WA's conservation, parks and wildlife magazine

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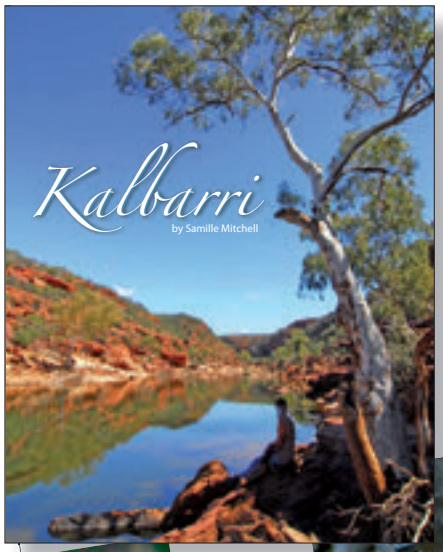


Walpole-Nornalup National Park

Echinoderms

Land snails of the Kimberley

A million wild camels **Windjana Gorge National Park** Heeding kyloring's warning







Visually stunning, this new book captures the beauty of Kalbarri and its national park.

Kalbarri takes you back in time to learn about the area's original Aboriginal inhabitants and leads you through the subsequent history, from early European explorers to modern-day development. It delves into the fascinating geology which shaped Kalbarri's spectacular river and coastal gorges, and it reveals something of the ancient creatures that once roamed here.

The book also details some of the more common and some of the most interesting flora and fauna species you may encounter in the area, as well as its marine environment.

Finally, the book provides information on the myriad ways you can explore Kalbarri and its natural wonders.

Kalbarri

RRP $29.95

Available from good bookshops, newsagents, tourist information centres and Department of Environment and Conservation (DEC) offices, by mail order (postal charges apply) addressed to Locked Bag 29, Bentley Delivery Centre, WA, 6983, by contacting DEC on phone: (08) 9334 0333, fax: (08) 9334 0498, TTY (hearing impaired) facility: (08) 9334 0546 or ordering online at DEC's website at www.dec.wa.gov.au/shop.

Department of
Environment and Conservation

Our environment, our future


Abby Berryman


Frank Köhler

contributors

Abby Berryman is a conservation officer with the Department of Environment and Conservation (DEC) based in Albany. She has been working on the Western Ground Parrot Recovery Project since 2008 and during the past year has been involved in establishing a western ground parrot captive management project. She has worked with south coast threatened birds species since 2002 through Honours and PhD projects studying the vocalisations of the noisy scrub-bird. During this time she also worked on a casual basis for DEC assisting with monitoring and translocations of noisy scrub-birds and western bristlebirds.

editor's letter

Early in the 1990s well-known American journalist-naturalist Bill McKibben engaged in a radical experiment. He sat down and watched 24 hours' worth of television on all 93 network and cable channels available in his town of Fairfax, Virginia. Then he spent 24 hours climbing and camping on a mountain near his house. Throughout both exercises, he kept careful and thorough notes of what he observed. The resulting book, *The Age of Missing Information*[1], is a compelling if somewhat worrying analysis of how much the two experiences yielded in the way of information.

It's perhaps not surprising that the mountainside experience would be more enjoyable than sitting still for several weeks in front of videotapes of game shows, sit-coms, info-mercials, and soap operas as well as round-the-clock news and current affairs. But it is intriguing, and of no small concern, that even taking into account the dozens of hours of high-quality nature documentaries that were in McKibben's TV mix, the amount of information—meaningful, worthwhile information; the kind that added to knowledge and understanding of the world around him—was far greater in his one day of direct, unmediated contact with the natural world.

Nature documentaries, he found, are forced to mislead if not lie for the medium: "...for all their dart guns and millions of feet of film," he writes, "they actually get across remarkably little information...half the time they specialise in misinformation, undercutting their message with their pictures. The Englishman is telling you that this great flightless bird is on the edge of extinction, but for half an hour he is showing you endless pictures of this great flightless bird, so how bad could it be?" In contrast, the insight McKibben gains from lying on his stomach watching a duck swim back and forth, or lying on his back watching hawks circle above him, is that living things "are marvellous for their own reasons, that they matter independently of us..." and that "the sad picture on the screen is no substitute for the deep and lifelong understandings we've let slip away."

Nowadays, of course, we are even more plugged into screen-based devices than we were then. We are as likely as not to be carrying our internet access around in our pockets, even as we set out on a bushwalk or camping trip. But this kind of constant 'connectedness' to the virtual world could surely only detract from the real thing: for example seeing first-hand the stunning diversity of echinoderms to be observed in the waters of Ningaloo (Echinoderms, p 18), or being part of an expedition that doubled the number of species of land snails known to science in the Kimberley (Diversity hot spot revealed, p 26).

So this spring, why not switch off, unplug, and surrender yourself completely to what's on offer in your nearby patch of bush? You'll be surprised what there is to learn!



Madeleine Clews
Executive Editor

[1]NY: Random House, 1992.

2010 International Year of Biodiversity

Frank Köhler is a land snail systematist with DEC's Kimberley Island Survey team, based at the Australian Museum in Sydney. During this work the team has not only found virtually hundreds of new species but has also gained insights into their evolution. Prior to starting work with DEC in April 2008, Frank worked for several years at the Natural History Museum in Berlin on projects including the evolution of European water frog species and the systematics, phylogeny and evolution of Asian freshwater snails. He graduated from Humboldt University in Berlin in 1998. Frank is interested in the evolution and systematics of non-marine gastropods.

Bron Anderson worked as a biological control officer with the Northern Territory Government before joining DEC in 2008. As an interpretive officer for the department's Warren Region, Bron has been involved in numerous projects including the development of interpretive panels, fact sheets and brochures, all of which enhance the experience of people visiting the area. She also promotes DEC and the Warren Region though community events and school activities. It is Bron's passion for the great outdoors that has led her to pursue a career in sharing her knowledge of the local environment with others.

Alex Errington was an 'original' member of the former Department of Conservation and Land Management when it was formed in March 1985, and was the Director of Corporate Services from 1985 to 1992. After a break of 10 years when he was the Deputy State Ombudsman, Alex returned to work on a range of land-related projects with DEC; an example being the consolidation of Benger Swamp Nature Reserve, which is featured in this issue. Recently, he has spent much of his time purchasing land to add to the State's conservation reserve system. He still gets a buzz from acquiring special pieces of land which provide habitat for our unique flora and fauna.


Bron Anderson


Alex Errington

also contributing...

Ann Storrie, Lesley Gibson, Vince Kessner, Melanie Smith, Sarah Comer, Allan Burbidge, Cameron Tiller, Deon Utber, Joanna Moore, Bruce Ward, Neil Burrows, Mark Lethbridge, Keith Morris, Brent Johnson, Bill Muir, Samille Mitchell, Anne Cochrane, Rebecca Dillon, Sarah Barrett, Emma Adams, John Hunter and Christie Mahony.



Cover illustration by Philippa Nikulinsky
The prickly honeysuckle (*Lambertia echinata* subsp. *echinata*) is ranked as critically endangered. This attractive shrub is only found in Cape Le Grand National Park, where several small groups of plants are known, mostly near Lucky Bay. It was first collected by the notable British botanist Robert Brown and described by him in 1810.
Illustration reference photo by Anne Cochrane.

Back cover photo by Emma Adams/DEC
Wild coastal scenery, rugged granite peaks and dense heathlands characterise Cape Le Grand National Park. The park is known for its atractive bays with sparkling waters and wide sandy beaches set between rocky headlnds, such as Lucky Bay, shown here.

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Department of
Environment and Conservation

Our environment, our future









Orchard bears fruit

It's a great feeling of satisfaction to a gardener when a carefully planted and tended orchard bears fruit. Native seed orchards are no exception.



by Anne Cochrane, Rebecca Dillon, Sarah Barrett and Emma Adams

The prickly honeysuckle (*Lambertia echinata* subsp. *echinata*) is known from only several small groups of plants in Cape Le Grand National Park, east of Esperance. It inhabits windswept coastal slopes and occurs in sandy loams over granite among coastal heaths rich in species from the families Myrtaceae (eucalypts, peppermints, paperbarks and claw flowers) and Proteaceae (bankias and hakeas). Its leaves have long sharp points and the woody fruits are beaked. The trumpet-shaped flowers occur from late winter to late spring and are predominantly bird-pollinated. Most plants occur near the crystal clear, sparkling waters of Lucky Bay, one of Western Australia's most beautiful beaches.

Dieback and other risks

Unfortunately, this attractive orange-red flowered shrub is on the brink of extinction. Although the species was declared rare in 1980 and ranked as critically endangered in 1995, the number of plants in the wild continues to decline. Plants are highly susceptible to the deadly plant disease caused by the pathogen *Phytophthora cinnamomi*, which infests a large portion of the park. One group of plants inhabits a small 'island' in an old disused gravel pit, already infested with the disease; another is dangerously close to a public visitation site and at risk of trampling and the introduction of disease. Disappointingly, in shadehouse experiments, the prickly honeysuckle





Above View over Lucky Bay from the location of one of the wild populations.
Photo – Emma Adams/DEC

Left Unopened flowers of the prickly honeysuckle.
Photo – Anne Cochrane/DEC

Below left Immature beaked fruits of the prickly honeysuckle.
Photo – Emma Adams/DEC

shows a poor response to the application of phosphite, a fungicide which halts the decline of a number of other highly susceptible species. However, phosphite does protect the habitat of the plants, providing protection from the indirect effects of the disease (for example, reduced canopy cover) as well as slowing the spread of the pathogen.

Despite many surveys, no new locations of the prickly honeysuckle have been found since 2001. It is currently only known from three disjunct populations and about 254 plants, 141 of which are juvenile plants and not yet reproductive. This means the species is now also threatened from having a limited gene pool. This may ultimately reduce its ability to respond to threats such as climate change.

Recovery actions initiated to safeguard these plants from extinction include the collection and conservation of seeds and the translocation of plants back into the wild. About 4,000 seeds have been collected and conserved at the Department of Environment and Conservation's (DEC's) Threatened Flora Seed Centre from 64 plants in three wild populations, with 12 collections made over 13 years. Seeds from these collections enabled a number of translocations into the wild, one in 1998–99 and two in 2004.

Until recently, all efforts to create new populations have failed. At two sites, plants died as a result of *Phytophthora* dieback and, at the other site, plants succumbed to drought. Despite these failures, the resulting increased understanding of the ecology of the prickly honeysuckle will improve future recovery efforts. With the species' natural environment so heavily infested by *Phytophthora*, finding a new translocation site within the park has also been a major challenge. As a last resort, sites outside the species' known distribution were chosen to save the prickly honeysuckle from potential extinction.



Left Planting seedlings into the seed orchard.

Below left The Albany seed orchard three years after planting.
Photos – Anne Cochrane/DEC

Bottom left The bird-pollinated trumpet-shaped flower of the prickly honeysuckle.
Photo – Emma Adams/DEC



Seed orchards

Seed orchards are established to provide a safe haven for threatened plant species, to boost plant numbers, to create more opportunities for seed collection and to reduce pressure on wild populations for seed collection. Sites such as these can be monitored and managed more easily, as well as manipulated for scientific experiments.

In the rescue mission for the prickly honeysuckle, young seedlings were planted into an existing seed orchard north-east of Albany (see 'A safe haven for threatened plants', *LANDSCOPE*, Summer 2005–06) as well as a newly created one at Dalyup, north-west of Esperance in 2006. Survival of plants at both sites has been very high. Funding from the State Government and the Australian Government through South Coast Natural Resource Management (NRM) has supported these orchards. The Albany and Esperance rare flora recovery teams and members of the community volunteered their time to assist with the planting.

Fruits of their labours

After a number of years of careful watering, excluding herbivores and monitoring of growth and flowering, the prickly honeysuckles in the seed orchards have finally produced fruit. Initially predated by parrots and insects, undamaged ripe fruits were first seen in 2009 and seeds were collected from reproductive plants from July that year. Material from 15 plants at Dalyup and 55 at Albany have been harvested so far, with a total of 750 seeds collected in 2009. Some 200 of these seeds were germinated at DEC's Threatened Flora Seed Centre and provided to the Botanic Gardens and Park Authority's Kings Park accredited disease-free nursery which then supplied the resultant seedlings for a new translocation aimed at boosting plant numbers in the wild.

Preliminary mapping and soil sampling for *Phytophthora* at more than 20 potential translocation sites revealed the presence of the pathogen in most cases and therefore established the sites as unacceptable. Recently, two new pathogen-free sites were found within nature reserves east of the natural populations. While they are up to 55 kilometres from the natural populations, their soil and plant assemblages are very similar to that of the natural populations. With funding support through the State Government's NRM program, the new seedlings were planted in autumn 2010 and are now being carefully nurtured until they become established.

The outlook for the prickly honeysuckle is now looking brighter. The seed orchards have been a successful enterprise—plants in the orchards were originally created from wild seed sourced from Lucky Bay and, in turn, these plants are providing their own seed for conservation. While there is now less need to collect seed from the wild, the natural populations will continue to be protected and monitored for survival and recruitment. Further research to find an effective means of protecting the last remaining precious plants in the wild by eradicating or halting the deadly *Phytophthora* is a high priority. Continued funding support for maintaining both wild and newly translocated populations will be integral to ensuring the survival of the prickly honeysuckle for the benefit of future generations.



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bookmarks by Joanna Moore

Wildflower country: discovering biodiversity in Australia's southwest

Author: Stanley Breeden
Photographers: Stanley and Kaisa Breeden
Publisher: Fremantle Press
www.fremantlepress.com.au
224 pages, hard cover, colour photographs throughout
ISBN: 9 781 921 361 784
RRP: $75



"The southwest corner of Australia is the place of the ultimate wildflowers," claims author Stanley Breeden in *Wildflower country*. And he and Kaisa Breeden stunningly capture the wondrous variety of wildflowers in the region in their photographic exploration of the South-West Botanical Province. In fact, the images are extraordinarily striking and detailed—the product of exposure blending—and demonstrate the amazing results that can be achieved by digital camera techniques in close-up nature photography. Part one of the book examines this 'new nature photography' as well as the classification of plants and the 'species-making' processes of the south-west, while part two is divided into seven geographical areas. The hundreds of photographs throughout this beautiful book are bound to impress.

Australian Botanist's Companion

Author: Alex George
Publisher: Four Gables Press
Available from the author (a.georg e@murdoch.edu.au)
671 pages, hard cover, black and white
ISBN: 9 780 958 034 111
RRP: $77



This comprehensive reference book provides a wealth of information on the history and sources of information relevant to the systematics of plants (the identification and taxonomy of plant species) in Australia. It includes information on published and electronic references on botanical and related subjects, the histories of botanical institutions, flora and faunal emblems and key honoured figures in the field. There is also a listing of all the people who collected plant specimens in Australia between 1699 and 1900 as well as information on every ship that carried out a scientific expedition in Australian waters since 1699. The 'ABC' will be a useful tool for any researcher on plants in Australia or those working on or interested in Australian natural history.

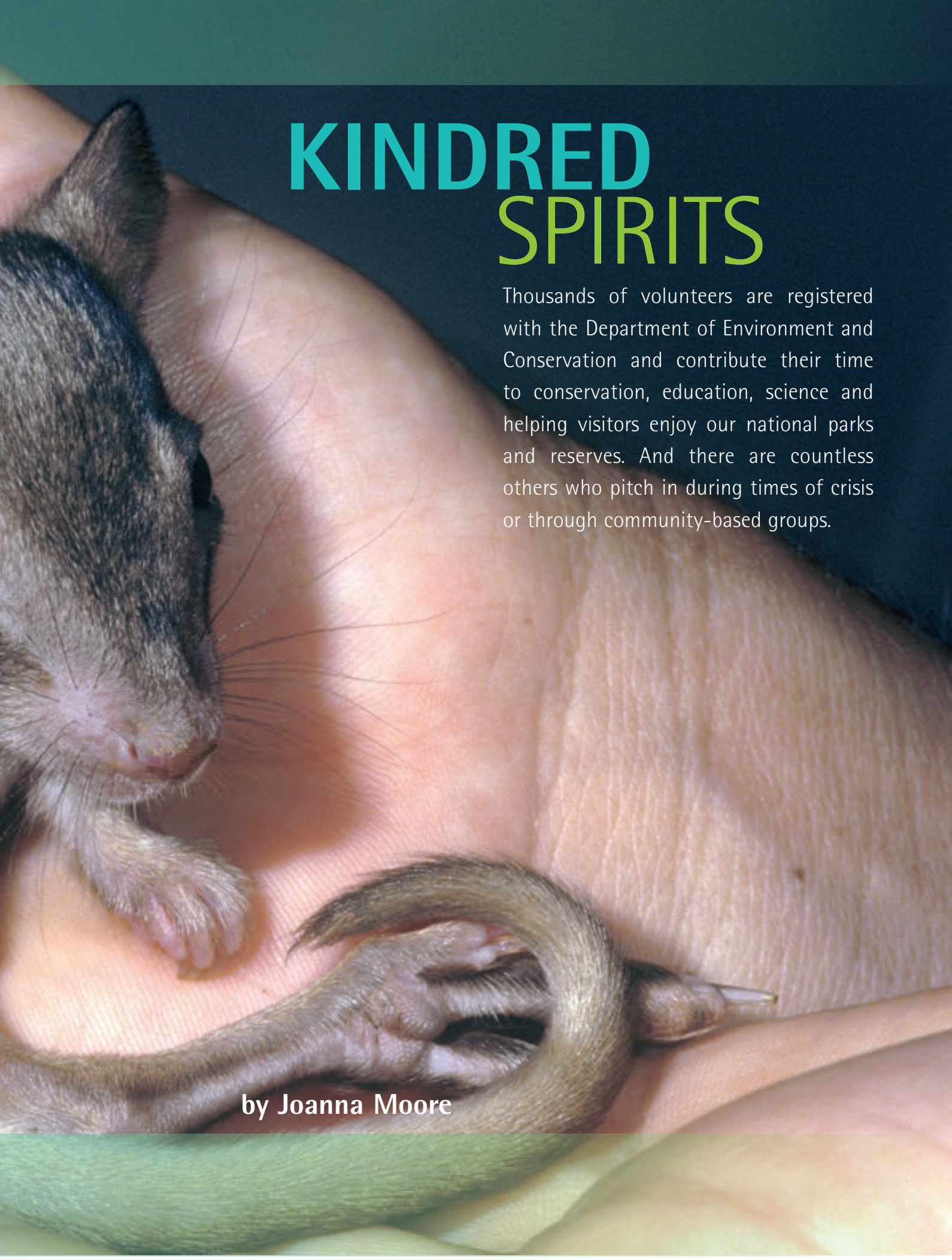


Stromatolites

Author: Ken McNamara
Publisher: Western Australian Museum
www.museum.wa.gov.au
88 pages, paperback, colour photographs
ISBN: 9 781 920 843 458
RRP: $18.95

This very accessible book would be a great introduction for students to the 'living rocks' that are stromatolites. These complex columns of sediment are formed by microbiological communities and are living examples of one of the most ancient forms of life on Earth. Information is provided on examples of Western Australia's living and fossil stromatolites (the greatest range in the world) including stromatolite conservation.





KINDRED SPIRITS

Thousands of volunteers are registered with the Department of Environment and Conservation and contribute their time to conservation, education, science and helping visitors enjoy our national parks and reserves. And there are countless others who pitch in during times of crisis or through community-based groups.

by Joanna Moore





Across the vast state of Western Australia, people contribute hundreds of thousands of hours of unpaid time to protecting and conserving the environment. Without these volunteers, many conservation and research projects, community activities and environmental education initiatives would not be possible.

As the government agency responsible for the management and protection of WA's incredible natural spaces, the Department of Environment and Conservation (DEC) has a wide range of programs through which community members can volunteer to help in the care of our environment. There are more than 11,000 registered volunteers who help the department in the collective role of protecting and conserving our environment, 3,900 of whom actively volunteered in 2009–10.

During 2009–10, this considerable number of DEC volunteers contributed 421,000 hours in 156 different programs. These programs ranged from helping with maintenance work in a variety of national parks and other conservation reserves, to recovery programs for threatened flora and fauna species and collecting and mounting plant specimens. Hundreds more volunteered their time as part of anti-litter initiatives.

Helping wildlife

WA's Wildcare Helpline is staffed entirely by volunteers. Started in 2001, this helpline receives calls 24 hours a day, seven days a week from members of the public who have found injured native animals and want to be put in touch with a DEC-registered volunteer wildlife rehabilitator. About 30 volunteers on the phones link callers with dozens of wildlife carers across the state. One pair of extremely dedicated volunteers, Brian and Robyn Foley, were recognised with a Volunteer of the Year Award in 2009 for their work on the helpline. Brian and Robyn staff the helpline from Friday night to Monday morning every weekend of the year except Christmas, receiving up to 150 calls each weekend.

Another way community members support native animal welfare is through the wildlife rehabilitation program. Volunteer wildlife rehabilitators in this program attend DEC wildlife courses to learn how to care for sick, injured, diseased or abandoned animals until they



Previous page
Main A volunteer handraises a burrowing bettong.
Photo – Lochman Transparencies

Above Curtin University environmental biology student Josey Stewart volunteers as a Wildcare Helpline operator.
Photo – Judith Holmes/DEC

Above left The late Caleb Delamare with a peregrine falcon. Caleb was a DEC-registered wildlife rehabilitator who supported the Wildcare Helpline by rescuing and rehabilitating raptors throughout the metropolitan area. People he worked with describe him as a wonderfully dedicated man who was passionate about conservation, education and caring for birds of prey.
Photo – Nancy Tang

Left Learning how to handle and rehabilitate reptiles such as bobtail lizards is part of DEC's wildlife carers courses.
Photo – Judith Holmes/DEC





Above DEC-registered volunteer wildlife rehabilitator from the Native Animal Rescue rehabilitation centre Kelli Ellemor helps with the release of a rescued albatross to its natural habitat.
Photo – Peter Lambert/DEC

Above right Volunteers help with the relocation of cygnets at Forrestdale Lake.
Photo – Sonia Chalmers/DEC



Right Volunteers Phylis Robertson and Val Preston discover fungi as part of the Perth Urban Bushland Fungi project.
Photo – Neale Bougher/DEC

recover and can be released into their natural environment. More than 300 wildlife carers are trained by DEC each year, who then go on to work across the state. These volunteers have a personal commitment to keeping injured native animals alive, and dedicate many hours to this often-challenging work.

Bird lovers to the rescue

Community bird groups often pitch in when native creatures need their help. In 2009, volunteers from bird handling organisations, wildlife rehabilitation centres and other volunteer groups joined DEC staff to rescue black swan cygnets from Forrestdale Lake, near Armadale, which had dried up. The cygnets were destined to come to a sad end, unable to escape predators such as foxes due to the lack of water, and so were relocated to Loch McNess in Yanchep National Park. Volunteers were central to the rescue of these iconic animals, the official bird emblem of WA.

In another example of bird-lovers volunteering with grassroots conservation, some 350 people took part in the Great Cocky Count in April 2010. Volunteers at Carnaby's black cockatoo roost sites across the Swan Coastal Plain counted birds as they came in to roost in order to estimate total numbers and monitor trends through time. These volunteers, and many others who regularly help with cockatoo surveys, contribute to a powerful planning tool to help conserve these beautiful and threatened birds.

At the herbarium

The WA Herbarium also benefits significantly from the work of volunteers. In 2009, volunteers mounted 11,639 specimens and labelled 10,155 specimens at the herbarium, as well as helped with imaging specimens. They also helped audit the herbarium collection and generally kept the Reference Herbarium running smoothly, enabling technical staff to focus on other work.

Barbara and Bob Backhouse are two individuals whose work shows particular dedication. For more than 10 years, they volunteered at the WA Herbarium and consistently contributed the most hours of any herbarium volunteer. They managed the logistic and technical aspects of the Reference Herbarium which is accessed by members of the public, community groups, universities and environmental consultants, such as those who carry out work on behalf of mining companies.

Sadly, Bob passed away in 2009 and Barbara has now changed the focus of her contribution. A mining company consultant gave a eulogy







at Bob's funeral honouring his contribution to the conservation of the state's flora, illustrating how much their work was respected in the conservation and mining communities. Barbara's contribution as one half of the remarkable team who grew the Reference Herbarium from 6,000 taxa in 1990 to 11,000 taxa by 2009 was recognised with a Volunteer of the Year Award in 2009.

In our national parks

Yanchep National Park has been benefiting for many years from the work of volunteer Rob Foulds. Also recognised with a Volunteer of the Year Award in 2009, Rob dedicates many hours to sharing his knowledge about caves, supervising volunteers and collecting data. At caves elsewhere in the state, such as in Leeuwin-Naturaliste National Park, dozens of volunteers share their knowledge of caves with visitors on guided tours.

The allure of camping in some of WA's most spectacular natural environments has made DEC's volunteer campground host program one of its most popular and successful. Since it was launched in 1991, hundreds of people have taken part in the program. Some 420 people are registered as DEC campground hosts, with about 220 volunteer placements around the state each year. It is estimated that these people volunteered 125,875 hours during 2009–10.

Top left Aboriginal cultural protocol training is an important part of preparing campground hosts and honorary CALM officers for their work in national parks.
Photo – Judith Holmes/DEC

Centre left DEC campground hosts welcome visitors to Kennedy Range National Park.
Photo – Courtesy Evelyn and Gorden Cole

Left DEC marine conservation officer Marissa Speirs and volunteer Anna Vitenbergs with a nesting hawksbill turtle on Rosemary Island in the Dampier Archipelago. Anna has volunteered tagging turtles with DEC for 20 years.
Photo – Adam Williams/DEC





These volunteers play a very important role as they are often the first point of contact for visitors to a national park. They have a wide range of duties including collecting fees and visitor statistics, providing advice, information and answering questions, monitoring site usage, cleaning facilities, transporting water and firewood and sometimes helping DEC staff with light maintenance tasks. Before taking up a position at one of the 53 sites across the state, campground hosts learn about fire awareness, first aid, Aboriginal cultural protocol and strategies for communicating pleasantly and effectively with a range of people.

Another key group of volunteers who support the work of DEC are honorary CALM officers, who have powers under the *Conservation and Land Management Act 1984*. These individuals are recommended by their representative organisation or company—such as the Bibbulmun Track Foundation, a commercial tour operator or a four-wheel-drive group—as having skills, knowledge and values which will support DEC's conservation goals and help the department do its work. Honorary CALM officers assist DEC staff and park rangers as extra eyes and ears on the ground, particularly in remote areas, and may be the only people visitors meet that can direct them or answer their queries about isolated parks or features. Thirty-three people have passed the training course run by DEC and work across WA voluntarily looking after our protected land and helping visitors safely enjoy their nature-based experience.

Throughout WA's national and marine parks and reserves, volunteers are involved in activities as diverse as dune rehabilitation, dieback treatment, western ground parrot camp-outs, *Western Shield* surveys, water monitoring, fauna translocation, cane toad busting, turtle tagging, seed collection, flora surveys, astronomy guiding and more. As well as carrying out conservation work, community-based volunteer groups such as 'Project Numbat', the Malleefowl Preservation Group or the Gilbert's Potoroo Enclosure project often play an important role in raising funds and awareness for conservation efforts carried out or supported by DEC. Many community groups are supported by the State Government's Environmental Community Grants Program which recognises the enormous contribution community-based organisations make to protecting the state's environment and conserving the nature of WA.



Above Honorary CALM officer Ray Harris shows four-wheel drivers appropriate driving tracks in Nambung National Park.
Photo – Courtesy Ray Harris

Above right Volunteers after a good day's weeding at Yanchep National Park.
Photo – Julia Coggins/DEC

Right Children examine a quadrat during seagrass monitoring at Roebuck Bay, a project run with significant volunteer contribution.
Photo – Fiona Bishop





Not so alluring

Often, volunteers work in particularly unglamorous roles: for example euthanising injured animals such as kangaroos and emus when they are struck by cars on our roads, removing invasive weed species, or trapping feral goats or pigs which are causing damage in national parks. While often little-recognised, this work is a valuable contribution to conservation.

One challenging volunteer role is snake removal. Some 180 people across WA are registered as volunteer reptile removers. These brave souls are on call to safely catch and remove snakes from people's homes and backyards.

Keeping our state clean

Not many people enjoy picking up rubbish but each year hundreds volunteer their time to do so. Keep Australia Beautiful WA (KAB WA), part of DEC, coordinates anti-litter programs to encourage people to offer their time to keeping the environment rubbish-free. Four thousand registered litter reporters, 150 Adopt-a-Spot groups and hundreds of entrants in the Sustainable Communities Awards programs all volunteer their time on activities to reduce litter and protect the environment.

Cadets, friends and guardians

Organisations such as Conservation Volunteers Australia, the Department of Corrective Services, the Bibbulmun Track and Munda Biddi Trail Foundations and four-wheel-drive clubs also work on a volunteer basis with DEC. Additionally, many nature reserves and marine parks have friends groups—members of a community who are particularly attached to a natural space and work together to help look after it.

Many DEC-managed regional parks are cared for by these hard-working friends groups, including Yellagonga, Woodman Point, Herdsman Lake, Piesse Brook, North Lake, Kalamunda and many more. Often friends groups play an important educational role through sharing their knowledge about an area in talks or guided tours.

Other people play an environmental education role through volunteering with DEC's *Nearer to Nature* program or as volunteer instructors in DEC's Bush Ranger cadet program. And, of course, the students themselves volunteer considerable hours to conservation during their time as cadets.

Iconic tracks and trails managed by DEC such as the Bibbulmun Track, Munda Biddi Trail and Cape to Cape Walk Track also benefit from the passion and attention of volunteers. The work of friends groups that carry out trail maintenance and monitoring, and volunteers who 'adopt a section', provide a significant contribution towards keeping these trails safe and enjoyable for users.

Meanwhile, some people choose to turn their environmental interest into action by joining the Swan River Trust's River Guardians program, through which they help protect and restore the Swan and Canning rivers and their foreshores.



Above Bibbulmun Track Foundation volunteer Grayden Sambell carries out trail maintenance.
Photo – Guy Spouge

Above left Volunteer Jo Williams releases a western barred bandicoot on Bernier Island.
Photo – Linda Reinhold/DEC

Left Volunteering can take you to beautiful locations. Here, volunteers Colin Steele and Shane Hall carry cage traps to a remote part of Two Peoples Bay Nature Reserve as part of Gilbert's potoroo radio-tracking in February 2009.
Photo – Tony Friend/DEC



Above Volunteers care for false killer whales during a stranding near Augusta in south-west WA in July 1986. Of 114 whales stranded, 96 were returned to the sea (see 'Saving the Whales', *LANDSCOPE*, Summer 1986–87).
Photo – Jiri Lochman

In times of crisis

Volunteers are indispensable in crisis situations, such as marine mammal rescue. Two mass strandings of false killer whales near the south-west town of Busselton on 3 April and 2 June 2005 is testament to this (see 'Stranded!', *LANDSCOPE*, Spring 2005). At these strandings, requests for help from the community by one of DEC's predecessor departments, the Department of Conservation and Land Management, led to many hundreds of volunteers working to save the whales.

In the second stranding—a massive rescue operation involving 40 staff and some 1,500 volunteers—more than 100 whales were herded out to sea within eight hours. This was one of the most successful whale rescues ever undertaken in WA with all but one of the whales surviving. This success demonstrates the huge benefits that can be achieved through collaborations between government agencies and the community. Without those volunteers, there might have been a very different outcome on that day.

Why volunteer?

The benefit of this massive volunteer force to the environment—and to DEC—is clear, but what do volunteers get out of volunteering? There is the camaraderie experienced through working with other people, particularly in high-pressure situations such as whale strandings. Such situations provide the chance to escape our usual routines and an opportunity to meet challenges not experienced day-to-day.

Volunteers are people who are environmentally committed and have taken a stance on their commitment by turning it into action. They enjoy seeing the right thing done and want to help make it happen. Perhaps they get a sense of satisfaction through training their fellow four-wheel drivers to be environmentally aware—and so choose to become honorary CALM officers. Maybe they value the healthy lifestyle gained through spending time in national parks and like to help other people enjoy it. Campground hosts certainly have the luxury of being in touch with some of the best places WA has to offer.

Volunteers, such as those at the WA Herbarium, may also have an intrinsic interest in the field to which they choose to donate their time. This may be coupled with a desire to increase their knowledge and develop new skills. Volunteering sometimes provides special opportunities for people to explore their special interests or demonstrate their skills. It is also true that volunteers often bring with them knowledge and specialist experience: learning is always two-way. Some of the most experienced people, with high levels of expertise, are often hard at work, unpaid, for conservation.

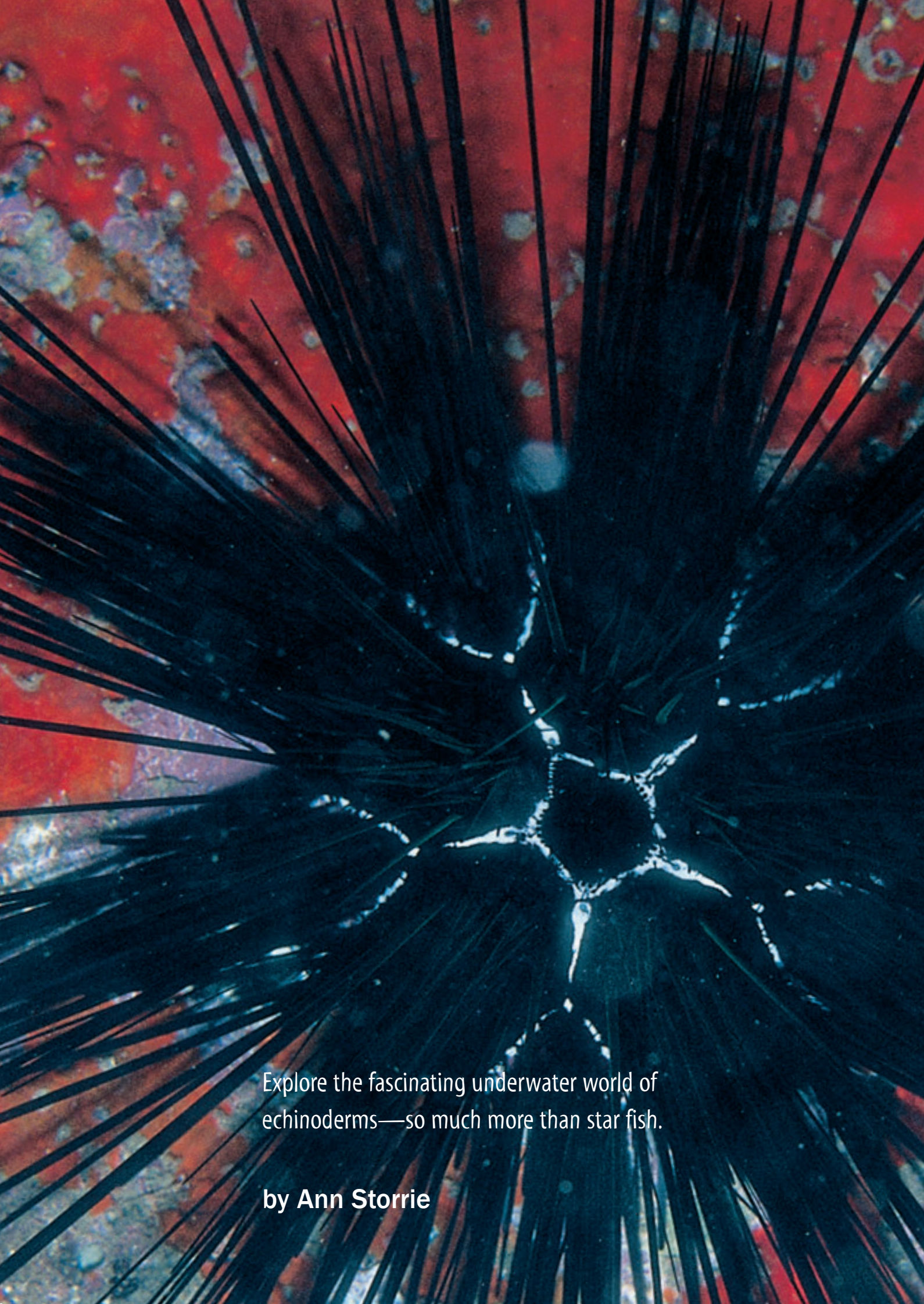
Volunteering—whether in tree planting, clean-ups or guiding cave tours—is also a way for people to become actively involved with nature, rather than just enjoying passive recreation. DEC's *Healthy Parks, Healthy People* program, in partnership with KAB WA and Mentally Healthy WA's Act Belong Commit campaign, aims to get more people connecting with nature and feeling better about themselves and the world around them. The notion of 'giving something back' can be really rewarding.

The benefits of volunteering spread widely through our society. Through their unpaid work, volunteers gain knowledge and new understandings of the complexities of conservation and environmental management. This then spreads throughout the wider community, raising awareness of conservation generally and leading to more sustainable behaviours. Helping others enjoy and recreate in our state's national and marine parks and reserves can also be a satisfying and meaningful experience.

The protection and conservation of the WA environment cannot be achieved alone: it is only by working as part of a greater environmental community that our conservation objectives can be reached.

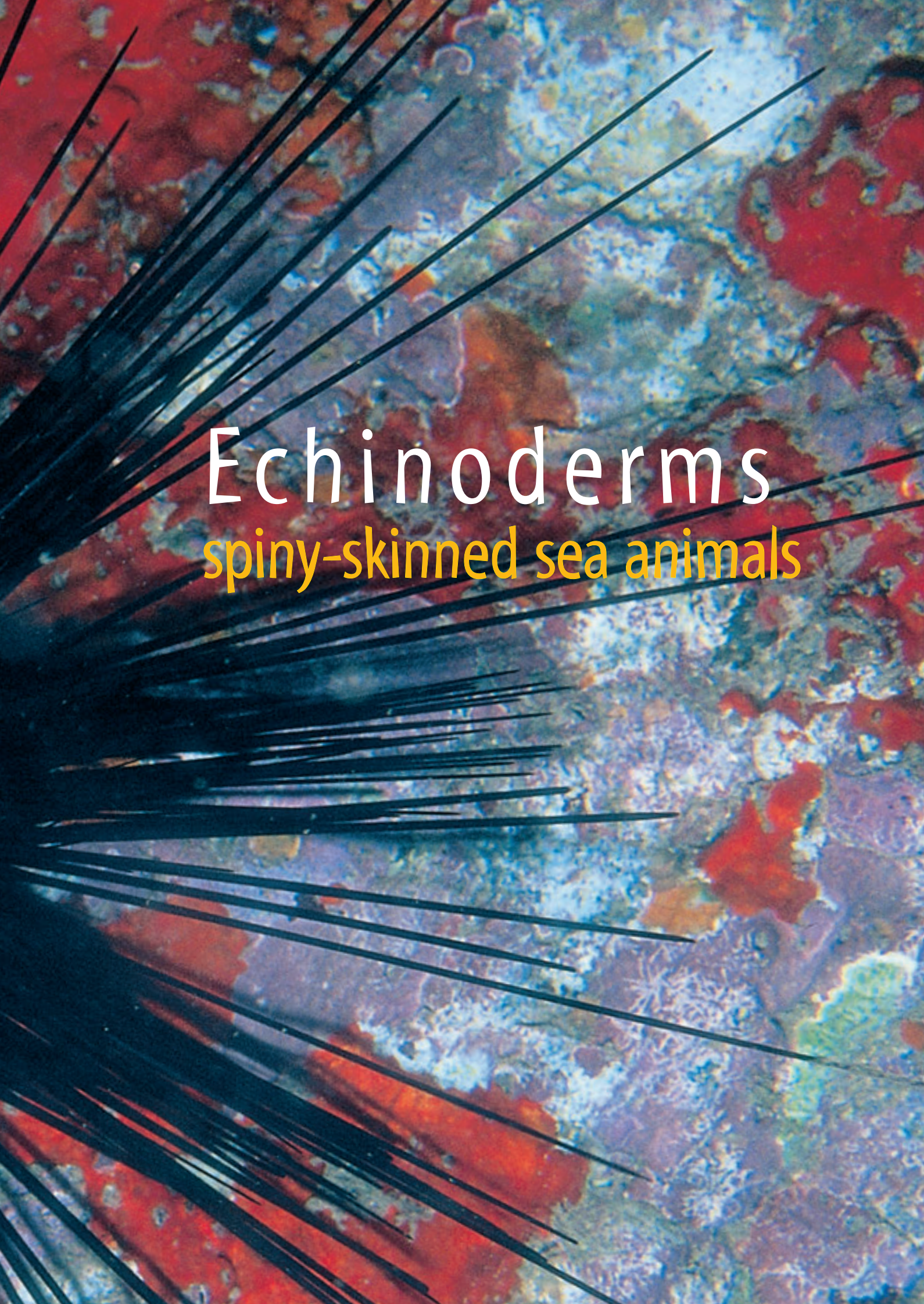
Joanna Moore is a Department of Environment and Conservation (DEC) publications officer and *LANDSCOPE* editor. She can be contacted on (08) 9389 4009 or by email (joanna.moore@dec.wa.gov.au).

The author would like to thank staff from DEC's Community Involvement Unit for their assistance. People interested in volunteering with DEC can contact the Community Involvement Unit. The Wildcare Helpline ((08) 9474 9055), in particular, is seeking more volunteers to staff the phones. Please call (08) 9334 0468 or email community.involvement@dec.wa.gov.au if you would like to help. Volunteers do not need to have experience as training and support is provided.



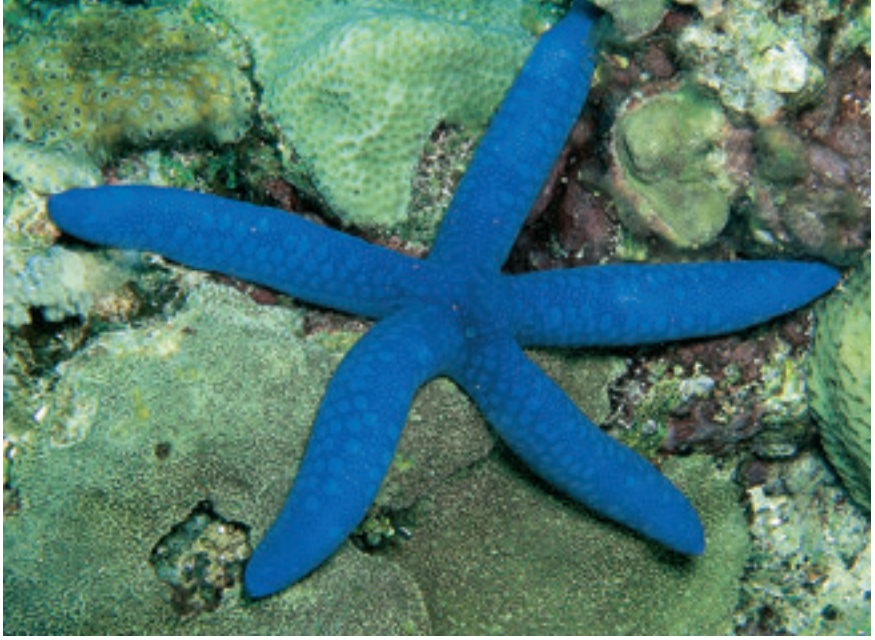
Explore the fascinating underwater world of echinoderms—so much more than star fish.

by Ann Storrie



Echinoderms

spiny-skinned sea animals



Sea stars, brittle stars, feather stars, sea urchins and sea cucumbers comprise the five groups, or classes, of echinoderms. The Latin word echinoderm literally means 'spiny-skinned' and is derived from the Greek word, echinos, which means 'hedgehog'. With a vivid imagination, a sea urchin could resemble a hedgehog, but others, such as feather stars, look more like beautiful flowers. The large, leathery-skinned sea cucumbers that browse over the ocean floor are often thought to be slugs, worms or waste products. Despite their diverse appearance, all echinoderms have many features in common, including a calcareous skeleton of plates, or tiny ossicles, in their body wall. Hence their name, spiny-skinned animals.

One method to help link the shapes of the different animals in the groups of echinoderms is to start with the sea urchin. Like sea stars, it has a body plan divided into five similar portions. If you stretch these portions, you will form a sea star. Imagine pulling the arms out further and you have a brittle star. Add more, thinner, branched arms for a basket star (a type of brittle star), or put hair-like growths called pinnules on the arms for a feather star. If you flatten the sea urchin, you can make a sand dollar, or if you stretch the urchin's body out vertically, you have a sea cucumber. With a little imagination, you may be able to envisage how all the echinoderms are related.

Other characteristics that belong to these fascinating creatures include extendable, hollow tube feet, most with suction-like tips. The feet are hydraulically expanded and contracted by a water vascular system within the body. The system is so delicately balanced that the feet can be waved about in any direction in a very flexible manner.

Echinoderms are also radially symmetrical which means they have two or more planes of symmetry. (Bilaterally symmetrical bodies, such as ours, have one plane of symmetry meaning if divided in half from the mouth down the body length, the right and left halves would be similar.) Unlike corals, echinoderms do not possess stinging cells, although some have venomous spines. Most are quite unpalatable to other animals and have few predators. This enables them to be very 'user friendly' to an enormous number of small sea creatures such as molluscs, shrimps, crabs, lobsters and tiny fish that seek shelter and food, and often live their entire lives within the arms, or on the calcareous skin, of their congenial hosts.

Previous page
Main Long spines of the diadema sea urchin.

Above right The blue sea star (*Linckia laevigata*) is common on shallow reefs and lagoons at Ningaloo Reef.

Below Feather stars or criniods will take advantage of coral outcrops to feed in the current.
Photos – Ann Storrie

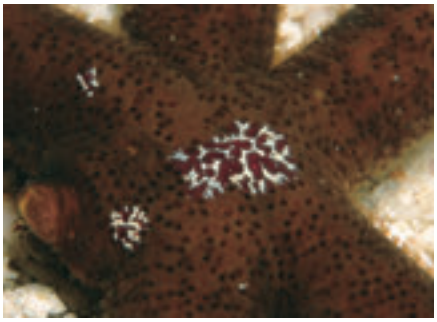


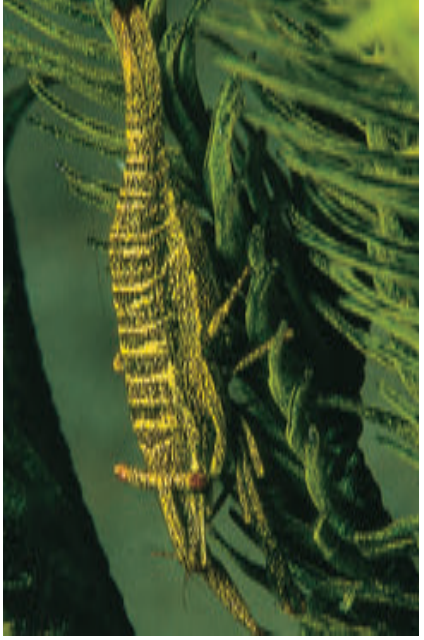
Sticking to sea stars

Of all the echinoderms, sea stars (often referred to as star fish) are probably the best known. Most have five arms, although several have seven or more, and their central mouth is on the ventral (bottom) surface. A very large and conspicuous sea star of the tropics is the blue sea star (*Linckia laevigata*). This sea star is common as far south as Ningaloo Marine Park and is often found in the shallow waters of Coral Bay. Its colour varies from bright blue to green, pink or yellow.

Tiny crabs, shrimps and molluscs are often found on this sea star and, in particular, a parasitic snail named *Thyca crystallina*. It lives on the sea star's under-surface where it feeds between the tube feet. Several of these tiny snails may be found on the same sea star. Don't try to prise them off as they stick very strongly to the spiny skin.







Far left top A parasitic snail *Thyca crystallina* on the underside of the blue sea star (*Linckia laevigata*).

Far left bottom Comb jellies known as ctenophores can be found live on sea stars.

Left Commensal shrimps living among feather star arms take on a similar colouration to their host.

Below The majority of sea stars have five arms but their body mass can disguise the fact, like this pin-cushion sea star. *Photos – Ann Storrie*

The sea star shrimp (*Periclimenes soror*) adopts the same colouration as the sea star on which it lives. It grows to only one centimetre in length and is quite thin and streamlined, which makes it difficult to see as it scurries around on its host. Like the snails, several shrimp often live on a single sea star.

Sea star shrimp also live on several other species of sea stars, including the large cushion stars (*Culcita* sp.) Cushion stars grow to about 25 centimetres in diameter and are like huge, colourful pincushions sitting on top of the reef. Unfortunately, some divers are tempted to pick them up to throw to one another. Please don't do this. It is far more interesting to gently turn them to look at the fascinating tiny animals underneath and to then place them back on the reef as you found them. Please don't move them onto a lump of hard coral. You can almost hear the sea star squealing as its little tube feet propel it off the stinging coral polyps.

Unusual comb jellies are also found on some sea stars. Comb jellies are gelatinous, jellyfish-like animals that are called ctenophores (pronounced teen-o-fours). They come in many shapes and colours and none possess stinging cells. The jelly-like forms have bands of tiny hair-like cilia that luminesce in the light as they swim through the water. Other forms of ctenophores, known as benthic ctenophores, or platyctenes, do not float free in the ocean, but live on the sea bed (benthic means 'bottom-dwelling'). Some are flattened, colourful creatures that are often mistaken for flat worms. One species named *Coeloplana astericola* is oval-shaped with dark, reddish-brown blotches on a white base. These ctenophores stick tightly to the spiny skin of sea stars from the genus *Echinaster*. Several may be found on one sea star, giving the star a colourful, mottled appearance. If you look very closely, you may be able to see the ctenophores' thread-like tentacles moving over the sea star.

Basking in brittle stars

While brittle stars are the most numerous echinoderms, their nocturnal and secretive habits ensure that they are not as easily seen as sea stars. They have a central disc with a mouth on the underside, their arms are usually longer and more flexible than that of sea stars and their tube feet lack adhesive suckers.

Basket stars are very interesting types of brittle stars. These echinoderms have huge spreading arms that may measure up to 60 centimetres across. During the day, they curl their arms into a tight ball that looks more like a rope coiled and stuck to a rock or coral, than an animal. At night, the arms unfold to form a huge net, or basket, that traps plankton. The food is then transferred to the mouth via grooves that run beneath the arms.

The basket star shrimp (*Periclimenes lanipes*) lives in large, tropical basket stars. The shrimp is very small, extremely shy of bright lights and is almost impossible to find among the network of branched arms. It usually has pale stripes and a similar base colour to that of the basket star. If you touch the arms of a basket star, or even shine a bright torch on them, they will curl inwards, completely enclosing the shrimp. It is best to wait quietly with a soft light and watch for tiny movements among the arms to catch a glimpse of this elusive little animal.







Left A brittle star on a soft coral.
Photo – Ann Storrie

Far left The basket star has a large cluster of arms that fan out to feed in the current.
Photo – Eva Boogaard/Lochman Transparencies

Below A feather star on a gorgonian sea fan.
Photo – Alex Steffe/Lochman Transparencies

Feather star friends

Feather stars, or crinoids, are some of the most colourful animals on the reef. They have feathery arms that range in colour from bright yellow and orange, to deep red, purple, blue and green. Some even have different colours and stripes or bands in their arms. Most of the large, colourful species occur in the tropics; however, some species live in temperate waters. Many stay well hidden during the day in crevices in the reef. At night, they perch on top of coral, or other animals such as gorgonians or sponges, to get a good vantage point to catch passing plankton.

Feather stars differ from sea stars and brittle stars in several ways. Their mouth is on the top of the body, rather than underneath, and their tube feet have been modified into types of tentacles called pinnules on the arms. These are coated with mucous to help catch food which is then swept into grooves that run down each arm towards the mouth. Like sea stars, their anus is also on the dorsal surface, but is elevated in a cone. Leg-like projections called cirri enable the feather star to 'walk' on the reef and to grip it tightly in a current. They can also 'swim' almost as elegantly as a Spanish dancer by moving their arms up and down.

The number of arms varies greatly between species. Feather stars of the genus *Comanthina* may possess more than 150 arms.The arms are very tightly packed—even the largest feather star reaches only 25 centimetres in diameter. Many tiny shrimp, squat lobsters and even fish have taken advantage of the shelter and steady food supply in these miniature ecosystems.

The crinoid clingfish (*Discotrema crinophila*) is an attractive, elongated fish with a short, rounded snout. It can assume a base colour similar to the colour of its host feather star, and it usually has one or two yellow or white stripes running from the eyes to the tail. A pair usually lives in their feather star, although they are so well camouflaged and fast to move under their host that you are lucky to glimpse either.

At least two species of commensal shrimps from the genus *Periclimenes* live and feed entirely within the feather



star's arms. It is thought that the larvae take on the host's colour after several moults; however, if the shrimps have to change hosts, their colours can change to match. The adults' bodies are banded similar to bands on their host and their base colour provides almost perfect camouflage. The maximum length of these shrimp is about two centimetres, they have very short antennae and their eyes sit on thick stalks that extend either side of the head. It is amazing that sometimes the stalks and eyes are the same colour as the tips of the pinnules on the feather star's arms.

The elegant squat lobster (*Allogalathea elegans*) is not always considered to be very elegant! Terms such as bizarre, ugly, spider-like or alien are more commonly used to describe these amazing little animals. They have huge chelipeds (pincer-like claws) and a long, tapering rostrum. (The term 'huge' is, of course, relative, as the entire animal grows to only two centimetres in length.) Like their shrimp neighbours, they adopt the same colours as their host. They usually live in pairs, the female being the larger.

Several other strange animals such as translucent snapping shrimps, orangutan crabs (*Achaeus japonicus*) and crinoid brittle stars may also live within the protective arms of feather stars. Finding these creatures requires lots of patience and care. If you pick up a feather star, its arms, which break very easily, will stick to your hand and wet suit. To avoid this, use a probe or chopstick to gently part the arms. The less movement the better and, if you are lucky, your tiny creature may sit still and in full view for several seconds.



Above Elegant squat lobster (*Allogalathea elegans*).

Below left Some sea urchins can be quite striking looking but also poisonous.

Below A clingfish found among the spines of a diadema sea urchin.
Photos – Ann Storrie

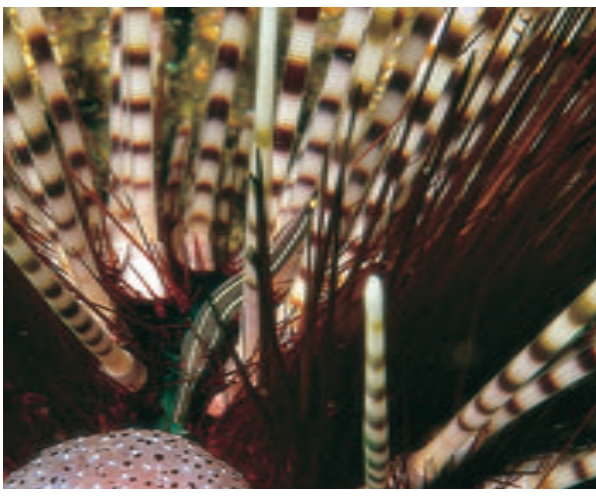
Safety in spines

Sea urchins are usually spherical animals with a five-plated internal case, or shell, that is known as a test. This is covered with a thin layer of skin and spines. Some spines, such as those on pencil urchins, are large with blunt ends, while diadema urchins have long, thin, needle-sharp spines that contain venom. The beautiful fire urchin that is common at the Houtman Abrolhos Islands has very short spines that are highly venomous, can penetrate most gloves and can cause intense pain.

Many small fish shelter within the long spines of diadema urchins. Pipefish align themselves with the spines for camouflage, while the urchin clingfish (*Diademichthys lineatus*) may live most of its solitary life within the confines of the spines. This attractive little fish is usually red to brown with white or yellow stripes running from the tip of its head to the tail.

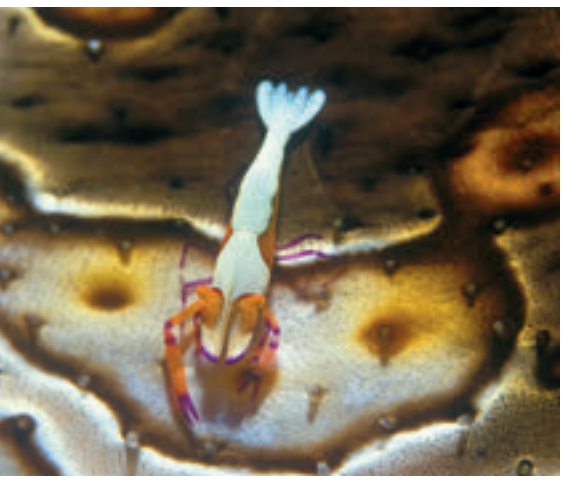
Many small shrimps and crabs also live on urchins, scurrying between the spines for a meal. The parasitic snail *Luetzenia asthenosoae* feeds on the fluids of its host and is sometimes seen in groups during a 'mating frenzy', leaving eggs trailing through the urchin's spines.

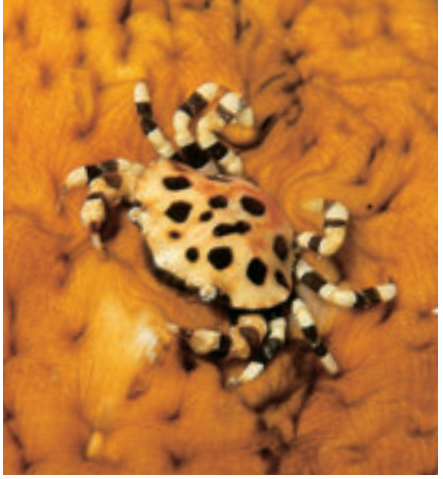












Co-habiting with sea cucumbers

Few divers spend time seriously looking at sea cucumbers. These echinoderms are sausage-shaped and many move over the sea bed on their five rows of tube feet, vacuuming up sediment and detritus, extracting the edible material and then excreting the waste in a characteristic trail behind them. Although some are black and ugly, others have beautifully patterned leathery skin which occasionally excites abstract photographers and which harbours many interesting animals.

The scale worm *Gastrolepidia clavigera* moves around the lumpy skins of several species of tropical sea cucumbers. The worm can change colour to match the surrounding blotches and patterns and is usually found on the under surface of its host. Several scale worms may live on one sea cucumber.

The tiny swimmer crab *Lissocarcinus orbicularis* has partly flattened hind legs to aid swimming and burrowing. If disturbed, it hides in the folds of skin and sometimes burrows part way into the sea cucumber's anus where it is almost invisible. *Periclimenes imperator*, a very attractive shrimp with a flattened head and purple-tipped chelipeds, is often close by. These commensal shrimps also live within the gills of the Spanish dancer nudibranch and on large sea stars. If you are very lucky, you may also see a bumblebee shrimp (*Gnathophyllum americanum*). It has a blunt head, one very long cheliped, black and white bands on the body and orange markings on the tail and chelipeds. It is associated with several echinoderms including sea stars and urchins.

One of the most bizarre relationships occurs between large sea cucumbers and the pearlfish (*Encheliophis homei*). These slender, translucent, elongated fish live within the body cavity of their host and only emerge at night to feed. They usually enter either tail or head first through the anus, although they have been observed entering via the mouth. A pair will sometimes be seen close to their host. They do not venture far and will shoot back inside if danger threatens. It is thought that they may also feed on the gonads and other tissues of their host. These fish have also been found in large sea stars as well as pearl-oyster shells.

This fascinating group of marine animals that provide food, shelter and protection to so many other organisms occurs in all our temperate and tropical seas. Some live in intertidal pools; others are found in the deepest parts of the ocean. Wherever you see an echinoderm, think of its marvellous adaptations to its environment, and its own private ecosystem of tiny shrimps, crabs, worms or fish. Never dismiss it as another boring sea star.

Above A tiny swimmer crab *Lissocarcinus orbicularis*.

Top left Even though sea cucumbers are bottom feeders, they can be observed extending their bodies up into the water column.
Photos – Ann Storrie

Centre left A striking sea cucumber that is common in the warmer waters extends its tentacles to feed in the current.
Photo – Alex Steffe/Lochman Transparencies

Left A commensal shrimp on a sea cucumber.
Photo – Clay Bryce/Lochman Transparencies



Ann Storrie is an accomplished underwater photographer and marine enthusiast. She has co-authored and photographed the Department of Environment and Conservation publications *Turquoise Coast* and *Wonders of Western Waters*. Ann can be contacted at naturescapes.au@hotmail.com.

endangered

by Melanie Smith



Muchea bell

Commonly known as the Muchea bell, *Darwinia foetida* is an erect or spreading shrub up to 70 centimetres tall, with green hairless linear leaves that are triangular in section and crowded at the end of branches. Inflorescences of 12 to 15 flowers, that are enclosed by several rows of long, hairy, red-green leaf-like bracts, are found at the end of branches and are nodding or rarely erect in young plants. Flowering occurs in October to November and pollination is by birds. *Darwinia foetida* is named after the distinctive foetid (rotten) smell of the flowers.

The Muchea bell is known from only four populations restricted to grey-black sandy rises in winter-damp to wet clay flats in the Muchea area. Habitat is *Regelia-Kunzea* tall shrubland over white myrtle (*Hypocalymma angustifolium*) low shrubland or low *Melaleuca* shrubland. The species is also associated with the 'Shrubland and woodlands on Muchea limestone' threatened ecological community, which occurs on an unusual limestone soil type. More than 90 per cent of this community type has been cleared for farming.

The Muchea bell was first collected in 1927. What was thought at the time to be a "newly discovered species of *Darwinia*" was recorded in Muchea in the early 1980s. Thereafter, several other collections of the species were recorded in the same area under different informal names. The species was consolidated under the phrase name *Darwinia* sp. Muchea (B.J. Keighery 2458) and was formally named *Darwinia foetida* in 2009.

Targeted surveys for the Muchea bell in the 1990s confirmed three populations within a five-kilometre radius with only part of one population found within a nature reserve. This resulted in *Darwinia foetida* being listed as declared rare flora (initially under its phrase name) in August 2001, giving it special protection under government legislation. It is currently ranked as endangered in Western Australia due to it being known from less than five locations, with continuing decline in area, extent and quality of habitat. A new population has recently been found on private property, extending the number of populations to four. Current threats to this species include weeds, grazing by rabbits and too frequent fire.

The Muchea bell does not re-sprout after fire but instead regenerates from seed. It is thought that this species takes two years for seedlings to mature as the species has been noted flowering two years after summer fire. Part of one population was recently burnt and post-fire monitoring by Department of Environment and Conservation Swan Coastal District staff 12 months later recorded more than 400 healthy seedlings. If fire was to be introduced to this area before plants had matured and produced enough seed for future regeneration it could lead to the extinction of the population.

Recent recovery actions undertaken for the Muchea bell include mapping of weeds and dieback, weed control and fencing along the boundary of a nature reserve to protect one of the populations.

Photos by Melissa Okely DEC



Diversity hot spot revealed:

land snails of the Kimberley



Since late 2006, the Department of Environment and Conservation has been working in collaboration with the Kimberley Land Council, Western Australian Museum, Australian Museum and traditional owners on the Kimberley Islands Survey. One aspect of the survey has revealed an amazing diversity of land snails, doubling the number of species previously known to science in the Kimberley.

by Lesley Gibson, Frank Köhler and Vince Kessner



The ancient spectacular landscapes of the Kimberley region of Western Australia are unique not only for their rugged beauty, but also for the incredible biodiversity they support. With so much of Australia's biodiversity exposed to various threatening processes, it is hard to believe that the north-west Kimberley has experienced no known plant or animal extinctions to date.

A component of this biodiversity which has received relatively little attention so far is the land snail fauna. Early work in the rainforests of the Kimberley uncovered a large diversity of land snail species, but up until recently, just how extraordinarily diverse this fauna is had not been fully recognised.

The land snail fauna of north-western Australia is dominated by the species of one family, the Camaenidae. Species of this family have developed adaptations that enable them to occupy a range of habitats from tropical rainforests to near deserts. Centres of high diversity appear to be the wetter coastal areas of the northern Kimberley where rainforest patches, including vine thickets, are most common.

Also within this area are extensive archipelagos and island groups which, created by the drowning of an ancient coastline, represent much of the adjacent mainland's geology and vegetation types. During a recent biological survey of a selected number of these islands it was realised that the Kimberley is a diversity hot spot for land snails.

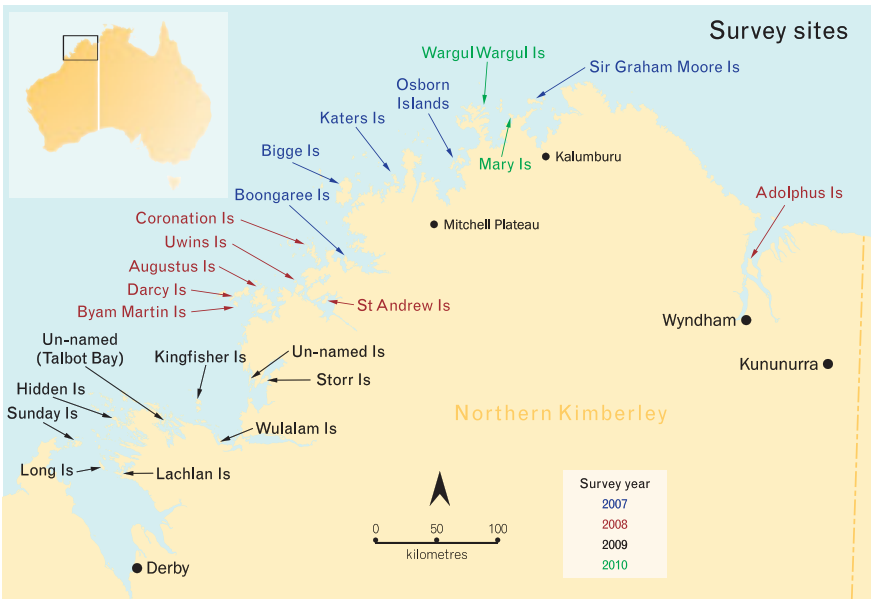
Snails: a target group

Being remote and inaccessible, the Kimberley islands have been largely sheltered from human-related disturbances. However, in recent years, there has been increasing interest in these islands, particularly for tourism, fishing, aquaculture, mining and oil and gas exploration. Information about the distribution of animals with limited mobility and restricted distributions, such as land snails, is crucial to gauge the possible impacts of these activities on a local to regional scale. For this reason, land snails were one of the groups targeted for the biological survey of the islands.

The survey also provided the opportunity to learn more about the diversity of land snails on the islands, as well as contributing to what is already known about the overall diversity of land snails in the Kimberley region in general. Additionally, as the islands are largely protected from mainland disturbances such as fire, pastoralism and introduced species, they have the potential to act as refuges for many species that are impacted by these threats, including the land snails.

The Kimberley Islands Survey has been ongoing since late 2006, and during this period the fauna and flora of 24 of the largest islands have been sampled. Field work for the survey is now complete, with analysis of the data collected well under way.

Selected sites on these islands have been visited twice, once for an extended period in the dry season and again for a shorter visit during the wet season. In collaboration with the Kimberley Land Council and Australian Museum, teams of scientists from the Department of Environment and Conservation and the Western Australian Museum have been conducting the surveys, in conjunction with traditional owners from the Balanggarra, Uunguu, Dambimangari, Mayala and Bardi-Jawi peoples.



Previous page
Main A newly discovered species of *Rhagada* collected from Byam Martin Island.

Above A newly discovered species of *Kimboraga*.
Photos – Vince Kessner/DEC

Sampling land snails

Once dropped off by helicopter, the snail collector in the survey team had six days at each site to search for land snails. Densely vegetated areas such as vine thickets are suitable habitat for land snails and so these were usually targeted.

Collecting land snails is an arduous task, particularly in the dry season when the snails are aestivating. This is a form of hibernation carried out during the driest time of the year and snails do this to conserve moisture, burying themselves in the soil or sheltering deep in rock crevices or under rock piles. Many species use calcified mucus to seal their shell to the surface of a rock, log or even to another snail shell. Other species are 'free sealers', meaning that once retreated to their hideaway, they secrete a sheet of mucus across their shell opening. Finding the snails involves raking leaf litter, lifting rocks, digging, searching under logs and examining tree crevices. Litter samples are also collected and later sorted in the laboratory. Some of the smaller species of snails are found this way.

It is usually easier to search for snails in the wet season, although climatic conditions during this period make it less than pleasant. If there has been sufficient rainfall, the snails emerge from their retreats and can be found on trees, moving among the leaf litter, or along rock surfaces. Land snails are active for only a short period of time during the wet season, when feeding, reproduction and growth take place.

Land snails are hermaphrodites, having both male and female reproductive organs. Individuals exchange sperm and their eggs are fertilised internally. Typically, young snails mature as functioning males by their third wet season, with female organs maturing late in the same season. By the fourth wet season the snails function as both males and females. They may live as long as eight years.



Right DEC senior technical officer Vince Kessner collecting land snails in the wet season.
Photo – Mike Lyons/DEC

Below right Kimberley Islands.
Photo – Jiri Lochman

The Kimberley Islands Survey

In December 2006, the Department of Environment and Conservation, in collaboration with the Kimberley Land Council, Western Australian Museum and Australian Museum, started preparations for a biological survey of the remarkable islands of the Kimberley (see 'Treasures of a sunken coastline', *LANDSCOPE*, Winter 2008).

While there was information on plant and animals for some islands, most previous studies had been opportunistic or focused on particular types of species. The survey aimed to expand knowledge of six ecologically and biogeographically different components of biodiversity across the variety of islands present. The survey focuses on mammals, reptiles, frogs, birds, plants and land snails, groups considered highly susceptible to threatening processes affecting the mainland.

The project was jointly funded by the Western Australian and Australian governments, with three dry season (winter) and wet season (summer) surveys planned over three years.

There are hundreds of islands along the Kimberley coast, with 155 of them bigger than 100 hectares, 22 of more than 1,000 hectares and nine exceeding 2,500 hectares (two of which are nearly 20,000 hectares). While most of the islands are big enough to support a diversity of plants and animals, only a small subset could be sampled within the project's time frame. As such, 19 of the biggest islands were initially chosen, especially those with a variety of geological surfaces and those at varying distances from the coast (and therefore variable distances from land-based threats). An additional five islands were added to the selection during the survey.

To date, the survey has revealed the presence of additional island populations of many vertebrates, and has more than doubled the species lists from most of the islands visited. Being among the most diverse but least known groups, land snails were expected to add most to the species inventory.







Above Stuck together—a smaller species of land snail sealed to a much larger species.
Photo – Vince Kessner/DEC

Above right Kimberley wetland.
Photo – Marie Lochman

What species is that?

There are various ways to identify land snail species. Some species can be identified by the shape of their shell alone. However, as the shell morphology often reflects ecological adaptations rather than relationships, just using shells may not always be a reliable way to determine species.

A more reliable source of information is the internal anatomy of the animals. Where there are only subtle shell differences between species, they can usually be differentiated by diagnostic features of their reproductive organs. Identifying species in this way is a very time-consuming task as each specimen needs to be dissected, and then organs carefully measured and compared. Sometimes the radula (a ribbon that supports the snail's teeth and is used to scrape food off surfaces) can be used in the identification process.

Species differences can also be detected using modern genetic techniques, sometimes called DNA barcoding. This is usually a very efficient method of separating species that look very similar. However, as this approach can also be subject to errors, it is best complemented by anatomical descriptions.

Interestingly, species found at the same locality (sympatric species) tend to show more obvious differences in their shell shape than species occupying geographically separated habitats (allopatric species). Sympatric species often belong to different genera, with each genus showing unique adaptations with respect to aestivation behaviour, life style, body size or shell shape, indicating that they use distinct ecological niches. In fact, the shape of the shell can give some clues as to the type of substrate snails use. For example, species with flattened shells use mainly horizontal surfaces, while species with tall spired shells tend to use vertical surfaces, and species with globe-shaped shells tend to burrow in soft soil. Shell size can also give some clues about the habitat land snail species use. Larger snails are often found in moister habitats.

Revealing results

Prior to the Kimberley Islands Survey, 185 camaenid land snail species in 23 genera were known from the Kimberley region and immediately adjacent areas. This is the largest known regional diversity of camaenids in Australia. Even more astounding is the fact that all of these species and almost all of the genera are endemic to the region; that is they are found nowhere else.

Generally, the species have very restricted geographic ranges with an average range size on the mainland of well below 20 square kilometres. Some species are even found on only a single rock outcrop, with a range diameter of mere metres.

While the Kimberley Islands Survey is still in progress, 175 species have been identified as a result of the survey, including some that were collected during earlier surveys on the Kimberley mainland. With 142 of these being newly discovered species, the number of known species in the Kimberley has almost doubled as a result of this project.

On the islands, about 90 camaenid species have been identified (72 new species and five new genera) with almost all of them being endemic to their respective island. Up to 12 sympatric species have been recorded on a single island which is exceptional for Australian camaenids and only equalled by some regions in tropical Queensland.

The survey also provided information about non-camaenid snails. So far, the survey has revealed 21 species of non-camaenid snails from both terrestrial (16 species) and freshwater (five species) habitats. Most terrestrial species are widespread and found on a multitude of islands, and all

species found in the current survey were already known from the Kimberley. Fewer species of freshwater snails are likely to be found on the islands due to the scarcity of permanent or semi-permanent freshwater bodies on the surveyed islands. In general, the diversity of non-camaenids is comparatively low, with only 50 species known from the Kimberley. Unlike the camaenid land snails, the geographic distributions of the non-camaenid species are not restricted to the Kimberley, but extend widely to other regions. The tiny size of non-camaenid snails (one to 10 millimetres) probably enables their dispersal by wind, water and birds.

Why so many?

Historical changes in climate are the likely explanation for the amazing diversity of land snails now found in the Kimberley. About five to 10 million years ago, the global climate went through a phase of cooling and drying. As sea levels fell and rainfall decreased, the lush rainforests that covered much of northern Australia at that time contracted into wetter coastal areas, leaving isolated rainforest patches. Favoured by land snails, these habitat patches became refuges for the ancestral populations of today's land snails. Unable to travel the distances between patches, over time new land snail species evolved within each rainforest patch. With the same evolutionary processes occurring within each of these patches, the end result is a suite of species assemblages that are unique to each patch.

Diversity hot spot

Through the survey of just a small number of islands and selected areas on the mainland, there has been a substantial increase in knowledge about the diversity of land snails in the Kimberley. This suggests that the number of undiscovered species in the Kimberley is likely to be considerable. There are still a significant number of unsurveyed islands and other equally inaccessible areas on the Kimberley mainland. Current evidence suggests that at least 600 endemic camaenid land snail species may exist in the region, making the Kimberley a hot spot of diversity and endemism for this group—certainly in Australia and perhaps even on a global scale.



Right A newly discovered species of *Amplirhagada.*
Photo – Vince Kessner/DEC

Below Vine thickets at the base of a cliff wall.
Photo – Lesley Gibson/DEC

Bottom A newly discovered species of *Torresitrachia* collected from Boongaree Island.
Photo – Vince Kessner/DEC





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The authors wish to thank everybody who contributed to the successful implementation of the survey work. This includes colleagues from DEC, the Australian Museum, Western Australian Museum, Kimberley Land Council, Biota Environmental Sciences and the participating Balanggarra, Uunguu, Dambimangari, Mayala and Bardi-Jawi traditional owners.



Walpole-Nornalup Nationa

From a small park proclaimed in 1910, Walpole-Nornalup National Park has grown
It features iconic attractions including the Tree Top Walk in the Valley of the Giants



l Park

celebrating 100 years

to a reserve of national significance.
s and is part of the magnificent Walpole Wilderness.

by Christie Mahony and Bron Anderson



Looking out over the Frankland River at Monastery Landing, deep within Walpole-Nornalup National Park, it is possible to imagine what the first Europeans to see the area were thinking. Gliding up the tranquil river, the tall, impenetrable forest on either side must have seemed both beautiful and imposing.

William Nairne Clark, who visited the south coast area in 1841, wrote in his diary:

> "The sail up was truly delightful. The river actually appeared to be embosomed amongst lofty wooded hills, with tall eucalypt trees 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 the other quarters of the globe."

(See 'Walpole Wilderness', *LANDSCOPE*, Winter 2008.)

Well before European settlement in Australia, the tall forests, coastal heathlands, rivers, inlets and ocean in this area were home to the Murrum Aboriginal people. This area provided all the natural resources they needed to live. The Murrum hunted and collected an extensive variety of plants and animals to be used as food or medicine and to make tools, clothes and shelter.

European exploration

It's believed the first European sighting of the area was by those aboard the *Gulden Zeepaert* (Golden Seahorse), a Dutch East India ship which passed the southern coastline in 1627. French and British explorers followed nearly a century later and, in 1791, Captain George Vancouver, commanding the *Discovery*, made a closer inspection of the coastline. At a glance, the coastline appeared unappealing compared to the green and fertile shores of their European homelands. However, this view was to change half a century later when the area was explored more extensively on foot.

William Nairne Clark was a feisty young Scotsman who came to the Swan River Settlement in 1831. In 1841, he was one of the first Europeans to explore the forest, rivers and inlets of the south coast. He was enthusiastic and heavily involved in the opening up of new land in the south-west. After hearing stories of rivers and inlets on the south coast, he was determined to explore this new area. One of the places that impressed him most was the Frankland River.

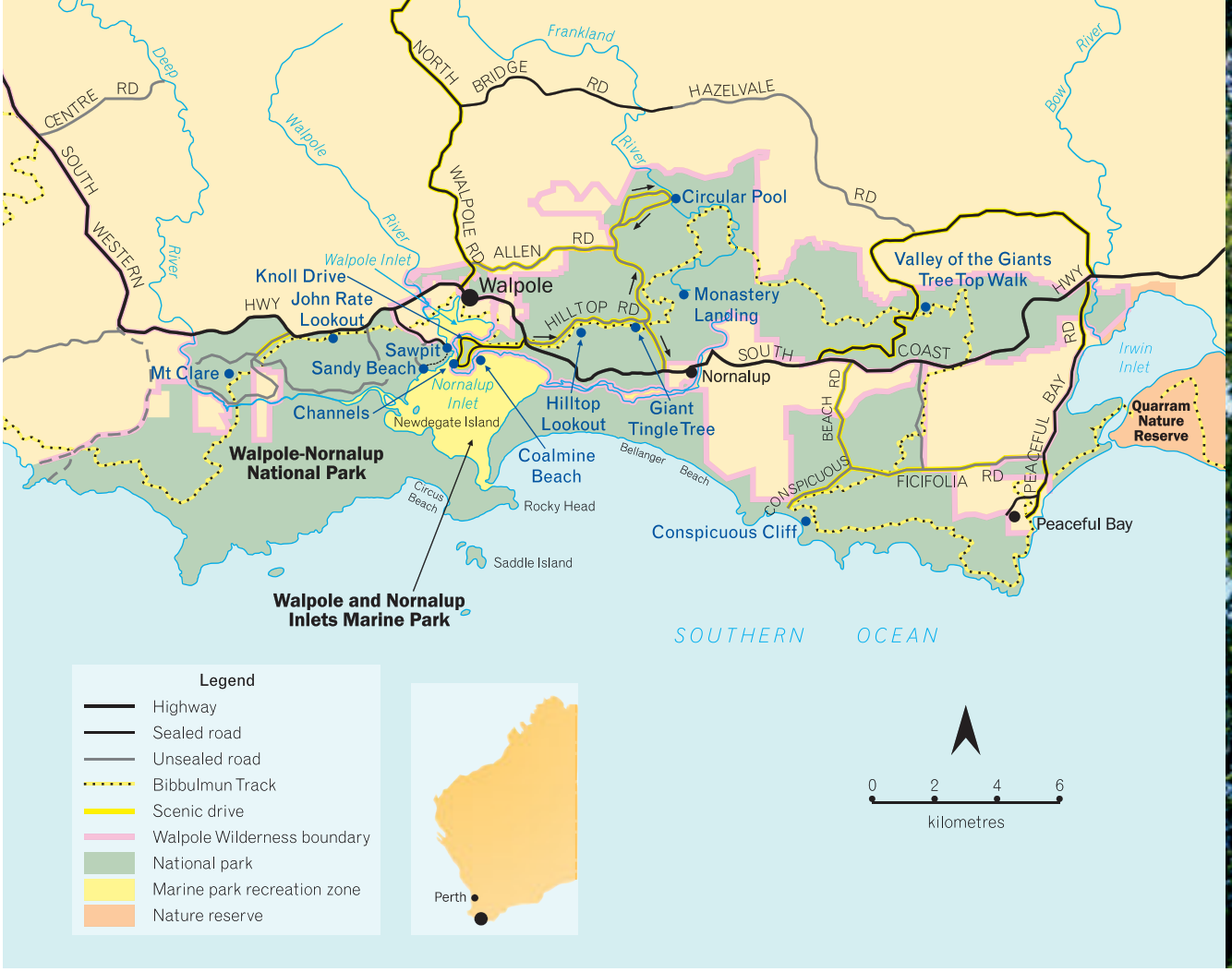
The Bellanger family were the first Europeans to settle in the area permanently. Arriving at the mouth of Nornalup Inlet in March 1910 aboard the *Grace Darling*, they travelled up the Frankland River in small boats containing all their possessions as well as supplies and building materials. They settled on the bank of the Frankland River and, until the homestead was built in 1914, lived in huts and tents. They later opened their home as a guesthouse and became famous for their hospitality, playing host to many influential people.



Previous page
Main Nornalup Inlet.
Photo – Brett Dennis/Lochman Transparencies
Inset Boating on the Frankland River.
Photo – Bert Saw, courtesy Walpole Nornalup and Districts Historical Society

Above Monastery Landing, Frankland River.
Photo – Bron Anderson/DEC

Left Red flowering gum (*Corymbia ficifolia*).
Photo – Rob Olver



Right Sir James Mitchell's ministerial party at Bow River in 1910.
Photo – Bert Saw, courtesy Walpole Nornalup and Districts Historical Society



Proclaimed for conservation

Around this time, Minister for Lands and Agriculture James Mitchell had a 'grand vision for development in the south-west' which included agriculture, timber production and dairying. With this in mind, he visited the Nornalup area and stayed with the Bellanger family with his ministerial party in tow. They were rowed up the Frankland River to Monastery Landing and saw a place of incredible grandeur and solitude.

So impressed was Mitchell by the beauty of the river and the surrounding forest, that he made an on-the-spot decision to set aside the area for conservation. An area of 370 hectares adjacent to the Frankland River was gazetted as a class 'A' reserve—the highest level of protection land could be given. The area reserved was named Nornalup National Park and would later grow to become what is known today as Walpole-Nornalup National Park.

Mitchell wasn't the only visitor to the area to recognise the importance of conserving the magnificent forests of the south-west. When Baron von Mueller, an eminent botanist and explorer, visited the karri forests in 1877, he wrote these somewhat prophetic words in his diary:

> "But as nowhere, not even in the most extensive woodlands can the supply of timber from natural forests be considered inexhaustible, a rational far seeing provision for the maintenance (if not enrichment) of its forest-treasures is needful for Western Australia, however indiminishable these may appear to be at present."

The large karri (*Eucalyptus diversicolor*) and tingle trees found within the region almost overshadowed a smaller, but equally beautiful tree species. The red flowering gum (*Corymbia ficifolia*), with its spectacular red blossoms, has a restricted habitat stretching from the Irwin Inlet to the mouth of the Shannon River. In 1912, the Albany District Surveyor prompted the creation of a class 'A' reserve for the protection of red flowering gum west of the Irwin Inlet. This small parcel of land later became part of Walpole-Nornalup National Park.









Group settlers

Major changes came to the area in the 1920s as settlers arrived looking for good land for agriculture. The Group Settlement Scheme was set up by James Mitchell and was intended to create a flourishing agricultural community that would provide livelihoods for migrant men and their families. Group 116 at Tingledale was one of the first such establishments in the area. Twenty-three families arrived in 1924 to start the mammoth task of clearing the huge karri trees to farm the land. Group 138 at Hazelvale followed in 1927.

In 1926, Newdegate Island and the unnamed island at the mouth of the Frankland River were declared class 'A' reserves and added 15 hectares to

Above Tree felling.

Top left Settlers outside their tent.
Photos – Bert Saw, courtesy Denmark Historical Society

Centre left Original settlers camp on the Frankland River.
Photo – Courtesy Helen Pierce

Left Early tourism in the forest. Before its collapse in 1990, people used to drive their cars into this giant tingle tree.
Photo – Courtesy Walpole Nornalup and Districts Historical Society



Nornalup National Park. In the same year, Tom Swarbrick was granted land at Rest Point on the western shore of the Walpole Inlet. The original camping area at this point was called 'The Rendezvous'.

Early tourism

The following year, Tom Swarbrick was appointed as the first ranger to Nornalup National Park on a part-time basis. Tom was reported to be a man of considerable strength of character and integrity. These traits proved essential in finding a balance between running a successful tourism business and ensuring the protection of national park values.

Tourism really took off in the area in the late 1920s with more and more people coming to experience the magnificent forests and the beautiful scenery of the inlets and coastline, as well as try their hand at fishing. As the locals came to rely on income from tourists, preserving the land in national parks for all to experience became increasingly important. Additional guesthouses were opened by the Thompson, McIntosh, Swarbrick and Burnside families.

Hard labour and fire

In 1930, as part of the continuing Group Settlement Scheme, unemployed married men were moved from Perth to establish a settlement on the bank of the Walpole Inlet. The settlement was originally called Nornalup but the name was changed to Walpole in 1934. It had inauspicious beginnings with the settlers living in bush pole shanties at the main camp while blocks of 120 acres of forested land were allocated to each family by ballot. Then began the backbreaking task of clearing the land for agriculture.

Not only did the settlers have to clear the huge trees from their land, they also had to erect fences for stock and build themselves homes. The task of clearing the land of its giant trees, combined with the infertile soils, lack



Above Late afternoon light, Nornalup Inlet.

Right View from Mount Frankland—one of three sites which make up the Walpole Wilderness Discovery Centre.
Photos – Rob Olver







Top Giant tingle tree in Walpole-Nornalup National Park.
Photo – Rob Olver

Above *Chorizema retrorsum* at Horseyard Hill in Walpole-Nornalup National Park.
Photo – Bron Anderson/DEC

Left The Tree Top Walk.
Photo – Gorden Roberts/DEC

of farming skills and the hardships of the 1930s depression were too much for most to bear. Only a third of the original families stayed on and eked out a living from dairy or beef cattle.

The forests of Nornalup National Park were devastated by fire in 1937 in what became known as Black Wednesday. Tinder-dry forests combined with intense northerly winds were a disaster waiting to happen when lightning struck the forest near Northcliffe. The blaze spread rapidly southwards, consuming everything in its path. By the time the fire reached Nornalup National Park, the crown fire was 12 kilometres ahead of the ground fire and showed no signs of abating. The settlers fought hard to save their possessions and property but many lost everything. This was the last straw for many families who retreated to the city. Stark reminders of the fire can still be seen today in the dead 'stags' of karri trees that tower over the forest.

Conservation management and growth

The 1950s brought a new era of forest management to the Walpole area with the appointment of the district's first resident forester, John Rate. In addition to his duties as a forester, Rate was appointed Honorary Ranger of Nornalup National Park. It was thanks to him that the park got its first full-time ranger, Lionel Gunson, who was also the first full-time ranger to be appointed in Western Australia. The Nornalup Advisory Committee was formed to provide local input into management, resulting in a more strategic approach to conservation management in the park.

In 1972, the park experienced a huge expansion from 385 hectares to 15,865 hectares. Much of the land from Long Point in the west to Conspicuous Cliff in the east was now protected. At this time, Nornalup National Park changed its identity and became Walpole-Nornalup National Park.

Tourism took over as Walpole's main source of income in 1995 with the closure of the timber mill and the downturn of the logging industry in the area. The lure of the big trees was strong and more and more tourists were visiting the area to see the majesty of the karris and tingles.



Above Nornalup Inlet.
Photo – Rob Olver

Right Circular Pool on the Frankland River has become a popular recreation site.
Photo – Gorden Roberts/DEC

Below right Wildflowers at Horseyard Hill, Walpole-Nornalup National Park.
Photo – Bron Anderson/DEC

Bottom right A scenic view of the Frankland River.
Photo – Bert Saw, courtesy Denmark Historical Society



The Tree Top Walk

Walpole was thrust onto the international stage with the construction of the Tree Top Walk at the Valley of the Giants in 1996. This popular attraction provides visitors with the opportunity to immerse themselves in the forest canopy and get a completely different perspective of these giant trees. In 2002, the parcel of land that contained the Valley of the Giants was transferred from State forest to Walpole-Nornalup National Park, bringing the total land area under reservation to 19,000 hectares.

Conservation around Walpole was taken to even greater heights in 2004, with the creation of the Walpole Wilderness. The Walpole Wilderness protects more than 363,000 hectares and embraces the very essence of WA's southern forests and coasts. Old majestic jarrah (*Eucalyptus marginata*), tingle and karri forests surround imposing granite peaks, peaceful rivers, wetlands and tranquil inlets, and overlook picturesque sandy beaches, sheer coastal cliffs and the Southern Ocean. The Walpole Wilderness is a significant portion of a massive conservation reserve network stretching between Augusta and Denmark, encompassing seven national parks including Walpole-Nornalup.

Walpole and Nornalup Inlets Marine Park

Complementing the suite of terrestrial national parks is the recently gazetted Walpole and Nornalup Inlets Marine Park (see 'Walpole and Nornalup Inlets Marine Park', *LANDSCOPE*, Spring 2009). This marine park not only protects the Walpole and Nornalup inlets, but also extends deep into the heart of Walpole-Nornalup National Park along the Walpole, Frankland and Deep rivers. Together, these parks protect precious plants and animals, above and below the waterline.

James Mitchell could never have foreseen that his humble act of reserving the beautiful and pristine forest around Monastery Landing back in 1910 would have led to the creation of such an extensive network of conserved land and waters. The magnificent beauty and tranquillity of Walpole-Nornalup National Park has inspired many people throughout the past century and will continue to do so well into the future.



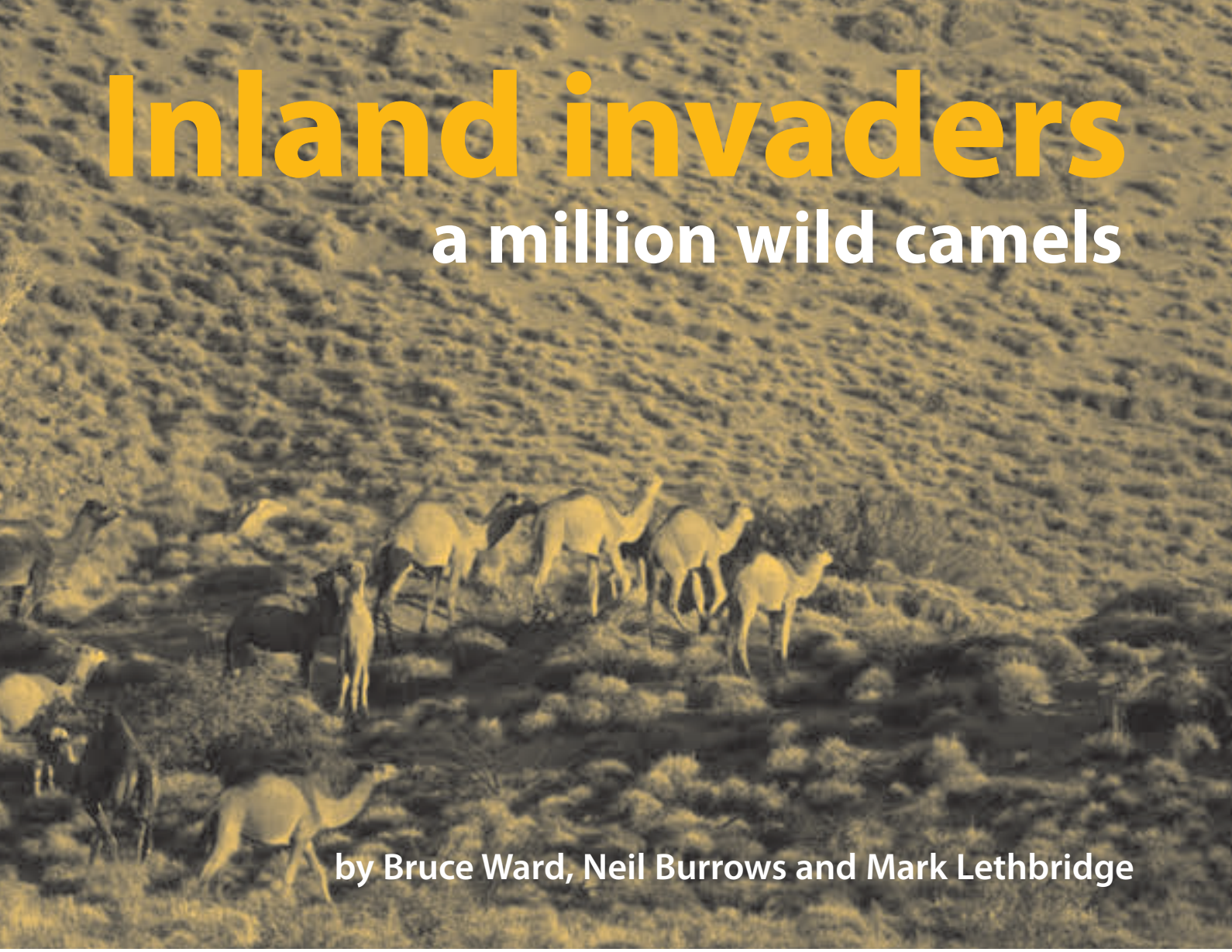
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Inland invaders

a million wild camels



by Bruce Ward, Neil Burrows and Mark Lethbridge

Who would have thought that the noble, iconic camel—the animal said to have carried the 'Three Wise Men'—would become a pest? The fact is the camel has joined the ranks of some 37 pest mammal species introduced into Australia since European settlement.

The dromedary or one-humped camel that has invaded the Australian inland is a mix of various breeds that mostly originated in India. These breeds include the pedigreed Bikaneri war camel of Rajasthan, the powerful, freight-carrying Indian camel, capable of moving loads of up to 800 kilograms, and the elite Bishari riding camel of North Africa and Arabia.

Camels were first introduced into Australia in the 1840s for transport and for exploration of the country's inland regions, although it was not until the 1860s that camels were recognised as a better draught animal than either horses or bullocks (see 'Desert Bigfoot', *LANDSCOPE*, Summer 1989–90). They are highly suited to the dry remote areas of central Australia and have adapted well. Until about 1907, thousands of camels were imported into Australia, mostly from India, together with 'Afghan' camel drivers who were actually from the drier parts of India. Goldrushes, exploration and the building of a nation all contributed to the need for camels and about 6,600 camels were imported into Western Australia alone.

Camel breeding stations were established by private individuals and by governments across Australia to supply the increasing demand for camels. In WA, government breeding stations were established at Londonderry (near Coolgardie), Yalgoo, Jigalong (near Newman) and Dromedary Hills (near Paynes Find). The latter two were established to support the construction and maintenance of the Number 1 Rabbit Proof Fence. By the 1920s, there were an estimated 20,000 domestic camels in Australia.

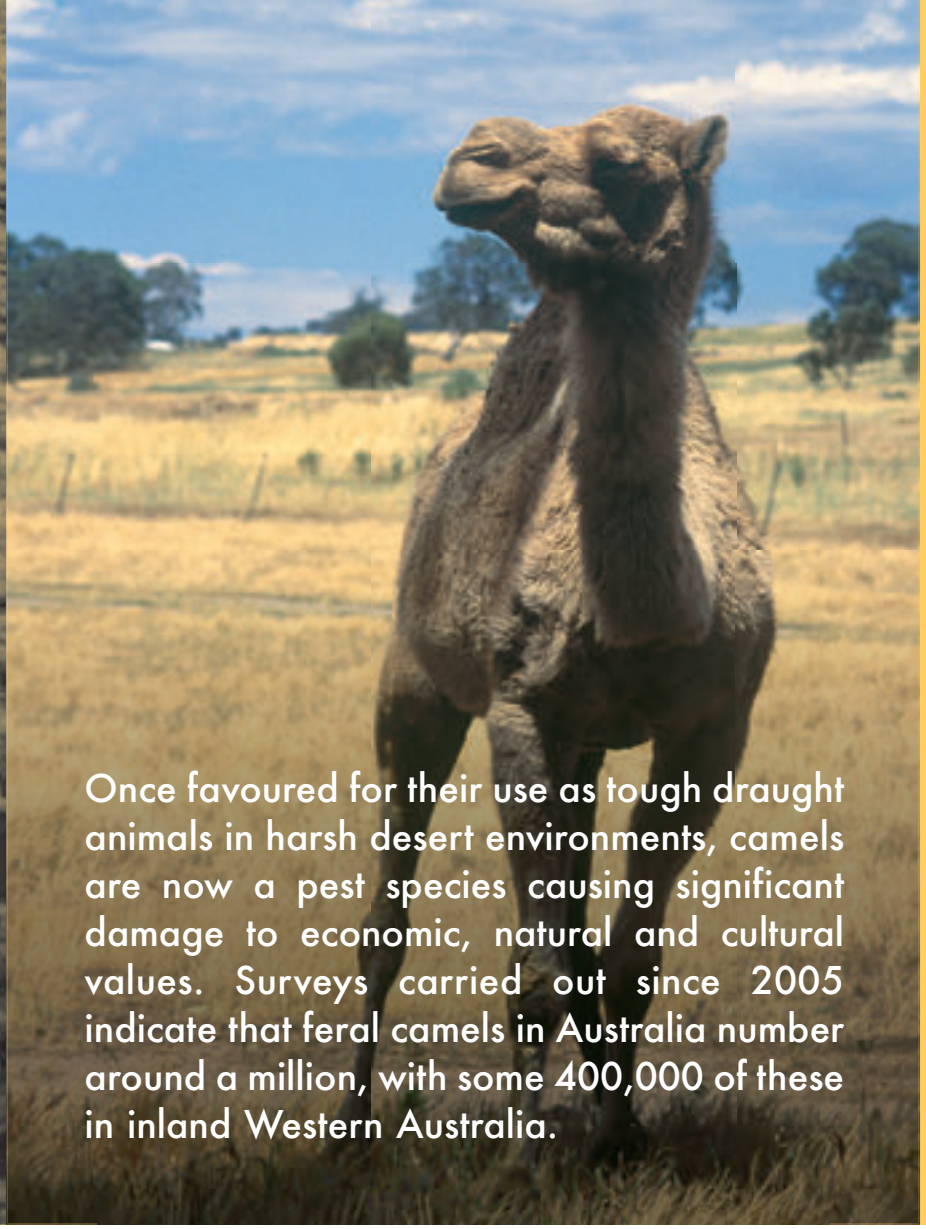
Turning feral

In the early days, the population of feral camels was small and scattered. This changed when domestic camels were abandoned in the 1920s and 1930s with the introduction of motorised transport. Motor vehicles and railways improved the speed and efficiency of travel and transport of goods, making the need for camels obsolete. Camels became virtually worthless, which led to owners disposing of their once valuable animals. Many were destroyed but most were released into the wild. The number of animals that escaped or were deliberately released in WA is not known but has been estimated at more than 5,000.









Once favoured for their use as tough draught animals in harsh desert environments, camels are now a pest species causing significant damage to economic, natural and cultural values. Surveys carried out since 2005 indicate that feral camels in Australia number around a million, with some 400,000 of these in inland Western Australia.

Opposite and this page
Main A camel herd in the Great Sandy Desert.
Photo – Jiri Lochman
Insets
Top left Leading Australian veterinary surgeon Wayne Boardman conducts animal health checks.
Photo – Neil Burrows/DEC
Centre left Released cow with calf.
Photo – Mark Lethbridge
Bottom left Researchers use a helicopter to locate and tranquilise camels.
Photo – Neil Burrows/DEC
Above Feral camel.
Photo – Marie Lochman

During the past 80 years, the feral camel herd has grown. Growth in numbers was slow at first, almost unnoticeable. In the mid 1960s, following an aerial survey of a portion of central Australia, the feral camel population was estimated at 15,000. Several other surveys followed over the next few decades, revealing a steady increase in camel numbers. However, during the past two decades, numbers have increased alarmingly as feral camels thrived in the Australian deserts. Today, outback travellers are almost certain to encounter camels. Increasing camel numbers and increasing tourist traffic has introduced a new hazard for motorists and camels alike—the first road fatality involving camels was in 2007 when a vehicle hit a camel on an outback road.

Pastoralists on the desert interface and Aboriginal people in remote desert communities were becoming increasingly concerned about the growing camel problem. While there were varying levels of camel control being implemented on pastoral leases, there was virtually no control of camels beyond these lands. During a drought in the interior of WA between 2001 and 2003, large herds of thirsty camels moved into remote communities and onto pastoral lands in search of water, causing damage to infrastructure and cultural values. There were also growing concerns about the impact of camels on fragile desert ecosystems.

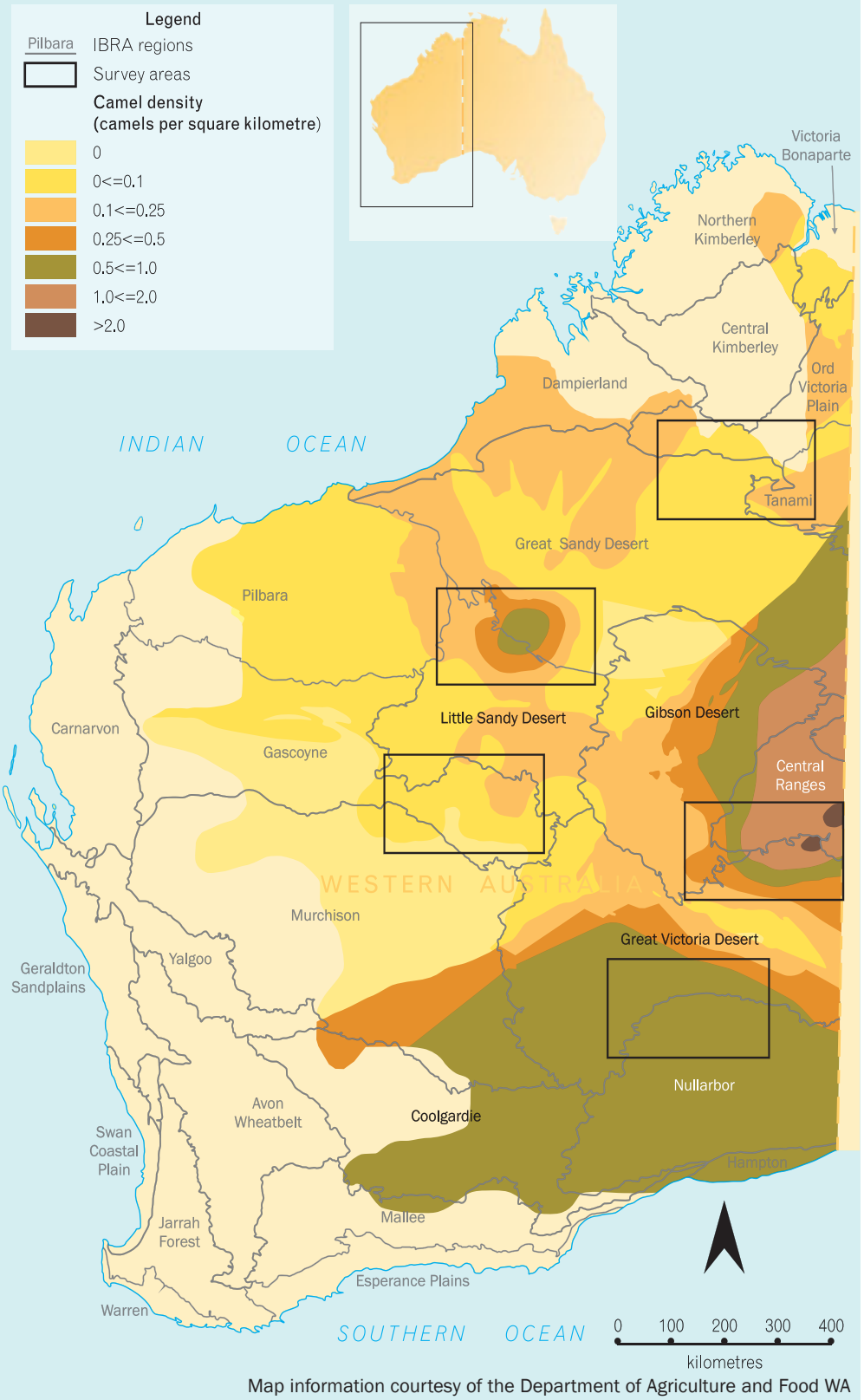
DEC gets involved

The then Department of Conservation and Land Management, a predecessor to the Department of Environment and Conservation (DEC), was alerted to the growing camel population following the publication of aerial survey data by Northern Territory Government researchers in 2004. The data showed that the feral camel population in the Northern Territory had doubled in 10 years. This initiated a series of systematic aerial surveys by department researchers in partnership with the Department of Agriculture and Food WA and Flinders University (South Australia) in order to better understand the density and distribution of feral camels in WA. The



Left Camels adapt well to the harsh desert environment.
Photo – Jiri Lochman

Camel population density



Map information courtesy of the Department of Agriculture and Food WA

first of six surveys through the remote interior of WA started in 2005.

Aerial survey is a widely used technique for reliably assessing the population of larger animals such as kangaroos and feral camels, cattle, horses and donkeys. The scientifically proven technique involves observers in an aircraft flying line transects at low altitude (76 metres or 250 feet) and counting animals that fall within a defined sample area on the ground, which is delineated by cords attached to the wing struts of the aircraft.

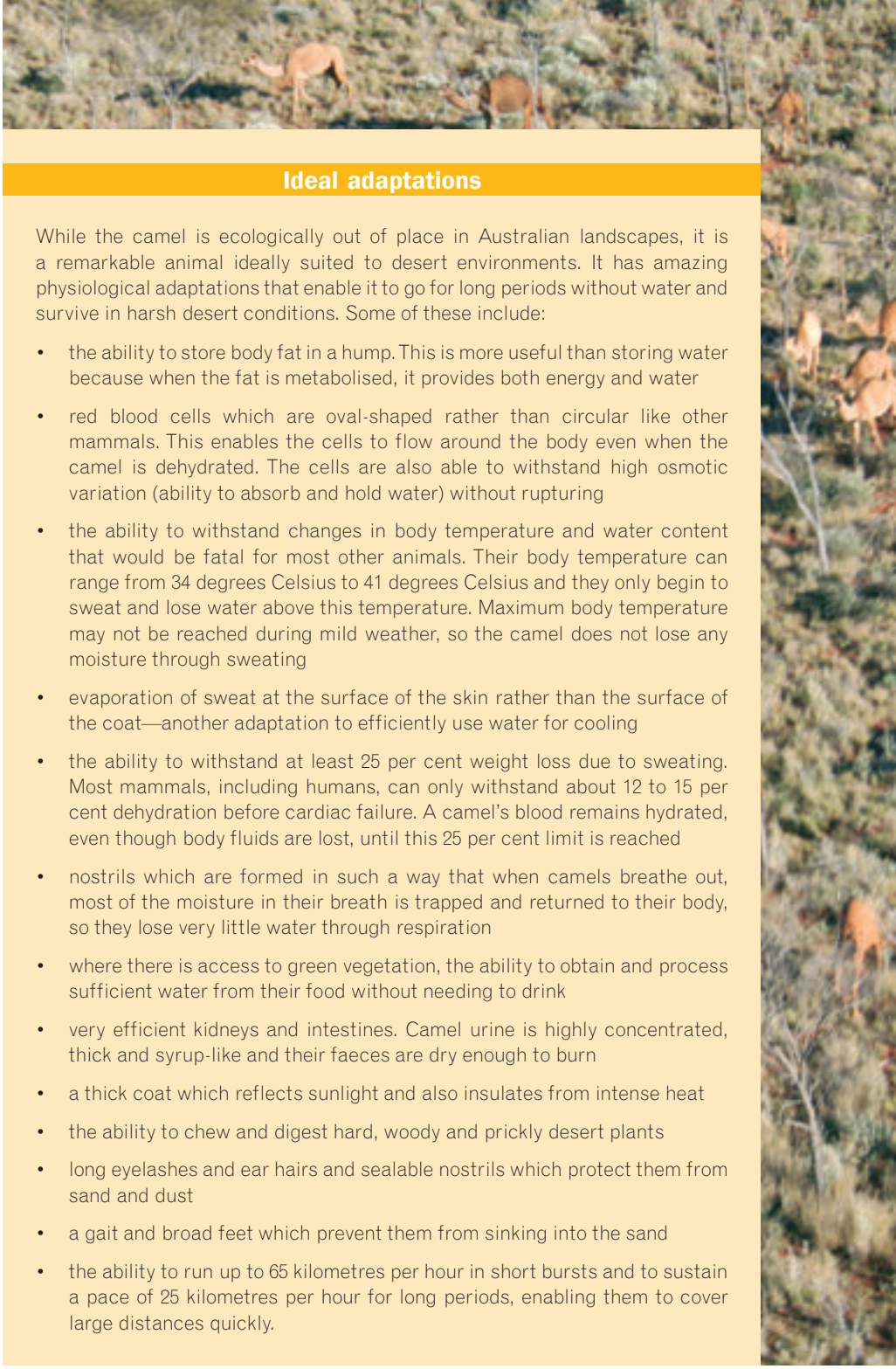
Six surveys were conducted in selected regions of the interior of WA to provide a representative sample of the areas occupied by feral camels. One site was surveyed twice—before and after a culling operation to reduce camels and other feral animals. Each survey covered an area of about 60,000 square kilometres made up of some 20 flight transects each 300 kilometres long and one kilometre apart. The total distance flown was about 40,000 kilometres and the total area surveyed was about 378,000 square kilometres—an area one-and-a-half times the size of Victoria.

The total number of feral camels in WA was estimated based on the number of camels counted during the aerial surveys and by making an estimate of where camels occur in WA. These data were contributed to a national database so the total number of camels in Australia could be estimated.

How many camels are there?

The number of camels in WA is estimated at about 400,000, with the Australian population estimated to be as high as one million, distributed across an area of 3.3 million square kilometres of central Australia. Based on repeated surveys, the feral camel population is estimated to be doubling every eight to 10 years.

The surveys also revealed that the distribution of camels is clumped rather than even, with, not surprisingly, the highest numbers found where there is ample water and food. Camel densities are high around areas where water



Right Camels have reached concerning levels in the desert regions.
Photo – Neil Burrows/DEC

is likely to persist for longer periods following rain, such as rivers, lakes and other drainage systems, and around low mountain ranges that contain rockholes. In other parts of the desert, such as the vast spinifex sandplains and dune fields, feral camels are sparse except after heavy rains that fill small claypans and creeks.

Effects on plants and animals

Camels are primarily browsers and can feed on more than 80 per cent of the plant species available in Australian deserts. Browsing by camels can damage trees and shrubs and severely defoliate preferred species. Camels also inhibit recruitment by suppressing flowering and fruit production and by browsing and killing juvenile plants. If unchecked, large congregations of camels have the ability to cause the local extinction of highly palatable species such as the quandong (*Santalum acuminatum*), plumbush (*S. lanceolatum*), curly pod wattle (*Acacia sessiliceps*), native apricot (*Pittosporum augustifolium*), bean tree (*Erythrina vespertilio*) and *Lawrencia* species. In central Australia, adverse effects on vegetation have been recorded where camels occur at densities of more than about two animals per square kilometre. In some areas, significant damage to native vegetation occurs at much lower densities. Camels have also been observed to concentrate their browsing on regrowth following bushfires.

Native birds and mammals are not exempt from the impact of feral camels. Impacts are most pronounced during drought, particularly when species depend on natural waterholes. These refuge areas can quickly become degraded to the point where native species may be severely disadvantaged and face local extinction.

Counting the cost

Many Aboriginal people live in areas where there are high numbers of camels and experience firsthand their impacts, which include damage to fences, water tanks, toilets, air conditioner units and standpipes. Camels also loiter on airstrips and roads, causing a hazard to traffic. Camels damage and foul-up sacred waterholes and denude the surrounding vegetation. Aboriginal people fear to camp in these areas as they are afraid of being trampled in the night.

For people who live with high camel numbers, most feel that reducing numbers is a good idea and are willing to discuss control options. However, in areas where camels are in low numbers, attitudes may be different as they are still a novelty and to cull animals goes against cultural ethics. The need to make decisions considering a wide range of views adds complexity to the camel control issue. While cost of infrastructure damage can be easily measured, what cost can be put on loss of cultural value?

Mining companies, pastoralists and the public can measure the cost of damage and losses from camels through lost production and replacement of infrastructure. The Desert Knowledge Cooperative Research Centre has calculated an annual net economic loss of $10.6 million Australia-wide from infrastructure damage and lost production alone. These costs will rise with increasing camel numbers.

Ideal adaptations

While the camel is ecologically out of place in Australian landscapes, it is a remarkable animal ideally suited to desert environments. It has amazing physiological adaptations that enable it to go for long periods without water and survive in harsh desert conditions. Some of these include:

- the ability to store body fat in a hump. This is more useful than storing water because when the fat is metabolised, it provides both energy and water
- red blood cells which are oval-shaped rather than circular like other mammals. This enables the cells to flow around the body even when the camel is dehydrated. The cells are also able to withstand high osmotic variation (ability to absorb and hold water) without rupturing
- the ability to withstand changes in body temperature and water content that would be fatal for most other animals. Their body temperature can range from 34 degrees Celsius to 41 degrees Celsius and they only begin to sweat and lose water above this temperature. Maximum body temperature may not be reached during mild weather, so the camel does not lose any moisture through sweating
- evaporation of sweat at the surface of the skin rather than the surface of the coat—another adaptation to efficiently use water for cooling
- the ability to withstand at least 25 per cent weight loss due to sweating. Most mammals, including humans, can only withstand about 12 to 15 per cent dehydration before cardiac failure. A camel's blood remains hydrated, even though body fluids are lost, until this 25 per cent limit is reached
- nostrils which are formed in such a way that when camels breathe out, most of the moisture in their breath is trapped and returned to their body, so they lose very little water through respiration
- where there is access to green vegetation, the ability to obtain and process sufficient water from their food without needing to drink
- very efficient kidneys and intestines. Camel urine is highly concentrated, thick and syrup-like and their faeces are dry enough to burn
- a thick coat which reflects sunlight and also insulates from intense heat
- the ability to chew and digest hard, woody and prickly desert plants
- long eyelashes and ear hairs and sealable nostrils which protect them from sand and dust
- a gait and broad feet which prevent them from sinking into the sand
- the ability to run up to 65 kilometres per hour in short bursts and to sustain a pace of 25 kilometres per hour for long periods, enabling them to cover large distances quickly.



Left Camels can be a hazard to drivers in desert regions.
Photo – Jay Sarson/Lochman Transparencies

Below Field staff collar a camel before a tranquiliser reversal drug is administered and the animal is released.
Photo – Neil Burrows/DEC

However, the cost on the natural environment and cultural values can not be measured in dollars and the value in lost species and local extinctions remains unknown. Much more work is required in this area to determine the impacts on plants and native species, and this will remain a topic for further investigation.

Camel migration patterns

Research to better understand the movement patterns of camels in various seasons is currently being undertaken using GPS-satellite tracking collars. In a joint project involving scientists from Flinders University, the Royal Zoological Society of South Australia, DEC and people from the Ngaanyatjarra Aboriginal community (Warburton), eight female camels were caught, tranquilised, fitted with tracking collars and released in July 2008. The information gained from this research will improve understanding of which parts of the desert are most at risk from damage by camels, and will assist with the development of targeted, cost-effective control programs.



The animals were automatically tracked for 13 months and while data are still to be fully analysed, some interesting information is emerging. Two of the collared camels travelled interstate, crossing the WA border into the Northern Territory and South Australia. On average, the camels moved between five and 10 kilometres a day, with most camels travelling about 30 kilometres per week in search of food and water. Distances in excess of 100 kilometres per week were not uncommon at warmer times of the year. The average monthly home range of the camels varied from an area of about 12,000 hectares in February, to a massive 260,000 hectares in November. Further analysis will add new information about which parts of the landscape camels prefer and how seasonal conditions influence their movement patterns.

Where to from here?

Management of feral camels and their impacts will involve the integration of all available control methods, both non-commercial and commercial, and the development of an integrated management framework that operates across jurisdictions, tenure, boundaries and industry sectors. There are only a few studies which have tried to quantify the environmental impacts caused by camel densities. However, the level of camel impact can also vary depending on the resilience of the ecosystem. So while in some areas, significant damage to native vegetation and cultural assets occurs at much lower densities, reducing densities to well under one camel per square kilometre on average is a reasonable start-point.

Current legislation needs revision to enable cross-jurisdictional management of feral camels, and legislative instruments at both the Federal and State level show a range of inconsistencies around issues including camel ownership, legal obligation to control, right of access to property, movement of firearms across borders and fencing of waterholes.

Unlike many other introduced pest animals, the size and relatively low fecundity of these animals means that it is feasible to reduce camel numbers significantly. However, this requires broad-scale, cross-jurisdictional and cross-tenure cooperation, which can be, to say the least, a very difficult task. The alternative, more costly and often less productive option is regular targeted local control to protect high value conservation, cultural and economic assets.



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Feral camel surveys in WA were carried out with the assistance of staff from the Department of Agriculture and Food. Warburton and Djugerari Aboriginal communities assisted with logistics and helped locate camels for satellite tracking. Thanks to Newcrest Mining and Anglogold Ashanti for use of their airstrips, accommodation for survey staff and sponsorship and to Esperance Air Service whose aircraft and pilots were used for the surveys. In total, the surveys covered 378,000 square kilometres, which is about one quarter of the area of camel distribution in WA.

Benger Swamp



Late in 2009 the whole of Benger Swamp, near Harvey in Western Australia's south-west, was reserved for conservation, finalising a process which started more than 35 years ago.

by Alex Errington and Joanna Moore

Benger Swamp Nature Reserve, about 155 kilometres south of Perth on the Swan Coastal Plain, has been the subject of one of the State Government's longest running conservation acquisition projects. The Department of Environment and Conservation (DEC) recently completed the consolidation of this important site for conservation, protecting important waterbird habitat.

Benger Swamp once covered an area of about 1,000 hectares, but during the past 100 or so years the swamp has been reduced to almost half this size, primarily through draining. The reserve is surrounded by farmland, most of which has been cleared, and a history of farming has significantly impacted on the swamp.

The swamp was originally known to European settlers as the Flats of Mornington, with the name Benger being derived from the local Aboriginal name for the area—Bengerup meaning 'place of water' and Beenja meaning 'big water'.

Potatoes, pasture and waterbirds

Benger Swamp and the land around it was granted to a settler in 1830 and



changed hands several times during the early years of European settlement. Agriculture began in the 1890s, with mostly potato crops grown as well as pasture crops such as clover, and peas and beans. Fertilisers and insecticides, such as DDT, were used. Levee banks and drains were constructed as part of the farming process.

In the late 1960s, the then Department of Fisheries and Fauna, one of DEC's predecessor departments, recognised the value of the area for conservation. In 1974, the department raised the issue of conserving the area in the context of protecting the rare freckled duck (*Stictonetta naevosa*). Considerable data had been collected by Honorary Game Warden Reg Taylor about the significance of the area for waterbirds generally. Concerned individuals and organisations also encouraged the establishment of a nature reserve to protect the swamp.

However, the swamp was privately owned freehold land and was still being used to grow potatoes and other seasonal vegetable crops, despite the fact that crop yields were dropping. Increased salinity, a direct result of irrigation, was identified as a probable cause of this.

Protection puzzle

The swamp had also been the subject of two major subdivisions—in 1914 and again in 1929. The area was like a jigsaw puzzle, made up of dozens of separate small blocks of land. Before 1974, the reserve was divided into some 160 separate lots.

The first parcel of land was acquired for conservation in mid-1973—56 hectares of wetland. Another parcel of 80 hectares was purchased in the same year. This started a process lasting 35 years, in which successive conservation agencies purchased further holdings as they became available. The land was purchased in small sections, gradually making the vision to consolidate the swamp into one reserve more and more achievable.

In 1987, the then Department of Conservation and Land Management produced a management plan for the reserve. At this stage, the swamp was 19 per cent nature reserve, 70 per cent land already purchased by the Government for addition to the nature reserve and 11 per cent privately owned. The management plan included two key strategies: that the department continued its attempts to purchase the 29 blocks still remaining in private ownership; and that all purchased blocks be added to the reserve. The



Previous page
Main Benger Swamp Nature Reserve has been considered important for conservation of the rare freckled duck (*Stictonetta naevosa*) since the 1970s. *Photo – Dave Watts/Lochman Transparencies*
Inset Black swans with cygnets.

Left Australian shelduck.
Photos – Jiri Lochman





Above Signs remain from the redundant road reserve system inside the swamp, which has now been cancelled with the consolidation of the nature reserve. *Photo – Christine Fleay/DEC*

Above left Wetland rehabilitation site.

Below Moon rise over Benger Swamp. *Photos – Sallyanne Cousans*

goal was for the reserve to eventually encompass all of the swamp plus a small area of adjacent land, totalling 582 hectares.

In February 2006, DEC acquired the last two lots inside the swamp. It then started the necessary action to have the redundant road reserve system inside the swamp cancelled, and to rationalise the western boundary with a neighbour who had portions of his property jutting into the swamp.

In September 2009, the last purchases, the former road reserves and the strips of the neighbour's property were included into the reserve. Benger Swamp is now a consolidated 577-hectare nature reserve for waterbirds, some 35 years after the process began.

Conservation values

Benger Swamp is an important conservation reserve for several reasons. It is a seasonal wetland for a wide range of bird species including Australasian grebe, white-faced heron, sacred ibis, black swan, Pacific black duck, grey teal, Australasian shoveler, hardhead, black-winged stilt, marsh harrier, purple swamphen, spotless crake and little grassbird.

Diving ducks such as blue-billed ducks and musk ducks feed on the animal and plant life at the bottom of the swamp. In late October and November, waterbird numbers triple as water levels fall. Flocks of little pied cormorants, white-faced herons, great egrets, Australian shelducks, Australian pelicans, wood sandpipers and Eurasian coots can be seen. During the drying out months of December and January numbers of yellow-billed spoonbill, pink-eared duck, rufous night heron, Pacific heron, little black cormorant, hoary-headed grebe, banded stilt, greenshank and sharp-tailed sandpiper increase.

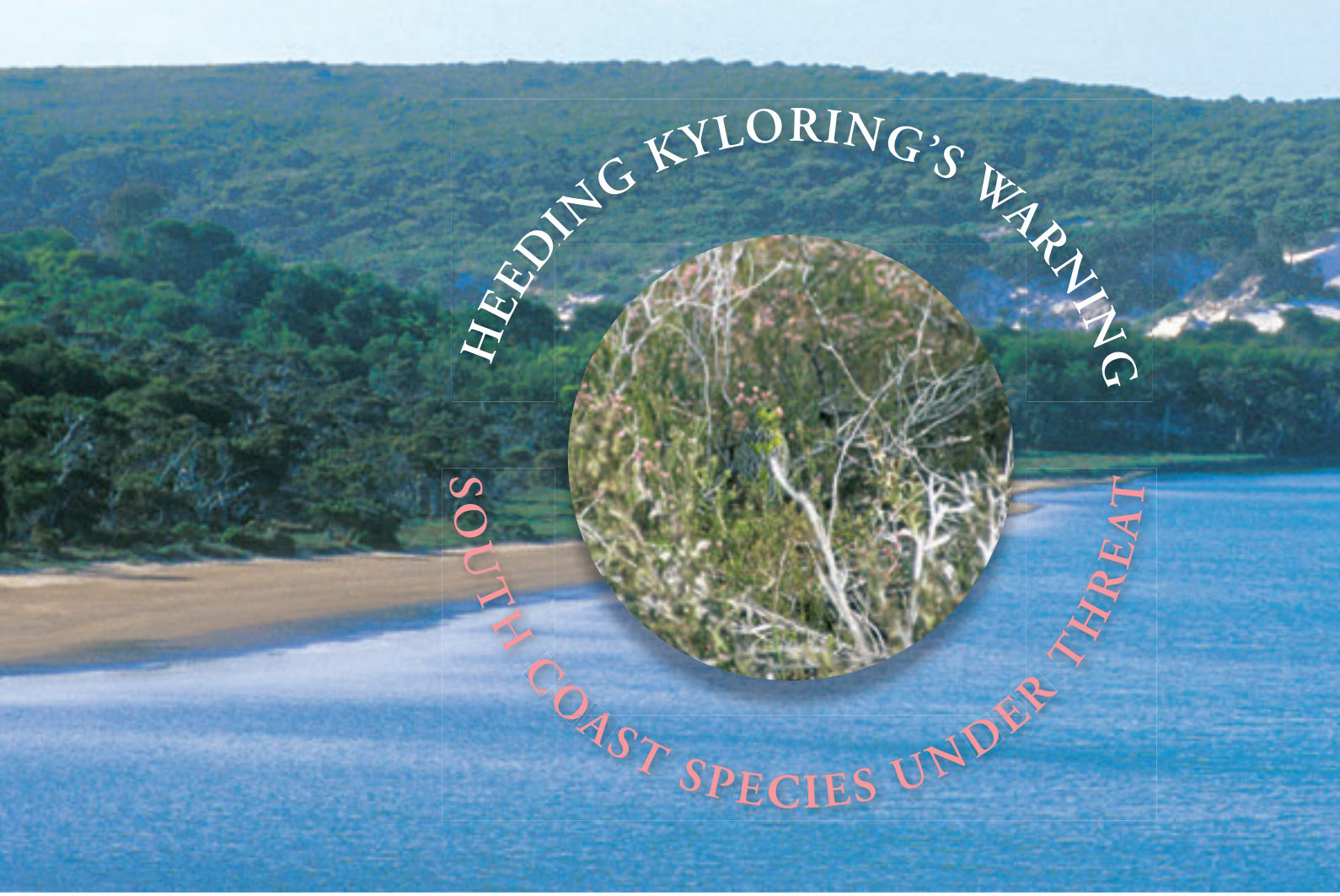
Recognition of the importance of Benger Swamp as a significant area for the conservation of the freckled duck has continued. The species is ranked as rare, or otherwise in need of special protection under the *Wildlife Conservation Act 1950*.

In recent years, field surveys have confirmed the persistence of Australasian bitterns within the swamp. Though recorded in 1987, this species has undergone significant declines across most of its range both locally and nationwide with the total WA population estimated to be between 38 and 154 individuals. As a consequence, the species may soon be listed as a Schedule 1 species in WA and nominated as endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. Benger Swamp Nature Reserve is the last remaining wetland on the Swan Coastal Plain where this species can reliably be found.



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HEEDING KYLORING'S WARNING

SOUTH COAST SPECIES UNDER THREAT

During the past decade, the western ground parrot has undergone a precipitous decline, causing alarm bells to ring with the South Coast Threatened Birds Recovery Team, the Friends of the Western Ground Parrot community group and staff from the Department of Environment and Conservation (DEC) who are working together to conserve this unique bird. There is also concern that a range of other threatened animals on the south coast may be at risk from the same factors that are threatening the parrots.

A parrot in peril

Historically, the western ground parrot (kyloring to the Nyoongar Aboriginal people) was found throughout near-coastal south-western Australia, occupying heaths and swamps from north of Badgingarra to Nuytsland Nature Reserve, east of Esperance. By about 1990, the species was restricted to about 400 individuals in three geographically distinct locations: the Waychinicup-Manypeaks area, Fitzgerald River National Park, and Cape Arid National Park and the adjoining Nuytsland Nature Reserve. Currently, there are fewer than 140 individuals known to be alive and the western ground parrot is classified as critically endangered.

Concern for the plight of the western ground parrot led to the formation of a recovery team in the early 1990s. Protection from wildfires and introduced predators (especially foxes) were identified as the priorities for research and management. Funding was a major challenge, but some progress was made in developing improved fire management for the species, and fox baiting on the south coast started under the *Western Shield* program in 1996.

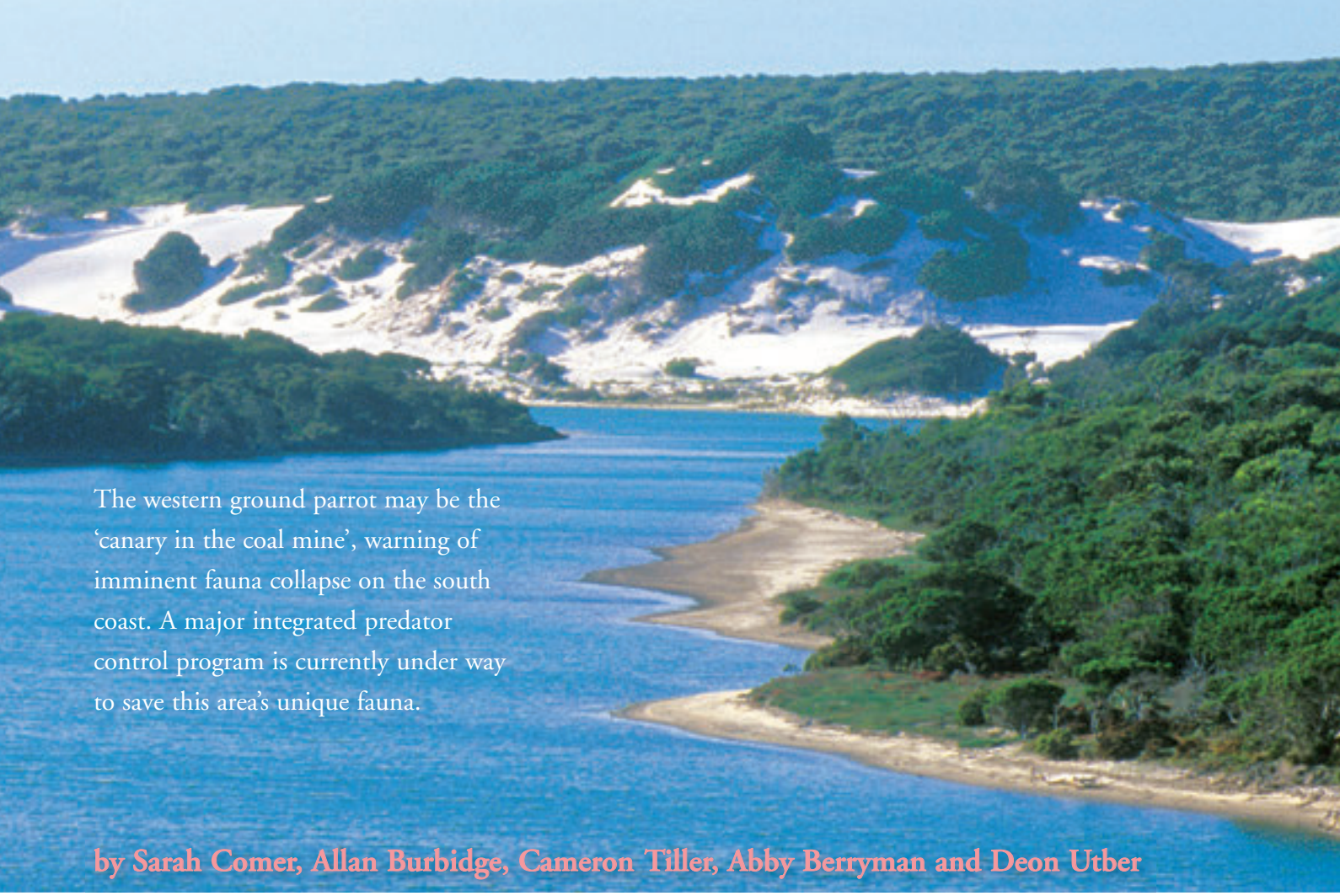
In late 2003, the Western Ground Parrot Recovery Project was fortunate to receive funding from South Coast Natural Resource Management, which provided for the employment of the first full-time team to work on this species. During the four years of this project, much work was done surveying populations across the south coast, looking for new populations, and studying the behaviour of this cryptic species (see 'The secret life of the western ground parrot', *LANDSCOPE*, Spring 2005).

Rarely seen and almost never photographed (see 'Wild with delight', *LANDSCOPE*, Summer 2005–06), the western ground parrot is a challenge to monitor. Counts are usually made through listening surveys carried out at dawn and dusk, when the parrots move from their daytime feeding areas to their night-time roosts.

While the original intention of the recovery project was to concentrate on translocating birds into former habitat, it quickly became apparent that the population in Fitzgerald River National Park—which had been considered one of the strongholds of the species—had declined to the point where removing birds was not an option.

On the brink

The project team turned its focus to survey work and, by analysing the results, was able to assess population densities across the range of the species. Despite considerable effort, no birds have been heard or seen in the Waychinicup-Manypeaks area since 2003 and this population is now considered locally extinct. Numbers in Fitzgerald River National Park have also



The western ground parrot may be the 'canary in the coal mine', warning of imminent fauna collapse on the south coast. A major integrated predator control program is currently under way to save this area's unique fauna.

by Sarah Comer, Allan Burbidge, Cameron Tiller, Abby Berryman and Deon Utber

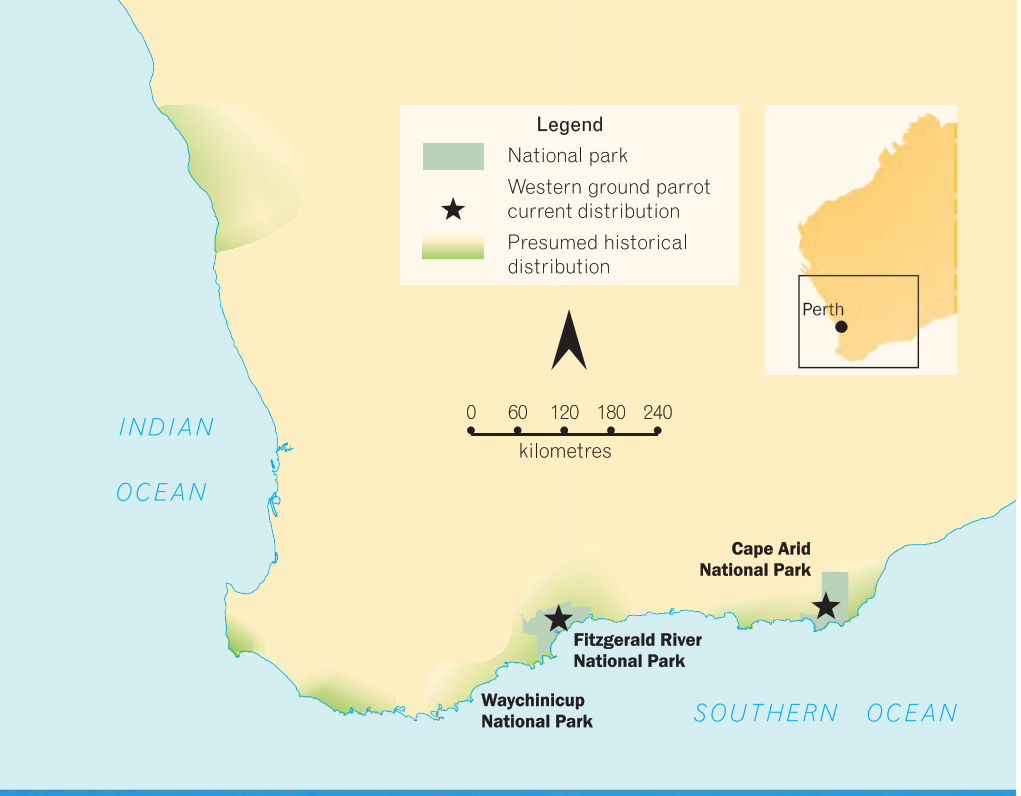
declined drastically, with what were once robust populations now either gone or supporting just a few individuals. In Cape Arid National Park ground parrots are faring slightly better, with these populations now considered the stronghold of the species. There may still be a small number of birds in Nuytsland Nature Reserve but these have not been located since 2006. In summary, surveys conducted during the past four years have confirmed that the population is undergoing a catastrophic decline.

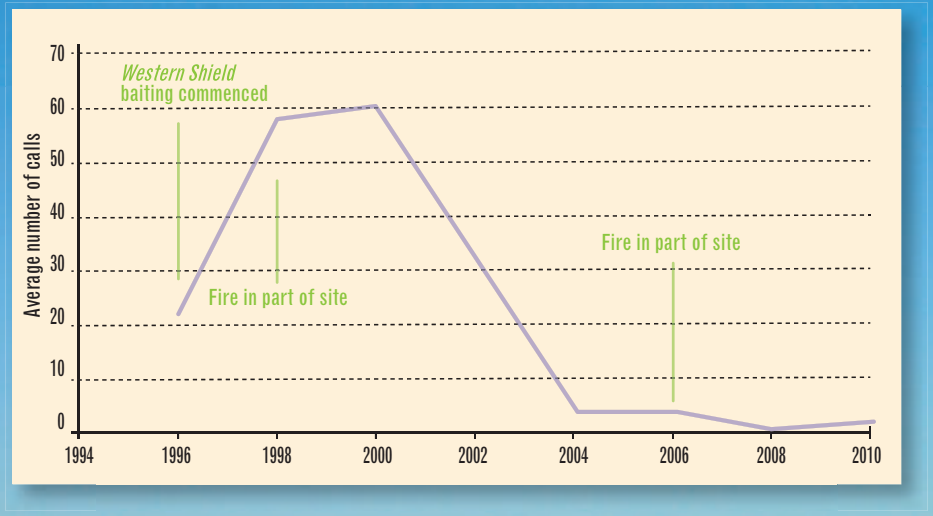
To add to the gravity of the western ground parrot story, recent genetic work has indicated that, contrary to earlier beliefs, the western bird is a distinct species from the eastern ground parrot. With this in mind, the recovery team and friends group have been working together with a wide range of individuals to ensure that the western ground parrot has a future. The numbers are so low that, without careful management, the western ground parrot is likely to become extinct in the next decade—possibly the first modern-day bird extinction in Australia.



Above and opposite page
Main Fitzgerald River Inlet.
Photo – Jiri Lochman
Inset Caught on film—the first photograph of a wild, unrestrained western ground parrot.

Left One of the only photographs of a wild adult western ground parrot, taken while trying to locate a nest in 2006.
Photos – Brent Barrett







Managing fire for ground parrots

Since 1985, there have been numerous surveys of ground parrots, initially by Birds Australia, and more recently by DEC and the Friends of the Western Ground Parrot. The data from these surveys have been used by the recovery team and DEC fire managers as a basis for informed fire management in the bird's habitat. While the exact relationship between preferred fire age (time since habitat has been burnt) and ground parrot usage of these areas is not known, it is known that frequent fire is a problem for them, as is extensive bushfire, but they are often found using habitat close to more recently burnt areas. The few remaining populations are found in areas containing at least some long unburnt vegetation (more than 40 years old in places), and it is hypothesised that this provides an important refuge, and possibly important areas for breeding. However, birds have also been recorded in more recently burnt country immediately adjacent to older vegetation, in some areas as soon as three years post fire, and it is thought that this may be due to the rapid production of seed from early successional species of plants. It is quite probable that the combination of older and younger vegetation is necessary to sustain populations.

Staff from DEC's Science and Nature Conservation divisions and the recovery team have worked with fire managers both in the development of prescription burns to provide protection for key areas of habitat, and in wildfire suppression. This approach has been extremely effective in recent years, and no major bushfires have affected areas occupied by ground parrots despite a significant number of fires starting near areas occupied by the birds.

Are cats the culprits?

In spite of improved fire management, the population decline continued, leading the recovery team to focus on other possible factors

Left Western ground parrot habitat in Cape Arid National Park.
Photo – Sarah Comer/DEC





Above left An adult western ground parrot.
Photo – Brent Barrett

Above Setting up mist nets in Cape Arid National Park.
Photo – Abby Berryman/DEC

What is adaptive management?

Adaptive management is management designed to facilitate learning. Essentially, decisions are made on the desired management outcome (for example, maintenance of an intact ecosystem), key threats are identified, and management actions are set up as experimental treatments at normal operational scales. The impacts of the actions are measured in such a way that understanding increases of both the ecological system and the way in which the management action influenced the outcome. This is done to enable evaluation of success and, most importantly, provide feedback to either change, stop or improve the management action as necessary.

impacting on ground parrots. In 2004, a preliminary assessment of feral cat numbers in Fitzgerald River National Park found a high abundance of feral cats, and it was recommended that some measures of cat control be trialled.

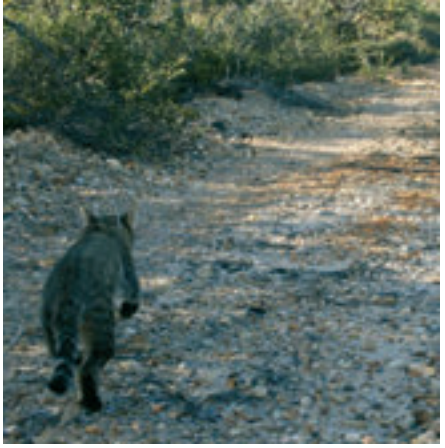
As no large-scale baiting targeting cats had been conducted in the south-west, it was important to identify non-target species that might be affected by the use of *Eradicat*® baits developed for feral cat and fox control. A number of other threatened species in the area, including the red-tailed phascogale (*Phascogale calura*), dibbler (*Parantechinus apicalis*) and chuditch (*Dasyurus geoffroii*), could potentially consume the bait. While the 1080 poison used in baits is derived from the native poison pea plant which is not usually toxic to native species, *Eradicat*® has a higher concentration of 1080 than the fox baits currently used. It is also a fresh meat bait, which means the baits might be more palatable to native species (see 'Controlling introduced predators in the rangelands: the conclusion', *LANDSCOPE*, Winter 2010). In order to identify any issues with native fauna potentially being affected by the use of the *Eradicat*® bait, two non-target trials were conducted with non-toxic baits.

With this work completed, staff from DEC and the South Coast Threatened Birds Recovery Team discussed emergency actions required to protect the remaining ground parrot populations. They identified predator control as the most likely effective action. The working hypothesis formed was that mesopredator release had resulted in an increase in the number of feral cats in the parks. Mesopredator release (see 'Will curiosity kill the cat?', *LANDSCOPE*, Autumn 2007) is a term used to describe the increase in abundance of subordinate predators when a top-level predator is removed or controlled within an area (see also 'Fauna recovery in the wheatbelt' on page 56). In this case, it was suspected that the removal of foxes under the *Western Shield* program reduced constraints on the feral cat population. If this was the case, then various other threatened species, including the red-tailed phascogale, dibbler, chuditch, western bristlebird and malleefowl, might also be at risk.

These discussions led to a project to control both feral cats and foxes, developed in an adaptive management framework (see box above), with the hope that funds might be available to implement the program. Together, Fitzgerald River National Park and the Cape Arid–Nuytsland area cover more than 600,000 hectares and so the proposal to bait both areas for feral cats and foxes entailed a major effort to address predation on a landscape scale. Ensuring that there was an opportunity to learn from this baiting was a priority.

The adaptive management project design was focused not only on obtaining information on the response of introduced predators to the introduction of baiting with the new *Eradicat*® bait, but also on examining the response of a suite of native species. To look at the effectiveness of the baiting program, sand plots were established in both areas to record the level of predator activity before and after baiting and were checked for cat and fox tracks each morning for four days to provide an index











of predator abundance. In addition, a number of feral cats were fitted with radio collars carrying a GPS device to both determine bait uptake and look at the use of habitat by feral cats. This information will be used to refine future bait delivery protocols.

At the same time as the cat work was occurring, a number of chuditch, dibbler and bush rats (*Rattus fuscipes*) in the baiting area were fitted with radio collars to determine if they were consuming the baits and, if they were, if a lethal dose of the baits was being ingested. All of the baits dropped were injected with rhodamine B, a dye bio-marker that causes fluorescence in whiskers if animals ingest it. The first trial involving the baiting of Fitzgerald River National Park using toxic *Eradicat*® baits was conducted during autumn 2010, with preliminary results supporting the previous work that found that while some native species were likely to sample baits, they don't take a lethal dose.

The results of the various monitoring programs will be fed back into the project design regularly, enabling adjustments to be made as required. A steering committee has been established to guide the project, with representatives from DEC's South Coast Region, Science Division and *Western Shield* program.

Captive breeding: an insurance

Although the ideal is to conserve the western ground parrot in its preferred habitat by managing threatening processes (particularly predation and fire), captive management was identified as an important insurance measure should the new baiting program be ineffective or an uncontrolled bushfire wipe out the remaining populations.



Top far left Sweating *Eradicat*® baits near Ravensthorpe prior to aerial delivery to Fitzgerald River National Park.
Photo – Cameron Tiller/DEC

Top left A feral cat in Fitzgerald River National Park.
Photo – Neil Hamilton/DEC

Above far left An endangered dibbler with a radio collar.

Above left Preparing sand pads in Cape Arid National Park.
Photos – Louisa Bell/DEC

Above Volunteers and DEC officers take part in the *Western Shield* fauna monitoring program in Cape Arid National Park.
Photo – Sarah Comer/DEC

Left Releasing a collared chuditch.
Photo – Cameron Tiller/DEC



Right A red-tailed phascogale.
Photo – Jiri Lochman

Below right A western ground parrot.
Painting – Wendy Binks

The western ground parrot has not been kept in captivity before. Therefore, the first step towards a full-scale captive breeding program was to take a small number of birds into captivity as a pilot husbandry project to refine techniques for captive management. Three birds taken into captivity in late 2009 have so far been kept successfully. Maintaining the health and well-being of the birds in captivity is one challenge of this contingency strategy and the recovery team has had significant support and advice from specialist staff from within DEC and Perth Zoo to assist in this process. The long-term goal is to shift to a breeding program, which will require significant funding. Captive breeding also relies on suitable habitat being available for releasing birds back into the wild—hence the importance of developing good landscape-scale management regimes to address threats.

The challenges of conserving the western ground parrot are significant but the individuals and organisations that have come together to take on this challenge are committed to ensuring a successful outcome for the parrot and to demonstrating that controlling feral cats and foxes in south coast systems has multiple benefits. While the ground parrot can be viewed as the 'canary in the coal mine' that has set alarm bells ringing, many other threatened species are expected to benefit from the landscape-scale approach to integrating control of introduced predators, including the chuditch, dibbler, red-tailed phascogale, western bristlebird and malleefowl. The results of the program will take a number of years to become apparent. However, if successful, the long-term benefits of establishing a truly integrated predator management regime will not only secure the future of the ground parrot but may also result in the restoration of a suite of native species to their former habitats on the south coast.

Multiple collaborators

Such a complex project would not be successful without input from a range of people with specialist skills and attributes. The past 10 years of the Western Ground Parrot Recovery Project have seen cooperation and collaboration with a number of partners including the Friends of the Western Ground Parrot, South Coast Natural Resource Management (NRM), Department of Environment and Conservation (DEC), Exetel, Perth Zoo, the Australian Department of the Environment, Water, Heritage and the Arts, State NRM, Birds Australia WA, Dr David Edmonds, Australian Wildlife Conservancy, CSIRO and Murdoch University. Numerous volunteers have played a major role in supporting this project.

People interested in assisting in the predator management program, taking part in surveys, or who have reports of the western ground parrot (particularly in other locations) should contact Sarah Comer.

Sarah Comer is DEC's south coast regional ecologist, based in Albany. She can be contacted on (08) 9842 4513 or by email (sarah.comer@dec.wa.gov.au).

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Cameron Tiller is an adaptive management conservation officer with DEC, based in Albany. He can be contacted on (08) 9842 4533 or by email (cameron.tiller@dec.wa.gov.au).

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feature park by Samille Mitchell

Windjana Gorge National Park

The spectacular walls of Windjana Gorge rise abruptly from the surrounding Lennard River flood plain, looming 100 metres high in some places. The 3.5-kilometre-long gorge cuts through the limestone of the Napier Range and is part of an ancient barrier reef that is also visible at Geikie Gorge and Tunnel Creek national parks.

In Windjana Gorge National Park, the Lennard River charges through the gorge during the wet season and forms pools embraced by shady trees and shrubs during the dry. In places, the pooled water mirrors the rock walls of the gorge towering high above.

History

The Bunuba people are the traditional owners of the Windjana Gorge area. The park earned its name from the Wandjina, an ancient mythological spirit of the Dreamtime; the current spelling arose from a mis-recording by William Forrester who took up nearby pastoral lease in 1884. The Bunuba people call the gorge Taley and occupied the area around the gorge for thousands of years—art sites, artefact scatters and mythological stories from the area are testament to this. At one place in the gorge, a large boulder, Bandigan Rock, sits in a pool of water in which the spirits of babies are said to be found.

In the late 1800s explorers and pastoralists arrived with their sheep and cattle, resulting in conflict with the land's traditional owners. Windjana Gorge was the site of one such conflict. For here, in 1894, a gun battle broke out between Bunuba freedom fighter Jandamarra and a party of 30 men revenging Jandamarra's attack on five cattlemen, three of whom were killed. Jandamarra was seriously wounded during the reprisal attack but survived the injury.

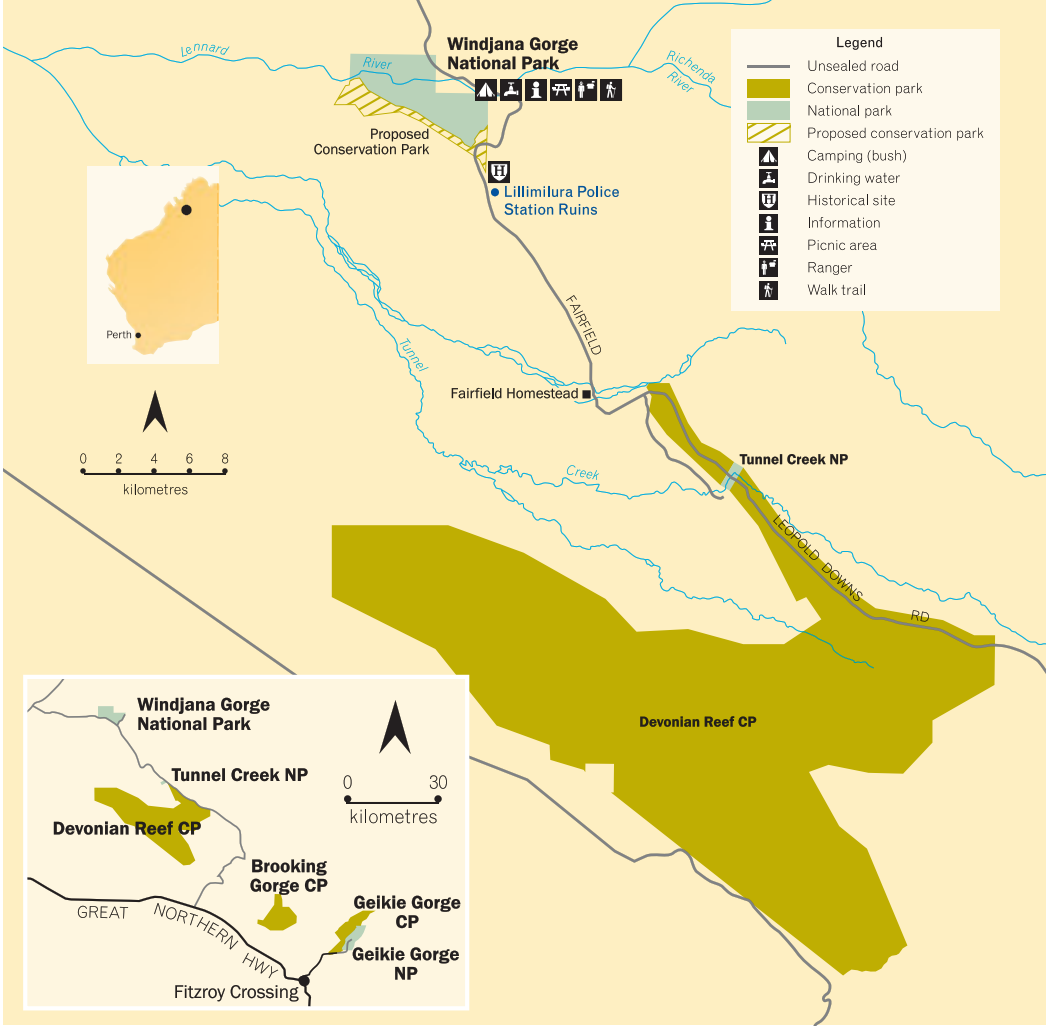
The national park was gazetted in 1971.

Natural attractions

Windjana Gorge was once part of a barrier reef that teemed with marine life. The reef formed 360 million years ago in the Devonian period when large parts of the Kimberley were covered by tropical seas. Fossils in the rocks at Windjana are world renowned for providing clues to this ancient epoch. Other fossils found in the area include a giant species of crocodile that grew







Opposite page
Main Windjana Gorge.
Photo – Marie Lochman

Top Little red flying fox.

Above Freshwater crocodiles can be spotted in the park.

Below right An iconic north-west species, the boab tree.
Photos – Jiri Lochman

to about seven metres long and a giant wombat-like marsupial called a Diprotodon.

In the gorge, river gums (*Eucalyptus camaldulensis*) and cadjeputs (*Melaleuca leucadendra*) fringe the banks of the Lennard River while spinifex adorns the plains and rock fig (*Ficus platypoda*) clings to the gorge walls. Boabs (*Adansonia gregorii*) and the coolaman tree (*Gyrocarpus americanus*) grow on the slopes of the gorge. Aboriginal people would use the smooth, shiny bark of the coolaman tree to make light containers for carrying possessions and cradling babies. Away from the gorge the vegetation is dramatically different with a savannah woodland of trees such as Kimberley bauhinia (*Bauhinia cunninghamii*), greybox (*E. tectifica*) and twin-leaf bloodwood (*Corymbria cadophora*).

The riverine vegetation is home to colonies of fruit-bats such as the black flying fox (*Pteropus alecto*), as well as large flocks of raucous little corellas and waterbirds such as the black bittern and the rufous night-heron. The waters here are also regarded as one the best places in the state to see freshwater crocodiles (*Crocodylus johnstoni*).

Peregrine falcons roost in the gorge walls and sandstone shrike-thrushes forage for insects in the crannies. Away from the gorge, you may see agile wallabies (*Macropus agilis*), recognised by their sandy colour and a light stripe down their cheek and thigh.

Exploring the park

During the wet season, the park is inaccessible and closed to the public. During the dry, you can set out on a range of walks including the Savannah Walk, Gorge Walk and Time Walk. The walks are well signposted with trailheads and trail markers present.

The ruins of the Lillimilura homestead are in the park and can be accessed via Fairfield Leopold Downs Road. The homestead was constructed from local limestone in 1884 for the King Sound Pastoral Company. The homestead was also site of the police outpost where Aboriginal freedom fighter Jandamarra shot a police constable.

There is a day-use site at the car park to the gorge and a camping area with water, toilets, showers and fire rings. The park is open from April to November. Rangers are present to collect camp fees and provide information.

park facts

Where is it? 145 kilometres from Derby and 150 kilometres from Fitzroy Crossing.

Total area: 2,134 hectares.

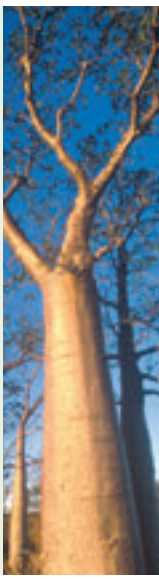
What to do: Camping, sightseeing, walking, photography, nature observation.

Facilities: Toilets, showers, water, information shelter, pay phone.

Camping: Camping is permitted in the park. Fees apply.

Park fees: Entry fees apply.

Nearest DEC office:
West Kimberley District Office,
111 Herbert Street, Broome
(08) 9195 5500.







FAUNA RECOVERY in the wheatbelt







A four-year study into the reasons for the recent declines of mammals in the south-west of Western Australia has just been completed. One part of this was a study at Lake Magenta, 400 kilometres south-east of Perth, and results from this research will be used to better manage for fauna conservation in the wheatbelt.







by Keith Morris, Brent Johnson and Bill Muir





Before European settlement, the Western Australian wheatbelt contained some of Australia's highest mammal diversity, with 35 species known to occur here. Following the extensive clearing of this area for cereal crops and sheep grazing, and the introduction of feral cats and foxes, 19 (54 per cent) of these species declined significantly or became extinct. Most of these were medium-sized mammals ranging in body weight from 50 grams to five kilograms.

This pattern was reversed to a certain extent from 1996–2000 when the then Department of Conservation and Land Management started its *Western Shield* fauna recovery program and broadscale fox control, along with the translocation of threatened native species. The *Western Shield* program involves laying meat baits laced with 1080 poison, derived from the native poison pea plant. Native animals have a tolerance to this poison, as they have evolved in the presence of the poison pea, but it is toxic to introduced species.

Several native species responded very positively to fox control and three—the quenda (*Isoodon obseulus*), woylie (*Bettongia penicillata*) and tammar wallaby (*Macropus eugenii*)—were removed from State and Federal threatened species listings. By this time at Lake Magenta, chuditch (*Dasyurus geoffoii*) and woylies had been translocated as part of recovery programs for these threatened species, and quenda and brushtail possum (*Trichosurus vulpecula*) populations had been 'rediscovered' after what appeared to be a successful fox control program.

Unexplained declines

Despite early success, by 2000–01, further declines in medium-sized mammals in the south-west of WA were reported and at that time the *Western Shield* monitoring program was not able to determine the cause or causes of this. At Lake Magenta, the chuditch and possum populations appeared to decline and the quenda and woylie populations became locally extinct. There were several possible causes for these declines at Lake Magenta, and elsewhere, including a reduction in the effectiveness of fox baiting, an increase in feral cat abundance following successful fox control (often referred to as mesopredator release, see box on opposite page), or other factors such as disease or a reduction in resources.

It was most probable that there were several factors operating together.



Previous page
Main Mallee shrubland east of Lake Magenta.
Photo – Michael James/DEC
Insets clockwise from top right Lake Magenta is one of the only sites in Western Australia where heath mice are found. *Photo – Bill Muir/DEC*; Brent Johnson about to release a chuditch at Lake Magenta. *Photo – Keith Morris/DEC*; a brushtail possum at Lake Magenta; a honey possum at Dunn Rock Nature Reserve; processing a chuditch at Lake Magenta; a pygmy possum. *Photos – Bill Muir/DEC*

Above A western mouse, Lake Magenta Nature Reserve.

Above left Brent Johnson with a possum, Lake Magenta Nature Reserve.

Left Brushtail possums were once widespread in the wheatbelt.
Photos – Bill Muir/DEC

Right A fox caught on camera at Lake Magenta.
Photo – Keith Morris/DEC

Below right Feral cats are significant predators of native mammals.
Photo – Jiri Lochman

Mesopredator release

Mesopredator release is an increase in the abundance of a subordinate predator following the removal of a dominant predator which previously held the subordinate species in check. In the context of this project, the abundances of feral cats and native predators such as chuditch were examined in relation to reduced fox abundances following baiting.



In 2006, a study into the reasons for the decline of medium-sized mammals at Lake Magenta was started. This was part of a broader study funded by the Department of Environment and Conservation (DEC) and the Invasive Animals Cooperative Research Centre examining the interactions of foxes and feral cats at several sites in the southern part of WA, and their role in fauna declines (see 'Controlling introduced predators in the rangelands: the conclusion', *LANDSCOPE,* Winter 2010).

The study sites

Lake Magenta was selected as a site for this study as it was a large, 100,000-hectare wheatbelt nature reserve that still had a relatively intact flora and fauna (despite recent mammal declines), it had been fox baited since 1996 and there was a considerable amount of fauna monitoring information. Researchers also selected another large nature reserve nearby, Dunn Rock, as an area where no fox baiting had been undertaken so it was possible to compare native fauna abundances, and the interactions of foxes and cats.

Lake Magenta and Dunn Rock both occur in the southern wheatbelt, in the Mallee IBRA (Interim Biogeographic Regionalisation for Australia) sub-region. They are dominated by mallee shrub and woodlands and botanically diverse heaths. This study was the first time Dunn Rock had been surveyed for vertebrates and it was found to have a diverse reptile fauna, but its small and medium-sized mammal fauna was lower in numbers compared to Lake Magenta.

Interestingly, chuditch and brushtail possums were trapped at Dunn Rock but at much lower frequencies than at Lake Magenta, where fox baiting was occurring. However, it was noticeable that other species such as the red-tailed phascogale (*Phascogale calura*), heath mouse (*Pseudomys shortridgei*), brush wallaby (*Macropus irma*), malleefowl and carpet python (*Morelia spilota*) were present at Lake Magenta but not recorded at Dunn Rock, despite similar habitat types occurring at both reserves. This greater diversity of the larger vertebrates was probably a result of the fox baiting program.

Monitoring techniques

The study focused on examining the responses of foxes and feral cats to current and modified fox baiting programs. However, these predators are very difficult to monitor as they are not readily trapped. As a practical alternative, sand plots stretched across tracks at 400 to 500-metre intervals, and running for 10 to 20 kilometres, have been shown to be an effective way of monitoring the activity of foxes, feral cats and other fauna across the landscape. There is some debate, however, about whether the activity indices derived are a good surrogate for animal abundance. It has been argued, for example, that when fox numbers are reduced through a toxic baiting program, the survivors are more wide-ranging. This gives the impression that activity stays the same or increases, instead of decreasing.

However, novel techniques to collect hair samples at sand plots, and DNA technologies to identify species and individuals, are now being used to validate and help interpret sand plot activity information (see 'Sand plots and sticky wickets—how the survey was done' in 'Controlling introduced predators in the rangelands: the conclusion', *LANDSCOPE*, Winter 2010). This provides more confidence about the effectiveness of pest animal











control programs. Researchers are also able to look at the pattern of fox activity along the sand plot transects and estimate the numbers of foxes using that particular track or transect.

In addition to being used to monitor the activity of foxes and feral cats, sand plots can be used to monitor fox behaviour in relation to uptake of baits. It was found that where a fox encountered a bait on a sand plot, it did not always take the bait, suggesting that some foxes are either avoiding the baits or finding them unpalatable. Foxes will investigate novel objects and it is possible that changing bait types regularly might improve bait uptake. It was also found that bait uptake 100 metres off tracks was very low in the densely vegetated heaths and mallee shrublands. This suggests that foxes prefer to use the cleared firebreaks and tracks to access Lake Magenta, rather than force their way through dense vegetation. These results indicated that while fox baiting had resulted in some benefits to the native fauna at Lake Magenta, baiting efficacy could be improved through modifications to the baiting program.

Fox baiting program

Another area of investigation was to examine the 11 years of fox baiting history, from 1996 to 2006. The *Western Shield* fox baiting prescription for Lake Magenta required aerial baiting to occur every 90 days, with synchronised reserve perimeter ground baiting. In addition, the internal tracks and fire breaks were ground-baited once a year. It was found that due to operational limitations to

Top far left Quenda tracking at Lake Magenta Nature Reserve.

Top left Sticky wickets set up at Lake Magenta.

Centre far left Checking a rain gauge at Dunn Rock Nature Reserve.

Centre left Installing pit traps at Lake Magenta.
Photos – Bill Muir/DEC

Left Volunteers checking pit traps.
Photo – DEC



Right Chuditch release at Lake Magenta.
Photo – Bill Muir/DEC

Below right Mallee heath at Lake Magenta.
Photo – Keith Morris/DEC

aircraft use and poor weather, aerial baiting was not consistently undertaken at 90-day intervals. Also, the ground baitings were not always timed to coincide with the aerial baiting.

During the first two years of the program, researchers also assessed the activity of foxes and feral cats, through the use of sand plots at both Lake Magenta and Dunn Rock. They found that fox activity at Lake Magenta was approximately half that at Dunn Rock, but that feral cat activity was higher at Lake Magenta. This suggested that although the fox baiting program at Lake Magenta was not as regular as it could have been, it was effective in reducing fox activity. Of some concern was the apparent increased activity of feral cats at Lake Magenta compared to Dunn Rock, raising the question: was this evidence of mesopredator release?

To see if fox activity could be further reduced at Lake Magenta, in 2008 a modified fox baiting program was commenced whereby aerial baiting was undertaken strictly between 90 and 100 days, and all the perimeter and internal tracks were baited at the same time as the aerial baiting took place. This resulted in a further 50 per cent reduction in the activity of foxes at Lake Magenta compared with Dunn Rock, where fox activity remained unchanged. This relatively simple change to the fox baiting program appeared to have improved fox control and has provided the opportunity to see if there is a consequent recovery of native fauna populations at Lake Magenta.

Quenda reintroduction

The real test as to whether the 'new' simultaneous aerial and ground fox baiting program was effective was in how the native fauna responded. Ongoing *Western Shield* monitoring of the small and medium-sized mammals will continue, and quenda have been re-introduced to Lake Magenta after an absence of 10 years.

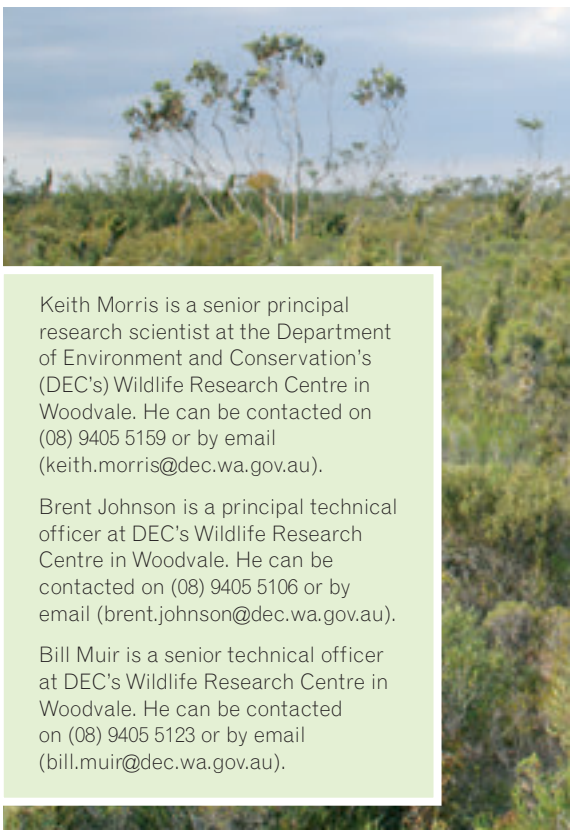
In October 2009, 41 quenda were released at Lake Magenta and monitored for the next three months. During that time, it was determined that five died, but not as a result of fox or cat predation. It is most likely that they were unable to find adequate food and shelter.

Most of the others spread out up to a few kilometres from their release site, and were occupying areas of Lake Magenta that they were originally found in. These are generally sandy shrubland sites, with an understorey of grasses, small shrubs and sedges among which the quenda dig for food and find shelter. It was also pleasing to find that many of the quenda had increased in body weight and the females had retained the pouch-young they had when released. More recently, additional quenda have been taken from areas to be cleared in the south-west and released at Lake Magenta and it is anticipated that these will help establish one of the most inland populations of this species.

The future

While this study has not confirmed the role of feral cats in the decline of native fauna at Lake Magenta, other studies in the south-west have shown that in the presence of fox control, feral cats are a significant predator of species such as woylies and western ringtail possums. Other work undertaken in the rangelands as part of the mesopredator research program has shown that annual cat baiting, with some supplementary fox baiting, can effectively control both feral cats and foxes.

There are issues surrounding the potential uptake of the more palatable cat bait by non-target species such as chuditch, dibblers and quenda, and the impact of this in the south-west of WA needs to be determined. Once this has been resolved and cat baiting is shown to not detrimentally impact on native species, cat baiting should be used at sites such as Lake Magenta and the original vision of reconstructing the mammal fauna here should be progressed. In the meantime, a regular and coordinated aerial and ground fox baiting program will also help with fauna recovery in this important natural remnant of the WA wheatbelt.



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urban antics

by John Hunter



Pigeon or dove?

My spring season in the western coastal suburbs during the 1940s was all colour and sound. For a suburb with relatively few people, Scarborough and its surrounding area was a wonderland of wildflowers and birdlife in a superb forest of eucalypts, banksias and prickle bush undergrowth.

It is said, however, that 'the grass is always greener on the other side of the fence' and I now concur, for it was that holiday once a month with my grandparents in Subiaco where I learned of other things such as trains, trams, bakers' carts, chooks and... pigeons and doves.

Most cities and suburbs of the world have pigeons and doves except those areas of the polar regions or the driest areas of the Sahara Desert. In the case of Perth, the obvious are two introduced species and, until modern times, our suburbs were also a regular haunt for about three native species.

Doves and pigeons are from the bird family Columbidae and are really one-and-the-same. Generally, 'pigeon' refers to the larger bodied bird and 'dove' the smaller.

The Columbidae are generally stout bodied birds with short necks, and have short slender bills with a fleshy cere. Like a few wild creatures, these birds readily adapt to living alongside humans where they can take advantage of food scraps, pet food and handouts. They also love to build their nests on and in our homes and business premises.

Like most children, it was a pleasure for me in times past to have granddad entice a chubby round-faced, red-legged wild bird onto the handrail of a sun-drenched back verandah and be fascinated with the up-close feverish performance of a handful of budgie seed being devoured.

It was fine, until one day there were lots more 'doves', especially bigger ones, in a feathered frenzy of feasting and pooing. The downside then, was it became my job to clean up the mess and restrict what had become bad practice.

Unfortunately, we humans are still attracting the introduced species of laughing dove (*Streptopelia senegalensis*) and its bigger cousin the spotted dove (*S. chinensis*) along with its even bigger relative the European domestic pigeon (*Columba livia*).

The feral European or rock pigeon has the largest territory in the world. Originally trained by the Egyptians more than five thousand years ago, it has grown with the spread of humanity and the availability of grain food and water. It is now causing pollution, damage and disease in cities and areas where numbers are out of control or where access is gained to internal structures for roosting and nesting by even a few pairs.

What is important, is that those local native pigeon species—the crested (*Ocyphaps lophotes*), brush bronzewing (*Phaps elegans*) and common bronzewing (*P. chalcopetra*)—although very shy of human development, are not forced further away due to displacement by their introduced cousins.

Because of hand feeding and uncontrolled availability of pet food, a build-up of introduced bird numbers could subject other native bird species as well as humans to the risk of disease and parasite transmission.

It would not be our wish for our native doves to go the way of their larger extinct cousins, the dodo and the solitaire bird.

DID YOU KNOW?

- Doves/pigeons are generally divided into two groups: the colourful plumaged fruit eaters that eat in trees and the somewhat drab seed eaters which are predominantly ground dwellers.
- The rock pigeon has been bred into several varieties by hobbyists, of which the best known is the homing or racing pigeon.
- If there are problems in your area, a feral pigeon control brochure is available from the Department of Health, or contact a licensed pest control operator or your Local Environmental Health Officer.



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Photo – David Bettini

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