WA's conservation, parks and wildlife magazine

LANDSCOPE

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Kimberley marine life

South coast banksia decline

Fauna of the Gnangara Mound **Faure Island** Peak Charles National Park

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Department of
Environment and Conservation

Our environment, our future


Alice Reaveley


Suzanne Mather

contributors

Alice Reaveley is a fauna conservation officer for the Department of Environment and Conservation's (DEC's) Swan Coastal District. Based at the Wanneroo office, she has been developing this new role for the past 18 months. Before this, Alice was involved as a conservation officer on a biodiversity survey of the Gnangara Mound as part of the Gnangara Sustainability Strategy. Alice has been with the department since 1997, working in a number of districts on nature conservation activities including flora conservation, land-use planning, reserve acquisition, *Western Shield* monitoring and fauna survey. She has now taken a break from work to have a baby but will be back soon to continue finding fauna persisting on the Swan Coastal Plain.

editor's letter

A quick flick through this edition suggests a stronger-than-usual emphasis on marine, or at least, aquatic life. And perhaps that's fair enough. After all, as Glen Cowans, author of *Beyond the Edge* ('bookmarks', page 9) points out, "we know this planet as Earth, but over 70 per cent of its surface is water and within that water exists 90 per cent of all living creatures. Our planet should be called Ocean." In this issue, we hear of a marine survey expedition in the Kimberley ('Northern exposure', page 10), explore symbiosis and other relationships among marine life ('Sponging off others', page 35), and find out about the freeloading habits of the marsupial freshwater mussel ('Piggyback on a fish', page 46).

But on a closer look a bigger recurring theme emerges. We find that banksias are fighting for survival in the face of threats from plant diseases heightened by human activity and by human-induced climate change ('Last chance to see: banksias of the south coast', page 17). Similarly, animals of the Gnangara Mound are declining in number because of increasing extraction of groundwater for commercial and private use ('Dry times ahead: the future for fauna of the Gnangara Mound', page 56). We look at changes in fire management to achieve 'best practice' in controlled burning regimes to maximise ecological benefits for the forest alongside ensuring safe human habitation ('Lessons learned since the Dwellingup fires', page 48). Even the marine environment is not beyond the reach of human activity: in 'Northern exposure' it's speculated that the reason the common lionfish, once endemic to the Indo-Pacific zone, is now established in the Atlantic is that six exotic specimens were set free when an American aquarium burst during a hurricane in the 1990s (see page13). Increasingly, stories coming from the field are about ever more complex management challenges presented by human impact on, and presence within, the environment.

We call this endeavour 'nature conservation'. But exactly what is meant by 'nature'? This is as much a philosophical as a scientific question. We live within these ecosystems. We're part of them, and our activities affect and change habitats, on an increasingly daunting scale. Referring to climate change, acclaimed science writer James Gleick, the author who introduced 'chaos theory' to the English language with his 1987 Pulitzer-prize-nominated book *Chaos: Making a new science*, recently said "whatever we once thought Nature was—wildness, God, a simple place free from human thumbprints, or an intricate machinery sustaining life on Earth—we have now given it a kick that will change it forever." The reality is that conserving nature, once considered some faraway place you 'get back to', is more and more a question of working out how the human species fits into the picture—here and now, and into the future.

Madeleine Clews
Executive Editor

Suzanne Mather is the recently appointed chairperson of Birds Australia Western Australia. Before this, she fulfilled a number of voluntary roles within the organisation for 12 years, such as co-editor of the quarterly publication *Western Australian Bird Notes*. Sue is passionate about the conservation of Australia's native birds and, after retiring from teaching and librarianship, pursued this passion through involvement with Birds Australia. Her recent post-graduate qualifications in ornithology have added a knowledge base to this passion. When she finds time, Sue enjoys researching the relationship between birds and mistletoe in the arid zone of WA.

Rick Sneeuwjagt is DEC's principal fire projects officer after recently moving on from his post as state manager for the department's Fire Management Services, a position he held from 1994. Rick has 42 years' experience in fire research, fire operations and statewide coordination. In the 1970s, he was responsible for the research and development of the WA forest fire behaviour system. Over the past 25 years he has led the development of planning systems and guidelines for prescribed fire to protect community and natural values, and the conservation of WA's rich biodiversity. Rick has been involved in dozens of national and international fire programs and initiatives and, in 2008, was awarded the Australian Fire Service Medal.

Emma O'Leary has been a media relations officer for DEC since 2008, based in Perth. In her role to liaise with the media, produce editorial material and develop communication strategies, she has been involved in many aspects of the department's work. These include fire management, nature conservation, environmental regulation and parks and visitor services. She enjoys the strong relationships she has developed with many DEC staff, whose knowledge and passion for their work help her learn more about WA's fascinating and distinctive environment.


Rick Sneeuwjagt

also contributing . . .

John Huisman, Rainbo Dixon, Samille Mitchell, Anne Cochrane, Sarah Barrett, Colin Crane, Chris Dunne, Renée Hartley, Greg Freebury, Brent Johnson, Murray Carter, Ann Storrie, Sarah Comer, Emma Adams, Michael Klunzinger, Adrian Pinder, David Cale, Alan Lymbery, Karla Forrest, John Hunter and Jill Pryde.


Emma O'Leary

Cover illustration by Gooitzen van der Meer
Ghost bat (*Macroderma gigas*) numbers are in decline and their range has contracted to the tropics of northern Australia, and the Pilbara, with only around 5,000 thought to occur in the wild. Ghost bats are the biggest microbat in Australia and the country's only carnivorous bat, with very sharp teeth for attacking prey such as frogs, lizards and other small animals. They are named for their thin wing membranes, which appear ghostly pale at night, and have grey fur on their backs and pale grey or white fur on their undersides. They have large ears for long-distance hearing.
Illustration reference photo by Jiri Lochman

Back cover photo by Jiri Lochman
The Rudall River at night.

Features

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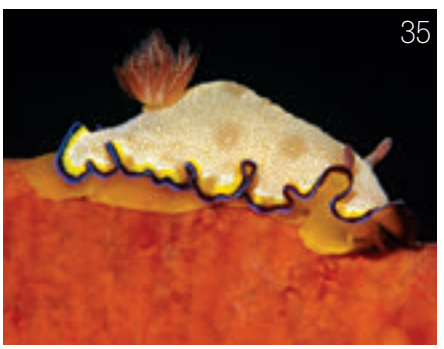
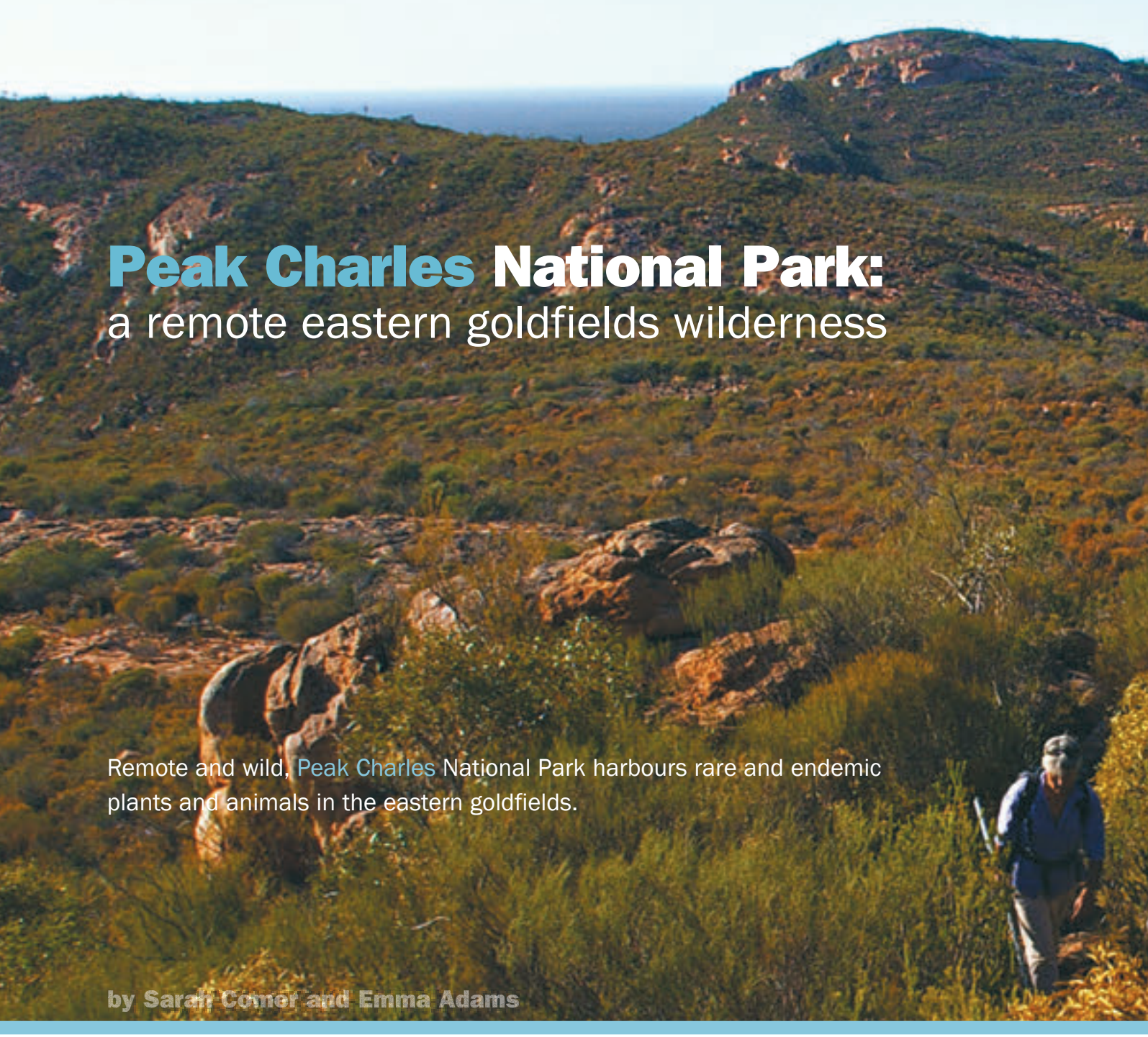




Peak Charles National Park: a remote eastern goldfields wilderness

Remote and wild, Peak Charles National Park harbours rare and endemic plants and animals in the eastern goldfields.

by Sarah Connor and Emma Adams

Rising high above the surrounding sand plain and framed by majestic salmon gums, the granite summits Peak Charles (658 metres) and Peak Eleanora (502 metres) are inspirational landscape features on the southern edge of the Great Western Woodlands and the Yilgarn Craton. Named by Lieutenant John Septimus Roe in 1848 as the Fitzgerald Peaks, these ancient intrusions of Proterozoic bedrock are the centrepieces of the remote Peak Charles National Park—some 40,000 hectares of wild landscape lying south of the Lake King–Norseman Road in the eastern goldfields.

The peaks are framed by a remarkable mosaic of different vegetation types and complexes associated with low-lying broad valleys dominated by diverse woodlands. Surrounding these are salt lakes that are part of the Lake Sharpe–Lake Tay chain—remnants of ancient rivers that would have once flowed into the Eucla Basin.

The park lies within the Great Western Woodlands, which at approximately 16 million hectares is one of the largest remaining areas of intact Mediterranean-climate woodland on Earth, and recognised globally for its biological richness (see 'The Great Western Woodlands: protecting our biological richness, *LANDSCOPE*, Summer 2010-11). The woodlands are now the subject of a management strategy to ensure the long-term conservation of areas unique culture and biology.

Wildlife refuge

Biologically, Peak Charles National Park is of significant interest and in recent years a number of flora surveys of the mountain-top communities have been completed. Between 1979 and 1981, biological surveys of sites in the eastern goldfields sampled fauna at eight biological survey sites in the Peak Charles area, recording four amphibians, 59 bird species, 35 species of reptile and eight native mammals.

The south-west endemic turtle frog (*Myobatrachus gouldii*) is at the end of its range in the national park. Reptiles including the racehorse monitor (*Varanus tristus tristus*) and the carpet phython (*Morelia spilota imbricata*) are

Main DEC staff Anne Cochrane and Emma Adams climbing Peak Charles.
Photo – Sarah Comer/DEC

Inset Top of Peak Charles.
Photo – Jiri Lochman

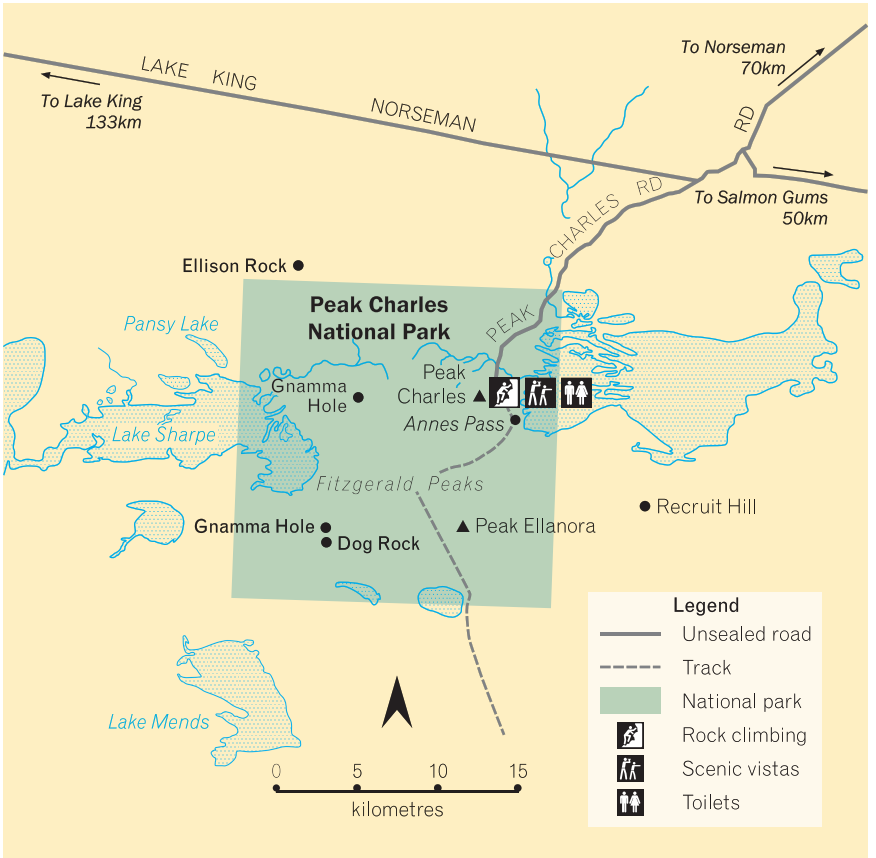
also close to their distributional limits in the park. Mammals recorded during the survey include the white-tailed dunnart (*Sminthopsis granulipes*) and ash-grey mouse (*Pseudomys albocinereus*).

Mountain-top surveys conducted in 1995 by Sarah Barrett of the Department of Environment and Conservation added some significant finds to the eastern goldfields data, with the discovery of the Lake Cronin snake (*Paroplocephalus atriceps*) on the summit of Peak Charles. In addition, the bush rat (*Rattus fuscipes*), which was not recorded in the eastern goldfields surveys, was found on peaks Charles and Eleanora at the inland limit of its range.

The diversity of habitats provides for a rich avian fauna, and a notable eight species of honeyeater are known from the park including yellow-plumed and spiny cheeked honeyeaters (*Lichenostomus ornatus* and *Acanthagenys rufogularis*). The mallefowl (*Leipoa ocellata*), peregrine falcon (*Falco peregrinus*), crested bellbird (*Oreoica gutturalis*) and crested shrike-tit (*Falcunculus frontatus*) are species of conservation concern with secure populations in the park.

Missing mammals

During a 1984 Nullarbor biological survey, Alexander Baynes from the Western Australian Museum examined surface deposits in caves on Peak Charles and found the present-day fauna impoverished when compared to the skeletal remains of fauna from the late 1800s. Missing from the landscape today are the wambenger or brush-tailed phascogale (*Phascogale calura*), dibbler (*Parantechinus apicalis*), western barred bandicoot (*Perameles bougainville*), quenda (*Isoodon obesulus*), brushtail possum (*Trichosurus vulpecula*),



Below left Woylies are among the mammal species that once occured in the park but have now disappeared from the area.
Photo – Jiri Lochman

woylie (*Bettongia penicillata*), black-footed rock-wallaby (*Petrogale lateralis*), and the heath mouse (*Pseudomys shortridgei*).

Interestingly, evidence of chuditch (*Dasyurus geoffroii*) was missing from both the Baynes and eastern goldfields surveys of the park. This threatened species has recently been recorded in both the Lort River catchment, just to the south of Peak Charles, and on the track into the Bremer Range, just north of the park.

Rare plants

The declared rare plant Peak Charles drummondita (*Drummondita longifolia*) is known only from Peak Charles, where it is found on the steep granite slopes. There are also a number of other species endemic to the Peak Charles area including *Hibbertia charlesii* and *Gastrolobium acrocaroli*, both of which are 'priority 2' species, meaning they are in need of further study before they can be given a conservation ranking. The latter two species are named after Peak Charles where they were found—*acrocaroli* is from the Greek words *acro* (peak) and *carolus* (Charles). Peak Charles remains the only place they are known to occur.

Peak Charles experienced an intense wildfire in 1991 which swept through most of the northern section of the park and subsequent fires in 2006 and 2008 have affected Peak Eleanora. Understanding of the impacts of fire on the communities in these areas is limited. In recent years monitoring plots have been established at Peak Charles and Peak Eleanora to begin assessing the potential impacts of fire on the different vegetation communities as well as the fire response of target threatened flora species including the Peak Charles drummondita.

Finding out more

Thirty years on from the eastern goldfields biological surveys, plans are afoot to revisit some of the historical survey sites in Peak Charles National Park. This work aims to document the current status of conservation values in the park, and to increase knowledge of this wilderness area. Researchers even hope to find evidence of chuditch present in the park.

Sarah Comer is the Department of Environment and Conservation's (DEC's) South Coast regional ecologist, based in Albany, and can be contacted on (08) 9842 4500 or by email (sarah.comer@dec.wa.gov.au).

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bookmarks by Karla Forrest

Beyond the Edge

Author/photographer: Glen Cowans
Publisher: Glen Cowans
www.glencowans.com
112 pages, soft and hard cover versions, full colour
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ISBN: 978 098 064 4302 (hard cover)
RRP: $45 soft cover, limited edition hard cover $95

"We know this planet as Earth, but over 70 per cent of its surface is water and within that water exists 90 per cent of all living creatures. Our planet should be called Ocean," claims photographer and author Glen Cowans. In this photographic book, Cowans presents an amazing collection representing the vast beauty and complexity that awaits those who venture underwater. His poignant words about diving, photography and nature accompany stunning images that capture the intricacy and rich colour of the aquatic realm. Cowans' passion for marine life is certainly evident in this personal collection.

Tempered by Fire

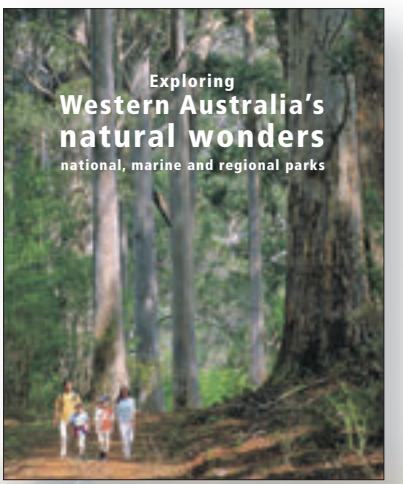
Editor: Roger Underwood
Publisher: The Bushfire Front
www.bushfirefront.com.au
184 pages, soft cover, black and white photographs
ISBN: 978 064 654 4984
RRP: $35

Tempered by Fire is a collection of stories from the people who fought and survived the Dwellingup bushfires in the scorching summer of 1961. It gives readers a unique account of these devastating fires by taking a personal approach—telling the human story. From a mechanic's harrowing trip from Nannup to Harvey in a sorely needed firetruck, to the tale of the local lookout man's narrow escape, the book tells a range of remarkable stories. Fifty years on, *Tempered by Fire* reminds and teaches people about the Dwellingup fires, while at the same time promoting a proactive attitude to forest management and fire suppression.

Exploring Western Australia's natural wonders: national, marine and regional parks

Author: Samille Mitchell
Publisher: Department of Environment and Conservation
www.dec.wa.gov.au/shop
328 pages, soft cover, full colour maps and photographs
ISBN: 978 192 170 3096
RRP: $39.95

This guide to Western Australia's national, marine and regional parks is an enjoyable read. The vivid, descriptive language evokes an appreciation of our natural spaces. The text is complemented by excellent maps and spectacular photography. Featuring 64 parks and reserves from the state's five tourism regions, this comprehensive book is a great source of information for those looking to explore WA's vast wilderness, or simply as a repository of striking images of some of the state's best scenery.



Northern exposure:

marine life of the Kimberley

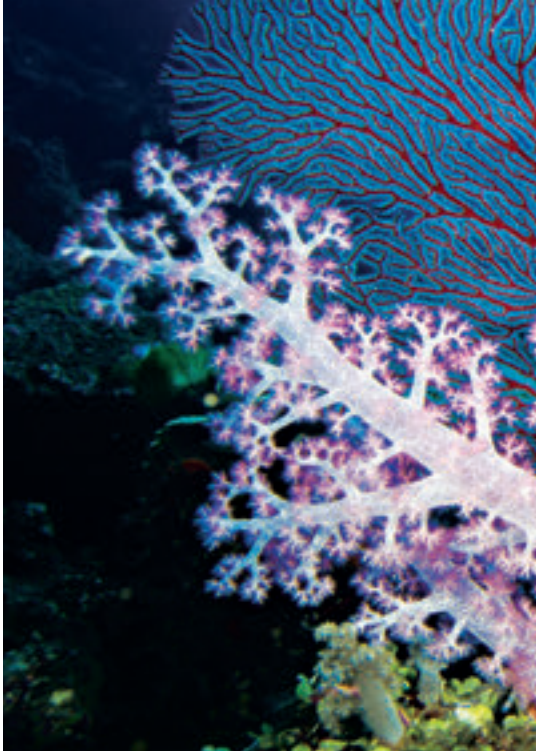
The marine life of Western Australia's remote northern Kimberley was in the public eye recently when footage of the activities of a team of biologists surveying the region was streamed via the web to a worldwide audience. This exposure highlighted some of the Kimberley's unique marine animals, but was only a brief glimpse into an intensive research program currently documenting the region's marine biodiversity.

by John Huisman and Rainbo Dixon

During October 2010, a 14-strong group of specialist biologists, each with a specific area of expertise, participated in a two-week expedition to survey the marine biodiversity of Cassini Island and Long Reef, in Western Australia's remote northern Kimberley. This expedition—organised and led by the Western Australian Museum, with funding support from Woodside Energy—also included participants from the Queensland, Australian and Victorian museums, plus Murdoch University and the Department of Environment and Conservation's Western Australian Herbarium.

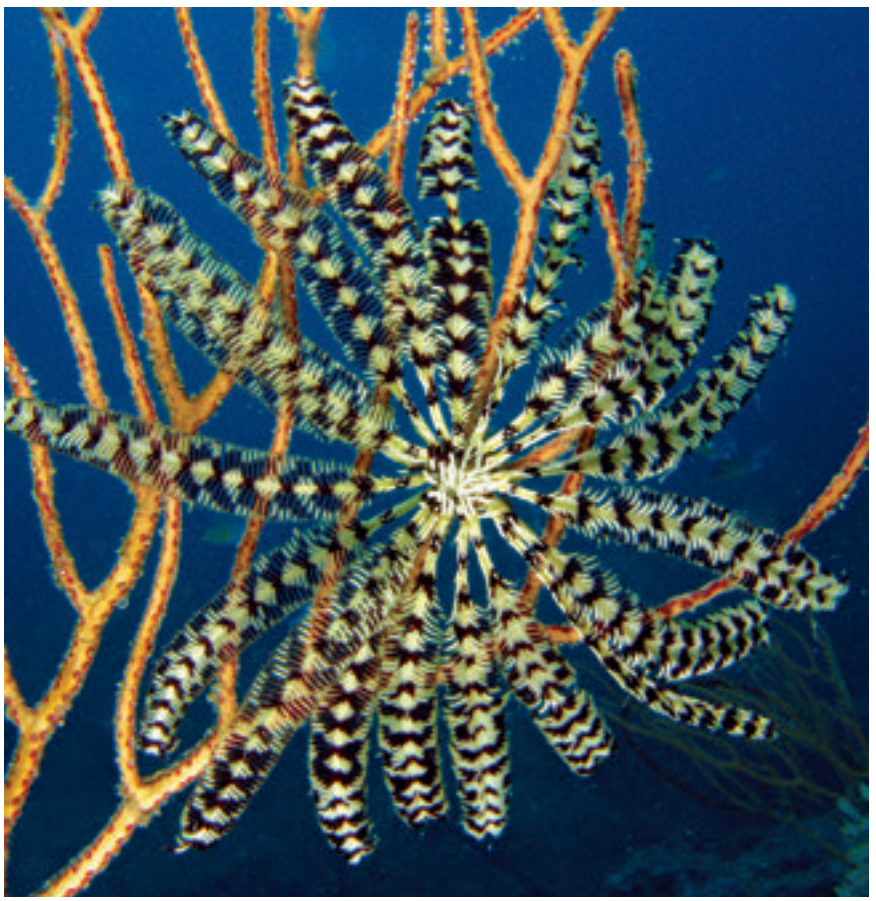
To most people, the names Cassini Island and Long Reef will not be immediately familiar. At about 2,300 kilometres from Perth, these are some of the most remote locations in WA. Cassini Island has an area of about 3.4 square kilometres and is generally flat, with much of its coastline lined by low cliffs. Long Reef—at about 30 kilometres long and 8.7 kilometres at its broadest—is considerably larger, but is only exposed at low tide.

The survey involved both scuba diving and intertidal reef walking. Diving in tropical waters is accompanied by certain preconceptions, only some of which apply to the Kimberley. The crystal clear waters one might associate with, say, the offshore Rowley Shoals (see 'On the edge: exploring the Rowley Shoals', *LANDSCOPE*, Spring 2008) are, for the most part, unknown in the Kimberley. The region experiences massive tides of more than 10 metres range, their movements creating swirling currents that stir up vast amounts of sediment, generating conditions akin to, if not quite pea soup, something like a thick broth. During neap tides (when the tide range is at a minimum), this moveable blizzard settles temporarily, and underwater visibility improves considerably but rarely approaches what might be called 'clear' water. At Cassini Island, the tidal range is less than that of the southern Kimberley, but spring tides still have a variation of around five metres, declining to around one metre during neaps.



World view

In a first for such expeditions, the biologists' activities were filmed and daily missives uploaded via satellite to the WA Museum's website. This provided the public the opportunity to follow the expedition as it was happening. It was hoped this would enable an appreciation of the importance of these surveys in understanding the Kimberley's unique marine animals and plants and, perhaps more crucially, provide an insight into the exploration and discovery process that so enthralls each of the participants. Filming the event was ably handled by Phil Tucak, who also doubled as the expedition's medical officer and stand-by diver.



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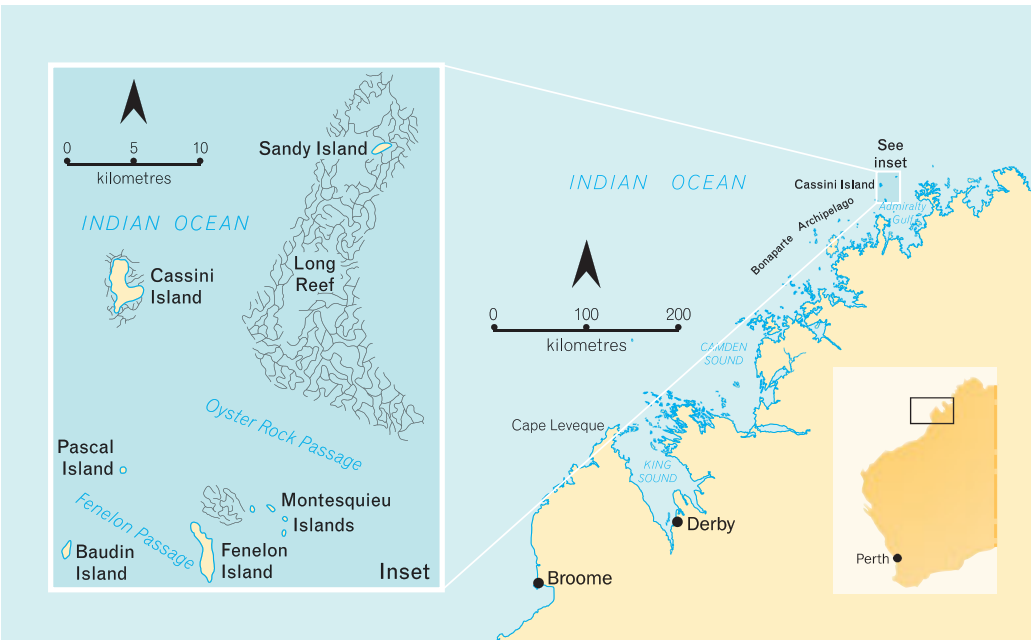
Main Long Reef at low tide.
Photo – Col Roberts/Lochman Transparencies
Insert Common lionfish.
Photo – Alex Steffe/Lochman Transparencies

Left A feather star on gorgonian coral.
Photo – John Huisman/DEC



Above left Carnation coral (left) and gorgonian coral with a feather star attached. *Photo – Clay Bryce/Lochman Transparencies*

Above The sinister-looking Darwin jawfish. *Photo – John Huisman/DEC*

Fishy tales

Surveying the fish species was the job of the WA Museum's Sue Morrison and Glenn Moore. Their encyclopedic knowledge allowed them to undertake visual surveys while diving, which involved identifying and counting the many hundreds of fish that, for the most part, were constantly on the move. This difficult task was tackled with relish by Sue and Glenn—after each dive they compared notes and discussed the few species that tested their identification skills. Some venomous species were encountered, including the common lionfish (*Pterois volitans*). This spectacular species was often spotted languidly lurking in hollows in the reef, not at all wary of divers or predators—well protected by its array of venomous spines. Common lionfish are native to the tropical Indo-Pacific, but in the past 20 years have been introduced to the Atlantic Ocean, along the east coast of the United States of America. No-one is sure how these fish came to be in their new home, but one possible source was a beachside aquarium in Biscayne Bay, Florida, which broke open during Hurricane Andrew in 1992, accidentally releasing six lionfish.

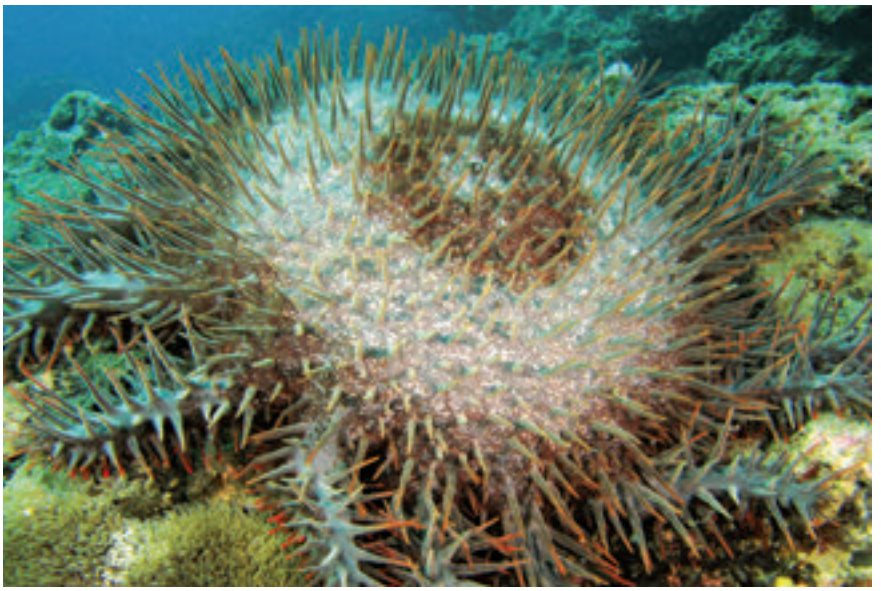
Another native of the tropical Indo-Pacific is the rather fearsome-looking Darwin jawfish (*Opistognathus darwiniensis*), which lives in elaborately constructed holes in the reef. These wary fish retreat rapidly when they feel threatened but, if approached slowly, will gaze curiously at the diver, perhaps weighing up whether a meal is in the offing! Also finding a home in the reef is the banded blenny (*Salarias fasciatus*), which lives on a diet of algae and detritus, a practice acknowledged by its alternative common name, the lawnmower blenny.

Other than the top-order predators, most reef fish are no more than a tasty snack in the eyes of many of their neighbours. Remaining constantly alert is often the only thing keeping them off the menu. The black-axil puller (*Chromis atripectoralis*) lives in small groups, typically hovering above branched corals and feeding on small zooplankton. When threatened, the fish retreat in an instant to the protection of the coral, cautiously emerging only when they feel the danger has passed.

Star watching

Echinoderms—that group of invertebrates that includes the sea stars, sea urchins, brittle stars, sea cucumbers, and feather stars (see 'Echinoderms: spiny-skinned sea animals', *LANDSCOPE*, Spring 2010)—were surveyed by Alison Sampey of the WA Museum. Feather stars (also known as crinoids) were common during the survey of these waters, often attached to gorgonian corals in areas of high

current, with their feather-like arms radiating from a small body. Feather stars feed by passively catching small particles drifting by in the water. They display a myriad of spectacular colours, often in intricate patterns. Sea stars were less commonly found, but those that were encountered were some of the largest invertebrates on the reef. The (perhaps unjustly) notorious crown-of-thorns sea star (*Acanthaster planci*) was often encountered. This species can grow up to 80 centimetres in diameter and is protected by an array of particularly fierce spines. It feeds on live coral and is a regular inhabitant of the reef, its predatory ways just one component of the unfathomably complex food web that coral reefs support. When numbers increase, however—as they do on occasions on parts of the Great Barrier Reef—the corals cannot keep pace with the voracious sea star and significant reductions in coral cover can occur. During the Kimberley survey, crown-of-thorns sea stars were often present, but never in large numbers and no significant coral damage was observed.



Less fearsome looking—in fact almost cuddly, if one could describe a sea star that way—is the pin-cushion star (*Culcita schmideliana*). These sea stars have patches of different colours on their surface, the shades and arrangement varying between individuals and, unlike most other sea stars, do not have extended arms.

Frequent on most reefs was the long-spined sea urchin (*Diadema setosum*), which often occurred in dense aggregations. This species is a grazer, feeding on small algae, and is commonly found throughout reefs in the Indo-Pacific.

The worm turns

Marine worms, much like their terrestrial counterparts, don't live out in the open. They tend to hide in hollows in the reef, or among the coral rubble that accumulates in depressions or at the base of the reef wall. Most species are less than a few centimetres long, so a great surprise was seeing the massive bobbit worm (*Eunice aphroditois*) which lives in holes in the reef and was observed foraging during low tide. These polychaete worms can grow to more than three metres in length (some up to six metres have been reported), with a diameter of several centimetres, and have an iridescent sheen. They are particularly fearsome ambush predators, with an array of sharp teeth and are lightning fast, often slicing their victims in two. Bobbit worms often appear as unwelcome guests in marine aquaria, unwittingly transported there when the rock housing their lairs is used for decoration. Within a short time they will decimate the tank's inhabitants, mostly at night, catching their victims unaware. Removing bobbit worms is virtually impossible, and invariably requires removing the rock in which they are living.

Of course not all worms are as fearsome, and one of the more common sights during the survey was

Top A massive crown-of-thorns sea star feeding on coral.
Photo – John Huisman/DEC

Above left The delicate Christmas tree worm lives in tubes in hard corals.
Photo – Clay Bryce/Lochman Transparencies

Left A bobbit worm foraging on the reef flat at low tide.
Photo – John Huisman/DEC

Above The giant mushroom coral (*Sarcophyton* sp.).

Above right A pin-cushion sea star with its distinctive array of colourful patches.

Right The nudibranch *Phyllidia varicosa* accumulates toxic chemicals that protect it from predators.
Photos – John Huisman/DEC

the colourful Christmas tree worm (*Spirobranchus giganteus*). These worms live in clusters on coral heads, into which they burrow before secreting their own protective tube. Most of the worm is hidden from view in its tube, the multicoloured spiral structure that is visible is the worm's highly modified mouth, which it also uses for respiration. When disturbed, the worms quickly retract into their tubes, closing the door behind them by plugging the opening with a modified spiral known as an operculum. The task of surveying the marine worms was the responsibility of Lexie Walker (Australian Museum) and Skip Woolley (Victoria Museum), with Skip rather bravely catching a specimen of the bobbit worm at Long Reef.

Corals, soft 'n' hard

Tropical reefs are, of course, dominated by corals. Zoe Richards of the Australian Museum surveyed the hard corals (those that build firm skeletons and form the primary reef structure), while Monica Schlacher-Hoenlinger of the Queensland Museum tackled the soft corals. Considering the relatively turbid water, Zoe was taken aback by the sheer diversity of corals she encountered. Of particular interest was the high cover of the organ pipe coral (*Tubipora* sp.) in the shallow fore-reef zone at Long Reef. *Tubipora* is actually a soft coral, but it forms a firm skeleton of fused spicules, the only soft coral known to do so. The skeleton of organ pipe coral is a distinctive bright red, and it is often collected for the jewellery and aquarium trade due to its attractive colour. Zoe and Monica discovered that this normally rare coral was the dominant organism, covering nearly 28 per cent of the fore-reef zone at Long Reef, more than twice the cover reported anywhere else. In the subtidal areas, soft corals such as the spectacular carnation coral (*Dendronephthya* sp.) were common, and gorgonian corals were often dominant in areas of high current.

Slugs and snails

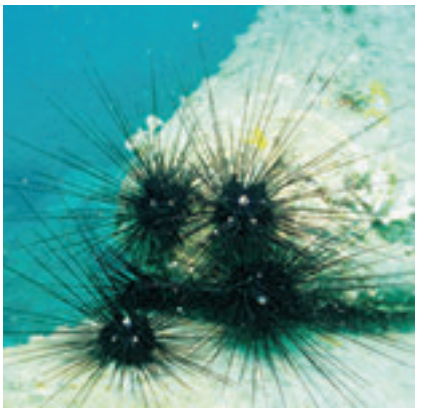
Expedition leader Clay Bryce, along with the WA Museum's Corey Whisson, were responsible for surveying the molluscs. These included the well-known gastropod snails, such as the tiger cowrie (*Cypraea tigris*), much valued by shell collectors, bivalves such as the Cock's comb oyster (*Lopha cristagalli*), and the sea slugs, the amazingly colourful and attractive nudibranchs which are related to the shelled snails but shed their shell after their larval stage. The name nudibranch means 'naked gill' and refers to the distinctive external branched gills that are often found on the animal's upper surface. In some nudibranchs, such as the exquisitely patterned *Phyllidia varicosa*, the gills are less obvious and are located on the sides of the animal.

Crabs

Surveying the crabs and other crustaceans was the responsibility of the WA Museum's Andrew Hosie and Lee Betterridge. Some large species, such as the mantis shrimp (*Stomatopoda*) and painted rock lobster (*Panulirus versicolor*), were common on reef flats and in shallow water. Like many other reef invertebrates, however, most crustacean species are small and inconspicuous, hiding away among the coral, in discarded shells, or burying themselves in coral rubble. Given this behaviour, even seeing the animals can be difficult—let alone collecting them, especially in areas with turbid water—which meant Andrew and Lee had one of the more difficult tasks. In many cases, the only option was to collect a piece of coral rubble and entice out the various crustaceans once back on board the boat.

Seaweeds

Although often thought of as unimportant, seaweeds are in fact a vital part of coral reef ecology. Crustose coralline algae form a thin, tough layer on the reef surface, appearing like a layer of pink paint and strengthening the structure, often reducing potential damage from rough seas. Seaweeds also form the diet of herbivorous fish and numerous invertebrates, therefore acting as one of the primary energy sources in the complex reef food web. Some damselfish actually tend a small garden of algae, by weeding out unpalatable species and killing off any coral that might be infringing on their patch. These damselfish are incredibly protective of their garden, and will aggressively ward off any intruders, including divers. Surveying the seaweeds, and avoiding damselfish, was the responsibility of the WA Herbarium's phycologist John Huisman.



Top The green seaweed *Caulerpa*.

Above left The distinctive cock's comb oyster was often found with an orange sponge coating.
Photos – John Huisman/DEC

Above Long-spined sea urchins typically occurred in dense aggregations.
Photo – Clay Bryce/Lochman Transparencies

Below left Collecting specimens on Long Reef at low tide.
Photo – John Huisman/DEC

Where to from here?

This expedition was the second in the current program, following a similar trip to Adele Island and Montgomery Reef in 2009. Three trips to other inshore Kimberley locations will occur in the coming years. In addition, the overarching project, the Marine Life of Kimberley Region, will assemble and analyse all known inshore Kimberley and offshore atoll marine collection data. This cache of information will be an important asset, enabling informed decision making regarding sustainable development, business and conservation policies, and assessment of national and world heritage values. In addition, the project will provide a wealth of educational resources, increasing awareness of the Kimberley's unique and exceptionally diverse marine life.

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Rainbo Dixon is a PhD student at Murdoch University, examining the taxonomy of the brown seaweed genus *Sargassum*. Rainbo took part in the 2009 expedition to Adele Island and Montgomery Reef. She can be contacted by email (rains.rmd@gmail.com).

The authors thank the WA Museum (particularly Clay Bryce) and Woodside Energy for the invitation to take part in the expedition.

For more information about the Marine Life of Kimberley Region project and to view videos from the expedition visit www.museum.wa.gov.au/kimberley/marine-life-kimberley-region.

Last chance to see: banksias of the south coast of Western Australia

Ravaged by diseases such as aerial canker and *Phytophthora* dieback, altered fire regimes and a changing climate, these unique plants are rapidly declining along the south coast of our state.

by Anne Cochrane, Sarah Barrett, Colin Crane, Chris Dunne, Renée Hartley and Greg Freebury

Members of the genus *Banksia* are some of Western Australia's most distinctive plant species, perhaps because they are also some of our most readily identifiable native flora. The flowers and leaves have been used extensively in flower arrangements and specimens are planted in many home gardens for their floral display and their attraction to native birds. With recent taxonomic changes, there are now more than 170 species in the genus, which includes the previously recognised genus *Dryandra*.

Banksias are typically 'keystone species'—that is, they are functionally important components of native plant communities in the south-west, including heathlands, shrublands and forests, and they play a major role in supporting native fauna. In the wild, they are pollinated by birds—honeyeaters such as the New Holland honeyeater (*Phylidonyris novaehollandiae*) and red wattle bird (*Anthochaera carunculata*)—and mammals, such as the honey possum (*Tarsipes rostratus*), bush rat (*Rattus fuscipes*) and dibbler

(*Parantechinus apicalis*). In addition, they provide food in the form of nectar and seed, as well as habitat for a large range of species.

Adult plants store their seeds in the leafy canopy, generally releasing these seeds from woody fruiting cones after fire. This canopy storage or 'serotiny' maximises the number of seeds available for post-fire regeneration. This plant strategy is considered to be favoured in fire-prone regions such as the south-west of WA that have reliable seasonal rainfall. Some species may live for up to 100 years, sometimes taking 10 to 15 years to flower and fruit sufficiently for population persistence in the face of further fires. The wind-dispersed seeds may travel up to 40 metres from parent plants after fire, with long-distance dispersal events of several kilometres occurring rarely. In the south-west, more than 60 per cent of banksia species are known as obligate seeders. These seeders are killed by fire and reproduce only from seed. The remaining species are able to resprout from rootstock after fire or have fire-tolerant trunks.

A warming, drying climate

In WA, most banksias are confined to the south-western corner, being naturally restricted to areas with greater than 250 millimetres of rainfall. Unfortunately, as the climate changes, so too will the reliability of rainfall. Total annual precipitation has declined in the south-west over the past 50 years, with the most significant decreases seen in the Augusta to Albany region and along parts of the south coast. In addition, temperatures across WA have increased by approximately 0.8 degrees Celsius since 1910, with most of the increase occurring since 1950.

Under future predicted climate scenarios, the south-west is projected to become even warmer and drier and this will affect the frequency of fires and droughts. This means that although the fossil records tell us that the 'original' banksias have been around for the past 40 to 50 million years virtually unchanged in appearance, having managed to survive past climate shifts, their future survival may be compromised. Climate modellers have already predicted dire consequences for the fate of WA banksias, with many species expected to decline dramatically or become extinct by 2080, due mainly to changing climate.

For much of the south-west flora, germination of seeds is cued

Previous page
Main Showy banksia (*Banksia speciosa*) with Cape Arid in the background.
Photo – Jiri Lochman

Left Candle banksia (*Banksia attenuata*) at Stirling Range.
Photo – Marie Lochman

Above Downloading temperature and humidity data at an aerial canker monitoring transect.
Photo – Anne Cochrane/DEC

to the cooler wetter months around winter. If temperatures rise and rainfall decreases, regeneration of these species after disturbance could be threatened. Currently, the Department of Environment and Conservation is supporting a project assessing how well banksia species will adapt to reduced moisture and increased temperatures during germination and early seedling growth. The potential for adaptive responses is being assessed for a number of significant banksia species with distributions along the south coast of WA. From previous seed germination research, it is already known that some banksias have quite restricted temperatures for germination; it remains to be seen whether they will cope with the new warmer and drier climates forecast for the future and avoid widespread germination failure as the climate changes.

Going, going, gone ...

In addition to the potential impact of a changing climate, over the past few decades banksias have been exploited for the local and overseas cut flower industry. Fortunately, the pressure of wildflower picking has eased in recent years with more stringent regulations and wildflower plantings. Not so the pressure of disease. These beautiful plants are highly susceptible to aerial cankers and introduced *Phytophthora* dieback (*Phytophthora cinnamomi*), with the incidence of these pathogens increasing steadily. From year to year, the evidence of decline and death is highly apparent in the landscape.

Most of the aerial cankers are caused by fungi and are recognisable on plants as the death of twigs and branches, browning unhealthy leaves and limbs with discolouration just beneath the bark. In banksias, cankers may only kill one branch on a host plant, but in some cases they can cause almost complete crown death of the infected plant or the collapse of the entire community. Worldwide, the incidence of canker diseases caused or associated with fungi has been steadily increasing and climate change is seen as the driving force behind these once-minor diseases. The contribution of canker-causing fungi to stem and branch death in southern WA is not yet well documented or understood. Currently, two declared rare flora—the granite banksia (*Banksia verticillata*) and the round leaved honeysuckle (*Lambertia orbifolia* subsp. *orbifolia*)—are being severely impacted by canker disease and concerns have been raised that this may be caused by emerging pathogens in a changing climate.

Studies of banksia decline have now identified a number of associated fungal species, including *Neofusicoccum, Cryptodiaporthe* and *Microthia*. Monitoring of transects established in 2010 to track the health and survival of three keystone banksia species of the south coast—Baxter's and scarlet banksia (*Banksia baxteri* and *B. coccinea)* and granite banksia—has identified an increase in canker incidence and a further increase is forecast due to the future climate change scenarios projected for the region. Increasing canker impact on Baxter's banksia has been closely linked to increases in maximum and average temperatures and daily humidity. For scarlet banksia the influence of minimum temperatures and evaporation is apparent.

This research will determine the range of fungal pathogens affecting each species and clarify the relative impact of each. Data loggers located at

these sites will provide further clues as to environmental triggers that initiate major canker epidemics, such as the one near Cheyne Beach east of Albany in 1989 when large numbers of scarlet banksias were dying downward from their apex-forming branches, with rapid complete death typical for many diseased stands. A number of transects established in this project revisited sites from the 1990s and, in at least two sites, scarlet banksia populations were no longer present. The rare granite banksia has also undergone population extinctions due to aerial canker, in addition to death from *Phytophthora* dieback. Fortunately, several fungicides have shown some ability to reduce canker lesion development and will be useful for treatment of high-value wild or translocated populations of declared rare flora.

In addition to canker studies, the past few decades have seen a number of research projects investigating the impact, biology and spread of *Phytophthora cinnamomi* in native plant communities across our state's south-west. The *Phytophthora* pathogen is a 'water mould' that favours warm, moist conditions, yet can survive dry periods within the plant tissue. Attracted to plant roots, *Phytophthora* is carried through soil water and attaches to the plant, eventually stopping the plant's uptake of water and nutrients, causing death. More than 40 per cent of native flora species are susceptible to the disease, including more than 50 per cent of our declared rare flora. Activities such as bushwalking, four-

Top left Soil fumigation at a *Phytophthora cinnamomi* site.
Photo – Colin Crane/DEC

Centre left Crown death due to aerial canker on the rare granite banksia at Woolbales, near Walpole.
Photo – Anne Cochrane/DEC

Left Installing electric fencing in Fitzgerald River National Park to deter fauna movement across a dieback site. Fauna are considered to be a significant agent of spread for *Phytophthora cinnamomi.*
Photo – Renée Hartley/DEC

Right Newly developing *Microthia* canker in Baxter's banksia in Fitzgerald River National Park.
Photo – Colin Crane/DEC

Below right Sampling aerial canker fungi causing decline and death of scarlet banksia in Gull Rock National Park.
Photo – Sarah Barrett/DEC

wheel driving, timber harvesting and track or road establishment pose a high risk of spreading the disease. This risk can be significantly reduced, however, with appropriate planning, using only clean machinery and equipment, and restrictions associated with soil and weather conditions.

Recent studies have demonstrated the loss of ecosystem services that occurs after healthy native vegetation is invaded by this destructive plant pathogen. In particular, the loss of keystone species such as banksias often leads to a significant change in vegetation structure and, as a consequence, the ecosystem functions less well. For example, all banksia species in Stirling Range National Park were found to be susceptible, with infestation destroying all but seven per cent of canopy cover. As banksias are integral elements of many native plant communities, their death has flow-on effects to other flora, dependent fauna and ecosystem processes. The impact of *Phytophthora* dieback is often compounded by too-frequent fires and other plant diseases such as aerial canker. Climate projections for the south-west include an increase in the likelihood of extreme summer rain events which are expected to worsen the impacts of *Phytophthora* dieback and aerial canker on banksia species.

The use of the chemical phosphite in areas of high conservation value is enabling banksia and other communities to survive for longer when threatened by disease. An innovative project is currently improving our ability to contain or eradicate *Phytophthora* dieback infestations in natural ecosystems and, incredibly, the past 12 months has seen the first eradication of a *Phytophthora cinnamomi* infestation in Cape Arid National Park on the south coast, east of Esperance. The technique involves a combination of controls that combat the pathogen's key strategies for spread and survival, such as managing water movement, treating vegetation with herbicide to remove hosts and fumigation of the soil. However, eradication is a last resort for management, and prevention of introduction and spread is essential to the health of our native communities.

Lastly, ongoing sampling of declining banksia species in coastal areas has confirmed the influence of armillaria root rot, caused by the basidiomycete fungus *Armillaria luteobubalina*, in plant death and population demise. Although an indigenous mushroom-producing plant pathogen, this fungus is believed to have caused significant deaths of banksias including oak-leaved, holly-leaved, slender and swamp banksia (*Banksia quercifolia, B. ilicifolia, B. attenuata* and *B. littoralis*). This adds to the already significant disease impact of *Phytophthora* species and aerial canker-causing fungi on the genus in the south coast.

Banksias and fires

Many features of the biology of banksias—for instance their long juvenile period—also make them particularly susceptible to frequent fire. Under future warmer drier climates, fire regimes are likely to change, resulting in an increase in fire danger. Fire management plans now seek to incorporate ecological guidelines for keystone banksia species

Top right Oak-leaved banksia.
Photo – Andrew Davoll/Lochman Transparencies

Top Aerial canker has caused severe decline and death of the threatened granite banksia in Torndirrup National Park.
Photo – Sarah Barrett/DEC

Above Scarlet banksia.
Photo – Jiri Lochman

based on known fire responses and time to first flowering and fruiting. This aims to ensure that there is sufficient time for canopy seed banks to re-establish between fires. At the other end of the spectrum, banksias in fragmented remnants that are long unburnt (more than 50 years) may also decline if they are unable to regenerate in the absence of fire. Careful fire management is needed where diseases such as *Phytophthora* dieback and aerial cankers are present because in these stressed environments regeneration can be poor or the impact of dieback can be accelerated. Grazing by native or introduced herbivores can further reduce survival of new seedlings.

A future for our banksias

Almost 100 banksia species are considered to be threatened in the wild and have a listed threatened status of some kind. Loss of habitat through land clearing has had the greatest impact on their conservation status over the past 50 years. Roughly a quarter of these species are found on the south coast of WA, where diseases and a changing climate are taking their toll, and these threats may pose the greatest impact on their future survival.

Some of our most well-known and highly visited recreational areas, such as Stirling Range National Park and Cape Le Grand National Park, have a high incidence of disease. When visitors move from these areas to enjoy the surrounding landscapes such as Fitzgerald River National Park—which currently has very little disease—there is a real chance they could be taking the pathogen with them.

People can help protect banksias and their dependent species by ensuring that all vehicles and footwear are clean from soil and plant materials when passing through bushland. Beyond the potential introduction and spread of disease, recreational impacts—such as soil compaction and trampling—exert multiple stresses on vegetation communities. Other impacts of recreational pressure include nutrient enrichment, increased fire risk, erosion and the introduction of weeds. Without systematic monitoring of their presence and health, some banksias may disappear before our eyes without our even being aware, until it is too late. We can each play a part in ensuring the survival of banksias for future generations; our bushland will be poorer for their absence.

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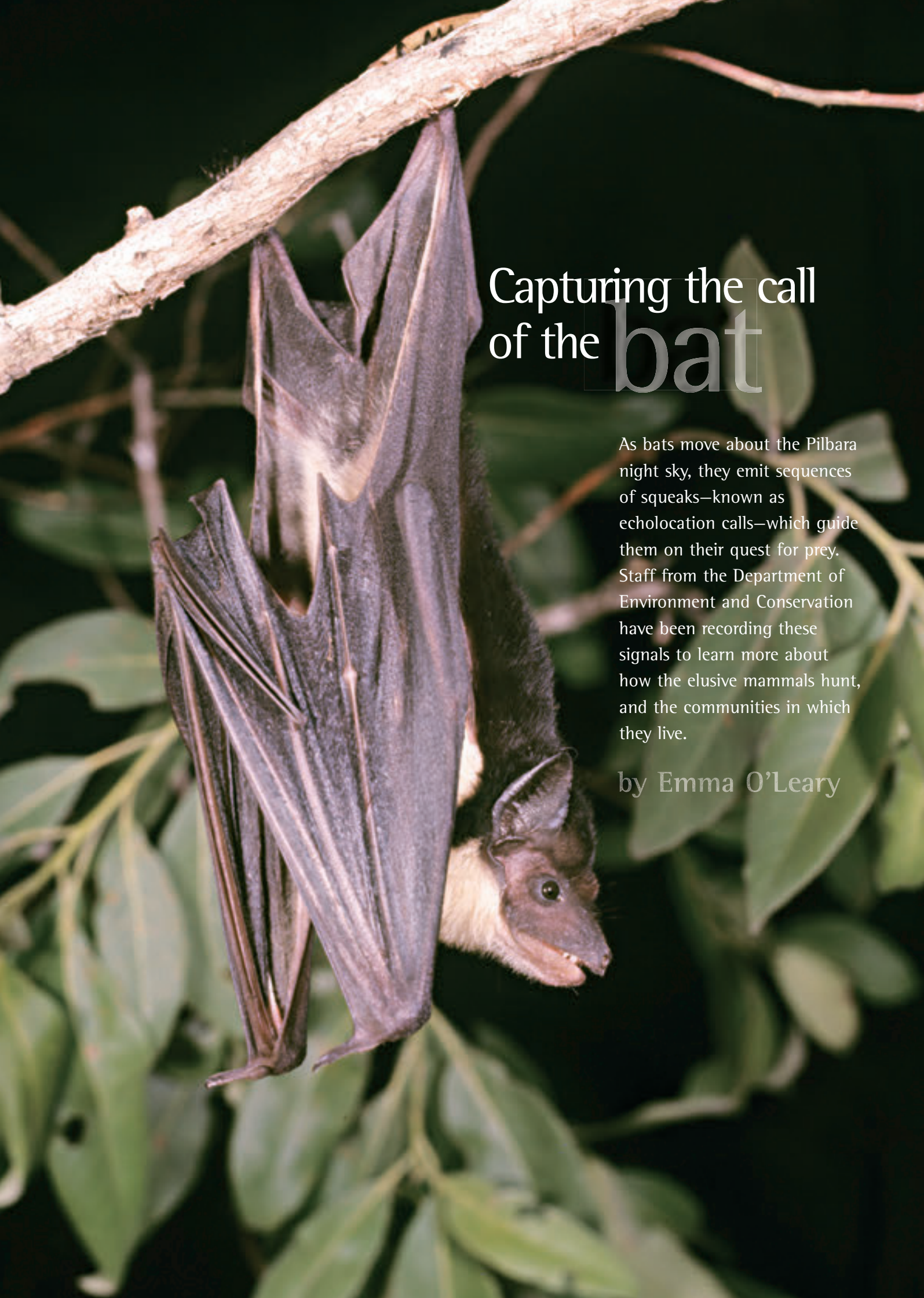


Capturing the call of the bat

As bats move about the Pilbara night sky, they emit sequences of squeaks—known as echolocation calls—which guide them on their quest for prey. Staff from the Department of Environment and Conservation have been recording these signals to learn more about how the elusive mammals hunt, and the communities in which they live.

by Emma O'Leary

On a starry Pilbara night, small digital audio recorders are scattered along creeks and across sand plains, mulga flats, mangroves and low, open woodlands. The recorders are there to trace microbats flying the night sky searching for prey. Microbats are extremely efficient hunters and this is lucky, as the average microbat needs to catch one insect per minute for two or more hours each night to meet its metabolic energy needs. The term 'microbat' is an abbreviation for bats that belong to the suborder Microchiroptera, as opposed to the fruit and nectar-eating bats that belong to Megachiroptera and, unlike the microbats, do not echolocate.

As these small flying mammals emerge from their roosts in the early evening or at night, they generate rapid sequences of high-frequency calls that bounce off objects, and the returning echoes provide details of their surroundings. This echolocation—the same form of communication used by dolphins and toothed whales—is employed by the microbats to navigate and forage.

Department of Environment and Conservation (DEC) scientist Norm McKenzie has been studying the echolocation calls of microbats across Western Australia for 18 years. Working together with aeronautical engineer Bob Bullen, he has developed a dictionary of call sequences to help identify the bats in a non-intrusive, fast and more efficient way than traditional methods. Recordings exist of every known bat species in the state, and these are gradually being consolidated into a reference dictionary. The latest digital additions to this extensive library of sounds have come from the Pilbara.

Creating a dictionary

Bats have always been among the most elusive animals to capture in biological surveys. Comprehensive lists of bats and the areas they inhabit are very useful in determining how species live and interact to form communities, but this information takes time to compile. As the dictionary of bat calls progresses, future studies on bat species across WA will be much easier to carry out, because scientists can cross-reference sounds and easily identify species without having to physically trap and handle the bats.

To build the dictionary, bats are captured and dabbed with a non-toxic paint that glows in the dark for a few minutes. The bats are then released and their call sequences recorded using a digital recorder fitted with a high-frequency microphone. Using this method, echolocation calls by free-flying bats of known identity can be documented at sites around the state.

Scientists can learn much about a bat just from its call. The echolocation signal reveals the particular habitat the bat is adapted to hunt in—whether that is on the ground, among the branches of trees and shrubs (where aerial pursuit is the favoured hunting technique) or in the open air above woodland and forest canopies (where aerial interception works best). Increasing the knowledge of just how each bat finds its dinner can

Previous page
Main Yellow-bellied sheathtail bat.
Photo – Hans and Judy Beste/Lochman Transparencies

Left On bright moonlit nights, bats are able to use their vision as well as echolocation.
Photo – Jiri Lochman

Above Pygmy long-eared bats hunt along watercourses in the Kimberley and 'top end'.
Photo – Norm McKenzie/DEC

Right Finlayson's cave bat.
Photo – Jiri Lochman

help scientists understand each species' vulnerability against the background of changes happening in many parts of WA, where vegetation structures are being simplified and soil surfaces damaged by overuse of landscapes and high intensity bushfires. The bat sound dictionary provides scientists with clues about the vulnerabilities of different species, revealing their particular habitat requirements and role in ecological communities.

The evolution of bats

Specialisation by bats includes not only the structure and type of echolocation they use, but also extends to the way their airframes are designed and built. Data on body types of different species of bat is also being documented and incorporated into the dictionary. This includes the shape of their wings, the size of their tails—which they use as a rudder—and the size and shape of their ears. A bat's ears aren't just appendages to hear with—they also pre-process the airflow to optimise aerodynamic performance across the rest of the bat's body for a particular style and capability in flight.

Despite their small size, bats are still subject to the same rules that apply to everything that flies. Bats, and even insects, are considered relevant to contemporary aeronautical science, particularly as people try to increase their understanding of flight at different scales. Some microbats, such as the chocolate bat (*Chalinolobus morio*), are able to perform very agile, acrobatic turns that expose them to high wing loads and lateral forces. These turns can create high forces—equivalent to eight or nine times the force of gravity—on circulating blood and the bones that support their structure.

Human pilots can only withstand such forces by wearing special suits which control circulation and stop blood from running into their feet. Chocolate bats can out-turn their insect prey at flight speeds of six metres per second among the clutter of tree branches and foliage, but for this type of activity they must have finely tuned, high-frequency sonar calls. In contrast, the broadly tuned calls of relatively low frequency used by the northern mastiff bat (*Chaerephon jobensis*) are best suited to detect, identify and intercept prey from a distance. This species has wings optimised for fast, straight-line, open-air flight.

Microbats in the Pilbara

The Pilbara bioregion, which covers some 179,000 square kilometres, is known for its rich tapestry of landscapes. It is made up of seasonal river systems, tall riparian forests, low woodlands, grass plains, mangrove forests and a diversity of caves among a complex array of ranges and plateaux.

Top Lesser long-eared bat in flight.
Photo – Noel Speechley

Centre left A Pilbara bat sampling site in a gully on Mount Florence Station.
Photo – Norm McKenzie/DEC

Left Carawine Gorge in the Pilbara.
Photo – Marie Lochman

Above Gould's wattled bat, a very agile species that occurs throughout Western Australia.
Photo – Jiri Lochman

Right Eastern long-eared bat.
Photo – Hans and Judy Beste/Lochman Transparencies

Across these vast landscapes is an extensive range of ecosystems that maintain populations of flora and fauna not known to exist anywhere else on the planet.

The Pilbara bioregion also hosts 17 species of bat that use echolocation to forage and navigate. A bat will emit high-frequency sounds that bounce off objects in front of it, ensuring it doesn't fly into a rock or a tree. Or, if it gets lucky, the bat will register a little 'blip' that it identifies as food—a moth or a beetle perhaps, flying through the night sky, or an ant crawling over leaf litter.

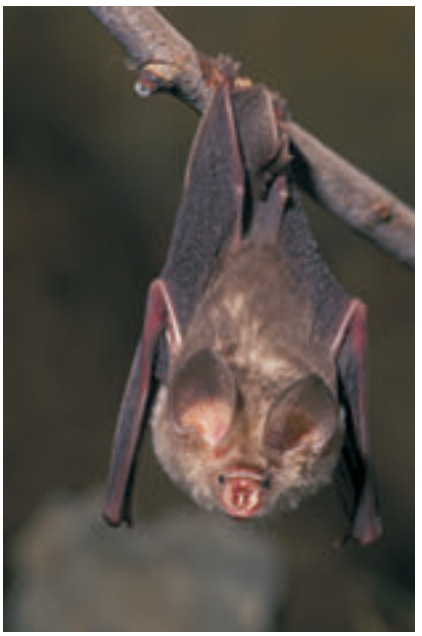
Not all 17 Pilbara bat species catch their food in the same way. There is a well-structured community of bats in the region, and different species hunt in different ways. Because they explore in different places—around bushes, along the ground or in the open sky—they use different echolocation frequencies. Their call is specific to the situation they hunt in and, through the evolution of bat communities, different family groups have become specialised to carry out different sorts of hunting.

Small night-time animals such as insects live in a whole array of places in the bush—on the ground, on the bark or leaves of trees, flying around flowers, or out in the open air—and there is a bat in each community designed to hunt for that sort of animal in those particular places. The bat's echolocation signal gives it an auditory image—an image of what's out in front of it, including its prey—in its brain. It overlays any visual image it can glean in the dark, which may not be much at all in some situations. Humans are not capable of deriving this type of auditory image from their ears, but bats can.

Bat data shows diversity

A DEC survey was carried out to gather data on bat echolocation, flight behaviour and foraging ecology in the Pilbara. The comprehensive survey encompassed 69 sites dispersed among 24 survey areas covering the entire region. While many bats were trapped for observation, the main focus was recording echolocation. These recordings were processed using software which matched bat echolocation sounds to the existing call dictionary, and identified the species that had flown past.

The Pilbara is the most recent region to be surveyed in what has become a statewide bat project. Bat recording data exists in varying formats for every known species of microbat in WA, though not all of it has been consolidated into the dictionary. Additionally, further recordings in a consistent, standard format are required for more accurate comparisons between some species, and to clarify region-to-region variation in calls by the same bat species.



Above Common sheathtail bat.

Far left Ghost bat.

Left The dusky leaf-nosed bat is a Kimberley species.
Photos – Jiri Lochman

The echolocation survey not only recorded all 17 Pilbara microbat species, it also revealed two distinct communities. One comprised 14 species that occupied landward environments, while the other community had nine species and lived in mangroves. (A few species were present in both communities.) The highest diversity of bats was recorded in productive riparian areas with complex vegetation structures and permanent pools set in cavernous landscapes.

The bat species forming each community showed clear differences from each other in terms of foraging behaviour and flight capabilities. Some bats hunted in the open air, clear of obstructions, while others hunted in cluttered air spaces close to surfaces. Many species hunted in various intermediate levels of clutter. There was significant variation in the way different species maneuvered. Some species were able to turn at low speeds, or even hover, while others specialised in tight, agile turns at moderate speeds and some demonstrated only limited agility but were able to fly at high speed. In one instance, six long-eared bats captured, tagged with non-toxic glowing paint and released were observed foraging among the upper branches and canopies of river gum woodland, up to 20 metres above the ground. They would perch for several minutes at a time, then spiral slowly through the canopy before flying to the next canopy—behaviour consistent with ambushing and gleaning. Species observed to intercept their prey in open airspace well clear of vegetation used straight, high-speed flight and had relatively low agility, while bats that foraged close to surfaces in cluttered environments showed either moderate to low agility in conjunction with low flight speeds or high agility in conjunction with moderate flight speeds.

Conservation

The Pilbara bat project was part of a wider biological survey carried out by DEC. The main objective of this wider survey was to determine the sorts of plants and animals that live in the region's different environments. The information is being used to monitor the condition of WA's wildlife, to assist

Above Nightfall in the Pilbara. Most bats emerge later, when it is completely dark. *Photo – Marie Lochman*

Right Northern long-eared bat. *Photo – Stanley Breeden/Lochman Transparencies*

in selecting future conservation reserves and to assess the comprehensiveness, adequacy and representativeness of the state's conservation reserve system. Information from the survey will also inform management decisions for the region to ensure the protection of environments that support a wide range of animals and plants.

Results from the survey revealed significant information on the distribution and conservation status of the Pilbara's bat species. In some instances, species that were thought to be extremely rare were found to be more widespread. Others were confirmed to exist in only one location or in one type of habitat, or to visit the region seasonally.

The survey identified several factors relevant to planning for conservation. It showed that loss of complexity in riparian vegetation, reduced permanence of pools, loss of mangrove stands and loss of suitable cave roosts were likely to reduce or even destroy bat populations in the Pilbara. Several areas were flagged for conservation, including Weeli Wolli Spring, which supported the richest assemblage of bats located during the survey.

The survey confirmed that Pilbara microbats have not yet suffered the extinctions experienced among other fauna in the region, but concluded that a comprehensive reserve system would be required to preserve these intact and fascinating microbat communities. The bat echolocation dictionary will be useful as a quick, inexpensive and non-invasive way to identify bats during environmental surveys of potential mine sites and for monitoring.

What's next?

Like the Pilbara, the highly rich and diverse Kimberley is home to many species of bat that hunt using echolocation. Twenty-two species of microbat are known to live here and DEC is now compiling an echolocating dictionary for this region, as part of a field survey of islands along the north Kimberley coastline that includes bat surveys. Once again, the surveys aim to increase understanding of how bat species congregate and hunt, and the studies in the Kimberley are revealing a complex model. There is a lot more that can be learnt about bats from studying these 22 Kimberley bat species.

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This article is based on interviews with and a paper by DEC senior principal scientist Norm McKenzie. He can be contacted on (08) 9405 5144 or by email (norm.mckenzie@dec.wa.gov.au).

Geikie Gorge National Park

Visitors to Geikie Gorge National Park in the west Kimberley can take a boat trip through the gorge or set out on one of several walk trails.

Above Geikie Gorge.
Photo – Jiri Lochman

Top right White-bellied sea-eagle.
Photo – Dave Watts/Lochman Transparencies

Above right Freshwater crocodile.
Photo – Damon Annison

Right Little pied cormorant.
Photo – Jiri Lochman

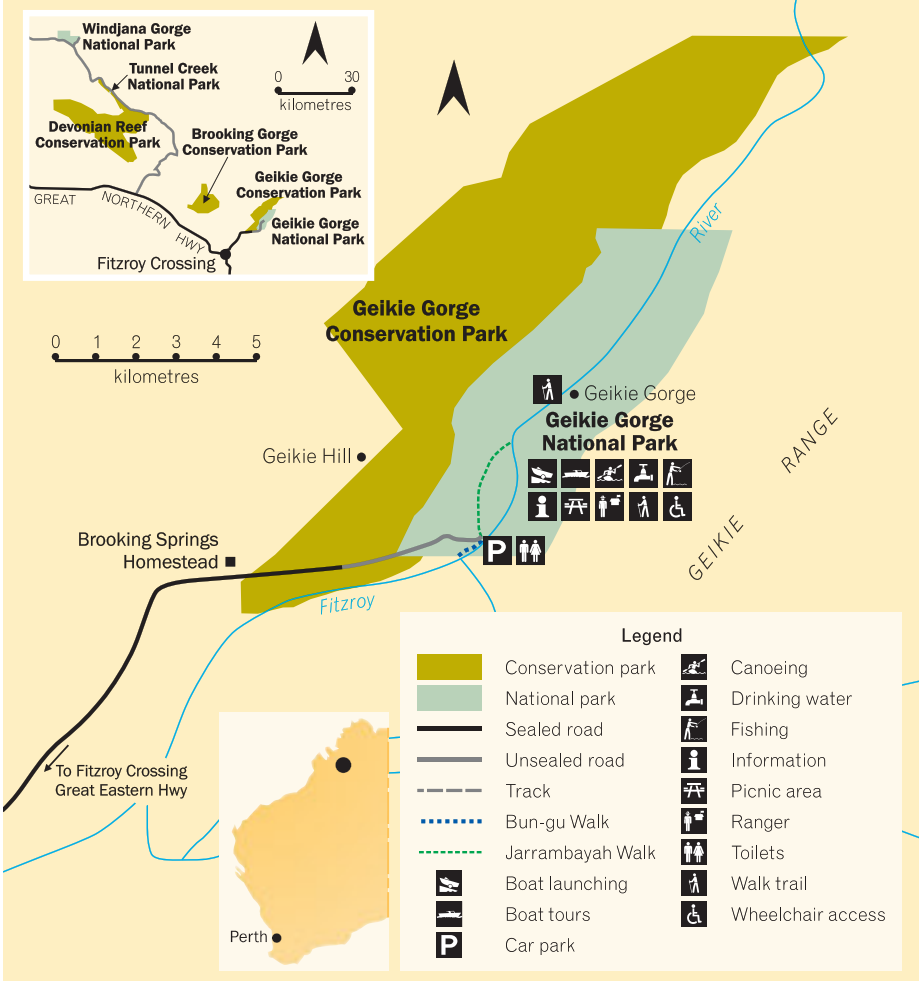
The floodwaters of the Fitzroy River have carved the 30-metre-deep Geikie Gorge through the limestone at the junction of the Oscar and Geikie ranges. The gorge is part an ancient barrier reef from the Devonian epoch rich in marine life. During the wet season, the Fitzroy River rises about 16.5 metres, staining the walls of the gorge and flooding the national park with seven metres of water. In the dry, between April and November, the river transforms into a quiet stream strung out beneath the towering cliffs of the ancient limestone reef. Here, layers of fossils and the limestone strata of the ancient reef are exposed in cross-section, showing glimpses of life in the Devonian period long before modern-day reptiles and mammals evolved.

History

The traditional owners, the Bunuba, call the gorge Darngku. It's here that a blind Aboriginal elder drowned in the Dreaming, after leaving his tribe to go wandering. The old man sighed and sneezed before he sank to the bottom for the last time. It's said his sighs can still be heard when the gorge is quiet.

The sandbar where the Mayalin or Margaret River meets the Fitzroy River is known as Bungku and was a traditional meeting place for the Bunuba and Goonlan people who came from the Fossil Downs area.

The Bunuba people also revere a site near the end of the western wall of the gorge as the place where fire was created. For here, in the days before the Bunuba people had fire, the old crocodile man Lullangarra resided, greedily keeping his firesticks to himself. One day the other animals plotted to steal the firesticks but no one was brave enough except Gid Gunya, 'the black kite man'. He dived down into the murky depths where Lullangarra lived and stole the sticks before changing into his bird form and setting the bush alight to produce fires for everyone to cook with. Even today, Gid Gunya, the black kite, can be seen wherever there are fires, maintaining the fires for everyone.



The park is named after Sir Archibald Geikie, a director general of the geological survey for Great Britain and Ireland.

It was gazetted as a national park in 1967.

Natural attractions

The park's main feature is the striking rock formations of Geikie Gorge. The vegetation fringing the river in Geikie Gorge is dominated by two species of cadjeput or paperbarks, *Melaleuca leucadendra* and *M. argentea,* interspersed with river gums (*Eucalyptus camaldulensis*), the cluster fig (*Ficus racemosa*), river fig (*F. coronulata*) and freshwater mangrove (*Barringtonia acutangulata*). Thickets of pandanus (*Pandanus aquaticus*) also occur along the river, providing a home for the threatened purple-crowned fairy-wren (*Malurus coronatus*).

The gorge's caves provide warm and humid resting places for the golden-furred orange leaf-nosed bat (*Rhinonicteris aurantia*) while the short-eared rock wallaby (*Petrogale brachyotis*) lives near the gorge.

Geikie Gorge is also home to a big variety of birds including the darter (*Anhinga melanogaster*), little pied cormorant (*Phalacrocorax melanoleucos*) and egrets. You may also see two species not often found this far from the sea—the white-bellied sea-eagle (*Haliaeetus leucogaster*) and the brahminy kite (*Haliastur indus*). Look out for sandstone shrike-thrush (*Colluricincla woodwardi*) along the cliffs, while the restless flycatcher (*Myiagra inquieta*) and brush cuckoo (*Cacomantis variolosus*) frequent the forest. Freshwater crocodiles (*Crocodylus johnstoni*) live in the riverside waters of Geikie Gorge but are usually harmless if you leave them alone.

Exploring the park

The Department of Environment and Conservation runs one-hour boat tours through Geikie Gorge in the dry season. The boat travels along the base of part of the 14-kilometre-long gorge, dwarfed by 40-metre-high walls of cliff face.

You can also set out on three walks in the park. The 800-metre-return Bun-gu Walk follows the Fitzroy River to the sandbar (bun-gu) marking the meeting place of the Margaret and Fitzroy rivers.

Upstream from the car park is the Jarrambayah (Reef) Walk—a three-kilometre-return walk along the banks of the Fitzroy River floodplain to the west wall of Geikie Gorge. You'll pass limestone reef outcrops sculpted by seasonal flooding.

The one-kilometre-return Rarrgi Walk branches off Jarrambayah Walk.

Private boats and canoes can access the gorge in the dry season after 4.30pm.

park facts

Where is it? 20 kilometres from Fitzroy Crossing and 280 kilometres from Derby.

Total area: 3,136 hectares.

What to do: Boat tours, sightseeing, photography, walking, nature observation.

Facilities: Toilets, gas barbecues, tour boats, disabled access.

Camping: You can camp in privately operated facilities at nearby Fitzroy Crossing.

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

Faure Island: a shorebird haven

by Suzanne Mather

Members of Birds Australia recently took a trip to Faure Island in the Shark Bay World Heritage Area. It was their third such visit to the Australian Wildlife Conservancy sanctuary, to conduct surveys of shorebird species presence and abundance.

On our first trip to Faure Island in 2008, we realised it was going to be a great week when we were greeted at the Denham airport by a southern scrub-robin (*Drymodes brunneopygia*). Seven members of Birds Australia (BA) had gathered *en route* to Faure Island, an Australian Wildlife Conservancy (AWC) sanctuary. We had a triple purpose for our initial survey of the island's avian species: to contribute valuable data from a little-known island to the BA Shorebird 2020 project; to confirm shorebird species presence and abundance for AWC; and to conduct BA Atlas surveys. BA Western Australia and AWC have an agreement to undertake surveys at the organisation's four south-west sanctuaries: Faure Island, Paruna, Karakamia and Mount Gibson. Consequently, the Faure Island survey was carried out in November 2008, September 2009 and October 2010.

Flying in a six-seater Cessna over Disappointment Reach in Shark Bay, we were transfixed by the turquoise blue sea, white sand, red sand dunes and cliffs climbing out of this shallow channel-streaked body of water. The wedge-tailed eagle (*Aquila audax*) cruising along beneath the plane added to the excitement.

Previous page
Main Pied cormorants in the mangrove rookery.

Left The Tadpole, a tidal creek with mudflats—an ideal foraging ground for shorebirds.

Below Pied cormorants in the mangrove rookery at the Tadpole, with samphire along the creek line.
Photos – Wayne Lawler/AWC

Shark Bay is more than 250 kilometres long and, in parts, more than 110 kilometres wide. The north-facing bay is marked by low elongated prongs extending into the mostly shallow water, with tidal flats often exposed at low tide. The 6,000-hectare Faure Island, within the Shark Bay World Heritage Area and surrounded by Shark Bay Marine Park, is only 26 metres above sea level at its highest point.

The vegetation of low acacia shrubland is dominated by *Acacia ramulosa* and *A. tetragonophylla* on undulating red sand plains interspersed with birridas (claypans) surrounded by low succulent shrublands in the lower areas. Coastal white and red sand dunes are dominated by *Spinifex longifolius* grasslands and mangrove communities of *Avicennia marina* are found scattered along the east, west and north coasts. Apart from small stands in the Houtman Abroholos Islands and Bunbury, these are the southernmost mangroves in WA. Unfortunately, buffel grass (*Cenchrus ciliaris*)—introduced during the island's pastoral history—

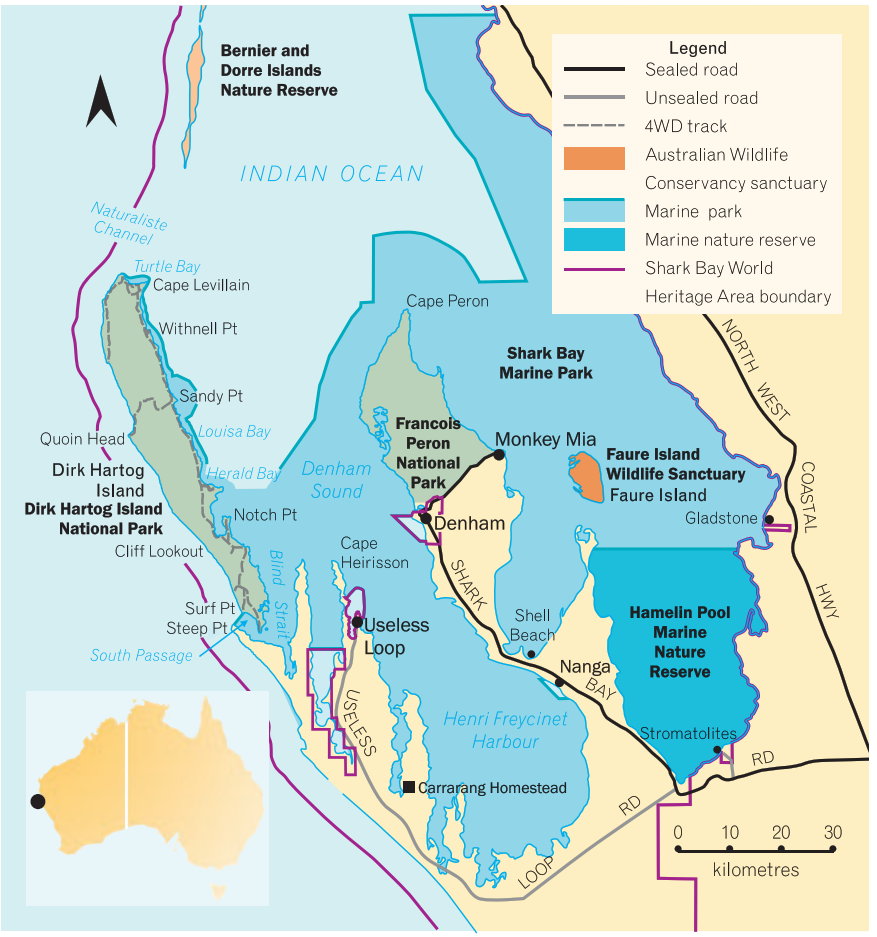
Right Dunes occur along the coastline of Faure Island.
Photo – Wayne Lawler/AWC

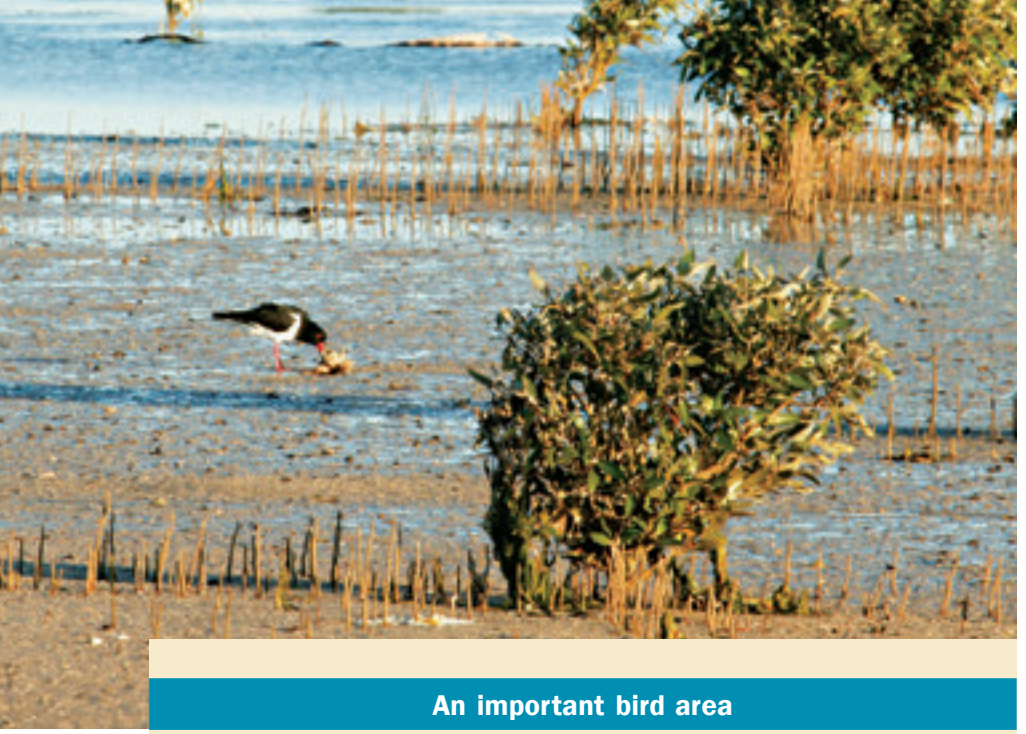
dominates some areas, particularly in the south. The area has a semi-arid to arid climate, which means hot dry summers and mild winters with an average annual rainfall of 222 millimetres per year, mostly falling in winter though occasionally a summer cyclone hits the area.

AWC and Faure Island

AWC, founded by Perth businessman Martin Copley and based in Perth WA, is committed to the effective conservation of all Australian animal species and the habitats in which they live. It is an independent not-for-profit body and undertakes scientific research in collaboration with other organisations. AWC currently owns 22 sanctuaries covering more than 2.6 million hectares, capturing a wide variety of ecosystems including tropical Queensland rainforests, arid inland deserts, savannas of the Kimberley, tall forests of the south-west and the serpentine coastal habitats of the Gulf of Carpentaria. More than 90 per cent of the organisation's annual expenditure is on conservation programs including land acquisition.

Faure Island was one of these acquisitions—purchased in 1999 after a long history as a pastoral lease for sheep and angora goats (see 'Return to Faure Island', *LANDSCOPE*, Autumn 2007). Preparing the island for the change to a sanctuary for threatened species required some work. More than 3,400 sheep and goats were removed and feral cats were eradicated. A biological survey involving a number of agencies was carried out in 2000 to help provide a sound knowledge base and determine the suitability of the island habitats for the reintroduction of threatened species. Species introduced to date include the Shark Bay mouse (*Pseudomys fieldi*), boodie (*Bettongia lesueur*), banded hare-wallaby (*Lagostrophus fasciatus*), western barred bandicoot (*Perameles bougainville*) and greater stick-nest rat (*Leporillus conditor*). These animals were either confirmed to have previously occurred on Faure Island based on fossil evidence, or to have occurred in the region in similar habitats to those found on the island. Biannual surveys of the translocated animals have shown that the boodies are thriving, and that the Shark Bay mice and western barred bandicoots have established self-sustaining populations. Walking the beaches and driving the tracks, we were amazed at the network of Australian mammal tracks. And not a cat paw-print to be found.





Above Red-necked stint.
Photo – Rob Drummond/Lochman Transparencies

Above left A pied oystercatcher foraging at low tide in the mangrove mud flats.
Photo – Wayne Lawler/AWC

An important bird area

Faure Island has been listed internationally by Birdlife International and Birds Australia as an 'Important Bird Area'—identifying it as a priority place for bird conservation. The listing of Faure Island is based on it supporting the threatened fairy tern (*Sterna nereis*), and the presence of more than one per cent of the world populations of the Australian pied oystercatcher (*Haematopus longirostris*) and red-necked stint (*Calidris ruficollis*)—Birdlife International's recognised threshold for one or more congregatory species.

was a baseline list of bird species present on the island and figures on their abundance, especially of shorebirds.

Surveying

Walking, telescope-laden, along the shoreline nearing high tide as abundant small sharks swam a metre or two from the water's edge—apparently following us—we were reminded of the origins of the name for these waters. William Dampier named Shark Bay in 1699 after his protein-starved sailors caught an 11-foot tiger shark (*Galeocerdo cuvier*) as well as seeing many more in the biologically rich waters of the bay.

There are three important shore habitats on Faure Island—the intertidal flats, the shallow lagoons and the mangroves. In addition to this are the many shallow areas of sand flats and nutrient-providing seagrass beds around Shark Bay. The bay continues to be an important and rich area for fish as well as shorebirds.

Surveying the shoreline involved dividing it up into sections and, working in pairs, identifying and counting shorebirds at each high tide over four days. Each team was equipped with telescopes, binoculars, radios and a GPS. To everyone's excitement, it quickly became apparent that the island is an important site for shorebirds, particularly those species that migrate here from the northern hemisphere in their non-breeding season. The presence of species not listed on the BA Shorebird 2020 list was also noted.

In order to survey the terrestrial species (bush birds) on Faure Island we also undertook the standard Birds Australia Atlas two-hectare 20-minute survey method at 16 additional non-coastal sites. These sites were selected to cover the major vegetation types found on the island. This method records the presence or absence, and breeding evidence, of birds. Data are then added to a national database, which began in 1998 and is accessible through the BA website.

Shorebirds abound

Shorebird surveys before those described here either had not been ground surveys or had been carried out at a time of year when the trans-equatorial migratory species would not be expected on the island. The comprehensive Royal Australasian Ornithologists Union waterbird survey of Shark Bay in October 1987 counted 27,900 birds, of which 54 per cent were shorebirds. However, because of weather constraints, Faure Island was only surveyed from the air—so many shorebirds in the extensive mangrove areas may have been missed. It was noted that Faure Island and the surrounding tidal flats might be the most important area for migratory shorebirds in the bay. The results of these new surveys certainly confirmed this.

The total shorebird number recorded was an amazing 8,442 birds in 2008 and 5,395 in 2009 from 35 species in both counts, and 9,654 in 2010 from 40 species. The abundance figures for migratory shorebirds or wader species that migrate to breed in the northern hemisphere were 5,058 in 2008, 3,265 in 2009 and 7,202 in 2010. Thus, Faure Island may be an important feeding site in its own right and a significant stopover for a group of birds that disperses widely in Australia in non-breeding time.

The migratory wader species recorded during the November 2008, September 2009 and October 2010 surveys included the Pacific golden plover (*Pluvialis fulva*), black-tailed godwit (*Limosa limosa*), ruddy turnstone (*Arenaria interpres*), sanderling (*Calidris alba*) and sharp-tailed sandpiper (*C. acuminata*). The terek (*Xenus cinereus*), common (*Actitis hypoleucos*) and marsh

(*Tringa stagnatilis*) sandpipers were also recorded, along with the great knot (*C. tenuirostris*) and red knot (*C. canutus*). The pectoral sandpiper (*C. melanotos*) and long-toed stint (*C. subminuta*) were recorded in low numbers, with just one pectoral sandpiper spotted in the 2009 surveys and eight long-toed stints recorded in November 2008.

Species that favour tidal flats were found in significant numbers, such as the lesser and greater sand plovers (*Charadrius ruficapillus* and *C. mongolus*), bar-tailed godwit (*Limosa lapponica*), grey-tailed tattler (*Heteroscelus brevipes*), common greenshank (*Tringa nebularia*) and red-necked stint (*C. ruficollis*). Mangrove stands are a favoured habitat for the whimbrel (*Numenius phaeopus*) and eastern curlew (*N. madagascariensis*). Shark Bay is internationally important for the eastern curlew and nationally important for the common greenshank (*Tringa nebularia*) and grey plover (*Pluvialis squatarola*). Many of the species in this group of birds were displaying traces of breeding plumage, suggesting a recent arrival in Australia.

Ramsar staging thresholds

It is possible to compare the results of these surveys with the sixth criterion of the Ramsar Convention—an intergovernmental treaty which aims to provide the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (see 'Western Australia's Ramsar wetlands', *LANDSCOPE*, Autumn 2011). This criterion says that a wetland should be considered internationally important if it regularly supports one per cent of individuals in the global population of one waterbird species. Faure Island appears to be an important regular feeding area for particular migratory shorebirds. This is certainly the case for the bar-tailed godwit and the red-necked stint, for which numbers much greater than these thresholds were recorded. The threshold number for the bar-tailed godwit is 812, while 1,087, 855 and 2,009 birds were recorded in the 2008, 2009 and 2010 surveys respectively. For red-necked stints, the numbers were 2,911, 1,683 and 3,228 for the corresponding years, compared with the Ramsar staging threshold for this species of 813. Many other species

Right High numbers of red-capped plover were recorded.

Below The numbers of eastern curlew suggest that the island is an important non-breeding site for this species.
Photos – Wayne Lawler/AWC

Above Great egrets settling at the Tadpole as the incoming tide floods through the samphire.

Below Faure Island coastline.
Photos – Wayne Lawler/AWC

were also recorded at least once in numbers above their Ramsar staging threshold.

Opportunistic records of migratory wader presence and abundance made during the winter months—when breeding birds would be expected to have left Australia—suggest that this area is also an important site for non-breeding birds. For example, species such as the bar-tailed godwit, eastern curlew, common greenshank, red-necked stint and sharp-tailed sandpiper were recorded during surveys carried out by AWC staff and volunteers in May 2002 and July 2002.

Why so significant?

What is it about this small area of Shark Bay that enables it to support the observed number of shorebirds? These trans-equatorial migratory waders arrive in Australia after their long flight with very few stopovers through the Asian flyway. They are hungry and the marine habitat of the area provides much-needed food and protection.

Shark Bay has many shallow areas, sand flats and seagrass beds. Surrounding waters have varying levels of salinity, largely depending on depth and distance from the open ocean. This is reflected in the abundant and diverse bottom-dwelling invertebrate fauna, including 218 bivalve mollusc species, which are dependent on the level of salinity, the mangroves and the tidal flow. In contrast, there is not the abundance and species richness on the southern coastline of the island. The Faure Sill creates a different marine environment to the south of the island in the form of a landlocked hypersaline marine basin.

Additionally, the shoreline of Faure Island is relatively undisturbed and provides a rare opportunity for the birds to feed away from human impacts. Undisturbed foraging grounds have become increasingly important as China, North and South Korea reclaim large areas of mud flats in the Yellow Sea—where many of these birds live and feed during other times of the year. It is also possible to make much more accurate estimations of shorebird numbers over time when the human variable is absent.

The transition of animal occupation from sheep, goats and cats to Australian native fauna has had measurable positive effects on the land and its flora. With the resulting increased plant cover, water and nutrient run-off from the island is also reduced. And many species benefit in addition to shorebirds—we saw numerous seed-eating birds, raptor species and mangrove-dwelling birds, despite the history of cat presence.

For us BA volunteers, these visits are fantastic—providing the chance to discover a new shorebird-rich area and explore an island that is relatively inaccessible to the public. The field trips also provide the warm satisfaction of knowing that we have made a valuable contribution to another not-for-profit environmental organisation.

Suzanne Mather is a volunteer with Birds Australia and is currently the chairwoman of the Western Australian Group. She can be contacted by email (mail@birdswa.com.au).

Birds Australia is a national organisation working for the conservation and protection of Australia's native birds and their habitats. For more information visit www.birdsaustralia.com.au.

The Australian Wildlife Conservancy establishes and manages wildlife sanctuaries in areas of high conservation value around Australia. For more information visit www.australianwildlife.org.

Many will have heard the term symbiosis. But there are many and varied ways in which marine species embody interesting interrelationships.

Sponging off others: complex relationships in the sea

Words and photographs by Ann Storrie

Relationships between species are extremely complex and often misunderstood. Symbiosis is a term that means 'living together' and refers to different species that have a close interrelationship with each other. Even the term symbiosis is not straightforward. Some scientists define symbioses as relationships that benefit both species that are co-existing; others apply the term to three types of relationship—mutualism, commensalism and parasitism. Mutualism is where two different species benefit from living together, while commensalism is defined as where one species benefits while its host gains no advantage in the relationship. When one species benefits to the detriment of the other, the relationship is described as parasitic.

These relationships, especially in the sea, are often very difficult to separate. In fact, in some instances, all three appear to occur simultaneously. Many examples, especially of mutualism, have been published in previous *LANDSCOPE* articles (see 'Sea anemones', Winter 2001; 'Corals and their cryptic collaborators', Spring 2006; 'Coral castles and their inhabitants', Summer 2009–10 and 'Echinoderms', Spring 2010). Parasites and commensal animals, however, are often a little more cryptic and less understood, yet there are thousands upon thousands of these relationships in our oceans. Some scientists have postulated that there could be more than 40,000 parasites that infest fish alone.

The term parasitism is derived from the Greek word *parasitos* which means 'one who eats at the table of others' (*para* meaning 'beside' and *sitos* 'food'). Its meaning was originally quite respectable and simply meant a table guest. Around 400BC, however, Greek comedy began featuring rude, hard-to-get-rid-of dinner guests and the word became associated with freeloaders and those who overstayed their welcome. The Romans borrowed the word which became *parasitus* in Latin (*situs* meaning 'position' or 'site') and was thus corrupted to mean those taking advantage of their host by sitting next to him or her at the dinner table. The word continued to trickle down to French and English where parasitism now refers to the relationship whereby the parasite takes advantage of the host which is disadvantaged in some way.

Parasites can generally be divided into two groups—endoparasites and ectoparasites. Endoparasites are those that live within the body or tissues of the host. Ectoparasites sit somewhere on the outside of the host. They may be temporary or permanent, they may have one or several hosts and the host may be harmed slightly, suffer severe damage, or may even be killed. It is generally not in the best interest of the parasite to kill its host and this is usually a rare event in the ocean. (An example of this in terrestrial invertebrates is the malarial parasite.)

Previous page
Main Many nudibranchs, including these beautiful *Chromodoris bullocki*, feed on sponges.

Above The pink squat lobster has a commensal relationship with large barrel sponges.

Above left A large barrel sponge amid a complex marine ecosystem.

Left Christmas tree worms bore into hard coral skeletons.

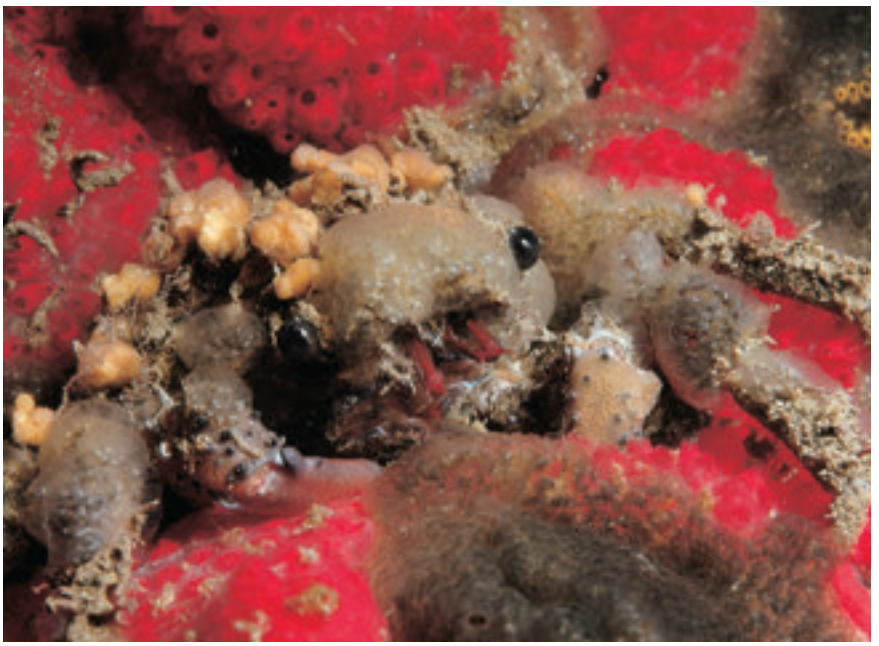
Surviving on sponges

Although many sponges have needle-sharp spicules and tough cells that contain highly toxic chemicals to deter predators, they are still the food of choice for thousands of parasites and commensal animals. Possibly the most primitive type of parasitism could have developed from predation by molluscs on sponges. Ancient slit shells, umbrella shells, some cowries and many carnivorous sea slugs, or nudibranchs, feed directly on sponges, often causing severe damage to their hosts.

The rose sponge nudibranch (*Verconia verconia*) is a tiny nudibranch only three centimetres long, yet several of these may consume nearly all but a few strands of the rose sponge (*Dendrilla rosea*). Although a slow grower, the rose sponge (like all sponges) will regenerate from just a few cells. Some nudibranchs make use of toxic chemicals found in many sponges. They retain the chemicals from their host sponge within their own bodies to use as a deterrent to fish predators.

Many echinoderms—such as sea stars and sea urchins, plus worms and small crustaceans—live on and in the structure of sponges. Many of these creatures—such as the pink squat lobster (*Lauriea siagiani*), and several species of porcelain crab that live between the folds and within the central cavity of large *Xestospongia* sponges—are probably more correctly commensal animals than parasitic animals, as it is doubtful that the sponge is harmed by them. These crustaceans simply use the sponge as a place of refuge while feeding on detritus and particles that land in the sponge.

An interesting relationship occurs when some species of crab use pieces of other animals for camouflage. Spider crabs, or decorator crabs, attach sponges, corals, hydroids and other invertebrates to their carapace. These sedentary invertebrates can all grow on the rough surface of the crab's exoskeleton. They are probably not disadvantaged by the relationship and some may even benefit from suddenly having a mobile existence. Most sponge crabs break off large pieces of sponge and hold them over their bodies with their specially adapted back legs. It is quite an amusing sight to see a sponge appearing to trundle along the sand or over the reef, the crab invisible beneath this protective shield.

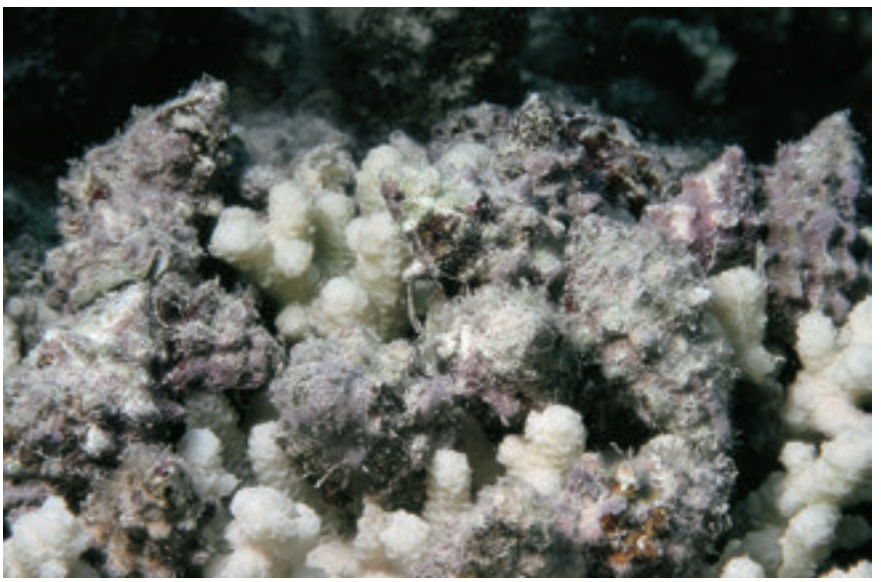


Top The rose sponge nudibranch (indicated by the arrow) is hard to distinguish from its host sponge. This one is laying a white ribbon of eggs.

Above Decorator crabs often 'plant' sponges onto their carapace for camouflage.

Predation is also a term that can be closely associated with parasitic relationships. Many parasites predate on their host, yet some sources define the difference between a predator and a parasite as one in which the predator kills its prey and the parasite does not. It is obviously a far more complex issue as many parasites do kill their hosts and many predators do not. Like the rose sponge nudibranch, the regal angelfish (*Pygoplites diacanthus*) predates on sponges, but does not eat all the sponge which can thus regenerate. However, because the angelfish is not living in a close symbiotic relationship with the sponge, the fish is termed a predator, not a parasite.

Sponges themselves are usually not considered true parasites; however, a few species of the genus *Cliona* bore into the shells of molluscs which causes the shell to become brittle. Other sponges are known to bore into the calcium carbonate base of some corals for protection.



Cravings for corals

Corals belong to a group of animals called Cnidaria which includes sea jellies, hydroids and anemones. All animals in this phylum have stinging cells for capturing food and for defence. It would thus be easy to assume that few parasites could live on coral polyps, yet corals host more species of parasitic and commensal molluscs than does any other group of marine animals. Many species of worm, crustacean, echinoderm and fish also feed on coral polyps and some make their homes by boring into hard coral skeletons.

Two of the most destructive and infamous coral predators in Australia are the crown-of-thorns sea star (*Acanthaster planci*) and a small gastropod mollusc, *Drupella cornus*. Both species feed on live coral polyps. The crown-of-thorns sea star often occurs in large numbers on the Great Barrier Reef where it has destroyed huge amounts of coral. Its numbers, however, have not fluctuated greatly in Western Australia and as a small, natural part of the reef fauna, these sea stars have had less impact on our corals. *Drupella* snails, conversely, have consumed large patches of hard corals in Ningaloo Marine Park in the past (see 'Snail threat to Ningaloo Marine Park?', *LANDSCOPE*, Summer 2007–08). Since 1989, the Department of Environment and Conservation and one of its predecessors, the Department of Conservation and Land Management, have conducted several surveys which have shown large variations of population densities of the snails at different sites; however, their overall numbers have been low to moderate and have caused no significant loss of coral cover at Ningaloo Marine Park since the outbreak that occurred in the late 1980s and early 1990s.

Top left Crown-of-thorns sea stars have eaten large amounts of coral on the Great Barrier Reef.

Above left *Drupella* snails eat coral polyps, leaving the white skeletons behind.

Left Ovulids, or allied cowries, feed on soft corals.

Far less visible and less destructive—and also very attractive—predatory–parasitic molluscs that are all associated with Cnidaria belong to the family Ovulidae. Most ovulids (also known as allied cowries, spindle cowries and egg cowries) live permanently on their host. These hosts are soft corals and gorgonians. The ovulids feed on the coral polyps, the polyps' secretions, and possibly on sediment and other animals such as sponges and brittle stars that live on the same host.

Many ovulids are very difficult to see as they are often only a few millimetres in size and are extremely well camouflaged. Their mantles (fleshy folds of epidermis that secrete the shell and can either cover it, or retract back into it) are usually the same colour as the coral polyps. Some even have polyp-like protrusions on their mantle. Surprisingly, these can be retracted or flattened when the coral polyps retract, thus rendering them almost invisible whether the coral polyps are displayed or not.

Most ovulids lay their eggs on their specific host. It is thought that the hatchlings—or veligers—which hatch into the water column, are programed with the colour of their food, enabling them to detect and land on it. To find tiny spindle cowries, look for small mounds on the stems of gorgonian fans or peer into the folds of large leather corals for beautiful egg cowries (*Ovula ovum*) that are very common in Ningaloo Marine Park and Coral Bay.

Fish are great predators on coral (see 'Reef fish and corals: unlocking the secrets', *LANDSCOPE*, Autumn 2011). In some areas they eat about one third of the annual growth of coral. Parrotfish, in particular, can often be seen (and heard) crunching on hard coral colonies. Most butterflyfish and coralfish, and some angelfish, feed on coral polyps. Their tiny mouths and snouts are designed to pick individual polyps from the reef. This adaptation has been taken almost to extremes with the forceps fish (*Forcipiger flavissimus*), also known as the long-nosed butterflyfish, and the long-nose butterflyfish (*F. longirostris*), once known as the longer-nosed, or big long-nosed butterflyfish. The latter beats its close relative by a nose! Its snout is around half its body length. Interestingly, both these butterflyfish feed on small crustaceans and other invertebrates found in coral crevices as well as on the occasional coral polyp. Other species of butterflyfish feed exclusively on coral polyps.

The world is my oyster

"Why then, the world's mine oyster, which I with sword will open." Shakespeare invented this phrase in 'The Merry Wives of Windsor'. Most of us know about pearls in oysters and understand this reference to oysters being something from which to extract great profit. However, oysters are truly the world and sustenance for a tiny parasitic crab, the female of which may spend its entire life feeding and breeding inside the shell of a single oyster.

Pea crabs of the genus *Pinnotheres* are (surprise, surprise) about the size of a pea. Different species are found in different hosts, and clams, mussels, other bivalve molluscs, sea urchins and sand dollars all have their resident pea

Above right Beautiful spindle cowries are often only a few millimetres long.

Above far right The female oyster pea crab lives her entire life inside an oyster.

Right Parrotfish crunch the coral with their strong parrot-like beaks.

crabs. Some pea crabs even invade the burrows of mud shrimps, live in the gills of sea squirts and in the rectum of sea cucumbers. Oyster pea crabs (*Pinnotheres ostreum*), however, invade the commercially harvested oyster, *Crassostera virginica*.

The larvae of these crabs are usually free swimming and feed on plankton. During their first stage of development, the soft, juvenile crabs invade the oysters and feed on particles caught in the oyster's gills. As they develop, males leave their hosts in search of mature females which can carry more than 9,000 eggs.

Fishy feeders

Internal and external parasites of fish have been studied extensively due to their importance in the commercial fishing industries. Aquarists are also very familiar with many fish parasites that threaten their fish tank inhabitants. Recreational divers, however, are often unaware of the parasitic relationships around them. The larger species of ectoparasites, such as fish lice that live on the bodies of many fish, are the most obvious.

Fish lice are isopods which belong to a diverse group of small crustaceans, many of which are parasitic. They attach themselves to the body of their host, often in the gill region, where they can feed, with ease, on their host's tissues and body fluids. Like most parasites, fish lice do not usually kill their hosts, so only one, or at the most two, parasites are found on each fish. When a fish louse larva lands on an unoccupied host, it will develop into a female. If another larva lands on the same host, it will develop into a male, thus maximising reproductive potential. All fish—from the largest shark to the smallest damselfish—are susceptible to fish lice.

Most ectoparasites found on fish are too small to be seen by the human eye. Protozoans, microscopic worms, tiny crustaceans, larvae and many other organisms invade the epidermis of their fish hosts. One of the most fascinating methods which most fish employ to control some of these parasites is to have another close symbiotic relationship with cleaner fish and cleaner crustaceans. Several species of wrasse, goby, clingfish and shrimp hover over, or hop on board, their fish visitors and methodically pick parasites from the fish's skin, fins, mouth and gill slits. Most cleaner fish choose a 'cleaning station'—somewhere sheltered on the reef where fish regularly visit. The process can be quite a sight: large predatory fish hover, waiting to be cleaned by these small fish that would make a tasty, bite-sized meal. Even enormous moray eels open their mouths wide for cleaner wrasse and shrimp to disappear inside to clean their teeth and gums.

Above Tiny cleaner wrasse would be a bite-sized meal for large moray eels.

Right A fish louse in the gill slit of a wobbegong shark.

Below A regal angelfish eating a sponge.

These examples of the complex relationships between marine creatures are only a drop in the ocean. There are many, many more fascinating stories to be told of life in the sea, and even more that are yet to be discovered. Understanding the complexity of life in our oceans is mandatory if we are to protect our wonderful underwater world.

Ann Storrie is an accomplished underwater photographer and marine enthusiast. She has contributed numerous articles to *LANDSCOPE* magazine, as well as having co-authored and photographed Department of Environment and Conservation books such as *Wonders of Western Waters*. She can be contacted by email (naturescapes.au@hotmail.com).

endangered

by Jill Pryde

Shrublands on dry clay flats

Seasonally wet clay-based wetlands are among the most threatened plant communities in Western Australia. One particular clay pan community found only on the Swan Coastal Plain is 'Shrublands on dry clay flats'. It was described in a 1994 report about the vegetation that occurs on the southern Swan Coastal Plain, and is one of four clay-based wetland communities listed as threatened in WA. The community is currently ranked as endangered.

'Shrublands on dry clay flats' is the fastest drying of the clay-based wetlands identified on the southern Swan Coastal Plain. The thin soils are soaked by winter rainfall and local surface water flows, and, as temperatures rise, dry to a hard clay pan in summer. This community typically occurs in low-lying areas that hold surface water, and groundwater levels may come close to or reach the surface in wetter months.

As clay-based wetlands dry they display a vast range of colourful flowering herbs. 'Shrublands on dry clay flats' typically contains an average of 52 species within 100 square metres. As the name suggests, this community is dominated by a dense shrub layer. Typical shrubs include furrowed hakea (*Hakea sulcata*), variable-leaved hakea (*H. varia*), swamp tea-tree (*Pericalymma ellipticum*), compacted featherflower (*Verticordia densiflora*), fringed regelia (*Regelia ciliata*) and swishbush (*Viminaria juncea*). During spring, as water begins to recede, a suite of herbs appears and includes the pointed centrolepis (*Centrolepis aristata*), *Aphelia cyperoides*, procumbent siloxerus (*Siloxerus humifusus*), sundews *Drosera gigantea* subsp. *gigantea* and *Drosera menziesii* subsp. *menziesii*, and the weed tiny flatsedge (*Cyperus tenellus*).

The heavy soils of this clay pan community were useful for agriculture and were mostly cleared and drained soon after settlement, or the clay was used for brick and tile production. Many of the remaining clay pans were close to Perth, and were later cleared for residential development.

Now, only about 83 hectares of the clay pan community remains in small patches of bushland from Armadale south to Busselton. About one-third of this area is protected within reserves for conservation.

Threats to the clay pan community include weed invasion, rising saline groundwater, changes to drainage, drying climate and possibly too-frequent fires. Many occurrences of this community are small and fragmented and are often dissected with drains, or have been disturbed for infrastructure such as roads. The community is also vulnerable to nutrients from run-off, from sources such as roads, drains and agricultural lands. Changes to the cycle of wetting and drying of the wetlands are potentially a significant threat as the community is dependent on these. The significant decline in winter rainfall on the Swan Coastal Plain in recent years affects this cycle, and this drying trend is predicted to continue. A recovery plan is currently being prepared for the community and will outline actions such as weed control, drainage management, fire control and monitoring.

Photos by Jill Pryde

Scientists are putting the freshwater mussel under the spotlight in a bid to learn more about this little-known creature.

Piggyback on a fish:

the marsupial freshwater mussel tells its tale

Around the same time as dinosaurs were diversifying, during the Triassic period, an ancient group of bivalve (meaning 'two-shelled') molluscs was moving from marine to freshwater environments. This order of freshwater mussel, known as Unionoida, is found on every continent apart from Antarctica, with more than 850 known species worldwide. The Australian family, Hyriidae, is made up of 18 species, with another 58 species of hyriid found in other parts of Australasia and South America.

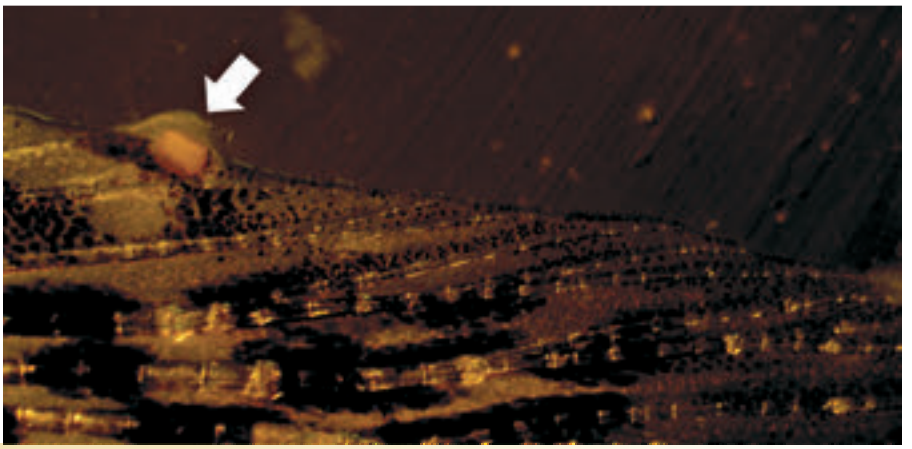
Marine versus freshwater mussels

Unlike their marine relatives—which bind themselves to reef platforms and jetty piers with attachment organs called byssi—freshwater mussels are free moving. They use a muscular, tongue-like foot to drag themselves around and burrow into river sediments, setting themselves up to 'filter-feed' on tiny particles such as plankton, algae and other microorganisms. In this way, they help keep our freshwater lakes, rivers and streams clean and clear.

What separates the Unionoida from other bivalves is their distinctive larval form, known as 'glochidia'. Emerging from specialised pouches of the female's gills, known as 'marsupia', these larvae have a very limited ability to move and so colonisation of new areas can be tricky. Fortunately, they have adapted a clever way to get around. The glochidia use hooks on the edges of their shells to attach to the fins or gills of passing fish. These parasitic glochidia live on the fish for periods of weeks to months as they metamorphose into their juvenile form, before dropping to the river bottom to begin life in the sediments.

Much of the biology and ecology of Australian freshwater mussels is still unknown. In Western Australia, almost no information is available for the five known species. Carter's freshwater mussel (*Westralunio carteri*) is restricted to south-western WA, with its historic range extending from Moore River in the north, to Kalgan River in the south. George Kendrick from the WA Museum documented a major decline in populations of Carter's freshwater mussel in the mid-to-late 1970s as a result of dryland salinity in the Avon River catchment. Results of a biodiversity survey of the WA agricultural zone showed that the mussel has declined more broadly

by Michael Klunzinger, Adrian Pinder, David Cale and Alan Lymbery



across the inland south-west, probably also as a result of salinisation. This resulted in the species being listed as 'vulnerable' by the International Union for the Conservation of Nature and as a 'priority 4' species by the Department of Environment and Conservation, meaning it is in need of further study.

Learning more

Recent work by Murdoch University researchers is attempting to answer several fundamental research questions about this species. They are seeking to understand what species of freshwater fish the glochidia attach to, their tolerance to salinity, their reproductive cycle, how fast they grow, how long they live, their current distribution, their population strongholds and where they have died out. This information will help in the protection of this obscure species.

Above left A pair of Carter's freshwater mussels from Beela Reserve, Brunswick River.
Photo – Brett Vukelic

Top An example of what a Carter's freshwater mussel looks like underwater, in Canning River, with filtering valves facing.

Centre The arrow indicates a larval form of Carter's freshwater mussel attached to the tail fin of a Swan River goby (*Pseudogobius olorum*).
Photos – Michael Klunzinger

Above A Carter's freshwater mussel from the fresh spring-fed stream of Yalyal Brook.
Photo – David Morgan

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Lessons learned since the Dwellingup fires

by Murray Carter and Rick Sneeuwjagt

It has been 50 years since the Dwellingup fires swept through the south-west, devastating townships and creating new lessons in fire management. So what wisdom has emerged from the ashes of this tragedy, and how have we continued to refine fire management since? The highly technical procedures used today are a far cry from those of yesteryear.

Previous page
Main Each year DEC fire forces attend more than 600 bushfires like this one throughout Western Australia.
Photo – Brett Dennis/Lochman Transparencies
Inset The Forests Department used 'Chev Blitz' military trucks as firefighting vehicles from after World War II until the late 1960s.
Photo – DEC

Above The extensive program of prescribed burning that followed the catastrophic bushfires of 1960–61 has resulted in a dramatic reduction in large destructive bushfires.
Photo – Jeremy Chick/DEC

Before European settlement of Western Australia in 1829, Nyoongar Aboriginal people used fire widely and frequently for a myriad of reasons, although the actual frequency with which Aboriginal people burnt the forests is uncertain. Following European settlement, there was little attempt to deal with bushfires in the south-west until after the passage of the Forests Act in 1918 and the establishment of the Forests Department in 1919. Early foresters were concerned by the extent of fire damage from the severe forest fires that were allowed to run unchecked as a result of the cessation of Aboriginal burning and uncontrolled logging during the 1800s and early 1900s. From 1924 onwards there was an attempt to apply a fire-exclusion policy to most of the cut-over jarrah forests.

During the 1920s and 1930s, fire management involved, among other things, the subdivision of the forest into areas which had been cut over for timber and regenerated, and those which had not. Attempts were made to exclude fire from cut-over forests. Some limited prescribed burning to create 'firebreaks' (narrow strips of forest between two tracks) was undertaken in the remainder of the forest. But these narrow firebreaks did little to prevent wildfires burning much of the forest in the early years.

The policy of restricting the use of broadscale planned burning and improved fire suppression saw heavy fuels steadily accumulating with time in most forest areas by the 1940s. From the late 1930s onwards, wildfires had started to become very large and difficult to control as fuels accumulated across the region. There were major fires in the jarrah forest in 1949–50, and in the jarrah and karri forests in 1937 and in 1950–51. In the long-unburnt compartments with heavy fuel loads, fires became uncontrollable once they exceeded about one hectare in size, even under mild weather conditions.

Also at about this time there were large, intense fires in the southern forest national parks, notably in the area that is now Walpole-Nornalup National Park and adjoining areas, where whole hillsides of karri and tingle trees were burnt. Few, if any, people were killed by the fires because these areas were sparsely populated at the time. But something had to be done.

Right Fire crews igniting and controlling a roadside edge burn.
Photo – John Kleczkowski/Lochman Transparencies

Centre right In concert with a network of lookout towers, DEC's fleet of surveillance aircraft ensures most bushfires in the south-west are detected and controlled while still small.
Photo – Greg Simpson/DEC

Below right Devastation after bushfire.
Photo – Jiri Lochman

Management begins

Recognising that the attempted fire-exclusion policy was failing, and as foresters better understood the role of fire in the environment, in 1954 the Forests Department changed its approach by introducing a policy of broadscale prescribed burning to manage fuel build-up. Because of the heavy fuels in most of the areas prescribed to be burnt, implementation of the policy was cautious and slow at first. There were also technical constraints, especially a lack knowledge of fire behaviour on which to base planning and burning prescriptions, and a lack of trained and suitably experienced staff to undertake the work. Lack of access and problems with predicting fire behaviour in complex karri and karri-tingle fuels were also significant issues. As a result, little effective burning was actually undertaken in the dense southern forests.

The Dwellingup bushfires watershed

The inevitable consequence of the early fire-exclusion policy culminated in massive bushfires in the summer of 1960–61. Preceded by drought, ignited by numerous lightning strikes and fanned by strong hot winds, intense wildfires swept through the forests of the south-west (see 'The great teaching event: memories of the 1961 bushfires', *LANDSCOPE*, Autumn 2011). The town of Dwellingup was burnt, as were the smaller settlements of Holyoake, Nanga Brook and Karridale. There were serious losses of houses, buildings, infrastructure, pasture, stock

Top A firefighter dampening down vegetation.
Photo – Dennis Sarson/Lochman Transparencies

Above left A bulldozer constructing a fireline in a forest fire. DEC has a large fleet of earth-moving machinery to prepare prescribed burn boundaries and firelines.
Photo – Ron D'Raine/DEC

Above This specialised fire tanker with a high-lift pump is used to extinguish fires burning in branches and hollows in the crowns of tall trees.
Photo – Allan Jones/DEC

and fencing. Fortunately no-one died in the fires, but many were injured, and the cost to the community was enormous.

In the wake of the 1961 fires, a Royal Commission was headed by the director-general of the federal Forestry and Timber Bureau. The report of the commission contained many recommendations on preventing and controlling bushfires. From the point of view of the Forests Department, recommendation 20 was the most significant. It read:

> "The Forests Department [is to] make every endeavour to improve and extend the practice of control burning to ensure that the forests receive the maximum protection practical consistent with silvicultural requirements."

This did not represent a complete redirection of policy for south-west forests; rather it unambiguously endorsed the policy which had been adopted in 1954. The Royal Commission's recommendations were adopted in full by the government of the day.

Fire behaviour in the spotlight

The decision to expand the use of low-intensity planned fire to manage wildfire in WA forests initiated a program of scientific research and technical development to underpin fire operations. Over about 30 years of research, fire behaviour scientists developed a firm understanding of how forest fires behave (their speed and intensity) under different conditions of fuel quantity and type, fuel moisture content, weather and topography. They also developed fuel accumulation and fuel moisture models. This knowledge was incorporated into fire behaviour prediction tables and a prescribed burning guide (also known as 'The Red Book'), which is used by field staff in rating fire danger, planning and implementing low-intensity prescribed burns and in the suppression of bushfires.

The most recent significant research work conducted in this area was

Above One of eight fixed-wing waterbomber aircraft hired by DEC to help ground forces contain moderate-intensity bushfires.
Photo – Natasha Oke/DEC

Fighting fire from the air

In the past 50 years, the Department of Environment and Conservation (DEC) and its predecessors have made considerable progress in the use of aircraft for fire management in Western Australia. In the 1970s, the department introduced spotter aircraft to augment and partly replace the fire detection system which was based on lookout towers (it still maintains a network of 13 lookout towers). It also started using aircraft to waterbomb and contain small initiating bushfires. Waterbombing aircraft have proven to be effective where the aircraft are able to apply the water/foam drops within 30 to 45 minutes of a fire starting. DEC's aerial firefighting fleet includes:

Aerial detection
Nine American Champion Scout fire detection aircraft which fly about 4,500 hours each season.

One full-time chief pilot, a senior base pilot and 12 seasonal pilots for the operational season.

Aerial suppression
Eight fixed-wing fire bomber aircraft that fly between 600 and 800 operational hours each year, attending, on average, 125 fires and delivering 3.4 million litres of fire suppressant each fire season. Fire bombers travel at 300 kilometres an hour and deliver, on average, 2,300 to 3,000 litres of product each drop. These aircraft are essential in slowing the forward spread rate of developing fires to allow ground crews time to gain access to the fire.

Aerial ignition
Two AS 350 Squirrel helicopters, which travel at 220 kilometres an hour and carry an incendiary machine, pilot and three crew, to conduct aerial prescribed burning.

Two GA8 Airvan fixed-wing aircraft that travel at 230 kilometres an hour and can carry an incendiary machine, pilot and four crew.

Air crew
DEC staff are trained in-house for a variety of fire aviation roles including air attack supervisor, incendiary machine bombardier, air observer, air base manager, search and rescue monitors, aircraft officer, helitorch ground crew and incendiary operations supervisor.

'Project Vesta'—a seven-year CSIRO and Department of Environment and Conservation (DEC) project initiated in 1996 to investigate the behaviour and spread of summer bushfires in dry eucalypt forest with different fuel age and understorey structures.

Fire's environmental benefits

Studies into the effects of forest fires on soil physical and chemical properties, flora, fauna, water resource values and forest regeneration started in the early 1960s and have continued since. This work has resulted in a major increase in knowledge about forest ecosystems and their response to fire. While knowledge is incomplete, there is adequate information to devise and implement fire regimes that are likely to be beneficial to the environment over the long term.

A multitude of fire ecology studies has shown that many plant communities throughout the state need particular patterns of fire to maintain their floristic and structural diversity. Fires in a particular sequence or scale are

Right The habitat of mainland quokkas is protected and regenerated by prescribed fires lit under a range of fuel moisture and weather conditions.
Photo – Babs and Bert Wells/DEC

needed to provide diversity of habitat for many animals. It is evident that no single fire regime is optimal for all species, although it is clear that many plant and animal species and habitats are detrimentally affected by severe and large wildfires.

The existing knowledge of the interrelationship between fire regimes and biodiversity is used by fire planners and managers to develop and implement ecologically based prescribed burn programs designed to protect biodiversity. Strategies that are applied to different vegetation types and landscapes to achieve these objectives include varying the season, frequency and interval of fire based on knowledge of the responses of key fire-sensitive species and habitats. This is best achieved by conducting mostly patchy, low to moderate-intensity burns that create mosaic patterns, thereby adding to the diversity of habitats.

Managing smoke

Smoke is the inevitable product of both prescribed fires and bushfires. To minimise the impact of smoke from prescribed burns on residents and agricultural crops such as wine grapes, DEC has attempted to manage burns in the south-west forests for more than 20 years. Based on smoke plume distribution studies undertaken by CSIRO and the Bureau of Meteorology since the 1970s, computer models have been developed and applied to accurately predict the behaviour of a smoke plume from a planned burn. In combination with long experience of fire practitioners, the model has been used to determine the favourable weather conditions, burn size and suitable locations and burn lighting schedule that will result in minimal impacts of smoke emitted from DEC burns. Since the introduction of the smoke management system in the 1990s, the incidence of undesirable smoke and heavy haze events from prescribed burns has been reduced dramatically.

Building capacity

Over the past decade, Department of Environment and Conservation (DEC) and its predecessors have built a significant resource available both for prescribed burning designed to minimise the risks posed by large uncontrolled bushfire, and for response to bushfires when they inevitably occur in such a fire-prone environment.

Resources currently accessible within DEC include:

600 staff able to fill a wide range of incident management and support roles

300 frontline firefighters

98 fire trucks (medium and heavy tankers)

180 light fire units

10 low loaders (for shifting heavy machinery)

11 bulldozers

11 front end loaders.

Three specialised high-lift fire pumpers have been developed to enable the extinguishment of fires burning in the canopy of tall trees that would otherwise need to be felled to avoid the risk of fire escaping.

As many major bushfire incidents occur in remote locations, DEC has developed portable incident control centres and communications facilities that enable large numbers of incident leaders, support staff and fire crews to be managed and coordinated effectively. DEC's large mobile communications trailer is fitted with the latest satellite communications systems, internet connections, terminals, servers, radios, phones, faxes, plotters and printers.

Above left A DEC fire crew igniting gully vegetation to regenerate ageing fauna habitat.
Photo – Richard Reid/DEC

Above A bushfire operations briefing.
Photo – DEC

In recent years the incidence of smoke haze from planned burns exceeding the National Environment Protection Council standards for fine particulate matter in the Perth metropolitan area has averaged less than two occasions per year.

Teaming up

Fire management has become an increasingly national and international business. DEC (along with other WA fire agencies) is currently very active in several national fire coordination bodies including the Australasian Fire and Emergency Service Authorities Council and the Bushfire Cooperative Research Centre.

Over the past decade DEC has contributed teams of fire leaders and specialist staff to many interstate and international firefighting efforts, including deployments of expert fire team leaders to assist in large-scale emergencies in South Australia, Victoria, the United States and Canada.

The future

Over the years, bushfire management has become an increasingly difficult and complex business requiring a high level of skill, commitment and teamwork in the development and safe implementation of risk management, fire preparedness and prevention, prescribed burning operations, fire suppression and coordination, scientific research and education, public liaison and communication.

Cooperative arrangements with other fire authorities, both intra and interstate are critical to successful fire management, and significant effort is being, and will continue to be, applied to further improving these. Strong productive working relationships with other agencies that support fire management such as WA Police, Fire and Emergency Services Authority WA, Main Roads WA and the Bureau of Meteorology are also very important to effective and sustainable fire management into the future.

Maintaining a best practice science-based fuel reduction burning program has its own set of challenges and will continue to be an area of strong focus. Every effort is being made to maintain the professionalism and currency of skills of existing managers, while also preparing the fire managers of tomorrow.

Murray Carter is the manager of the Department of Environment and Conservation's (DEC's) Fire Management Services Branch based at Kensington and can be contacted on (08) 9334 0375.

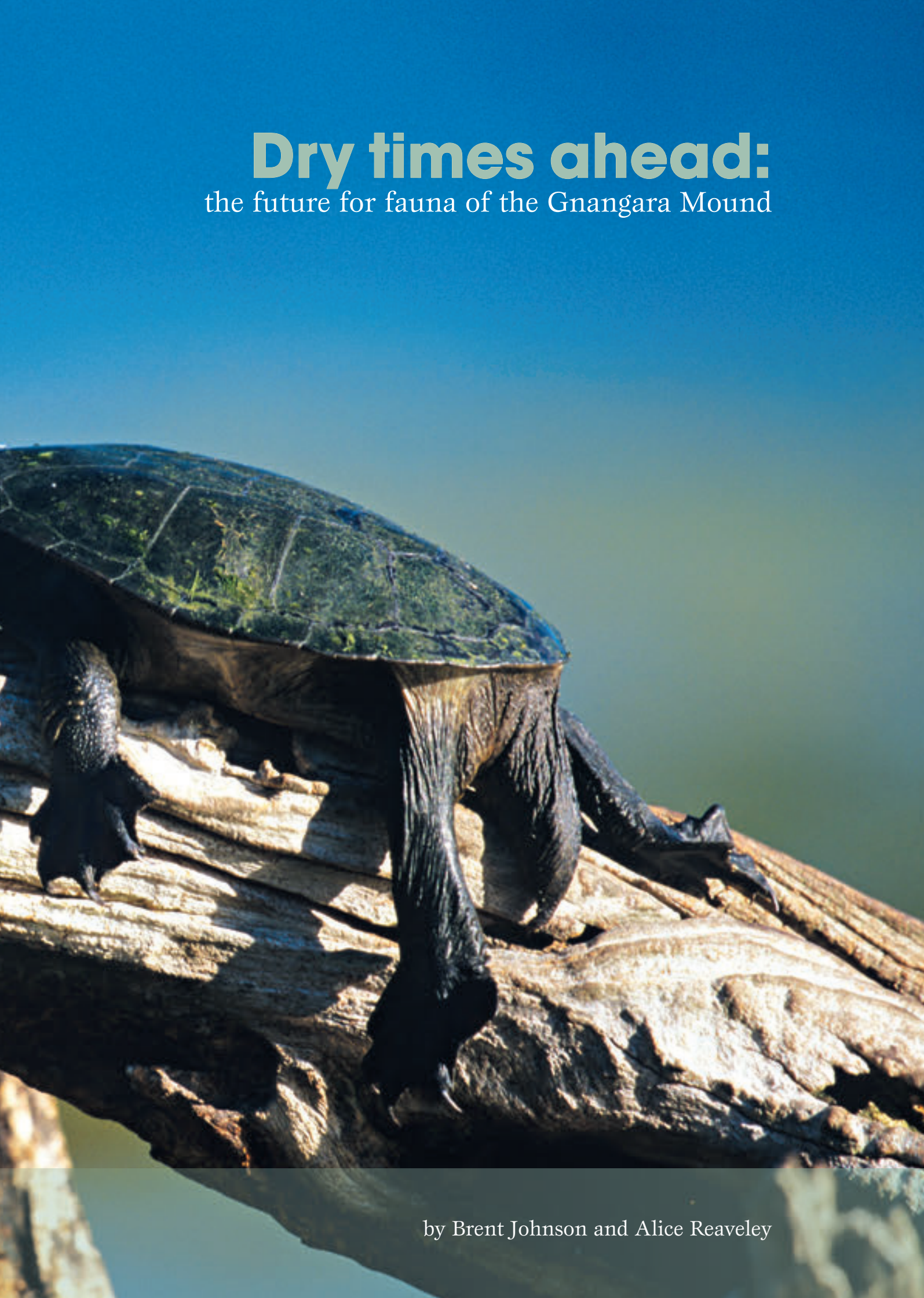
Rick Sneeuwjagt is currently a principal fire projects officer with DEC's Regional Services Division and was, until recently, the manager of Fire Management Services Branch. Rick can be contacted on (08) 9219 8765.

The United Nations General Assembly has declared 2011 as the International Year of Forests to raise awareness of sustainable management, conservation and development of all types of forests.

Are the animals of the Gnangara Mound north of Perth declining along with the groundwater levels? A new study investigates.

Dry times ahead:

the future for fauna of the Gnangara Mound



by Brent Johnson and Alice Reaveley

Early European settlers arriving at the Swan River Colony were greeted by many new sights, including curious-looking animals unlike anything found in the northern hemisphere. Biologists and collectors of the time recorded many of these animals in an area now known as the Gnangara Mound, north of Perth. Concerningly, many of the animals which once fascinated these newcomers have now disappeared from the mound.

In the 1970s, the Western Australian Museum documented the ecology of the Gnangara Mound to assess the effect of a new groundwater extraction scheme. This resulted in a comprehensive fauna survey and review of the old records. Since then, researchers have conducted many other smaller investigations in the area, usually focused on small reserves, bush fragments, developments and other specific issues. Their common finding? A significant decline in native animals since first settlement.

While there may be many factors contributing to this decline, museum staff and other researchers suspect changes to vegetation and wetland habitats due to a shrinking aquifer to be the major cause.

The Gnangara Sustainability Strategy

The Gnangara Mound groundwater system consists of several different aquifers on the Swan Coastal Plain.

The groundwater system is recharged directly by rainfall and covers approximately 2,200 square kilometres. It underlies suburbs as well as seasonal and permanent wetlands, farmland, pine plantations and extensive areas of native banksia woodlands. It also encompasses the largest areas of contiguous bush on the Swan Coastal Plain, significant threatened species and ecological communities and highly diverse groundwater-dependent ecosystems including wetlands, caves and tumulus mound springs. Importantly, these combined aquifers supply more than 60 per cent of Perth's public water. However, the sustainability of the Gnangara system is under threat because of declining groundwater levels. The decline has been attributed to decreasing rainfall over the past 30 years, increased groundwater extraction for commercial and private use, and water drawn by pine plantations.

In 2007, the state government established a taskforce to develop the *Gnangara Sustainability Strategy* (GSS), which aimed to ensure sustainable use of water and protection of the environment, and to develop land, environment and water management options to achieve these aims. It was led by the Department of Water, and included representatives from the Department of Agriculture and Food, Department of Environment and Conservation (DEC), the then Department for Planning and Infrastructure, Forest Products Commission, Water Corporation and CSIRO. A team of some 20 technical staff, academics and consultants undertook a range of field studies and reviews between 2007 and 2010. As part of the GSS projects, DEC conducted a number of biodiversity surveys across the Gnangara Mound to determine the current species richness and abundance of ground-dwelling vertebrate fauna and to investigate patterns of their biodiversity.

Mammals discovered

The survey team captured six mammal species across the Gnangara Mound and recorded an additional 10 species by observation. Of the 16 species recorded in total, nine were native to the area and seven were introduced species. Sadly, older historical data suggests up to 33 native mammal species once inhabited the area. The nine native species recorded during the recent surveys included the echidna (*Tachyglossus aculeatus*), honey possum (*Tarsipes rostratus*), bush rat (*Rattus fuscipes*), quenda (*Isoodon obesulus fusciventer*), brushtail possum (*Trichosurus vulpecula*), western grey kangaroo (*Macropus fuliginosus*), western brush wallaby (*Macropus irma*), rakali (*Hydromys chrysogaster*) and dunnart (*Sminthopsis* sp.). While the chuditch (*Dasyurus geoffroii*) was not recorded in

Previous page
Main The long-necked turtle is one of the reptile species on the Gnangara Mound that has lost large areas of suitable habitat. *Photo – Jiri Lochman*

Left Echidnas were one of nine native species recorded on the Gnangara Mound during recent surveys. *Photo – Wayne Eddy*

Above left The south western spiny-tailed gecko is a common inhabitant of the Gnangara Mound.
Photo – Leonie Valentine

Above Honey possums were commonly captured during surveys.
Photo – Alice Reaveley/DEC

this survey, there is substantial evidence that this highly mobile species has an increasing presence on the coastal plain (see 'Spotted surprise: the chuditch comeback', *LANDSCOPE*, Summer 2009–10).

Overall mammal capture rates were low, with honey possums the most consistently captured native mammal species. These were found to be distributed widely across the study area. Quenda were recorded at five of the nine sites that were selectively targeted for this species and rakali were trapped at three lakes. Rakali are semi-aquatic mammals and their survival is critically linked to the persistence of healthy wetland ecosystems (see 'Rakali: the Aussie otter', *LANDSCOPE*, Autumn 2011). Several of the remaining mammal species on the Gnangara Mound are most probably restricted to isolated remnants. In comparison with reptiles, mammals are considered to have less resilience to threats, particularly introduced predators, habitat loss and fragmentation, disease and altered fire regimes.

Resilient reptiles

The GSS survey captured 38 of the 64 recorded reptile species of the Gnangara Mound with most of the remaining species being recorded by other biologists in recent times. Nearly half of the 64 reptile species recorded on the Gnangara Mound are only found in south-west Western Australia and seven of these are unique to the Swan Coastal Plain. Australia's most threatened reptile, the western swamp tortoise (*Pseudemydura umbrina*), is the only reptile that occurs in the Gnangara Mound study area and nowhere else. It has lost much of its habitat to clearing for agriculture and housing and, as it requires water for part of the year, the reduction in rainfall and declining groundwater in the few suitable areas that remain make existence for this species very tenuous. The long-necked turtle (*Chelodina oblonga*), although not threatened, has also lost large areas of habitat.

Generally reptiles are a very resilient group and extinctions have been rare throughout Australia. The reptile assemblage on the Gnangara Mound is considered relatively intact, although some species have disappeared from some of the smaller fragmented reserves and uncleared areas that remain within the urbanised metropolitan area. The larger predatory reptiles such as the carpet python (*Morelia spilota imbricata*) and goannas (*Varanus* sp.), appear most affected by the changes occurring on the Gnangara Mound, probably by a combination of reduction in available prey and predation by foxes (*Vulpes vulpes*) and feral cats (*Felis catus*).

Different reptile species also have distinct relationships with the varying habitat types and vegetation structures that occur on the mound. In the surveys the banksia woodlands and coastal scrub were found to support the most diverse reptile fauna while the thick leaf litter found under tuart trees (*Eucalyptus gomphocephala*) had high numbers of several skink species. The presence of leaf litter and woody debris is largely dictated by the length of time since fire and these areas are important in conserving the biodiversity of bushland. Several species that prefer moist habitat, such as the western glossy swamp egernia (*Egernia luctuosa*), south-western cool skink (*Acritoscincus trilineatum*) and tiger snake (*Notechis scutatus*), have suffered a reduction in distribution throughout the study area.

Much of the Gnangara Mound is very sandy, and an interesting group of small burrowing snakes and legless lizards are present. Many have adapted to living in soft sand by being able to burrow or 'swim' swiftly through the loose soil. Several are insectivores, while some prey on smaller reptiles.

Above The moaning frog can remain underground for several months awaiting rain.
Photo – Leonie Valentine

Left Fire must be carefully managed in a drying environment.
Photo – Alice Reaveley/DEC

The small elapid (meaning 'front-fanged') black-striped snake (*Neelaps calonotus*) has the ability to hunt small skinks from under the soil, rising up to the surface to quickly snatch its prey.

Frogs

The previous WA Museum survey recorded 13 species of frog, none of which is considered rare or restricted to the Gnangara area. This study found nine of these species, with the remainder expected to still occur, although there has been a significant reduction in the available habitat for all frog species.

The diminishing number of permanent or near-permanent wetlands on the Gnangara Mound is likely to be having some effect on species such as the quacking frog (*Crinia georgiana*), slender tree frog (*Litoria adelaidensis*), motorbike frog (*L. moorei*) and pobblebonk frog (*Limnodynastes dorsalis*). With declining rainfall and lower groundwater levels, frog species that rely on seasonal wetlands—such as Glauert's froglet (*Crinia glauerti*), sandplain froglet (*C. insignifera*), moaning frog (*Heleioporus eyrei*) and Guenther's toadlet (*Pseudophryne guentheri*)—are more likely to have reduced breeding opportunities. Some, such as the burrowing and long-lived moaning frog, may be present for many years before this lack of breeding becomes obvious when a predominantly adult frog population eventually dies off. With shorter-lived frogs this effect will be noticed much sooner.

Another burrower, the turtle frog (*Myobatrachus gouldii*), does not require water to breed but has already lost much of its sandy banksia woodland habitat from clearing for urban expansion, horticulture and plantations. The pobblebonk frog and moaning frog spend the non-breeding season in upland woodland habitats and may also have locally declined as a result of this habitat loss.

Most of the species found on the Gnangara Mound are thought to be susceptible to the amphibian chytrid fungus, an infection that has caused the extinction of frog species elsewhere (see 'Fascinating frogs', *LANDSCOPE*, Spring 2008). This additional threat casts a darker shadow over frog populations on the Gnangara Mound.

Animal responses to fire

The results of the survey demonstrated that the composition of reptile communities varied among different combinations of vegetation type and the time since fire. Overall reptile abundance, as well as the abundance of some specific species, was higher in long-unburnt sites.

However, in the banksia woodland, reptiles tended to respond in different patterns to time since fire. This indicates that a diverse range of post-fire habitat is necessary to cater for the species-rich reptile fauna. For the mammals, honey possums demonstrated peaks in relative abundance at sites that were 20 to 26 years since the last fire.

Why have the animals gone?

Several threats have been implicated in the extinctions and declines of fauna on the Gnangara Mound. These include habitat clearance and fragmentation as a result of agriculture and urbanisation, changed fire regimes and predation by foxes and feral cats. The impacts of wildlife disease and the plant pathogen *Phytophthora cinnamomi* have also been implicated in the decline of mammal species in WA. Habitat destruction and fragmentation, which began with land clearing during the founding of the Swan River Colony, reduced the extent of native vegetation and systematically broke up the remaining tracts of bush into compartments that were often isolated.

Secondary threats such as fire have become a significant problem due to this fragmentation, with intense or too-frequent fire potentially causing local extinction from an isolated remnant

with no capacity for recolonisation. Habitat loss causes greater competition for the remaining refuge and food resources, and fragmentation provides boundary access for predators and exposure to animals moving between unconnected habitats. Habitat loss has included the draining of many of the lakes, sumplands and damplands on the Swan Coastal Plain.

The water issue

One of the main processes threatening biodiversity on the mound is declining groundwater levels due to climate change, reduced rainfall and increasing groundwater use. The dependence of mammals on groundwater is largely indirect, with the exception of the priority-listed rakali, which is restricted to more permanent wetlands and rivers. Other mammal species rely on the dense vegetation associated with wetlands for shelter. For nectar-feeding species such as honey possums, declining rainfall and a lowering groundwater table may affect the flowering period of banksia species, on which these marsupials primarily feed. Drought stress and the lack of soil moisture may have a significant influence on the duration and abundance of flowering, leading to banksia decline and corresponding declines in honey possum populations.

Overall, declining groundwater levels and reduced rainfall rates are predicted to alter vegetation communities, and subsequent changes may be expected in vegetation cover, floristic composition and productivity. These changes may result in altered microhabitats (for example, thermal properties) and resource availability for fauna (for example, food resources and protection from predators) as well as potentially modified fire regimes. Consequently, declining groundwater levels may indirectly affect all fauna on the Gnangara Mound.

Less rain, more pain?

The purpose of the recent survey was to identify biodiversity values on the Gnangara Mound and to provide a baseline for future work in the area. It appears that long-term reductions in groundwater levels and rainfall have already altered, and will continue to affect, the diversity of habitat above the Gnangara Mound and most members of the fauna community.

Reducing the pressures of other threatening processes occurring above the mound is also very important. Appropriate burning regimes that consider factors such as years since the last fire, season of burn and proximity to older unburnt vegetation will be crucial for the survival of species and successful recolonisation of recently burnt areas. The coordinated and integrated control and reduction of introduced species, particularly foxes and cats, on both conservation estate and remnant vegetation is also vital.

Major recommendations of the strategy released in 2009 included reducing abstraction of water by 20 per cent, developing additional desalination plants and injecting treated wastewater and stormwater back into the aquifers. Recommendations for improving the resilience of biodiversity included directing water to high-value wetlands and dependent ecosystems and establishing strategic ecological linkages.

The balance between maintenance of groundwater levels, the health of the environment and a variety of land uses will forever be a difficult and compromising matter for land and water managers on the Gnangara Mound.

Below Yeal Lake following a fuel reduction burn.
Photo – Owen Donovan

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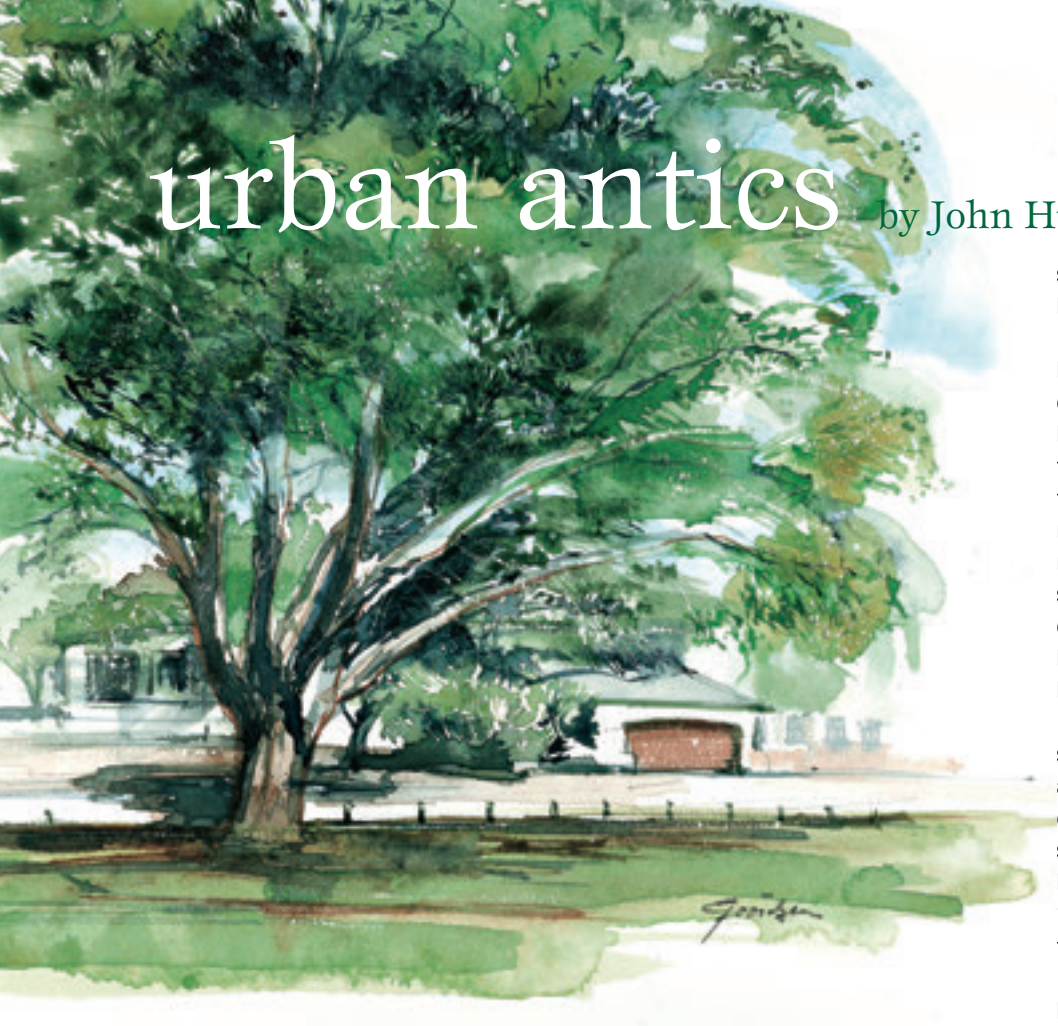
The reports of the Gnangara Mound studies are available at the GSS website accessed via www.water.wa.gov.au.

urban antics

by John Hunter



Eucalypts ...

In this 'International Year of Forests', it really seems there is an incongruity between the present parched, concrete desert of the Perth urban area and a sumptuous native forest of some international standing.

But there is a connection; for while there is a desperate need for reforestation and sustainable management of world native forests, there is also a need to protect and manage our own large endemic trees throughout Perth's environs.

I can hear the rumblings of disagreement from the western suburbs of shady exotica where a rubber tree is preferable to a eucalypt and from the vandals on the hill in Mosmans who recently ringbarked the last giant tuart between them and a Swan River view.

Of the 79 larger native tree species found around Perth, only 16 species are eucalypts or 'gum trees, the word 'gum' referring to the dried sap first observed by explorers on smooth-barked species on the eastern seaboard some 300 years ago.

In Australia, eucalypts do not grow naturally where there is less than 250 millimetres of annual rainfall unless it is special habitat, like a watercourse. Because the gums are therefore absent from most of the continent, wattles are considered far more typically Australian.

The genus name *Eucalyptus* means 'well covered' and while some people think it refers solely to the pungent aroma of the oil in the leaves, it also references how (in all species) the stamens are covered by a cap in bud.

The mostly crescent-shaped leaves of eucalypts are also distinctive in the way they are held on the tree. They hang down to conserve water, their surfaces facing morning and afternoon sun rather than the stifling heat of noon. Seedlings, however, usually situated under mature trees, need direct sunlight so their immature leaves are rounded, broader and held flat.

Growing up in the north-western suburbs in the 1940s and 50s, and relishing the inevitable bush escapades with now long-gone school mates, was then, as the lyrics of that old pop song goes ... "green, green it's green they say on the far side of the hill".

In those days, everyone's backyard contained at least one giant marri which bristled with ripening honky nuts and squabbling black cockies. In the spare block next door huge tuarts supported bric-a-brac tree houses and cool green cubbies while down the road the flooded gums of Perry Lakes shaded exploring cubs and scouts. And the jarrahs? Well they were singularly spectacular with their reddish bark, but more prolific on the Darling Plateau where, on weekend picnics, mum and dad cooked 'snaggers' and damper for us kids ... a valuable lesson on the simple side of life, and never forgotten.

DID YOU KNOW?

- Although rich in flora, Perth is poor in eucalypts with only 16 species occurring naturally.
- Eucalypts are part of the myrtle family which is also commonly found in South America, South Africa and Southeast Asia, lending weight to the theory that Australia was once part of a huge southern continent.
- The next edition of *LANDSCOPE* magazine will feature an article about the joys and challenges of creating native gardens and retaining native trees.
- The whole story can be read in *Leaf and branch*, a book on trees and tall shrubs of Perth by Robert Powell. The book is available from DEC.

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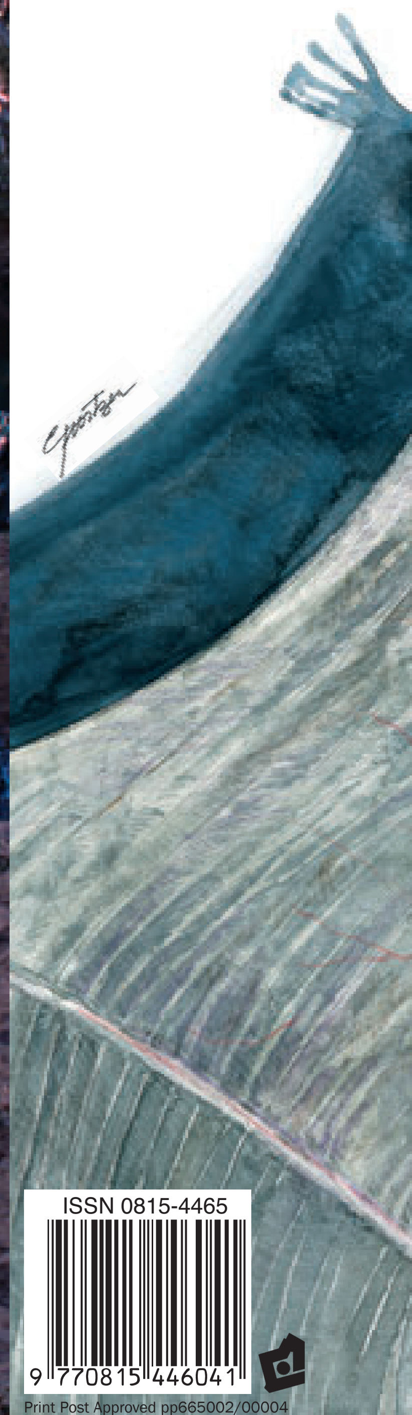

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