboretum species were planted. The golf course remained there until 1969, when the club moved closer to Mundaring. In 1973, the Forests Department began developing Fred Jacoby Park for casual forms of recreation. The Forests Department and its successor, the Department of Conservation and Land Managment, managed it between 1975 and 2002. A timber boardwalk was built around the English oak tree. The large open grassy



areas of Fred Jacoby Park have long been used for large family gatherings. Groups such as local scouts and guides, Little Athletics clubs and social clubs all regularly use the area for various purposes. The English oak tree is frequently used as a venue for wedding ceremonies and photographs.

Since the national park was formally created, a new fully-accessible boardwalk has been built around the English oak tree, and a new toilet block constructed at Fred Jacoby Park. Better access and parking facilities are also being provided.

Another major attraction is Golden View Lookout at South Ledge, a picnic area surrounded by jarrah forest. A short walktrail leads to the lookout and its spectacular views over the Helena Valley, Lake CY O'Connor and Mundaring Weir, which provide water to the Goldfields region. Interpretive panels provide information on the hydrology, landscape and heritage of the Helena Valley.

Perth Hills National Parks Centre

The hills east of Perth contain 10 national parks and five regional parks that are a natural playground of waterfalls, shady picnic areas, panoramic lookouts, campgrounds, cycle trails and scenic walks of every length and difficulty. Open seven days a week, the Perth Hills National Parks Centre is just 40 minutes from Perth and has information on all of the Perth Hills parks.

Located at the hub of the Perth Hills near Mundaring Weir, there are plenty of things to do at the National Parks Centre besides gather information. The interpretive displays inside the building provide an insight into the beauty and biodiversity found within a jarrah forest. You can experience the forest by walking one of the several walktrails available. The world-famous Bibbulmun Track passes right through the middle of the National Parks Centre and cyclists can also get easy access to the Munda Biddi Trail.

If you need a map, hat or water bottle or need to buy someone a present, the shop sells a variety of products. You can also buy a coffee or cold drink to enjoy while you peruse the displays or relax in the natural surrounds.

Don't rush off after having a quick look around as there are other interesting attractions nearby. You can experience beautiful evenings in the forest by staying at one of the National Park Centre's two campgrounds or the Djaril-Mari YHA, catch a movie at the Kookaburra Outdoor Cinema from November to April and have something to eat and drink at the historic Mundaring Weir Hotel or Lavender Path tearooms.

The Perth Hills National Parks Centre is on Allen Road (off Mundaring Weir Road), seven kilometres south of Mundaring, and can be contacted on (08) 9295 2244. Follow the signs from Mundaring or Kalamunda.

park facts

Where is it? 40 km east of Perth via Great Eastern Highway and Mundaring Weir Road.

Total area 4617 hectares.

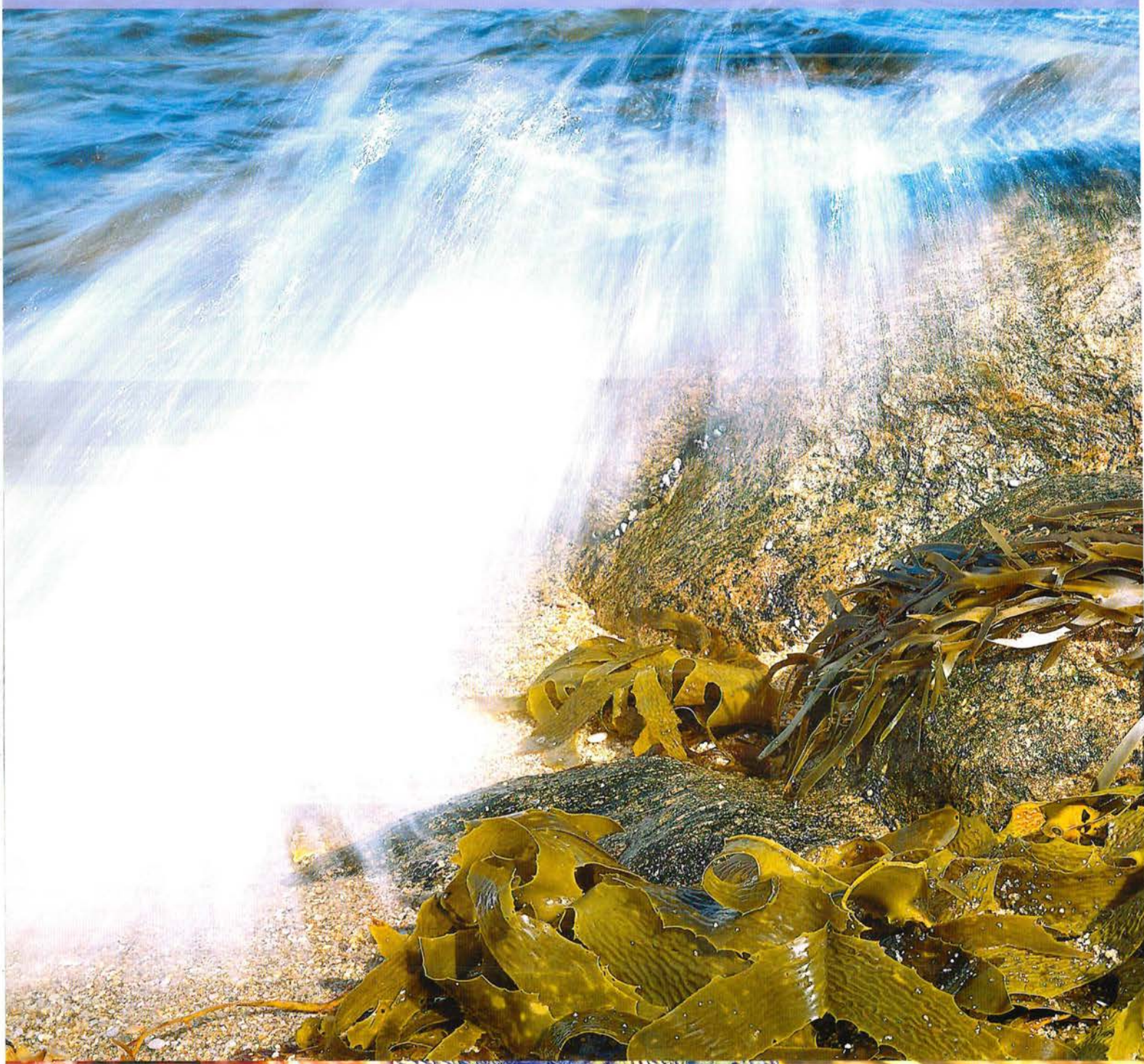
Naming The park is yet to be officially named. The working name 'Mundaring National Park' may change as a result of recent public consultation.

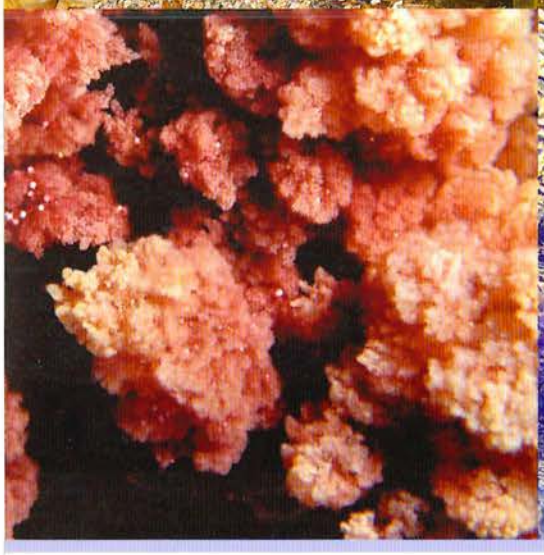
What to do Bushwalking, picnicking, wildlife observation, photography.

Must see sights Golden View Lookout at South Ledge, Fred Jacoby Park, North Ledge.

Facilities Wood barbecues (BYO wood), shaded picnic areas, toilets.

Nearest DEC office Perth Hills District Office, Mundaring Weir Road, Mundaring, phone (08) 9295 9100.

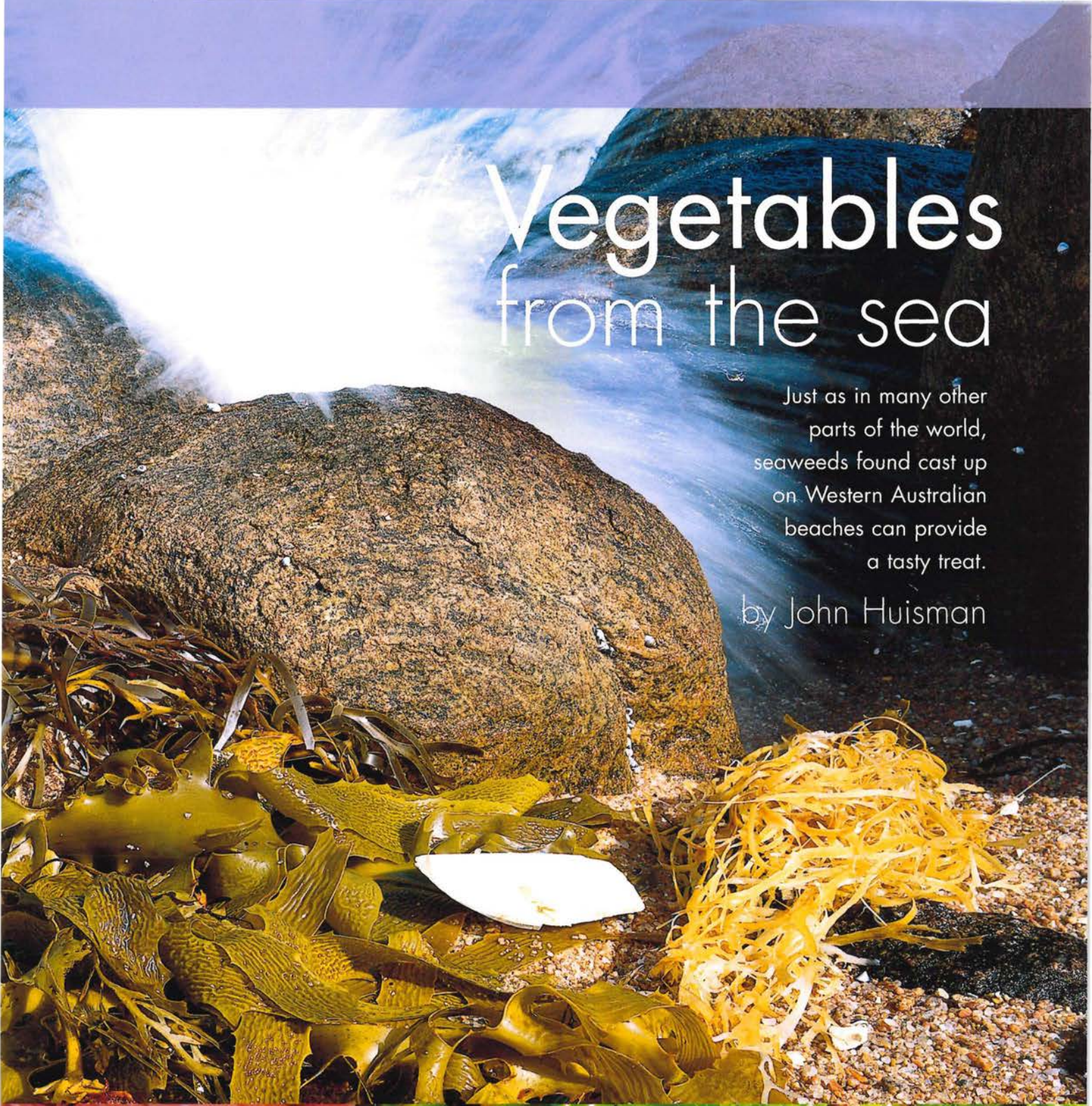


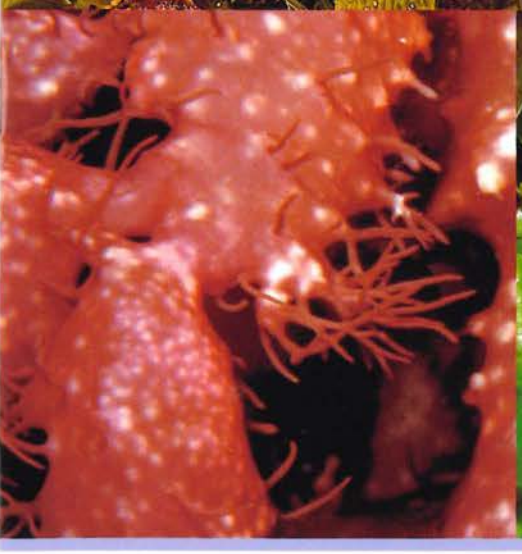


Vegetables from the sea

Just as in many other parts of the world, seaweeds found cast up on Western Australian beaches can provide a tasty treat.

by John Huisman





We often regard seaweed as something to avoid. It collects in huge smelly piles on the beach, or slithers around the ankles during a paddle in the shallows, generally making that trip to the seashore a less pleasurable experience. Sure, it is essential for the wellbeing of the coastal ecosystem, but what possible direct value might there be to people? Surprisingly to most, that value is immense and varied. Some 400 different species of seaweeds around the world are used by people for food, stock feed, medicines, fertilisers, and to provide raw materials for food processing and numerous industrial processes. And these seaweeds are valuable, generating billions of dollars each year.

Seaweeds have been a staple part of Japanese and Chinese diets since prehistoric times. As far back as 600 BC, Sze Teu wrote in China 'Some algae are a delicacy fit for the most honoured guests, even for the King himself'. Presently some 21 species are eaten in Japan, where they account for about 10 per cent of the Japanese diet. Seaweeds are also eaten in other parts of Asia, in Europe and in several places in the tropical Pacific. In the Hawaiian Islands, edible seaweeds (known as *limu*) are an important part of the local cuisine and have been for centuries.

As well as the species eaten directly, many seaweeds are used to make desserts. This is possible because the cell walls of these seaweeds produce compounds known as colloids, which can be extracted and will set at room temperature. The Western Australian jelly weed (*Betaphycus speciosum*) is one of the few examples of local seaweeds with a history of human use. In the early days of the Swan River Colony, beach cast plants of this seaweed would be collected and used to make jellies or blancmanges. Plants are cleaned and bleached in the sun, roughly chopped and then simmered in milk for about 30 minutes. Once the mixture starts to thicken it is strained to remove the seaweed (which is discarded), flavoured, and then allowed to set in the fridge or at room temperature.

Relative to other nationalities, Australians are newcomers when it comes to eating seaweeds, but our recent enthusiastic adoption of Asian cuisine is resulting in a broadening of tastes to include these marine vegetables. The thought of eating sushi rolls wrapped in seaweed would have been incomprehensible to most Australians of 50 years ago, but today these exotic foods are widely available and are even treated as a healthy alternative to fast food. By and large, however, all of the seaweeds eaten in Australia are grown overseas and imported, arriving here already processed. But with our vast coastline, we also have a great untapped natural resource,

Previous page
Main Common kelp (*Ecklonia radiata*) at Quarry Bay in the proposed Capes marine park.
Photo – Alex Bond
Insets (from left) Foxtails (*Asparagopsis*).
Photo – John Huisman
Common kelp.
Photo – Julia Phillips
Ogo (*Gracilaria*), jelly weed (*Betaphycus*), sea lettuce (*Ulva*) and sea grapes (*Caulerpa*).
Photos – John Huisman

Above left Alvarez's jelly weed (*Kappaphycus*) growing on rope in a Balinese seaweed farm.
Photo – John Huisman

Left Nori farm in Japan.
Photo – Tadao Yoshida

virtually on our doorstep. With a little encouragement and a taste for experimentation, it should be possible for Western Australian seaweeds to also find a place at the dinner table!

Only a few seaweeds have an appealing taste when eaten raw, so 'grazing' along the shoreline is unlikely to please the taste-buds. The coast of Western Australia supports more than 1000 different seaweed species, and it would be a huge undertaking to assess each one for edibility. Instead, it is worth looking at the practices in other cultures. Some 30 seaweeds are used regularly as food in other countries. Many species or closely related species used by those cultures can be found in Western Australia. This article examines just a few.

Nori

Nori (*Porphyra* species) is one of the most valuable products yielded by the oceans. In Japan, fishers have cultivated nori since the seventeenth century, by placing bamboo or brushwood poles in the ocean to increase the available surface area for plants to grow on. Annual production of nori in Japan is valued at well over US$1 billion dollars, making it one of the world's most valuable aquaculture crops. As well as being used as the familiar wrapping around sushi rolls (more accurately called *sushi maki*), nori is used to flavour a wide variety of snack foods. Nori is sold in sheets that may be toasted to give a green colour and then flaked and added to sauces, soups and broths. In the United Kingdom, *Porphyra* is known as 'laverbread' and is collected from the shore at low tide. Plants are boiled to make a spinach-like paste, which is then thinly spread on toast. In Wales, it is even added to cheese. *Porphyra* provides excellent nutrition. It has high protein content and is full of vitamins, trace elements and minerals. The vitamin C content of nori is 1.5 times that of oranges.

Nori grows during the winter months on rocks high in intertidal areas. It looks similar to sea lettuce, but is typically a purple colour. It is generally a plant of colder waters and, in Western Australia, does not occur further north than the Perth region.

Sea lettuce

Sea lettuce is the common name used for blade-like species of the green algal genus *Ulva*. Plants are thin and membranous, being only two cells thick. Sea lettuce can be used directly as a salad vegetable, or cooked and added to soups.

Top Sea lettuce (*Ulva*).

Above A fully laden kelp harvester in France. Alginates will be extracted from these plants, some of which will end up in expensive French cosmetics.
Photos – John Huisman

The wonderful world of seaweeds

Did you know?

Seaweeds form the basis of a multimillion dollar industry that produces jellies and thickening agents. The red seaweeds *Kappaphycus* and *Eucheuma* are cultivated in several tropical countries for carrageenan, a component of their cell walls that is extracted and used in a variety of foods, industrial processes, medicines and cosmetics, to thicken and stabilise liquids. Carrageenan is commonly added to toothpaste and shampoo, so you might well be using a seaweed product every day!

Seaweeds are also used in medicine. The red seaweeds *Digenea simplex* and *Chondria armata* (plus others) produce compounds such as kainic acid and domoic acid. These are toxic in large amounts but in small quantities provide an effective anti-worm treatment. In Asia, *Digenea* extracts taken orally have been used as a folk remedy to treat roundworm infestation for centuries. Several other seaweeds including foxtails produce high levels of iodine and have been used in the treatment of goiter (swelling of the thyroid). Other seaweeds are currently being investigated for anti-cancer activity.

Seaweeds can be used in gynaecology. When dilation of a narrow or closed cervix is needed before any gynaecologic procedure, a small tube of dried kelp seaweed *Laminaria* is placed in the cervix. This slowly absorbs moisture from the surrounding tissues and swells, gently opening the cervix and allowing access to the uterus and fallopian tubes. This type of dilation greatly reduces the risk of injury.

Seaweeds are the only source of agar, a complex carbohydrate that is extracted from some red seaweeds that solidifies at room temperature. Agar is used in many industrial processes and in the production of agar plates for microbiology.

Seaweeds are also a wonderful addition to the garden. As well as being excellent mulch, brown seaweeds are used commercially to produce fertiliser. These seaweed-derived fertilisers contain growth promoters and also compounds that enhance the health of plants, increasing their resistance to disease and attack by pests.

Left Foxtails (*Asparagopsis*).

Below left Ogo (*Gracilaria*).
Photos – John Huisman

Another option is to toast sea lettuce. Plants are cleaned then rubbed with a mixture of sesame oil and salt. Several sheets are then rolled together and left to stand for five minutes. The sheets are then unrolled and cooked separately in a hot pan until crisp, then cut into smaller pieces and served with rice.

Sea grapes

Some species of *Caulerpa* (*C. racemosa* and *C. lentillifera*) are eaten under the names sea grapes or green caviar. They are eaten raw and can have a pleasant crunchy texture, as the small grape-like vesicles 'pop' in the mouth. In south-east Asia, sea grapes are cultivated for human consumption. Sea grapes (*Caulerpa racemosa*) is the only species of seaweed mentioned here where some caution is advised, as it is known to contain certain compounds that could cause a reaction in people. If plants have a strong peppery flavour, they are probably best avoided (see the section 'Is it safe?').

Foxtails

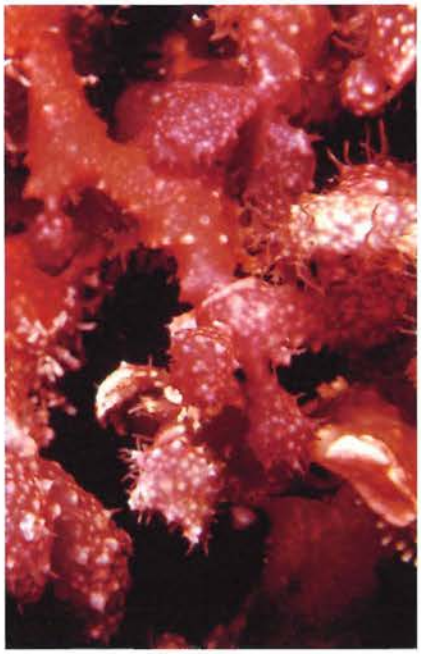
Foxtails or iodine weed (*Asparagopsis taxiformis*) is regarded as the supreme *limu* of the Hawaiians, where it goes under the name *limu kohu*. It is so popular that many Hawaiian reefs have been denuded of this seaweed, and it is advisable to collect only the fluffy upper portion, leaving the basal parts to regenerate. Plants are cleaned thoroughly, soaked overnight in fresh water (an essential step to remove potentially toxic compounds) and then lightly salted. Pieces are then rolled into small balls and added to raw fish or stews. The flavour is very strong and peppery, so only a small amount is used. Strangely, this seaweed finds favour with very few people not of Hawaiian origin, and its usage is virtually restricted to the Hawaiian Islands.

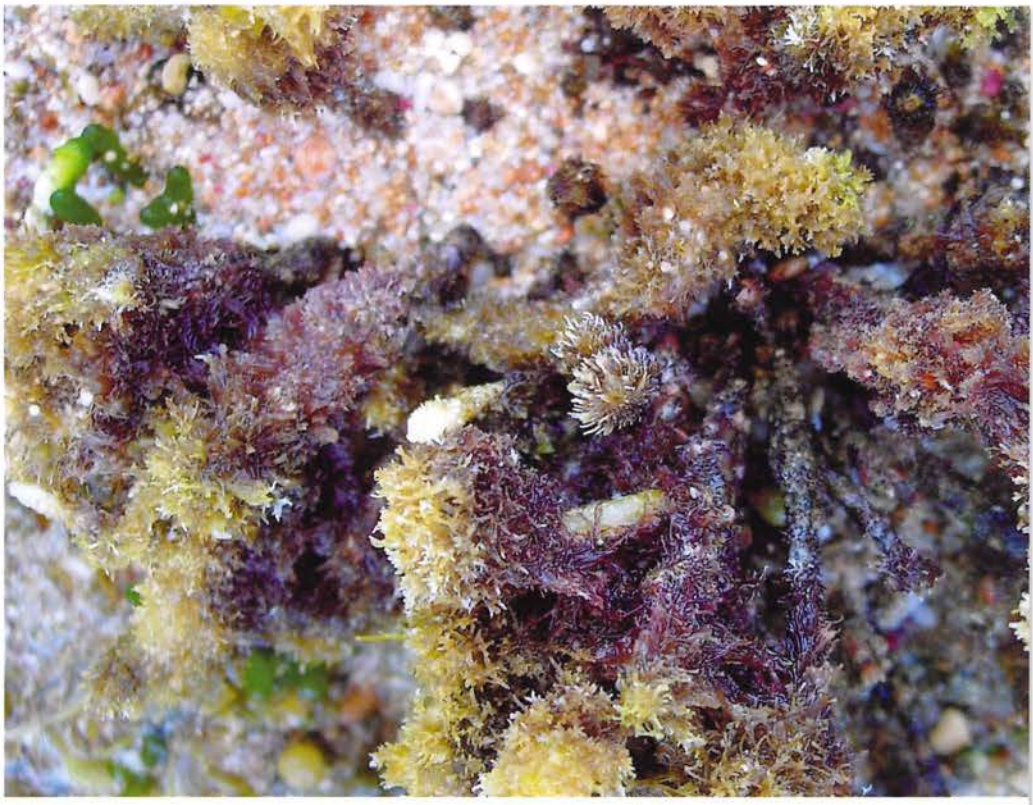
Ogo

Ogo (*Gracilaria* species) can be eaten raw, but some people recommend it first be plunged into boiling water for two to three minutes. It then becomes an attractive green while retaining its crispness. Ogo is a vital component of the Hawaiian dish *poke* (pronounced po-KAY), which is essentially cubed raw fish (generally sashimi-grade tuna), combined with soy, sesame oil, toasted sesame seeds, chopped ogo and sea salt. The mix can be served immediately or refrigerated for an hour or two.

Is it safe?

The vast majority of seaweeds do not produce compounds that are harmful to people. Some species in the genus *Caulerpa*, including sea grapes, have been reported to show some human toxicity. They produce substances, such as caulerpin, caulerpicin and caulerpenyne, which appear to repel grazers and possibly stop other organisms from settling on





Above left Jelly weed (*Betaphycus*).

Above *Digenea* from tropical Australia —used elsewhere to combat roundworm for centuries.

Right Hair weed (*Lyngbya*)—one to avoid!
Photos – John Huisman

the *Caulerpa* fronds. These compounds have demonstrable impacts on animals and on human cells, but the general belief is that the levels that might be ingested are not sufficient to cause problems. In other countries, sea grapes are reported to develop a bitter taste at particular times of the year, presumably as a result of toxin accumulation, so any plants with a bitter taste should be avoided.

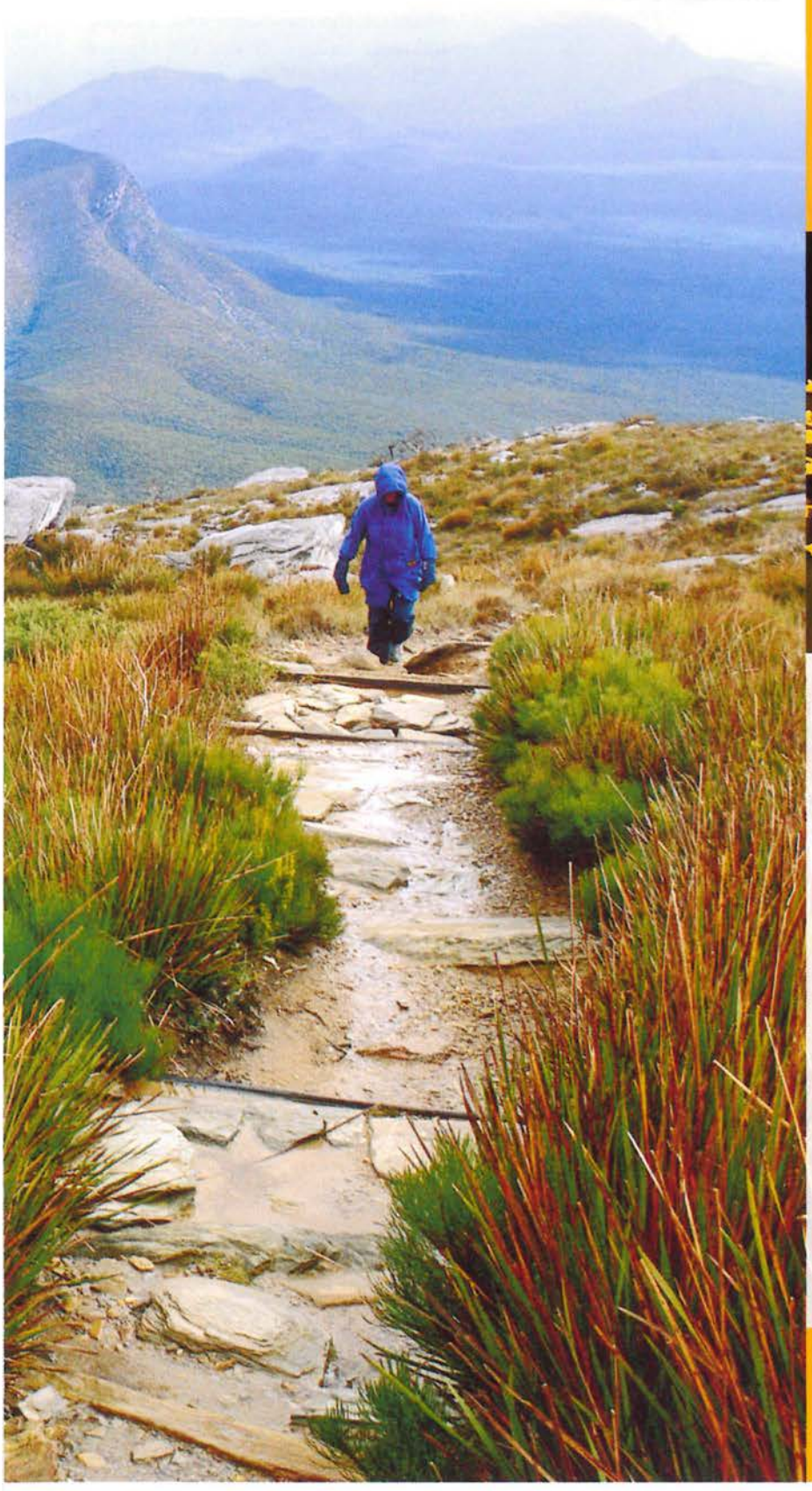
There have also been reports of *Caulerpa* causing an allergic reaction, with symptoms including dizziness, numbness at the tip of the tongue, and breathing difficulties. Whether these symptoms are the result of toxins produced by the seaweed, or something ingested coincidentally, is not known. Incidences of food poisoning from eating the red algae *Gracilaria* and *Acanthophora* have been reported in the tropical Pacific (such as in Guam, Hawaii, Japan and the Philippines). One outbreak resulted in eight deaths, but it is suspected the causative agent was not the seaweed, but associated microorganisms ingested with it. One of the compounds implicated in these deaths is known as aplysiatoxin. Aplysiatoxin was first discovered in the sea hare *Stylocheilus*, but actually originates in the blue-green alga *Lyngbya majuscula* that forms part of the sea hare's diet. In the tropics, *Lyngbya* can be a common inhabitant of reef flats and is known to cause contact dermatitis ('swimmer's itch'). There are also cases of *Lyngbya* causing the death of marine turtles in Queensland. This species grows to about 20 centimetres tall and looks very much like coarse, dark purple or black hair. It is definitely one to avoid!

Certainly, some caution is appropriate. Only eat seaweeds taken from unpolluted areas and which are themselves clean of associated epiphytes (attached plants). Never eat seaweeds growing in the proximity of *Lyngbya*. For the most part, seaweeds that taste good will not be harmful—it is perhaps redundant to say, but do not eat anything that is particularly distasteful. There is little danger of being poisoned by seaweeds that taste pleasant.

Remember, despite the implications of the name, all our seaweeds are native to WA coasts and their collection is managed by the Department of Environment and Conservation. Before gathering plants, ensure that appropriate licenses are obtained.

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 from various parts of the world.

If you enjoyed this article then look out for the new full colour pocket-sized Bush Book, *Marine plants of the Perth region*, which John has cowritten. It contains a wealth of information on our local seagrasses and seaweeds. It is available from most bookshops, Department of Environment and Conservation offices and online through NatureBase (www.naturebase.net) for a recommended retail price of $6.50.



Threatened communities on high: **Stirling plants**

Mountain environments are rare in Western Australia and their conservation is a priority. The mountain heath and thicket community of the eastern Stirling Range is no exception.

by Anne Cochrane and Sarah Barrett

The need to protect the mountainous environment of the Stirling Range was recognised by its declaration as one of Western Australia's first national parks in 1913. The park protects the only real mountain range in the south-west of the Australian continent, rising some 850 metres above the surrounding plains. Its highest point, Bluff Knoll, is 1080 metres above sea level.

Today, the Stirling Range National Park forms part of the internationally recognised 'megadiverse hotspot' of southern WA, an extremely rich botanical region. The Stirling Range National Park flora contains some 90 families, 384 genera and 1517 species—more than that recorded in many entire countries—within its 115,600 hectares. Eighty plant species are found only within the park boundaries and nowhere else in the world!

These mountains are effectively islands, providing a wide range of habitats in an otherwise largely flat landscape. Although the park experiences a typically Mediterranean climate with wet winters and dry summers, the mountains have a strong influence on local climate. The exposed higher peaks exhibit more extreme temperatures, with extended drizzle through summer and even occasional snow during winter.

The Stirling Range is composed largely of ancient sandstone and quartzite rocks formed from deposits in shallow waters at least 1100 million years ago. The major plant communities in the range relate to soils and topography. Thicket (dense tall shrubs) occurs on the shallow soils of the peaks, mallee-heath (multi-stemmed eucalypts over shrubs) on the slopes and plains, and woodlands clothe the valleys. Drainage from the slopes forms either salt lakes or freshwater swamps. Thicket and mallee-heath vegetation are rich in members of the banksia, pea, myrtle and southern heath families and contain many of the plants that are unique to the range.

Community values

In the eastern Stirling Range a mountain plant community—quite distinct from that in the central and western areas of the Stirling Range—is found at altitudes greater than 750 metres above sea level. The community structure is typically that of a dense heath or thicket with scrub vegetation on shallow soils, and it is one of the most threatened vegetation communities in WA.

This 'Eastern Montane Mallee Heath and Thicket Community', as it is technically known, of the Stirling Range extends from the easternmost

Previous page
Main A walker approaches the summit of Bluff Knoll.
Photo – Alex Bond
Inset Mountain kunzea (*Kunzea montana*).
Photo – Jiri Lochman

Left Sunrise behind Pyungoorup and Isongerup peaks in the Stirling Range National Park.
Photo – Alex Bond

Above left Yellow mountain bell (*Darwinia collina*).
Photo – Andrew Brown

Above Mountain dryandra (*Dryandra montana*).
Photo – Ellen Hickman

peak of the Stirling Range at Ellen Peak and continues at these altitudes to Coyanarup Peak and includes Pyungoorup (1060 metres), the Arrows, Isongerup (994 metres), Moongoongoonderup (750 metres) and Bluff Knoll. It covers about 375 hectares along this ridgeline. A separate occurrence of approximately 20 hectares is found on the summit area of Mount Success.

This threatened community contains most of the plant species that are unique to the range, including 11 threatened species. Three of them are members of the well-known mountain bell group: the yellow mountain bell (*Darwinia collina*), the fringed mountain bell (*Darwinia squarrosa*) and the Success bell (*Darwinia* sp. Stirling Range). Also threatened are Drummond's grass (*Deyeuxia drummondii*), mountain paper-heath (*Sphenotoma drummondii*) and mountain rattle-pod (*Daviesia obovata*).

The attractive feather-leaved banksia (*Banksia brownii*) was previously considered to be endangered but was upgraded to critically endangered because of recent population extinctions and a projected decline in population size of more than 80 per cent over the next three generations (see 'The feather-leaved banksia', *LANDSCOPE*, Autumn 2005). The giant andersonia (*Andersonia axilliflora*), mountain dryandra (*Dryandra montana*), small-flowered snottygobble (*Persoonia micranthera*) and Stirling Range beard-heath (*Leucopogon gnaphalioides*) are also listed as critically endangered. To protect the latter three species from extinction, a seed orchard has been established near the Porongurup National Park (see 'A safe haven for threatened plants', *LANDSCOPE*, Summer 2005-06).

Other species that characterise the community include mountain kunzea (*Kunzea montana*), southern sandplains beaufortia (*Beaufortia anisandra*), Stirling Range paper-heath (*Sphenotoma* sp. Stirling Range), hedgehog heath (*Andersonia echinocephala*) and Stirling Range clawflower (*Calothamnus crassus*). In spring, the thicket is a mass of flowering shrubs and is a sight to behold. This mass flowering occurs later than on the lowlands and is at its best in October. Eucalypt species are notable for their absence but occur at immediately lower altitudes.

Vegetation community at risk

The predominant threat to the plant species that form the rare mountain thicket and mallee-heath communities is the root-rot pathogen *Phytophthora cinnamomi*—or *Phytophthora* dieback—which transforms the vegetation. This soil-borne pathogen causes root-rot and death of susceptible plants. A range of proteaceous species such as mountain banksia (*Banksia oreophila*), Stirling Range banksia (*Banksia solandri*) and Stirling Range honeypot (*Dryandra concinna*)—which were once significant members of this community—are now rare, primarily due to the impact of *Phytophthora*-caused dieback. Sedges and other disease-resistant plants are progressively replacing colourful tall banksias and dryandras.

Fire is also affecting the biological diversity of the range. Fire is an important element in the regeneration of many native plants, but if fires occur too frequently they can change the composition and abundance of many species. Plant growth after fire is often extremely slow in exposed mountain areas as it is impeded by

Above Signage at Bluff Knoll.
Photo – Renee Hartley

Above right Hedgehog heath (*Andersonia echinocephala*).
Photo – Anne Cochrane

the low temperatures and high wind speeds that prevail for much of the year, affecting those species that are slow to mature and set seed.

Climate change (see 'Climate change and biodiversity' on pages 54-61) has also been identified as a major threat to the diversity of the mountain vegetation community. It is now widely accepted that the world's climates are changing due to the emission of greenhouse gases such as carbon dioxide and methane. Predictions suggest that, relative to 1990, south coast temperatures will rise by up to 1.5°C and rainfall may reduce by up to 60 per cent over the next 20 to 30 years. As there is nowhere for the mountain-top endemics to go, it is possible that many of these species will become extinct.

Recreational values

As it protects the most significant mountain environment in the south-west of WA, the Stirling Range National Park is highly valued by local and overseas visitors. Often enclosed in mist and cloud, the mountains are shrouded in mystery and this is part of their attraction. This iconic area has had a long history of recreational use and the high peaks of the park have attracted visitors interested in rock climbing, bushwalking and nature appreciation. The diversity of microclimates, soils and topography have also attracted biologists and naturalists.

Being the highest peak in the range, Bluff Knoll is the most popular day outing in the park and the five-hour return walk provides visitors with exceptional views from the summit on a clear day. In 2005-06 about 34,500 people visited the Bluff Knoll car park, although less than half of them completed the walk to the summit.

The walk from Ellen Peak to Bluff Knoll is a popular two-to-three-day wilderness walk that challenges a small number of people each year. The route passes through the unique mountain vegetation community. The major impact of recreational activity on the mountain thicket threatened ecological community has been increased spread of plant disease, most probably through the transport of infested soil. Due to the introduction of *Phytophthora* dieback to high points in the landscape by human and animal vectors, the entire eastern ridge is now infested. Any clearing of ground for tents can also impact on this threatened plant community. Trampling and braiding of tracks in some areas also has adverse effects on the fragile plant community, particularly in the early years after fire when seedlings are very vulnerable to damage.

Conservation strategies

A recovery team consisting of representatives from the Department of Environment and Conservation (DEC), local botanists and community groups assists with the management of the threatened mountain vegetation community in the park. Mapping of diseased areas, flora surveys and documentation of growth and survival in key threatened species are ongoing activities. Aerial spraying of infested areas with the fungicide phosphite has successfully slowed the decline of susceptible species in those areas. Implementing a fire management

Above Bushwalkers on the walk from Ellen Peak to Bluff Knoll.
Photo – Rob Olver

Below Fringed mountain bell (*Darwinia squarrosa*).
Photo – Andrew Brown

strategy and conducting ecological research is considered vital, and conserving the seeds of key species is being undertaken as a priority.

It is hoped that remote weather stations can be installed on some peaks in the future to gather long-term climate data. This would provide scientists and managers with a more precise understanding of the environmental conditions prevailing at these altitudes, and ecological parameters such as flowering, fruiting, recruitment and survival in key mountain species may then be linked to prevailing temperature, soil and rainfall conditions.

Harmonious coexistence

To ensure the ongoing survival of this unique vegetation community, a new code of conduct is being developed for walkers to minimise trampling, reduce camping impacts and discourage disposal of rubbish. Fires have been prohibited for many years and this is being strongly reinforced. The code of conduct—conveyed by trailhead signs and other information points—will alert users to the nature conservation values of the area and its unique flora. As well as the precious plants, numerous native animals, both large and small, rely on this mountainous environment and will also suffer if their habitat declines further.

More and more people are experiencing the pleasure of reaching a summit and glimpsing a sunrise or sunset, seeing the colours of the bush blanketed in snow or catching sight of a distant peak shrouded in mist or cloud. These experiences of the mountainous environment of the Stirling Range should be treasured. But this area and the precious plants that form the special vegetation community should be respected. We must all observe the signs, abide by the code of conduct to reduce the spread of *Phytophthora* and ensure that footwear is clean. It is our duty to ensure that generations to come can continue to enjoy the wildflowers of this area.

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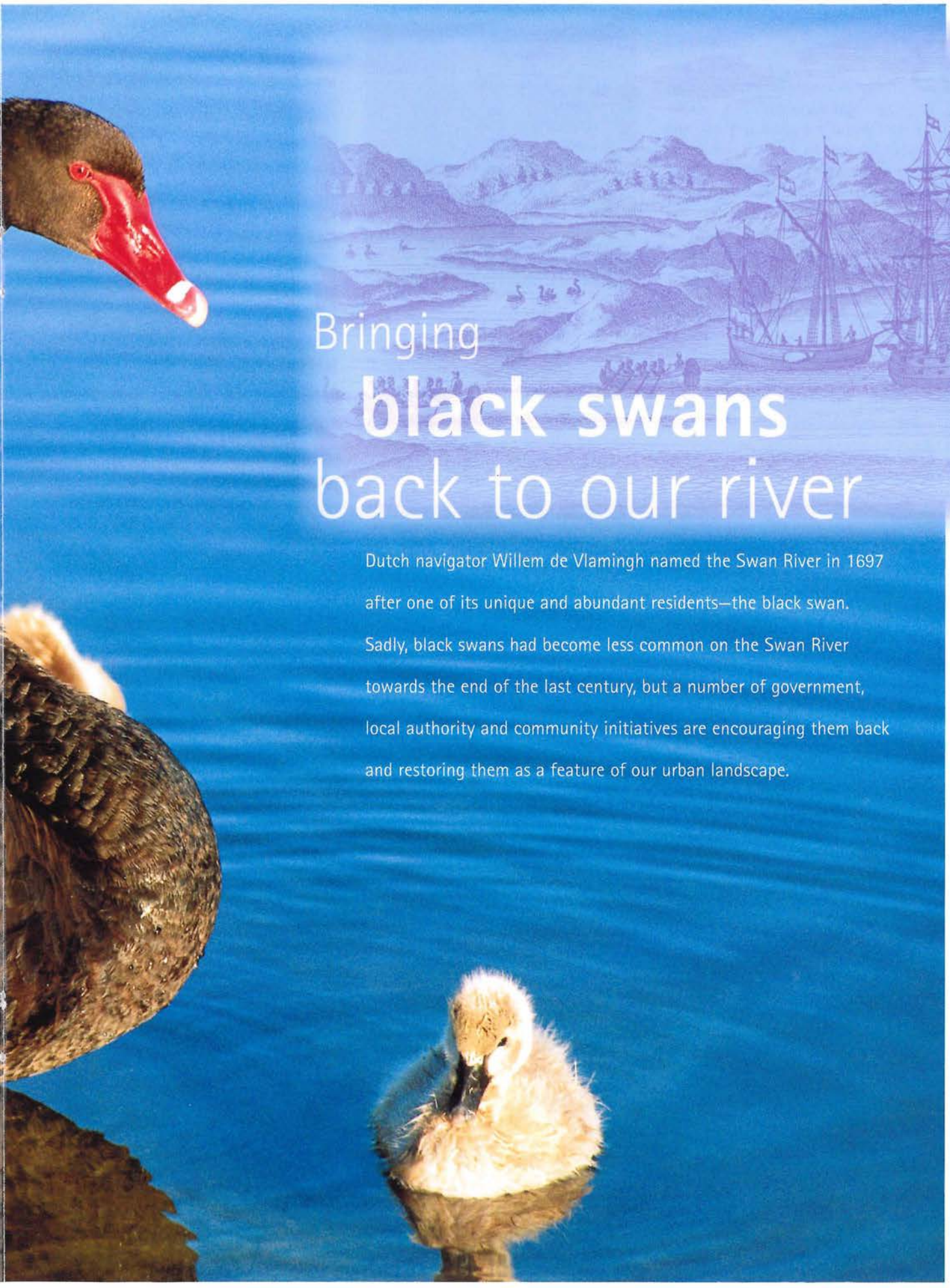


Bringing **black swans** back to our river

Dutch navigator Willem de Vlamingh named the Swan River in 1697 after one of its unique and abundant residents—the black swan. Sadly, black swans had become less common on the Swan River towards the end of the last century, but a number of government, local authority and community initiatives are encouraging them back and restoring them as a feature of our urban landscape.

by Rhianna King

Black swans (*Cygnus atratus*) are visible in much of Perth's urban landscape. Nowadays, they can be seen on a number of suburban wetlands and increasingly on the Swan River, while many government and city offices, businesses, universities, landmarks, taxies and even a theatre company carry the black swan image as their badge. Swan Brewery, an iconic Western Australian company, carries a picture of a black swan on its labels with the words 'The spirit of Western Australia'. It's open to interpretation as to whether the slogan refers to the swans or the liquid amber! The black swan is so synonymous with the identity of Western Australia that it is the State's bird emblem.

From ugly 'ducklings' to beautiful swans

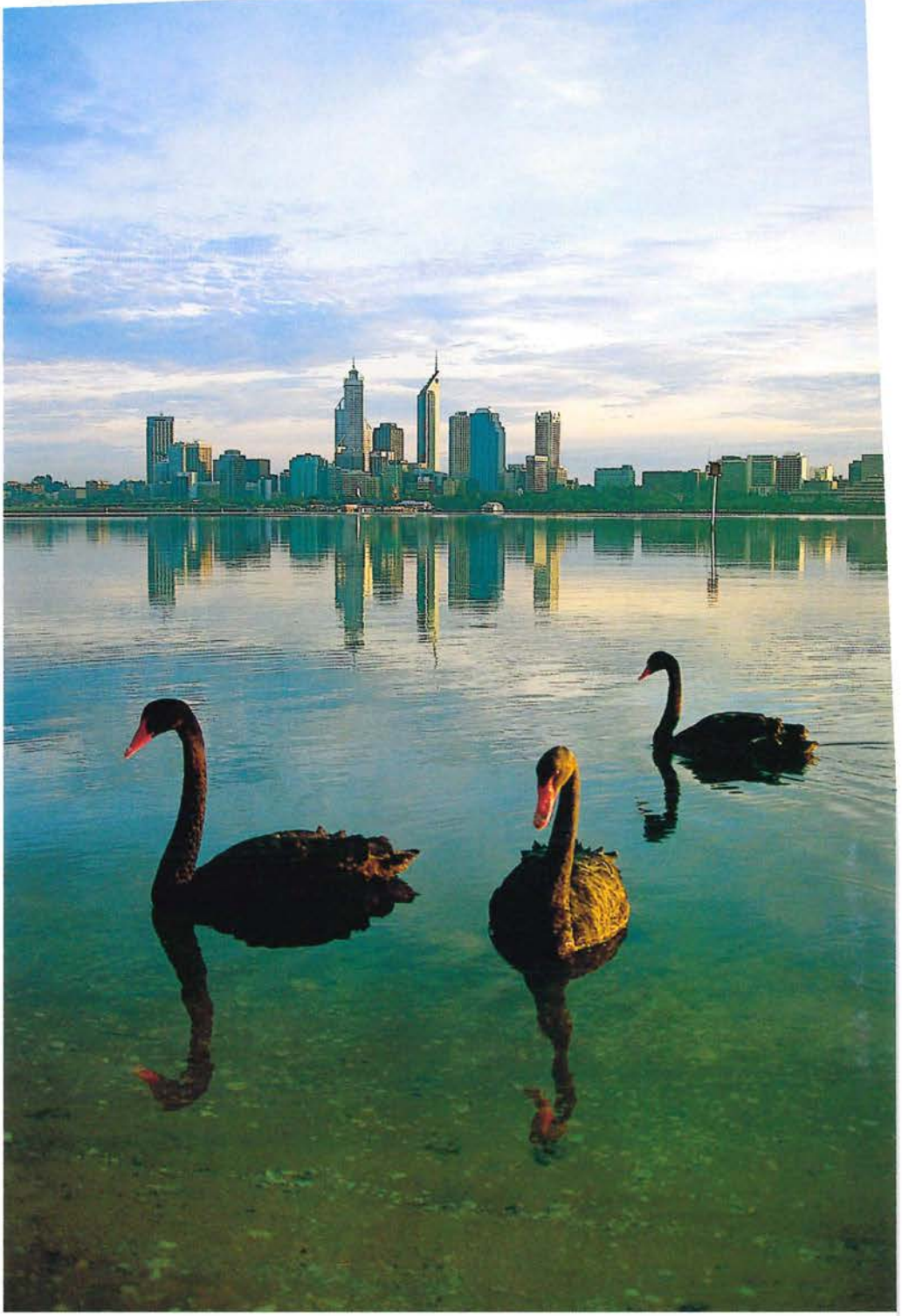
Black swan cygnets, with their light grey down, are anything but ugly. In fact, they are a beloved sight on metropolitan waterways when they emerge towards the end of winter, signifying that spring is around the corner. Cygnets develop light brown feathers after three or four weeks, and continue to get feathers until fledging. At around two months, their bills change colour from dark grey to black, to that of adults, which varies from orange to dark red with a white bar near the off-white, horny tip. Their eye colour also changes from grey to light brown as cygnets, to white and then red during the mating season.

Previous page
Main Black swans and their cygnets are WA's iconic bird species.
Photo – Jay Sarson/Lochman Transparencies
Inset Sketch of Vlamingh's three vessels lying at anchor on the mouth of the Swan River, with two smaller vessels about to enter the river where swans are abundant.
Image – Reproduced from the original with permission from Rare Book and Special Collections Library, University of Sydney.

Left A black swan with its cygnet.
Photo – Rhianna King

Below Black swans pair for life and both tend to their cygnets.
Photo – Michael James/DEC

Black swans are ready to breed at 18 months and most do so before they are four years old. Often, they select a temporary mate when they first reach sexual maturity but then find one they stay with for life and, like other swans,



Right Black swans on Perth's Swan River. *Photo – Andrew Davoll/Lochman Transparencies*

primarily remain monogamous. Black swans lay between two and nine eggs, during July and August, in nests that vary from a simple ring of plant matter to a large mound. After an incubation period of around 40 days, the cygnets hatch and take to the water shortly after.

In captivity, swans can live for up to 20 years. Their life expectancy is less in the wild where they are at risk of poisoning through pollution, botulism, fungal infections, parasites and worms, predation by foxes and birds of prey, and accidental death.

Early accounts

Black swans have a special place in Western Australian culture that dates back to long before the arrival of Europeans. In the Aboriginal Dreamtime, the totem (representative animal) of the Derbal Yerrigan (Swan River) clan is the 'Moorn Maarli', or the black swan, because a part of the river is understood to be shaped like one. Indigenous people also revere black swans because they are 'moort', or family orientated, like themselves. The black swan is also a totem bird for the Bibbulmun Nyoongar people who are responsible for conserving and protecting the totems.

Dutchman Willem de Vlamingh ventured up the Swan River in 1697. Vlamingh observed many fish and birds on the river, particularly black swans. Even though, more than 60 years earlier, fellow countryman Antonie Caen had described black swans on a visit to Shark Bay, many Europeans did not believe black swans existed. We now know there are seven species of swan, of which only the Australian black swan and the South American black-necked swan are black.

The former abundance of black swans on the river is clear from the accounts of explorers such as Captain James Stirling, who in 1827 marvelled at the hundreds of black swans on the Swan River, and NSW Colonial Botanist Charles Frazer who, in the same year, wrote that:

> 'The quantity of black swans, pelicans, ducks, and aquatic birds seen on the river was truly astonishing. Without any exaggeration, I have seen a number of black swans which could not be estimated at less than 500 rise at once, exhibiting a spectacle which, if the size and colour of the birds is taken into account, and the noise and rustling occasioned by the flapping of their wings previous to their rising, is quite unique in its kind. We frequently had 12 to 15 of them in the boats, and the crews thought nothing of devouring eight roasted swans in a day'.

It seems that in the early days of European settlement black swans were at risk of becoming a feature of the evening menu. But significant changes to the wetlands and rivers of the urban landscape, and the human activities they supported, most likely led to the decrease in the number of black swans, particularly on the Swan River, over the last century.

Widespread nomads

Black swans are nomadic and capable of moving long distances. They occur in every Australian state and territory and can be found throughout much of the country's south-east and south-west, to as far north along the eastern coast as Townsville in Queensland. In WA, black swans are found throughout the south-west and the Goldfields, as

well as in parts of the mid-west, Pilbara and Kimberley in varying frequencies and usually only when lakes in the area contain water. They are also known from salt lakes and coastal areas. They can even be found in large puddles or ponds on agricultural properties in the southern Swan Coastal Plain after heavy rains—often an unexpected sight. Between September and February black swans moult, rendering them flightless, and during this time they often gather on open lakes.

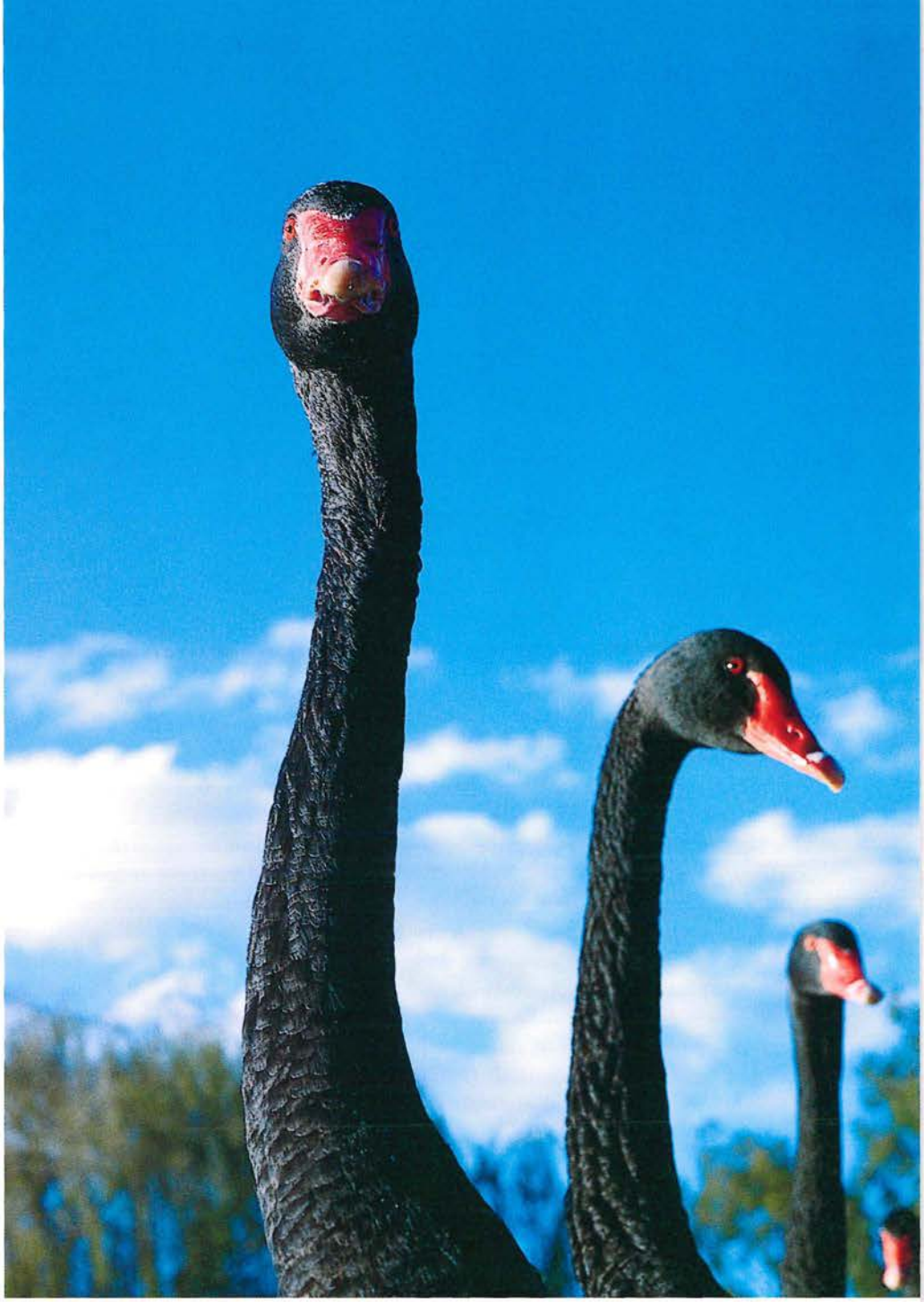
While it has been significantly modified since European settlement, the wetland system of the Swan Coastal Plain (including what is now the Perth metropolitan area) remains an important habitat for many waterbirds, including black swans. Black swans often nest inland on natural and artificial lakes and waterways and, despite having become an icon of the Swan River, seem to mainly occur on it when they are associated with adjacent wetlands. In the Perth metropolitan area they commonly occur on Lake Monger, Thomsons Lake, Bibra Lake, Forrestdale Lake, Herdsman Lake, Lake Cooloongup, Big Carine Swamp, Lake Kogolup, Gibb Road Swamp and Lake Yangebup.

The availability of food and suitable nesting sites are the primary factors of black swan habitats. While they occur on fresh and saline lakes, swamps, rivers and estuaries and at sea, black swans must drink relatively fresh water each day so they need access, within flying distance, to fresh water sources. They also need access to floating and submerged aquatic plants such as paddleweed seagrasses, pondweeds, introduced water-couch grass and young bulrush shoots, as well as other rushes and sedges for food. The lawns surrounding the lakes inhabited by black swans in metropolitan areas also play a role in their diets.

Top left Black swans seek habitats with suitable nesting sites.
Photo – Stuart Miller/Lochman Transparencies

Above left A pair of black swans 'duck diving' for food.

Left Lawns surrounding lakes play a role in the diet of black swans.
Photos – Rhianna King



Right Black swans.
Photo – Jiri Lochman

Black swans nest in colonies and as individual pairs, often in the same place each year. They create their nests in areas surrounded by water with protection from flooding and, nowadays, also from people and their activities, domestic pets and other animals. Black swans will only nest at locations where the water is at least 30 centimetres deep and where suitable materials—including reeds, samphires, aquatic plants, sticks and bark—are available for nest construction.

Swan's lakes

In recent years studies have been undertaken to determine the reasons for the decrease in black swans on the Swan River. These studies have been undertaken by State government agencies, local authorities and community groups, often in an attempt to find ways to reverse the decline.

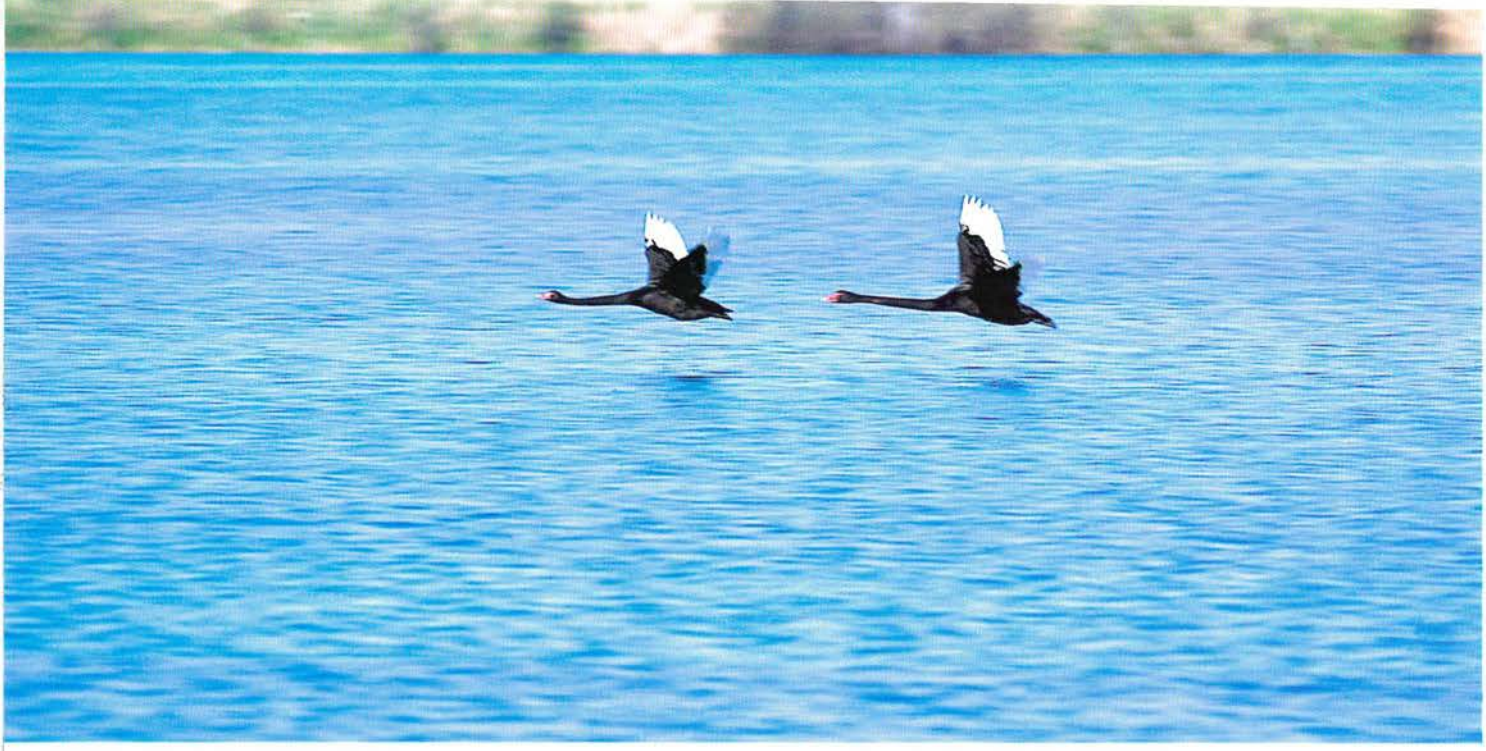
Years of lower rainfall and subsequent drying of smaller wetlands; changes to the river ecosystem through modified salinity as a result of dredging; modifications within the catchment area and pollution in the river affecting food sources have all been suggested as reasons for the decline in black swans. While these may well be contributing factors, a feasibility study conducted in 2000, by what was then the Water and Rivers Commission as part of a 'Bringing back the swans' project, concluded that the loss of shallow reef habitats—used by swans for nesting—due to land reclamation and urban development, and the availability of numerous wetlands in the Perth metropolitan area, were the most likely reasons for the absence of black swans from the Swan River. It also concluded that, if black swan habitats were restored and constructed, the birds would return to these sites. As a bonus, the areas would also appeal to other waterbirds that may have also left the Swan River due to loss of habitat.

The report identified a number of options to improve black swan habitats on the Swan River including creating permanent islands, creating embayments within the river, constructing wetlands, enhancing existing wetlands and improving existing features. In varying forms, these recommendations have been incorporated into a range of community and government-based projects.

A community effort

The 'Bringing back the swans' project has provided a basis for a number of projects designed to conserve and create habitats for black swans on the Swan River. It also highlighted the important role of local authorities and other stakeholders in getting such projects off the ground.

The development of Point Fraser, a recreational reserve adjacent to Riverside Drive not far from the northern end of the Causeway, is one such project. This area was reclaimed from the Swan River during the first half of last century. The redevelopment, in two stages, aimed to restore the riverine landscape that existed prior to European settlement; improve the health of the aquatic ecosystems through habitat restoration and best-practice stormwater management; interpret the natural, historic and cultural values and provide for passive recreation. A specification of the design brief was to create suitable habitat for black swans and other waterbirds. Stage 1 was completed in March 2004. Subsequent



Above Black swans in flight.
Photo – Dennis Sarson/Lochman Transparencies

Below Black swans are becoming a feature of Perth's urban landscape again.
Photo – Rhianna King

monitoring has shown that waterbirds are returning to the area.

The City of South Perth encompasses Sir James Mitchell Park, a high-profile area alongside the Swan River. A number of lakes within the park receive water from one of the City of South Perth's major stormwater drains and have been landscaped and designed for recreational use. With the Sir James Mitchell Park community working group, the City of South Perth is developing a plan to rehabilitate the beaches in the park and improve the quality of the lakes to encourage black swans to visit. The plan is expected to be completed by the end of the 2006–2007 financial year.

The 'Bringing back the swans' project also aims to ensure that planning of incidental foreshore redevelopment projects accommodate, and encourage, black swans. Other local authorities, such as the Town of Victoria Park, have long-term redevelopment plans that include considerations for black swan habitat. As with many projects of this nature, lack of funding is proving to be an obstacle. However, sponsorship and grants are being sought from a range of sources.

A far cry from a swan song

Black swans have not fared well since European settlement but remain an icon of the State. While anecdotal evidence suggests that the number of black swans found on the Swan River has increased in the past few years we still have a long way to go to redevelop and conserve their important habitats. Fortunately, the government and community projects working towards building a healthier and more swan-friendly environment are already showing signs of success.

The Swan Estuary Marine Park

Today the Swan River is a highly altered environment with relatively little of its original fringing vegetation. However, three important reserves at Alfred Cove, Pelican Point and Milyu are protected for their conservation value as part of the Swan Estuary Marine Park and adjacent nature reserves. The marine park was declared in 1990 and consists of 190 hectares at Alfred Cove adjacent to the suburbs of Attadale and Applecross; a 40-hectare area at Pelican Point in Crawley and 95 hectares at Milyu adjacent to the Como foreshore and Kwinana Freeway.

These areas encompass mudflats, seagrass beds and intertidal vegetation such as sedges and saltmarsh, which provide many different habitats for a number of animals. They are particularly important for a number of species of internationally protected transequatorial migratory wading birds, which are protected under the Japan–Australia and China–Australia Migratory Bird Agreements.

The marine park also plays an important educational role because of its close proximity to the Perth metropolitan area. It offers opportunities for birdwatching, fishing, windsurfing and boating and is a popular place to walk and cycle.

More information about the Swan Estuary Marine Park and its adjacent nature reserves can be found in the full-colour, pocket-sized book *Discovering the Swan River and the Swan Estuary Marine Park*, which is available for $6.50 from Department of Environment and Conservation offices, online at www.naturebase.net and from bookshops and newsagents.

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War against weeds

Weeds have long been a seemingly intractable—and growing—problem affecting conservation lands and other areas, displacing natural plants and destroying biodiversity. A raft of new initiatives, however, means that authorities may be finally beginning to turn the corner in the war against weeds.

by Greg Keighery and Kate Brown

Everyone who gardens recognises that weeds are undesirable. In gardens, in crops and in the bush they compete for space and nutrients and crowd out desirable plants. In Australia, weeds are major threats to agriculture (costing more than $4 billion per year in control and lost production) and biodiversity (displacing irreplaceable native plants and animals).

Most weeds entered Australia with European settlement. Between 1829 and 2006 Western Australia gained 1233 species of naturalised flowering plants (weeds). Of these, 677 species (55 per cent) are environmental weeds, recorded from natural bushland areas. The rest are weeds growing in agricultural and man-made areas, such as crops, lawns and gardens.

These weeds comprise 12 ferns, 15 pines, 345 monocotyledons and 861 dicotyledons. Another 94 plant species are listed as semi-naturalised garden escapes, chiefly around Perth. Most WA weeds are herbaceous annuals or grasses, with the largest groups being the grasses (Poaceae), with 196 species; daisies (Asteraceae), with 115 species; peas (Papilionaceae) with 106 species; and 53 species within the iris family (Iridaceae).

Checklists published in 1994 and 2004 showed that new species of weeds were naturalising in WA at the rate of 10 per year over this period. Since more than 27,000 species of plants are known to be cultivated in Australia, this suggested we were facing a situation like New Zealand where weeds outnumber the natives! However, over the past five years, a series of initiatives has helped to slow the introduction of potential new weeds, identify potential new weeds, limit their availability, remove small infestations and limit the effect of major weeds.

Previous page
Main Bulbil watsonia (*Watsonia meriana* ssp. *bulbillifera*) invading the herb-rich shrublands and winter-wet claypans of Meelon Nature Reserve.
Photo – Kate Brown

Top Ruby dock (*Acetosa vesicaria*) is a widespread weed in the Pilbara. Major control measures by DEC, mining companies, main roads and the public are limiting its impact and spread.
Photo – Rob Olver

Above left Kate Brown monitors the effectiveness of grass-selective herbicides on *Tribolium*, a weedy grass targeted as part of biodiversity conservation initiatives in the Swan region.
Photo – Grazyna Paczkowska

Left Weeds and native plants compete with each other near Gingin.
Photo – Sallyanne Cousans

Right Arum lilies grow along a creek in Gingin.
Photo – Sallyanne Cousans

Below The garden succulents *Cotyledon orbiculore* (right) and *Aeonium haworthii* (far right) have established in parts of the south coast and are being targeted for eradication.
Photos – Greg Keighery

Recognising the menace

In 1999, a group of weed workers —Roger Cousens, John Dodd, Penny Hussey, Greg Keighery and Sandy Lloyd—pooled their collective knowledge and, with the aid of the Plant Protection Society and Lotteries Commission, produced a colour field guide to WA weeds. *Western Weeds* subsequently sold more than 5500 copies and has been revised for a third printing.

As recognition has grown of the threat posed by weeds to our unique biodiversity, so have the range of efforts aimed at lowering this threat. Several initiatives and changes in WA have begun to limit and then reduce this menace. These initiatives have provided the resources needed to begin tackling environmental weeds that threaten our unique bushland. New resources are being applied to prevent new weeds from entering or establishing in WA, to eradicate small infestations of potential weeds and to control major weeds.

Prevention

During the past decade, there have been major changes to Australia's quarantine laws aimed at preventing new weeds from entering the country. The Australian Quarantine Inspection Service now subjects all requests to import new plants to a screening test to determine if they have characteristics that could aid their escape from cultivation and become weeds. This has largely replaced the old prohibited list of known weeds. The rapid growth in computer databases and the internet has helped this process, providing ready access to information about the weediness of thousands of plants from all around the world.

New biosecurity provisions recently enacted mean that WA retains the capacity to exclude plants found elsewhere in Australia that could be weedy here. While physical surveillance will always rely heavily on the collective knowledge of the Department of Agriculture and Food staff, utilising the internet as a database on potential weeds was pioneered by Rod Randall at the Department of Agriculture and Food. Rod, as part of his work with the Cooperative Research Centre (CRC) for weed management, has produced the ultimate guide to the world's weeds, *A Global Compendium of Weeds*, published in 2002.

Equally important in preventing new weeds is to understand how they have been introduced and spread. We know that more than 60 per cent of our weeds were introduced as garden plants, so it seems obvious that this is still a major avenue for our current and next crop of weeds. Preventing new weeds from establishing—for example, by educating buyers and sellers about weeds—has been another major recent focus of many weed workers. A list of 'garden thugs' was coordinated by Rod, and the Nursery Association is actively encouraging the replacement of these species with less weedy alternatives. Legislation also has a role. For example, arum lilies (*Zantedeschia aethiopica*) have recently been banned from sale throughout WA. This species was introduced by early settlers as a garden plant and its seeds float down creeks and rivers, as well as being spread by birds, and choke out the natural vegetation.

Another major source of weeds has been the introduction of forage species for animal production. In cooperation with the CRC for Dryland Salinity and the CRC for Australian Weed Management, Lynley Stone of the Department of Environment and Conservation (DEC) has been developing weed risk management protocols for agronomists attempting to introduce new perennial forage species to help combat salinity. The protocols will ensure that new pasture plants stay in the paddock and don't escape into the bush. Lynley will subsequently develop weed risk assessments for each

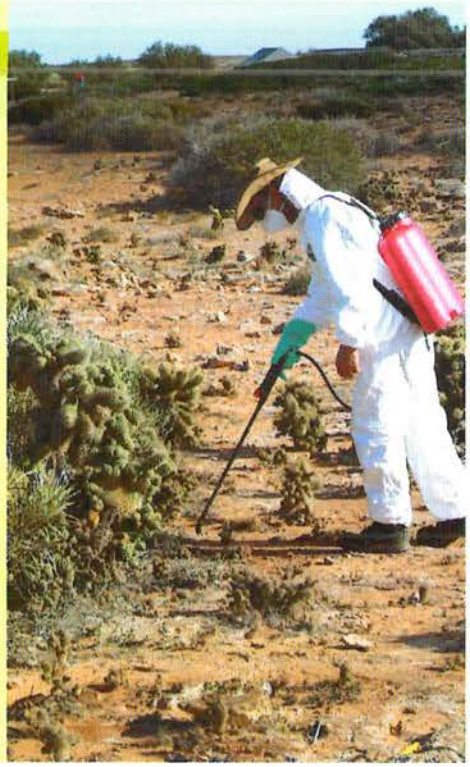
Eradicating Quobba cactus

The attack on Quobba cactus is a major conservation success story. Approximately 40 species of cactus are naturalised in Australia. Most of these (30 species) are in the broadly circumscribed genus *Opuntia*, which is currently normally divided into three genera: *Opuntia*, *Austrocylindropuntia* and *Cylindropuntia*. These weeds mainly infest areas of summer rainfall in semi-arid Australia.

Six taxa of *Cylindropuntia* (*C. imbricata* in NSW, VIC and SA; *C. tunicata* in NSW, SA, VIC and WA; *C. arbuscula* in NSW; *C. leptocaulis* in NSW and SA; *C. spinosior* in NSW; and *C. fulgida* var. *mamillata* in WA) are now naturalised in Australia. The genus is from southern USA and Mexico.

Quobba cactus (*Cylindropuntia fulgida*) is currently known from one infestation on Quobba Station—which lies 80 kilometres north of Carnarvon—on a low limestone ridge north of the homestead. The infestation covers between 12 and 20 hectares. Here, the cactus is locally abundant and is probably spreading via detached segments rather than by seed. Quobba cactus could be a major threat to the entire karst system of the North West Cape and the coastal limestone habitats between Shark Bay and Karratha, especially where fires are infrequent.

In eastern Australia some widespread species of *Cylindropuntia* are controlled by cochineal beetles, but this is not practical in WA. Conservation employees are killing the plants by means of the herbicide Garlon in Diesel or by pulling them up and burning them. Thanks to this work, the infestation has been greatly reduced and is on target to be eradicated by 2007.



State, and management guidelines to reduce weed risk during the breeding and selection process.

Another group in DEC's Science Division is checking the native species being trialled for forage, such as orange wattle (*Acacia saligna*), for their weediness and potential to cross-pollinate with local forms of these species. Orange wattle is a WA species that extends north to the Murchison River and east almost to Israelite Bay. It has become a serious pest in South Africa, where it was introduced to combat soil erosion, so it is best to be safe rather than sorry!

Staying ALERT

Removing weeds before they become widespread is the most cost effective means of reducing the future weed menace. While this has been long recognised as ideal, funding these programs has been difficult, since such weeds often occur on vacant lands that are not the direct responsibility of any land management or conservation body. However, three recent developments are proving highly effective in eradicating potential new weeds.

Weed control scientists have listed Australia's 20 worst weeds—Weeds of National Significance (WONS)—and a second list of potential weeds that need to be eradicated (ALERT list). While this has enabled some federal funding of these species, especially for biological control and targeting via the Natural Resource Management (NRM) process, many outbreaks of species on the ALERT list remained unattended.

This is changing. DEC recently received funding to employ 40 additional seasonal firefighters, who are available for weed control programs in the winter months. Programs for the conservation employees are set early each year, and more than 20 weed control projects are underway. The workers have been able to tackle several potentially serious weeds, including athel pine at Lake Boonderoo (see the box on page 43) and the Quobba cactus (see the box above). Since people and resources are usually the limiting factor in weed control, these additional employees are already making a major contribution.

Above Spraying Quobba cactus.
Photo – Scott Godley

Left A valley overgrown with introduced watsonia.
Photo – Sallyanne Cousans

The second development is the program of biodiversity conservation initiatives introduced in 2006 by the State government. The two-year, $15 million program comprises around 70 strategic projects targeting feral animals, weeds, biological survey and research, dieback and actions to recover threatened native plants, animals and ecological communities. Under the initiative, $1.7 million will be targeted to assist in removing 40 weed species—especially those nationally listed—across the State by whoever has management of the land and can carry out the program. Hopefully, over the next two years, this program will eradicate several weeds on the ALERT list (such as *Pelargonium alchemilloides*, several relatives of the bridal creeper and white broome) and reduce others, such as yellow soldiers (*Lachenalia reflexa*), to the point where eradication is feasible.

Conservation employees and biodiversity conservation initiatives in weed control are integrated by DEC's Michelle Widmer and Kellie Agar. This is facilitating coordinated activities against many widespread weeds across the department's administrative regions. For example, measures by Ian Wilson (Nature Conservation Coordinator in DEC's Donnelly district) to eradicate woody weeds such as acacias and Victorian tea tree from the karri forest are now being extended to control these weeds from Albany to Kalbarri.

Urban Nature

DEC recently established the Urban Nature program within its Swan region (encompassing Perth) to provide advice and assistance on bushland management, including weed control, to the numerous groups who manage remnant bushland in the region. This is urgently needed, as the region has the unfortunate distinction of having the largest number of weeds recorded from any natural bioregion (801 and 705 recorded for the Swan Coastal Plain and jarrah forest bioregions respectively).

The Urban Nature program is closely involved in the management of a number of regionally significant bushlands on the Swan Coastal Plain, and is undertaking research into how to best manage environmental weeds. The group provides advice on environmental weed management to DEC officers, local authorities, NRM and friends groups. It also prepares publications on environmental weed management, runs annual accredited training programs and organises specific workshops on weed management. In 2006, Urban Nature ran workshops on bulbous weeds and sharp rush. Proceedings and information sheets will result from the workshops.

A DEC project officer is currently undertaking a strategic review of environmental weeds in the Swan region for the Swan NRM group. This should result in robust ranking of all 1000 weeds recorded in the area, and control actions on six selected weed types.

The future

Cooperation and coordination at all levels of government and the public between scientists, managers, friends and practitioners is vital to hold back the weed menace. Fortunately, critically important resources—both human and financial—are also beginning to flow to this issue. We face new and occasionally daunting challenges in managing weeds on unallocated Crown lands and ensuring the implementation of the Good Neighbour Policy. However, the initiatives being undertaken acknowledge that weeds respect no administrative boundaries and are aimed at assisting and resourcing the coordination, cooperation and, most importantly, on-ground actions against weeds.

Athel pine at Lake Boonderoo

Athel pine (*Tamarix aphylla*) is a weed of national significance. A large, isolated infestation of this weed around the perimeter of Lake Boonderoo, with a total length of about 30 kilometres, is being removed in a joint project between DEC, Rangelands NRM, a local pastoralist and the Department of Agriculture and Food.

Lake Boonderoo is one of only two freshwater lakes in the Goldfields–Nullarbor region and provides an important habitat for waterbirds. The trees multiply rapidly and would take over the lake if left unchecked. This weed has caused enormous damage to the Finke River system in the Northern Territory, where it has infested 600 kilometres of the river system.

The eradication program, being carried out by a team of DEC conservation employees from Walpole, Perth, Kirup and Collie in the south-west, involves cutting the trees at ground level and spraying the stumps with herbicide. Removing this weed requires eight people to work for three weeks each year over three years. While this is a considerable investment, it should ensure the removal of the weed and the long-term protection of the wetland.

Above Athel pine along the shore of Lake Boonderoo.
Photo – Bill Muir

Greg Keighery is one of Western Australia's most eminent botanists. He is a Principal Research Scientist with DEC and can be contacted on (08) 9405 5100 or by email (greg.keighery@dec.wa.gov.au).

Kate Brown is DEC's Bushland Management Advisor with Urban Nature. She can be contacted on (08) 9368 4032 or by email (kate.brown@dec.wa.gov.au).

Putting the sting on feral bees

Feral bees can displace native bee species, reduce pollination of native wildflowers, lead to an increased risk of diseases affecting commercial beekeeping and take over tree hollows from threatened black-cockatoos and other native animals. New research offers hope for their control.

by Jacqueline Hay and Mary-Anne Clunies-Ross

Australia has a very high proportion of species found nowhere else on the planet (known as endemism), resulting from millions of years of isolation from other continents. South-western Australia is an area of particular significance and has been recognised globally as one of 34 biodiversity hotspots. It is the only area in Australia to be recognised in this way.

Biodiversity hotspots are biologically significant ecosystems that have high levels of natural diversity (large numbers of native and endemic species of plants and animals), coupled with a high degree of threat to that diversity. Threats to biodiversity in the south-west include land clearing, climate change (see pages 54–61), altered fire regimes, salinity, plant pathogens such as *Phytophthora cinnamomi* and introduced animals and weeds (see pages 39–43). According to the World Conservation Union (IUCN), introduced animals are, after land clearing, the second most significant threat to native and endemic species.

Previous page
Main A feral bee feeds on nectar.
Photo – Wade Hughes/Lochman Transparencies
Inset Feral honeybees swarming.
Photo – Jiri Lochman

Left Feral beehive at Stockyard Gully Reserve on the Turquoise Coast.
Photo – Ann Storrie

Below Feral honeybee.
Photo – Babs and Bert Wells/DEC

Another feral menace

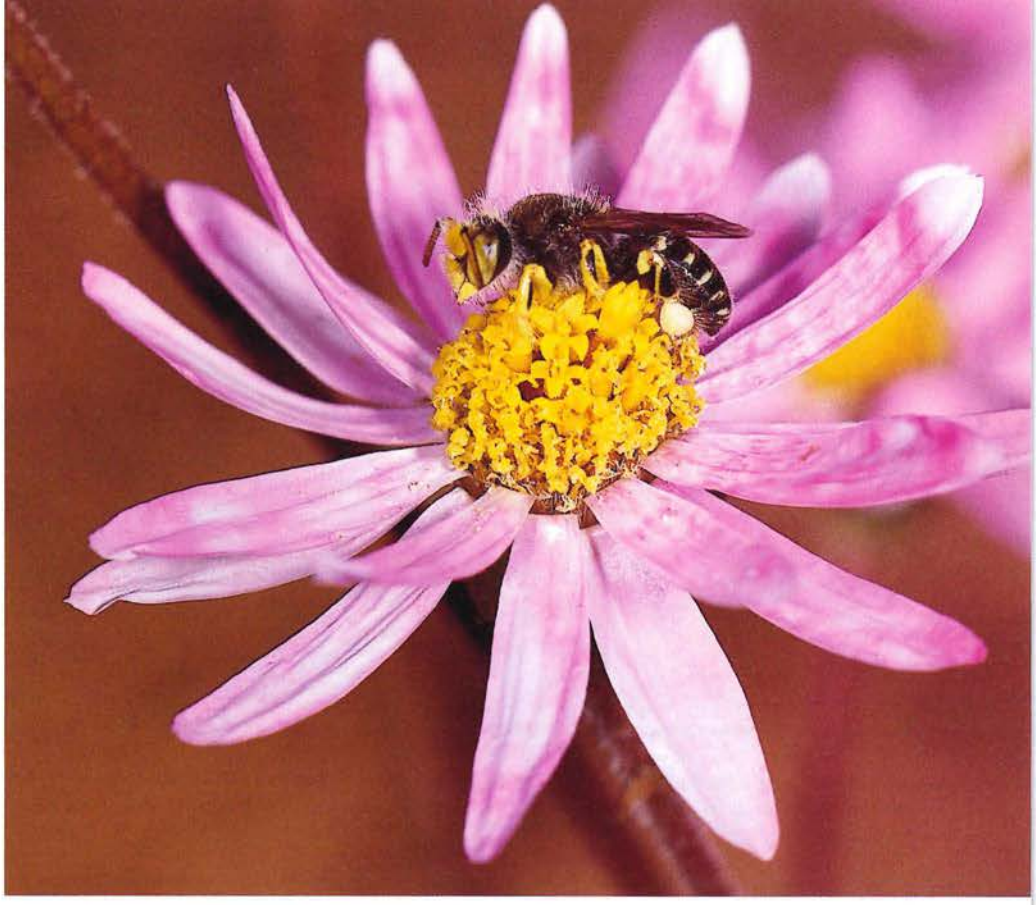
Feral animals—introduced animals living in a wild or untamed state—are generally escaped domesticated animals that have become wild, such as rabbits and pigs, or other animals such as foxes and cane toads. They have the capacity to reduce biodiversity through predation of native species, aiding in the spread and establishment of weeds, and by competing for food and nesting sites. However, another animal—an insect—is now also having a detrimental impact on WA's biodiversity.

The European honeybee or feral bee was introduced to WA in the 1840s for the production of honey, wax and to assist in pollinating crops. By the 1930s, honey production had increased dramatically because improved transport had enabled apiarists to travel throughout the State following seasonal flowering cycles or nectar flows. However, due to the natural ability of honeybees to swarm or abscond, unmanaged feral colonies are now widespread and exist in almost every part of WA that gets reliable rainfall, or is close to permanent water sources.

Swarming and absconding

Reproduction by swarming involves division of the colony, where the majority of the workers, together with the new or old queen, leave the hive to search for a new home. Absconding, which is slightly different, involves a colony abandoning its nest as a result of disturbance or a lack of food and water. To abscond, the colony forms a swarm that includes all workers and all viable adult queens, which then locates an appropriate nest space and reestablishes itself.

Swarms generally become established in suitable tree hollows, although they may choose to live in nest boxes and in buildings. Feral bees are also known to establish colonies underground and in caves. Colonies are classed as feral when people no longer manage them.



Right Native bee on everlasting.

Below right Native beehive.
Photos – Babs and Bert Wells/DEC

Feral versus managed bees

Feral and managed bees are the same species, but differ in their appearance and behaviour. Feral bees are generally darker in colour and are essentially wild and unrestrained honeybees. Differences in behaviour between feral and controlled bees are a consequence of circumstances and lifestyle.

Managed bees are always provided with water and are regularly moved into new areas that have rich supplies of nectar and pollen. In contrast, feral bees may live in areas where food and water are scarce at certain times of the year, leading to more aggressive behaviour and an increased tendency to swarm. Feral bees are usually considered a nuisance during hot weather when water sources have dried up and large numbers of bees will often exploit artificial sources of water, such as taps, sprinklers and stock watering troughs. Feral bees can also become a problem when there is little or no nectar and pollen available from native flowering plants, causing them to search for alternative foods such as stock feed.

Feral colonies are commonly weaker and smaller than those of managed bees. Because their hives are not actively managed by people and cleared of honey on a regular basis, they lack the desire of managed bees to store honey. The poor quality and production of honey from feral colonies makes them of little value to commercial honey producers.

Feral bees also represent a considerable risk to the commercial beekeeping industry: should an exotic disease or hive parasite that affects honeybees be introduced to WA the existence of feral colonies would enable it to spread more easily.

Native species versus the invaders

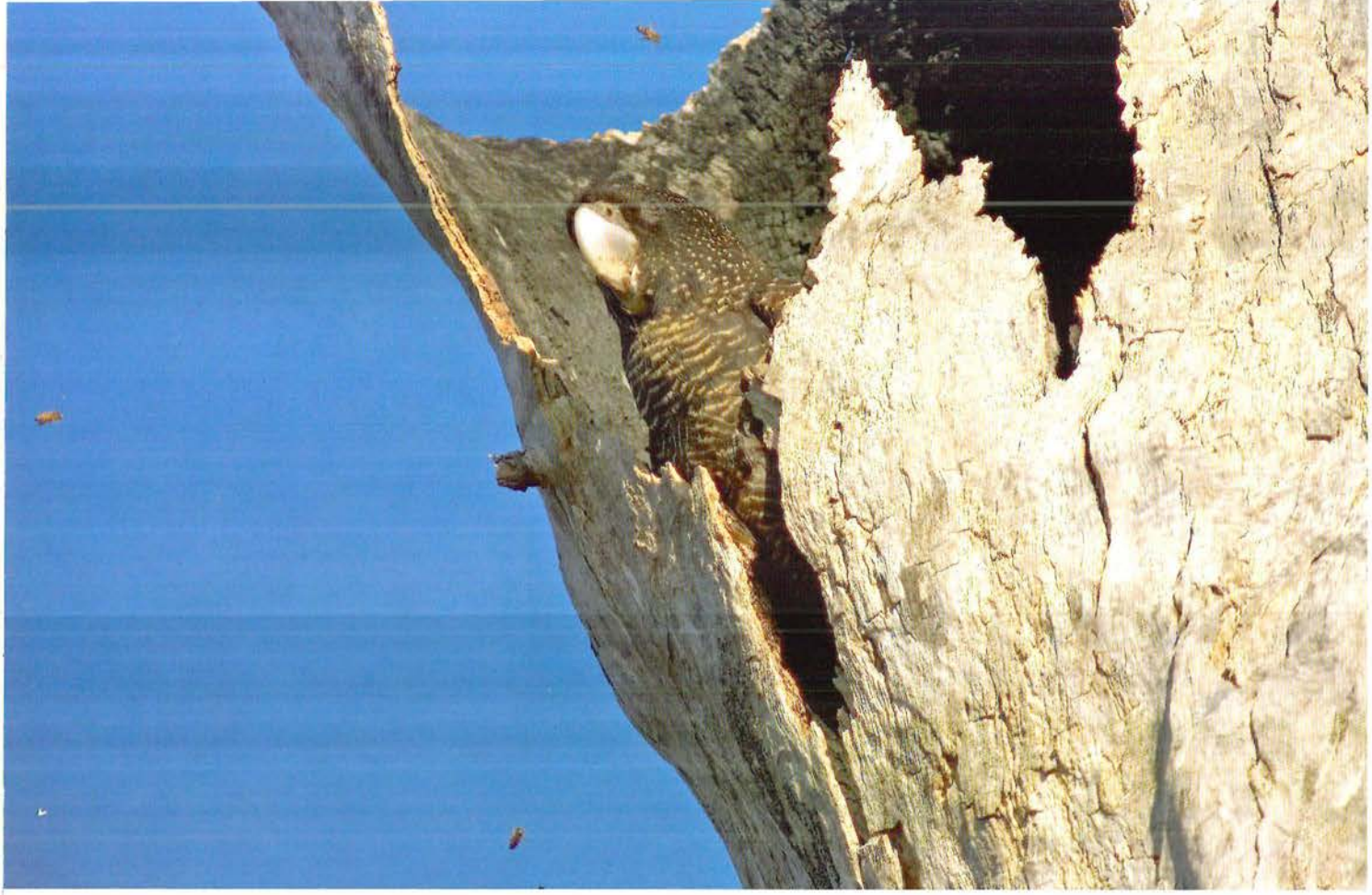
Australian plants, and their native insect and bird pollinators, have evolved largely in the absence of social bees and may therefore be vulnerable to pressures from feral bees.

The pollination of a flower occurs when pollen is transferred from the anthers to the stigma. Due to their size and foraging behaviour, feral bees are not as efficient as native bee species at pollinating some flowers. In fact, they may destroy some Australian native flowers, and harvest nectar without pollinating the flower at all, causing no seed to be set.

Observations of honeybees harvesting nectar of bottlebrushes (*Callistemon* species) have shown that honeybees only contact the stigma on about 4 per cent of visits, whereas native birds such as honeyeaters contact the stigma on more than 50 per cent of visits (based on more than 8000 visits). Furthermore, a honeybee visiting a native flower may remove pollen that has been deposited on the stigma by a preceding native pollinator, so the flower may not be pollinated and seed set will not occur.

In contrast, feral bees can be excellent pollinators of exotic or introduced flowering plants and therefore aid in the spread or establishment of undesirable weeds.

Feral bees are highly efficient foragers, capable of harvesting more than 80 per cent of the available nectar stocks in some



Above Forest red-tailed black-cockatoo nesting in a tree hollow.
Photo – Tony Kirkby

Left Honeycomb of the feral European honeybee.
Photo – Sallyanne Cousans

plants. This presents enormous potential for adverse interactions and may result in a competitive displacement of native pollinators from native wildflowers. Feral bees also compete with managed bees for floral resources, which could lead to reduced commercial honey yields.

Tree hollows—a valuable resource

A particular concern is the disturbing rate at which feral bees are taking over hollows in trees and evicting native birds and mammals that depend on hollows for nesting space, shelter and protection. The larger tree hollows take an average of 250 years to form, and are thus an extremely valuable resource in the south-west. The ongoing loss of tree hollows represents a huge risk to obligate hollow nesters (animals that will only nest in the hollows of live or dead standing trees) such as brushtail possums, parrots, owls and many other birds and reptiles. The risks to WA's three species of black-cockatoos are severe, as they are particularly susceptible to the ongoing loss of nesting hollows. Black-cockatoos are obligate nesters that are long-lived, slow to mature, require relatively large hollows and have a low annual reproductive output.

Threatened black-cockatoos

The Water Corporation and the WA Museum have established a joint conservation program known as Cockatoo Care (see 'Cockatoos in crisis', *LANDSCOPE*, Summer 2005–2006). The objectives of the Cockatoo Care program are to research the distribution, ecology and threats to the survival of each of these black-cockatoos as well as undertake habitat enhancement, feral bee research and community awareness and involvement.

Research by the WA Museum showed that, over a five-year period, feral bees took over an average of 20 per cent of nesting hollows used by forest red-tailed black-cockatoos (*Calyptorhynchus banksii naso*), Carnaby's cockatoos (*Calyptorhynchus latirostris*) and Baudin's cockatoos (*Calyptorhynchus baudinii*), all of which are threatened. All three species are endemic to the south-west and the loss of nesting hollows could significantly reduce their distribution and numbers, threatening them with possible extinction.

Developing a feral bee control strategy

Currently, the control of feral bees is done on a hive-by-hive basis. This is costly, time consuming and cannot be

Right Commercial beehives at Beekeepers Nature Reserve.
Photo – Ann Storrie

Below right Feral honeybee.
Photo – Babs and Bert Wells/DEC

undertaken on a wide scale. Research recently developed in New Zealand has examined a range of techniques capable of controlling feral bees.

In New Zealand, researchers have developed specially-designed bait stations, containing sugar syrup mixed with a small amount of pesticide. The pesticide is a slow-acting poison, capable of killing bees through both contact and ingestion. Feral bees visit the bait stations, take up the solution, return home and deliver the pesticide to the hive.

Results of the New Zealand study demonstrate that the method is effective, with bees attracted to baits promptly and in large numbers. It is estimated that if approximately 10 per cent of the bees in a colony visit a bait station and consume the poison, the entire colony will die. Although the results of the New Zealand study are promising, additional research is required to develop a safe and efficient control method that is appropriate for use in the Western Australian environment.

As a result, the Department of Environment and Conservation (DEC) has joined forces with the Water Corporation to conduct important research into the development of procedures to control feral bees in WA. The main aim of the strategy is to reduce feral bee populations in areas where they are having a negative impact on native plants and animals, particularly black-cockatoos, and on visitor safety at high-value recreation sites.

Research and baiting trials

Researchers will investigate the ecology of feral honeybees and how their behaviour is influenced by specific environmental conditions that may affect the development of procedures for their control. They will also try to ascertain if this control program poses any risks to native animals and determine how to reduce these risks to acceptable levels.

The study will examine the most effective method to attract bees, the average size and strength of a feral colony and the number of colonies or bees that visit particular bait stations. It will need to establish the volume of bait that is required and consumed by feral bees. It will also attempt to determine the distances travelled by feral bees to a bait station and hence the density of bait stations needed to treat a specific area. Finally, it will investigate how long it will take to kill feral bee hives in a specific area and how often hives or areas will need to be treated to keep them free from feral bees.

So far, trials have revealed a number of substances capable of attracting very large numbers of feral bees to bait stations. Preliminary trials have also demonstrated that remote bait stations

Interesting facts

European honeybees have a highly developed social structure, with three main types of colony members: workers, drones and a queen. The queen bee is responsible for laying thousands of eggs per day, and is also capable of commanding colony members to perform specific tasks by releasing specific chemical messages known as pheromones. Drones are male bees that serve only one purpose—mating with the queen—while workers are responsible for a wide variety of tasks including feeding the queen and drones, defending or protecting the queen, and collecting floral resources such as nectar and pollen.

Left A native blue-banded bee feeds on nectar from a eucalypt flower.
Photo – Jiri Lochman

Below DEC's feral bee project officer Jacqueline Hay conducting field trials.
Photo – Gareth Watkins

do not appear to pose a significant threat to non-target species, such as insects and birds, through primary poisoning. The concentration of pesticide proposed for use is extremely low and poses minimal risk to larger animals if consumed. However, bait stations will be designed to exclude birds and mammals from consuming the bait.

While baiting cannot discriminate between the feral bee and the non-target commercial honeybee, DEC manages beekeeper access to all public land through the *Conservation and Land Management Act 1984* and *Standard Apiary Site Conditions*.

Apiary site permits are granted by DEC to apiarists who agree to abide by stringent environmental conditions that, when followed, ensure compliance with the department's management for dieback control and fire prevention, and reduce the risk of bees swarming. Permit holders must contact their relevant DEC district apiary site officer prior to placing or removing beehives within their permit area. Effective management of these sites by DEC will allow segregation between managed bees and those feral bees being targeted in control programs. DEC will also work in consultation with the beekeeping industry to further eliminate risks to commercial bees, or reduce them to an acceptable level.

A standard operating procedures manual will be developed as part of this strategy, to address the rules and regulations that apply to the use of pesticides in Public Drinking Water Source Areas and occupational, health and safety guidelines.

It is hoped that the research will result in a safe and efficient method of controlling feral bees in WA. Feral bee control aims to preserve a more sustainable source of nectar and pollen for the beekeeping industry and minimise any impacts from a potential outbreak of disease.

If we can control feral bees we can lessen the threat to the survival of our unique black-cockatoos, and improve biodiversity values in the south-west by reducing the pressures faced by all of our native species, from the wildflowers and native insects to larger animals such as birds and possums.

Jacqueline Hay is the feral bee project officer with DEC's Species and Communities Branch at Kensington. If you would like to report the location of a feral beehive on public lands such as parks and reserves, contact Jacqueline on (08) 9423 0103 or by email (jacqueline.hay@dec.wa.gov.au). A GPS coordinate would be helpful, although specific details of the location would suffice.

Mary-Anne Clunies-Ross is the Cockatoo Care Coordinator at the Water Corporation in Leederville. She can be contacted on (08) 9420 2796 or by email (mary-anne.clunies-ross@watercorporation.com.au).

Fiery learning

by **Rhianna King** and **Liz Moore**

In January 2005, 28,000 hectares of forest in the Perth hills were burnt by the single biggest bushfire in the northern jarrah forest since the Dwellingup fires of 1961. Since then, the area has become a study site for teachers and their students looking at the importance of fire for biodiversity.

The effects of the January 2005 deliberately-lit wildfire in the Perth hills were widespread (see 'Perth hills under fire', *LANDSCOPE*, Winter 2005). For almost seven days, much of the Perth metropolitan area was blanketed in smoke. Almost 1500 firefighters from what was then the Department of Conservation and Land Management, the Fire and Emergency Services Authority, the Forest Products Commission, WA Police and volunteers assisted with the fire suppression operation.

Because the fire was in the forests immediately east of Perth, nearby communities had to be prepared to protect their homes or evacuate. The rest of the State looked on as orchards, fencing, farm buildings and pine plantations were damaged and sections of the Munda Biddi Trail and Bibbulmun Track were burnt. The erosion of soil bared by the winter rains resulted in silting of streams and deterioration of the water quality of Perth's catchments.

An event to learn from

The proximity of the fire to Perth city—and its size and intensity—was unlike any previously experienced in WA. It was clear early on that the fire would present many learning opportunities for agencies involved in fire suppression and biodiversity science. It also became clear to the Department of Environment and Conservation's (DEC's) Senior Project Officer, Liz Moore, and the Perth hills EcoEducation team, that WA teachers and their students could also learn valuable lessons. So, as the green shoots began to sprout and the bush began to regenerate, the seed was being sown for 'Fire, a force of life'—the newest of DEC's EcoEducation programs.

Hands on

'Fire, a force of life' is a program offering professional learning days for teachers, resources for the classroom and hands-on excursion activities. It was designed for Years 10, 11 and 12 to develop learning in the curriculum areas of Science, Society and Environment, and English. The full-day excursion is based at the Perth Hills National Parks Centre in Mundaring (see pages 18–19) close to the wildfire site. Activities are hands on, giving students an insight into the impact of fire on biodiversity in forest ecosystems; the interrelationships between fire, plants and animals; and the role of science in sustainable forest management.

Students are taken on a tour of part of the wildfire-affected area (the fire's actual perimeter was about 160 kilometres) and they do sampling work in quadrats set up in areas burnt by the fire to assess changes in the biodiversity. Photos taken at set points help to illustrate the changes to the plants and animals in the months following the fire. Students use biological and geographical field techniques to examine the impact

Previous page
Main During a professional learning day for teachers, Liz Moore (standing) checks a quadrat in the area burnt by the 2005 wildfire.
Inset The fringed lily (*Thysanotus manglesianus)* is one of the species that has resprouted in the burnt area.
Photos – Rhianna King/DEC

Left The wildfire in the Perth hills burnt through 28,000 hectares.
Photo – Ron D'Raine

on biodiversity of fuel reduction fires. They also learn about the practices employed by Aboriginal people on the land for the thousands of years they were its primary managers. This is done with consideration to the way plants and animals have adapted to fire. The students can then continue their learning back in the classroom with the student resources provided by EcoEducation.

The programs aim to encourage interest, debate and understanding in school communities about the science and challenge of fire management, including fuel reduction burns, as we are all directly or indirectly affected by wildfires. The programs provide students and teachers with the information to make up their own minds about fire management. It seems at the end there is one thing everyone agrees on—the complexity of the issue!

Above A student uses photos to compare the landscape in the months after the fire on the 'Fire, a force of life' excursion.
Photo – Liz Moore/DEC

Above right DEC Regional Fire Coordinator Rob Towers (left) uses a leaf litter gauge with teachers to measure the amount of fuel on the forest floor.

Right An area in the Perth hills where a fuel reduction burn was carried out.
Photos – Rhianna King/DEC

Rhianna King is a Communications Officer with the Department of Environment and Conservation (DEC) and a *LANDSCOPE* editor. She can be contacted on (08) 9389 8644 or by email (rhianna.king@dec.wa.gov.au).

For more information about any of the EcoEducation programs, contact Liz Moore, DEC's Senior EcoEducation Officer on (08) 9334 0387, by email (liz.moore@dec.wa.gov.au) or visit DEC's website (www.naturebase.net).

Climate change and biodiversity

by Richard McKellar and Ian Abbott

Climate change is recognised as a major global issue and is a growing challenge for all nations, most industries and many communities. Because climate has a fundamental influence on the distribution and abundance of plants and animals and the composition of ecosystems, changes to climate conditions will have significant implications for our environment.

In places where there are clear visual signs of a warming world, such as melting mountain glaciers, icefields or sea ice, the scale and significance of climate change are evident. But how is climate change affecting Western Australia and what can we do about it?

Temperatures throughout Western Australia have risen during the twentieth century (see the graph below), mainly due to warmer nights rather than hotter days.

Since the 1970s, average annual rainfall in many parts of the south-west region has fallen significantly (see map on page 57). Research by the Indian Ocean Climate Initiative (IOCI) partnership has revealed that this reduction has almost entirely resulted from a loss of rainfall in the late autumn and early winter months. The Bureau of Meteorology and CSIRO have advised that this change is at least partly due to global climate change.

Warmer weather and drier winters are great for hikers and campers, and for some sports and recreational activities. Agriculture also seems to have benefited from fewer waterlogged areas. But these changes have also generated significant economic and environmental costs.

Lower rainfall has already required new sources of water to be developed, with new infrastructure such as dams, pipelines and a desalination plant being constructed. Even with increased investments in water infrastructure and a stronger focus on using water efficiently, harvesting further water resources such as the Yarragadee aquifer is being considered.

This increased competition for limited water resources requires water planners and the broader community to determine how much water should be allocated to local communities and industries, how much to the regional centres, how much to the Perth metropolitan region and how much to the environment. When an already limited resource is reduced, competition becomes fierce.

It appears that reduced rainfall and increased water harvesting from the Gnangara aquifer (in the northern Perth region) have resulted in lower water levels in the caves of Yanchep National Park, threatening species found only in those caves. To maintain the environment these species require, the Department of Environment and Conservation (DEC) has pumped water into the caves for the past five years (see 'Threatened wildlife of the Yanchep caves', *LANDSCOPE*, Winter 2002). However, the region's wetlands and associated vegetation have also been affected and these environmental values are harder to maintain.

What about the future? How long can water pumping be maintained in the Yanchep caves and the rare species protected? How many ecosystems and habitats can be maintained artificially in this way, as living museums, if climate change continues to affect WA and forces society to make necessary but difficult decisions about responding to its impacts?

To understand these issues and be ready for the challenges they present we need to have reasonable projections of future climate conditions and a sound understanding of the relationship between climate and biodiversity values (species, ecosystem structure and ecological processes).

Climate projections for WA

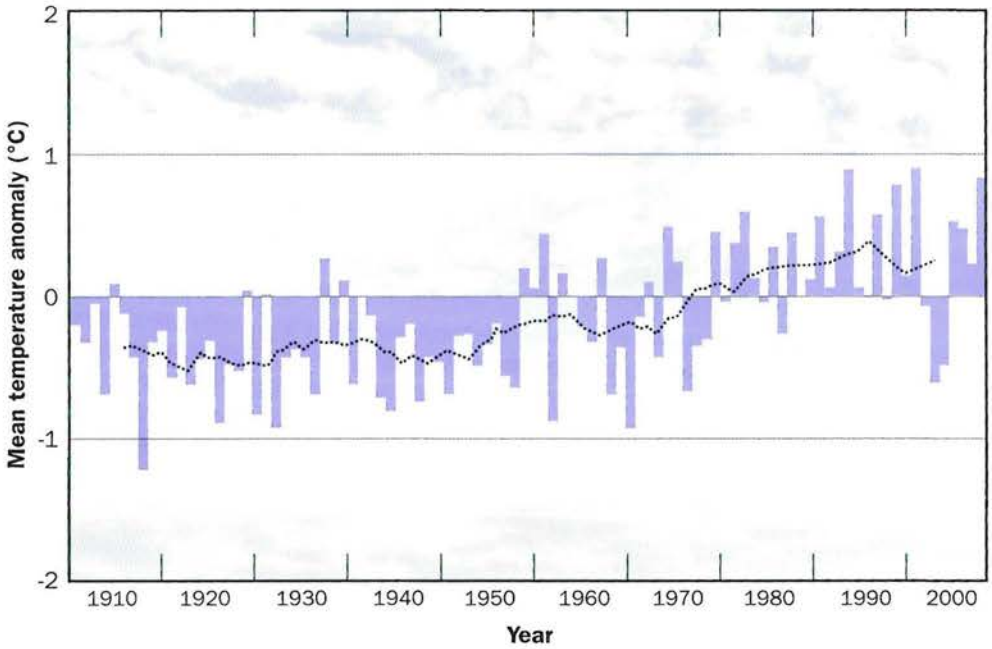
Climate projections, developed from computer models, suggest how the Earth's atmospheric processes are likely to change under specified conditions. Such projections are our best indication of future climates.

Previous page
Main Climate change will affect rainfall patterns and storm intensity.
Photo – Len Stewart/Lochman Transparencies
Inset Birds are a key indicator of environmental impacts resulting from climate change.
Photo – Jan van de Kam

Left Lower water levels in caves at Yanchep National Park threaten critically endangered invertebrate communities.
Photo – Michael James/DEC

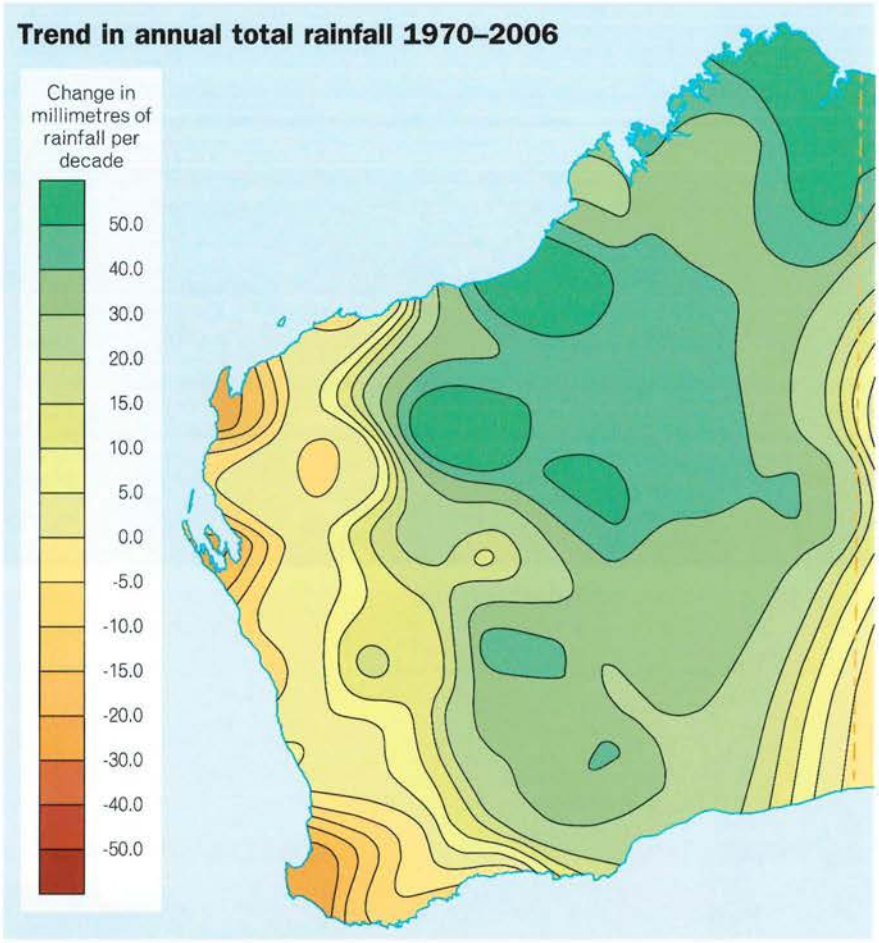
Below left Western Australia's annual mean temperatures increased during the twentieth century.
Courtesy Bureau of Meteorology

Western Australia's annual mean temperature (base 1961–1990)



Above Coastal wetlands such as Herdsman Lake could become smaller or disappear with lower rainfall and higher temperatures.
Photo – Michael James/DEC

Right Several coastal areas in WA—including the south-west—have had less rainfall while parts of the north-west have become much wetter over recent decades.
Courtesy Bureau of Meteorology



'Dangerous climate change' is a term used in the United Nations Framework Convention on Climate Change to indicate the level of change that should be avoided by international action. Analysis of the likely impacts of temperature increases suggests that dangerous climate change would occur if global average temperatures rose more than 2°C above the prevailing global average temperatures before widespread use of fossil fuels and land clearing started in about 1780. As temperatures have already risen by about 0.6°C since 1780, a further rise of only 1.4°C could bring dangerous climate change to the world.

Climate projections recently published by the CSIRO indicate that average annual temperatures are likely to continue to rise in WA. Even the relatively small temperature increases projected for the south-west approach 'dangerous' levels, but the temperature changes projected for the Pilbara far exceed dangerous levels. CSIRO projections of rainfall change in WA show that while average annual rainfall is likely to be reduced in the south-west region—a global biodiversity hotspot—it could increase in other parts of the State. However, the key climate events that affect our communities and the ecosystems with which we are familiar are likely to be more specific and local, such as hot dry periods, extended droughts, storms or floods. Global climate models are less capable of providing projections for

these parameters, so a risk management approach is required to analyse the potential impacts of climate changes of this type.

Climate and biodiversity

Climate is a fundamental determinant of where plants and other living species can establish themselves, survive and reproduce, and is a factor in the evolution of species. Therefore, when a region's climate changes, the region's biodiversity values—the species found in the region and the ecosystems they form—will also change.

Climate changes are having both direct and indirect influences on biodiversity values. Changes to climate directly affect species and the ecosystems they comprise, through changes to ambient temperature, rainfall, winds and extreme events. Climate changes also indirectly affect species and ecosystems by altering important factors such as fire frequency and behaviour, the spread and intensity of salinity and diseases such as dieback (caused by the introduced pathogen *Phytophthora cinnamomi*), competition and predation, and altering water flows and resources.

Other impacts will result from factors associated with climate change. For example, higher levels of carbon dioxide are likely to affect plant processes such as photosynthesis and are already increasing ocean acidity, with significant impacts on corals. Higher sea levels and more intense storm events will also affect highly diverse intertidal zones and wetlands.

Top left Climate change is expected to affect the spread of salinity, which is already a major threat to hundreds of species in the State's south-west.
Photo – Sallyanne Cousans

Above left Low-lying coastal areas are highly vulnerable to increased storm intensity and rising sea levels.
Photo – Clay Bryce/Lochman Transparencies

Left Scientists are yet to understand how climate change may affect the size and frequency of bushfires.
Photo – Len Stewart/Lochman Transparencies

Right Cracked earth caused by drought.
Photo – Marie Lochman

Below right White-striped freetail bat.
Photo – Babs and Bert Wells/DEC

Why is this animal moving home?

An animal's habitat comprises shelter and sources of food and water, all of which can be affected or even determined by weather and climate. When climate changes, so does habitat. The key question is whether thresholds of habitat change are crossed that result in habitat no longer being suitable for an animal. For instance, a drier climate may not support key seasonal food sources on which a species may depend.

While the range of most animals appears to be largely determined only partially and indirectly by climate, the range of a few animals appears to be directly affected by climate. For instance, the white-striped freetail bat (*Tadarida australis*) appears to have a climatic range determined by a combination of temperature and humidity threshold conditions. The bat migrates annually to stay within these conditions as seasons change and weather varies.

Ecological principles can provide guidance about many of these impacts. For instance, these principles would suggest that, as an area becomes warmer, species currently found there would migrate to a new location with their preferred environmental conditions. The new location would most likely be in an inherently cooler place, such as further from the equator, closer to a moderating influence such as an ocean or higher in the landscape, such as further up a mountainside. However, the situation doesn't appear to be as simple as this in WA.

Because the south-west has experienced repeated periodic climate changes over millions of years, many species indigenous to the region may have a very broad tolerance of extreme climate conditions. However, our understanding of how such episodic climate variation has affected the climatic dependence of the region's plant and animal species is limited. In other words, we are not sure what the climate thresholds might be for plants and animals in the south-west. This brings into sharp focus the need for effective and responsible risk management strategies.

Climate and soil are not the only factors that determine where plants and animals are found. Ecological processes, such as competition, are an important local factor in the distribution of plants and animals. Evolutionary history or local extinction from fire or predation also affect where species are found or are absent. To manage climate change, scientists need to know the extent to which climate is determining where a species is found; and whether climate change will favour rare or vulnerable plants and animals or the stresses and forces that may endanger them. In addition, little is known about the impacts of higher carbon dioxide concentrations on Australia's land and marine species.

Managing the risks of climate change

Because there are so many complex biological variables, it is hard to confidently project future climate conditions and the role of climate in determining the survival and reproduction of species. Observations of birds are frequently used, because they are well studied, highly visible and very mobile. Some observations indicate WA's ecosystems are already being affected by changes to climate. These include reduced productivity of some birds in the south-west, a southerly spread in the range of some tropical seabirds, and changes to the time of arrival and departure of some bird species in semi-arid regions.

What can we do in the face of this climate uncertainty and biological complexity? There are four key responses: firstly, to reduce the causes of climate change; secondly, to increase our understanding of the impacts of climate change on the State's ecosystems; thirdly, to limit the impacts of climate change as much as possible; and, finally, to safeguard the most vulnerable species.

Reducing the causes of climate change

Greenhouse gas concentrations need to be limited to levels that would not be dangerous. This will require reductions in global net emissions of 50 per cent or more by the middle of this century. Halting climate change will only be accomplished through concerted global action to increase energy efficiency, adopt renewable energy options, reduce greenhouse gas emissions through a range of technological innovations and minimise land clearing. However, biodiversity protection and land management can play an important role in lowering atmospheric concentrations of carbon dioxide by increasing vegetation. DEC is directly involved in developing and implementing revegetation options such as oil mallees and biodiversity plantings which help to

reduce salinity and erosion and protect biodiversity, while reducing atmospheric carbon dioxide. Similarly, removing stock and feral herbivores from pastoral areas and allowing vegetation to regenerate can increase carbon sequestration, protect biodiversity values and stabilise landscapes.

Better information

Understanding the role of climate in ecosystem composition and functioning will enable us to better prepare for the impacts of future climate change.

We need to identify the areas, species and ecosystems most at risk from projected changes in climate. Modelling climate change impacts requires good information about a large number of factors, including the distribution of species, the role of climate in determining this distribution, and climate thresholds species might have. Other required information includes the capacity of a species to migrate, the potential influence of climate change on pests, diseases, predators and other threats, and possible influences of higher atmospheric concentrations of carbon dioxide on plants and animals.

While changes to WA's climate have been measured using long-term specialised weather stations, there is no equivalent ecological monitoring system, apart from the FORESTCHECK system (see 'Keeping our forests in check', *LANDSCOPE*, Autumn 2004). Dedicated ecological monitoring stations in highly vulnerable ecosystems would enable scientists and managers to identify ecological changes and to develop and implement timely responses to them.

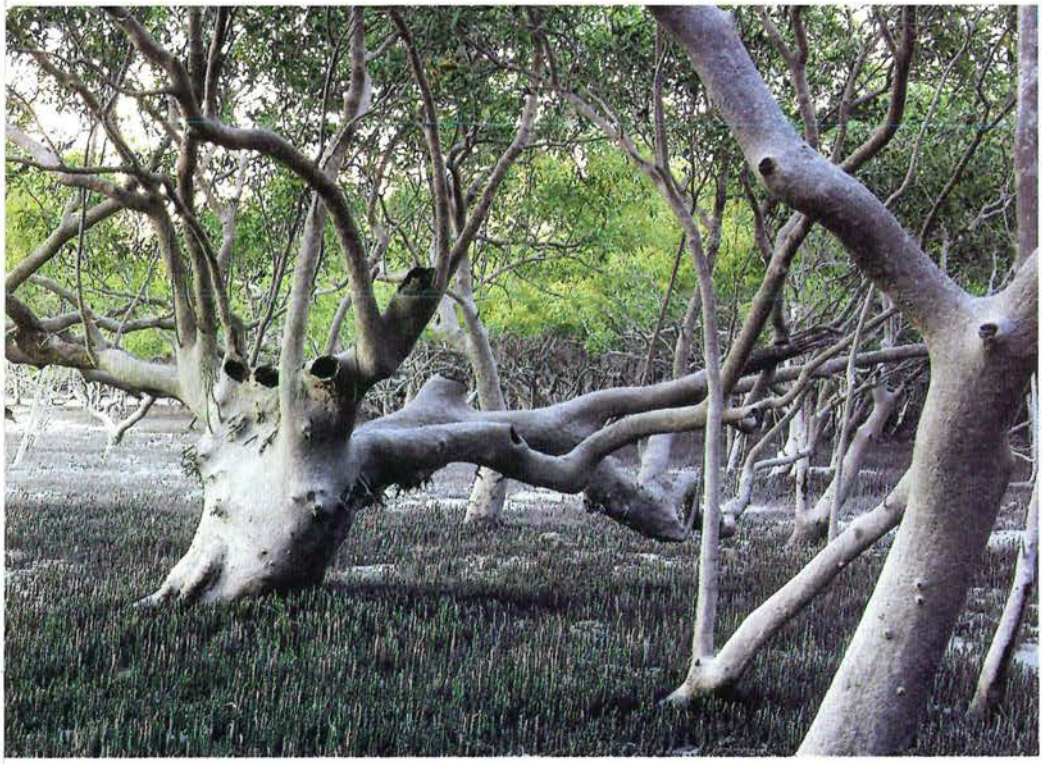
Refuges are likely to play a significant role in harbouring plant and animal species under changed climate conditions. It is important that the characteristics of future refuges be identified to support effective conservation initiatives such as national parks and conservation reserves. The implications of climate change for the design of WA's reserve system must be understood, and the role of regional links studied.

The indirect impacts of climate change also need to be well understood. For instance, lower rainfall will normally reduce the number and size of leaves, which in turn would reduce litter on the ground. But when lower rainfall is associated with a longer dry summer season and warmer temperatures are also experienced, the fire season is extended. In this circumstance, it is unclear how fire frequency, intensity and scale will be affected: more frequent, hotter and bigger fires or less frequent, cooler and smaller fires seem equally plausible using our current understanding of how climate change might affect fire behaviour.

Limiting the impacts of climate change

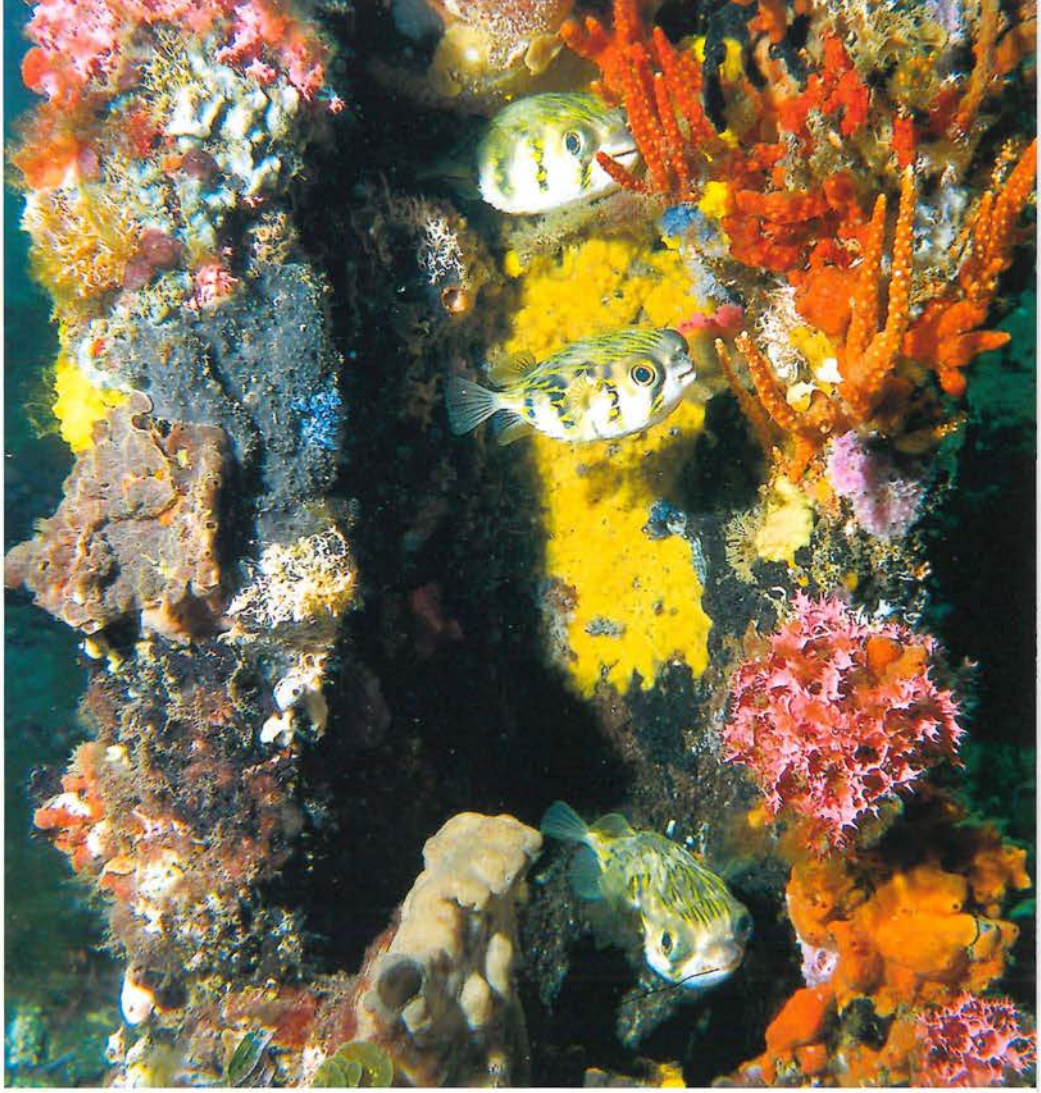
WA's ecological systems are already significantly affected by clearing, grazing, predation by introduced species such as the cat and fox, salinity, diseases such as *Phytophthora*-caused dieback and inappropriate fire regimes. Hence, one of the best ways to directly reduce the vulnerability of WA's ecological systems to climate change is to reduce the impacts and damage they already experience. We therefore need to replant or revegetate many cleared areas; reduce or exclude grazing and feral animals from areas having high biodiversity values; reduce cat and fox predation; reduce the spread of salinity and dieback; stop the introduction of new predators, pests and diseases; and take account of climate change when using fire as a management tool.

Protecting or establishing corridors that allow plants and animals to



Above left Insects and other rapidly reproducing highly mobile species can take advantage of changing climate conditions. *Photo – Dennis Sarson/Lochman Transparencies*

Left Sea level rises could affect mangroves which stabilise many of WA's northern coasts. *Photo – Jan van de Kam*



Right Beneath the Busselton Jetty. Low-lying coastal infrastructure and wetlands in the Busselton region are likely to be affected by rising sea levels and increased storm surges.
Photo – Ann Storrie

migrate as climate changes alter their environmental conditions and habitats is also a key strategy, both within the reserve system and across regional landscapes.

Identifying core climate refuges and providing them with specific protection will be an increasingly important option as climate change becomes more widespread. Where such refuges lie outside the reserve system, partnerships with landowners or extension of the reserve system will be crucial.

Safeguarding vulnerable species

Where climate change is likely to result in some species becoming locally extinct, seed collection and storage or protection in a zoo or a garden will be required. Protecting species in this way is an essential element of a comprehensive biodiversity conservation program, and will be an increasingly important option as climate change proceeds.

Our greatest threat

Climate change is increasingly described as the greatest threat facing the Earth and its ecosystems. WA is already being affected by climate change, with reduced rainfall becoming normal over much of the south-west. The impacts of this are already evident.

Maintaining WA's species and ecosystems will demand greater knowledge, increased efforts to reduce greenhouse gas emissions and actions to reduce environmental stresses such as salinity, diseases, introduced pests (see 'War against weeds' on pages 39-43) and predators and inappropriate fire regimes. In addition, climate refuges and links will need to be identified and protected.

Initiatives of this type already form the basis of DEC's nature conservation programs, but much more will be required to protect WA's biodiversity values if climate change alters the processes which underpin the State's ecological systems.

Causes of climate change

Scientists have long sought to understand the causes of climate change, including variations in the energy received from the sun, smoke from erupting volcanoes, the emergence of mountain ranges or islands, continental drift and changes in the chemical composition of the atmosphere.

While all these factors can affect climate, there are two broad causes of long-term climate changes. Variations in the amount of solar radiation and energy received by Earth—resulting from minor alterations in the Earth's orbit around the sun, the tilt of the Earth's axis and a wobble in the Earth's axis—could combine to alter the amount of solar energy received on the Earth's surface. These long-term influences on the Earth's climate, now termed the 'Milankovitch Cycles', have influenced the development of glaciations and warmer periods for millions of years. Milankovitch Cycles are independent of human activity.

The second long-term cause of climate change is altered composition of the Earth's atmosphere resulting from human activities, especially fossil fuel use and land clearing. Climate changes resulting from human-induced changes to atmospheric composition are popularly termed 'the greenhouse effect'. Society is challenged in 2006 both to reduce atmospheric changes and to successfully adapt to climate changes that are already unavoidable.

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In writing this article, the authors referred to a review article in the *Bulletin of the American Meteorological Society*, February 2006, by Lynda Chambers entitled 'Associations between climate change and natural systems in Australia'.

urban antics by John Hunter

Sandgropers

Insects... the hot summer day was full of them, the air was a crazy conglomerate, a soup of airborne invaders going... everywhere, anywhere and nowhere.

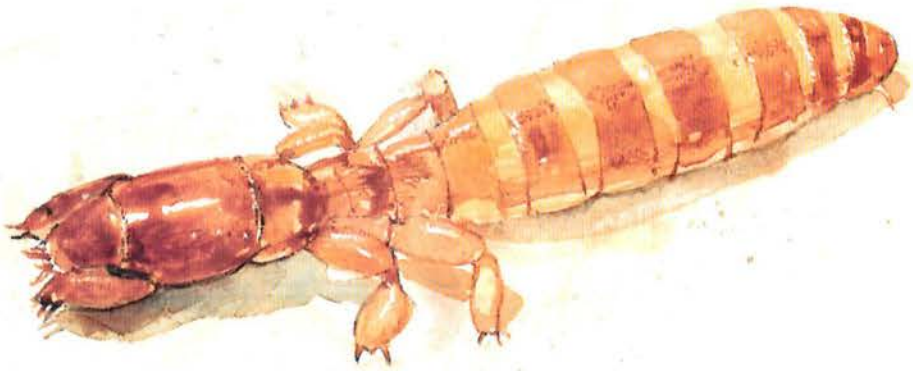
Resting with head on hands, I stared down through the crystal clear water at my feet on the top step in the swimming pool. Scuttling across the water surface were hundreds of little insects, then I realised there were still smaller beasts ducking and weaving among the others... thousands perhaps. Question is, how many millions couldn't I see? Was I about to be the host of these silent invaders? I retreated to my diggings in the backyard.

The creamy quartz sand grains fell away from the spade as I prepared a trench then, to my horror, it happened again. This time the grand-daddy of all local insects, a huge, brown, shiny sandgroper dropped onto my bare foot.

Now, I know they don't have fangs (like a pit-bull or a centipede), but it was a quick tango out of there for another little rest and to ponder, up close and personal, this ungainly arthropod. On the human scale of beauty, only their mothers would love them but, in some countries around the world, this fat little number would definitely rank highly as a gourmet's delight.

Relatives of grasshoppers and crickets, local sandgropers *Cylindraustralia kochii* or *C. tindalei* (the two found in the Perth area) are slow-moving subterranean insects that live in our sandplains and tunnel or crawl through loose quartz sands for virtually their entire life.

There is, however, a strange personal feeling of pride and protection in Western Australia whenever one is 'unearthed',



probably because the term 'sandgroper' has a long history as a colloquial name for people born and raised in the State. So all you 'out-of-staters' (and I know there are a lot of you, because I can't buy a cheap house anymore or drive to work in a respectable time) please treat sandgropers with respect.

The grub-like, very elongated and cylindrical body has small, thick mid and hind legs recessed in the middle section of its length, which enables it to move forward or back-pedal with ease along its tunnels. The forelegs are highly modified for burrowing and don't look like legs at all. They are also short, but are flattened, have pronounced finger-like spines and are situated on either side of the head.

The insects burrow by parting the soil ahead of them with breaststroke-like motions of their very powerful forelegs, compressing the soil and creating an open gallery as they progress. A tell-tale sign of their presence, particularly after rain, is the raised ridges of soil on windswept surfaces as they actively burrow just below the surface, possibly in search of the base of a succulent plant stem or looking for mates.

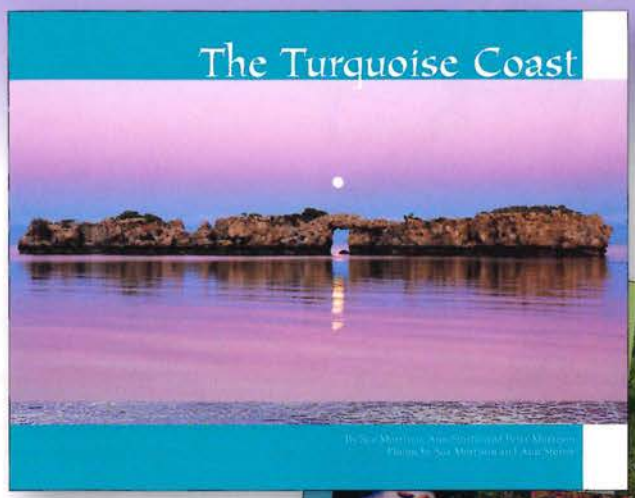
While farmers are a bit down on sandgropers for nicking the best selections in some cereal crops, city folk can take heart, as recent studies have shown that, besides introduced and native plant material, sandgropers eat sand-dwelling insects and the occasional feast of termites. Now that's squaring up the ledger.

DID YOU KNOW?

- Sandgropers were once thought to be degenerate mole crickets. While their digging apparatus and head are similar, mole crickets are long legged and a 'typical cricket' shape.
- Like grasshopper relatives, sandgropers do not change shape in metamorphoses. They develop from a single egg deep in a burrow and have no larval stage.
- Dr Terry Houston at the WA Museum would like frozen intact samples from the great southern and south coast regions of WA to further his studies on this amazing insect. You can contact him by email (terry.houston@museum.wa.gov.au).

North, south and somewhere in between...

Whichever way you're heading, explore Western Australia with WA Naturally Publications.



The Turquoise Coast book, the newest Department of Environment and Conservation publication, showcases the area spanning Lancelin to Leeman. With exquisite photographs, and fascinating information about the area's past and present, the book explores the underwater attractions of Jurien Bay Marine Park, the dozens of islands and the astonishing wildlife living on them, the remarkable Pinnacles, the wealth of wildflowers and caves, and the towns and landforms of the region.

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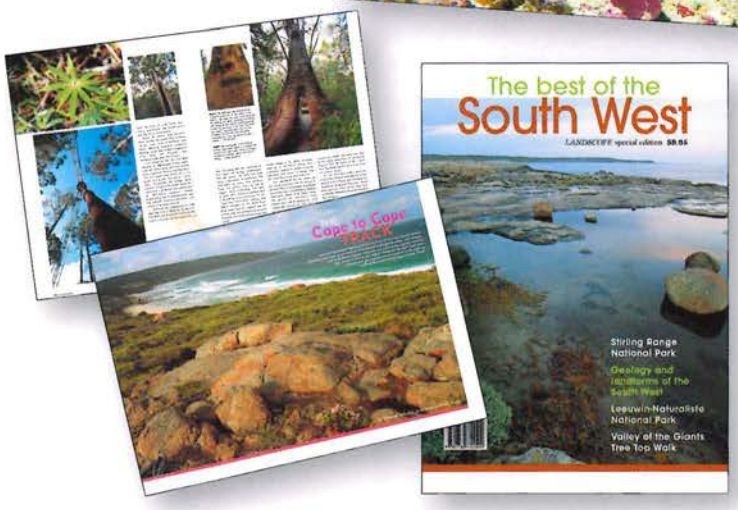

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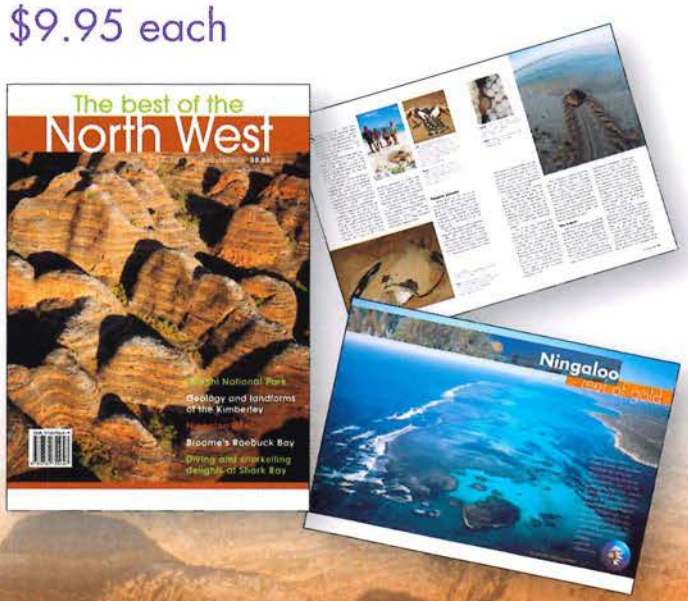

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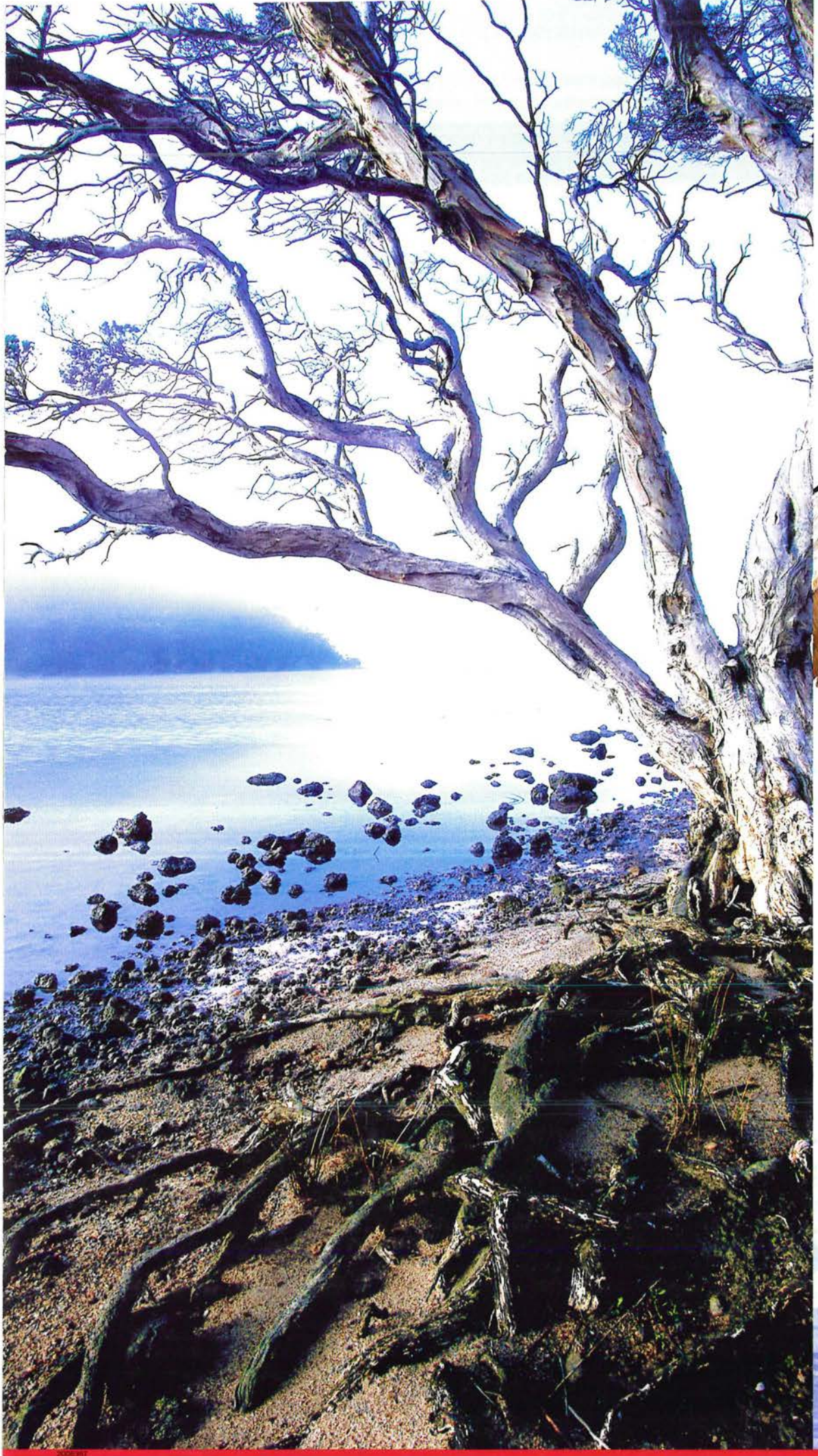

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ISSN 0815-4465

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Print Post Approved pp665002/00004