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LANDSCOPE

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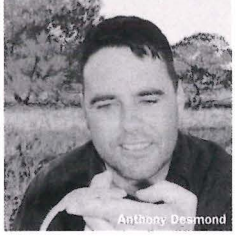
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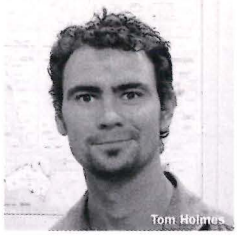
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Department of Environment and Conservation

Our environment, our future


Anthony Desmond


Tom Holmes

contributors

Anthony Desmond is the nature conservation regional leader for the Department of Environment and Conservation's (DEC's) Midwest Region. Based in DEC's Geraldton office, he has been involved in a wide range of conservation management activities since starting with the department in 1995. These include biological surveys, management of weeds and feral animals, threatened fauna management programs and restoration of degraded lands. He has enjoyed the magic of the Abrolhos Islands since his teenage years and, more recently, has worked on projects in the area including the control of African boxthorn and golden crown beard, carpet python monitoring and reptile surveys.

editor's letter

'Biodiversity' is a recent addition to the English language, a portmanteau word created in the mid-1980s to capture the concept that the diversity of species within a system is critical to the system's sustainability. In the 1950s, Watson and Crick were breaking life down to its smallest constituent particles to arrive at the double helix model of DNA. Meanwhile, another branch of biology was seeking to expand outwards and understand organisms as part of larger systems. Nowadays, while another portmanteau word, 'biotechnology', continues to make astonishing advancements in the understanding and manipulation of biological organisms at the molecular level, the study of biodiversity is beginning to show that the bigger picture of life on Earth is a lot more complex than any scientist might have imagined. After spending a few years as a 'buzz word', the term 'biodiversity' made its first appearance in print in 1988. In this issue of *LANDSCOPE*, acknowledging the International Year of Biodiversity 2010, 'A million reasons why: protecting our biodiversity' explores how this concept has since become a cornerstone of universal conservation theory and practice.

Another name that features in this issue of *LANDSCOPE* is Muir – a family eponym that pops up frequently in locations of the south-west—Lake Muir and the Muir Highway are notable examples—alongside the many '-up' and '-in/-ing' place names that are a legacy of the region's Aboriginal denizens, who managed the local natural resources for thousands of years before European contact. 'Manjimup and the Muirs' is a fascinating account of how the Muir family, from the time they first arrived in Western Australia from Britain in the mid-1800s, began not only gathering knowledge of the natural world around them, but also applying it in land management practices that have proven over time to show a deep intuitive understanding of environmental issues.

The Muirs were able to make their mark in this way thanks to a good relationship with local Aboriginal people, whom they respected as long-time stewards of the land. In particular, the Muir family noted the Aboriginal use of controlled burning to stimulate regeneration and minimise the intensity of wildfires—a practice which is reflected in prescribed burning regimes today.

Biodiversity wasn't a word when the Muirs first came here. But neither the Muirs nor the Aboriginal cohabitants whose knowledge of nature they so admired needed a word for it—it's a concept of which they shared an innate and timeless understanding.

Madeleine Clews
Executive Editor

2010 International Year of Biodiversity

Tom Holmes is a tropical research scientist for DEC's Marine Science Program, having joined the department in late 2008. Based at the Science Division in Kensington, he is involved in marine research and monitoring projects in marine parks throughout the north of the State. These currently involve investigations into the effects of climate change and fishing pressure on fish communities and recruitment on Ningaloo reef, as well as fish and benthic monitoring projects within the Shoalwater Islands, Ningaloo Marine Park and Montebello and Barrow islands marine parks and reserves. Tom's research interests include predator behaviour and broad-scale community processes on coral reefs and he is looking to extend these principles into algal and mangrove habitats.

Natalie Nicholson is a DEC recovery catchment officer in Western Australia's Wheatbelt Region. For six years, Natalie has been involved in managing the Lake Bryde Natural Diversity Recovery Catchment, an area with high natural biodiversity values including a threatened ecological community. Natalie is responsible for planning and implementing recovery actions, as well as monitoring and evaluation programs. Active in the catchment community, she has improved stakeholder involvement in environmental projects and encouraged scientific involvement from university and private research companies.

Glen Gaikhorst is currently a zoologist with GHD Pty Ltd in the ecology and marine group, but previously worked as the supervisor of Perth Zoo's Native Species Breeding Program. Glen continues to work in the Great Victoria Desert researching sandhill dunnarts for resource companies as well as conducting fauna surveys for environmental assessments. His experience extends into *in situ* and *ex situ* management of Australian fauna, in particular mammals, reptiles and amphibians.


Natalie Nicholson

also contributing. . .

John Hunter, Ann Storrie, Greg Durell, Ray McKnight, Cathy Lambert, John Huisman, Joanna Moore, Tim Gamblin, Carly Bishop, Samille Mitchell, Matthew Williams, Andrew Williams, Dave Algar, Jacqui Richards, Fran Stanley and Keith Morris.


Glen Gaikhorst



Cover illustration by Philippa Nikulinsky
Scarab beetles, the family Scarabaeidae, consist of some 30,000 species worldwide. Beetles of the genus *Diphucephala* are part of the scarab subfamily Melolonthinae and are a brilliant metallic green. Adults of *Diphucephala* are often seen in native bushland on flowers, such as here on the myrtle wattle (*Acacia myrtifolia*), also known as the red stem wattle. This bushy shrub is common in temperate southern Australia, often found in coastal or near-coastal areas. *Illustration reference photo by Sally Bostwick.*

Back cover photo by Ann Storrie
Moon rising in the Gannet Rock area near Meelup, south-west Western Australia.

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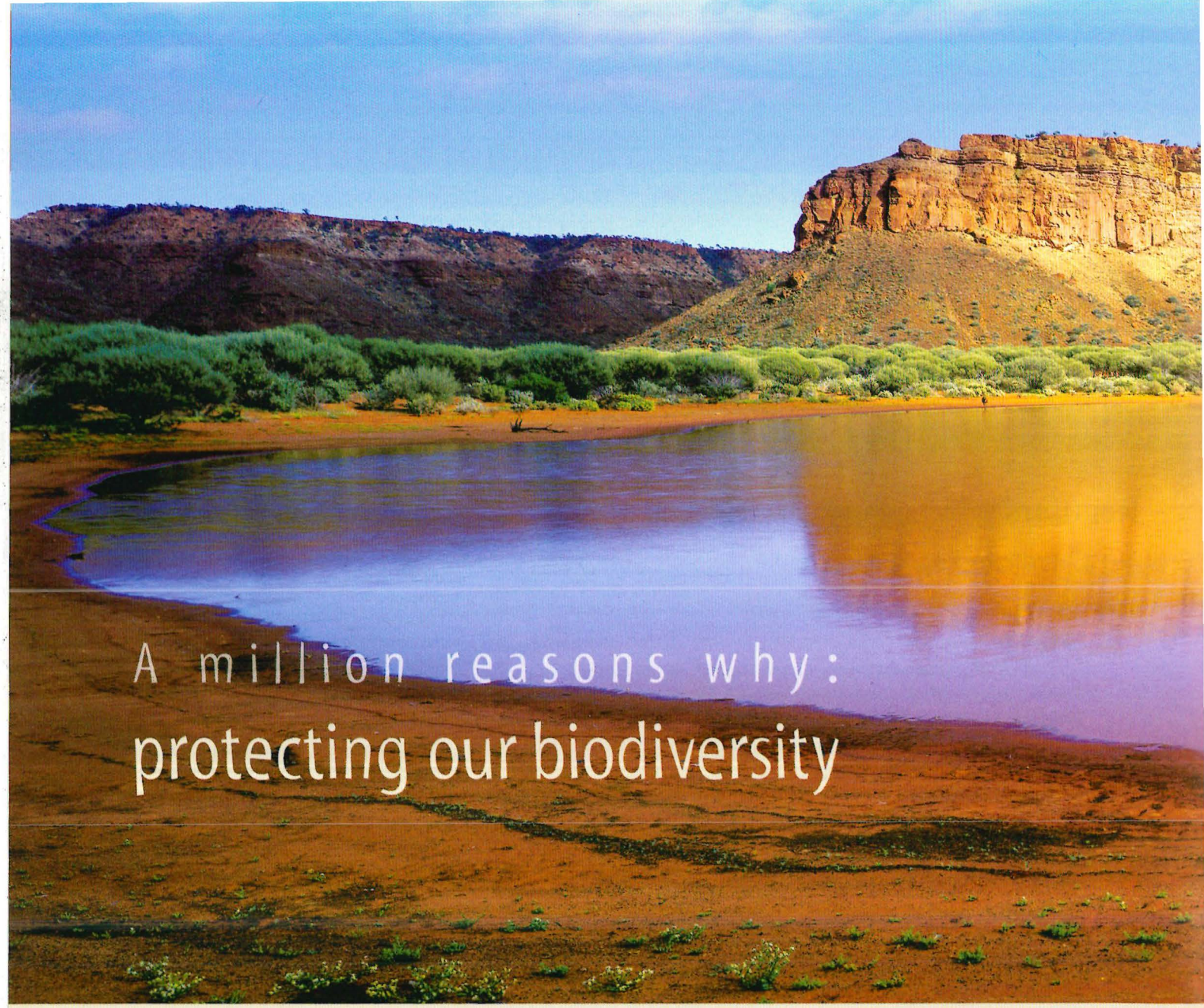
Our environment, our future











A million reasons why: protecting our biodiversity

2010 is the International Year of Biodiversity. Declared by the United Nations, it is a celebration of life on our planet and of the value of biodiversity for our lives. Celebrations around the world aim to increase awareness of biodiversity and its importance and to engage more people in biodiversity conservation.

What's in a word?

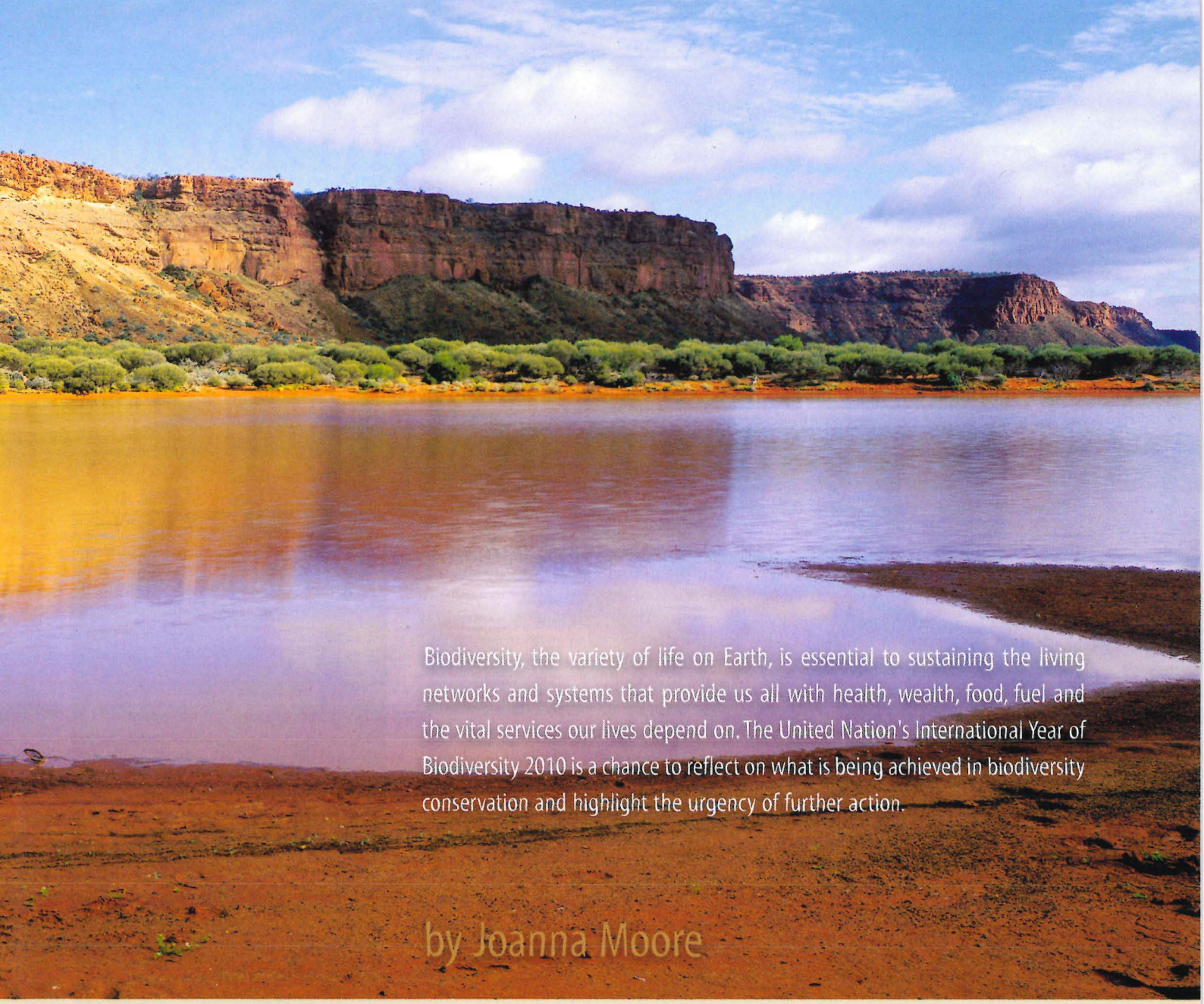
The term 'biodiversity' is now well known, but this has not always been the case. It emerged about 25 years ago, coined in the mid-1980s—a contraction of the words 'biological' and 'diversity'. Since then, the concept has achieved widespread use among conservationists and environmentalists, biologists and research scientists, political leaders and interested citizens throughout the world. Biodiversity courses are taught at universities around the globe and concepts such as 'threatening processes' and 'hot spots' have become central to understandings of biodiversity and its conservation.

Biodiversity has many interpretations. The spectrum of meanings associated with it range from species richness, or the number of species in a given area, to, at its broadest, a multi-dimensional concept that embodies the totality of life and all its elements.

Western Australia is a signatory to the National Strategy for the Conservation of Australia's Biological Diversity and so has adopted its definition. This defines biodiversity as the variety of all life forms—the different plants, animals, fungi and micro-organisms, the genes they contain and the ecosystems of which they form a part. In this definition, biological diversity is considered at three levels. Firstly, 'genetic diversity' is the variety of genetic information contained in all of the individual plants, animals, fungi and micro-organisms that inhabit the Earth. Genetic diversity occurs within and between the populations of organisms that comprise individual species, as well as among species. Secondly, 'species diversity' refers to the variety of species on Earth. Finally, 'ecosystem diversity' is the variety of habitats, biological communities and ecological processes.

Placing value

Conceptually, the notion of biodiversity has been instrumental in shifting conservation management from largely targeting human-valued species—often the 'cute and furry' threatened mammals such as the chuditch (*Dasyurus*) or bilby (*Macrotis*



Biodiversity, the variety of life on Earth, is essential to sustaining the living networks and systems that provide us all with health, wealth, food, fuel and the vital services our lives depend on. The United Nation's International Year of Biodiversity 2010 is a chance to reflect on what is being achieved in biodiversity conservation and highlight the urgency of further action.

by Joanna Moore

Above Kennedy Range in the State's north-west is an eroded plateau on the rim of the Gascoyne River catchment. Kennedy Range National Park retains a spectacular wilderness feeling, with gorges and precipitous faces, and a vast plateau of ancient dunefields on top of the range. *Photo - Jiri Lochman*

lagotis) or iconic ocean species such as whales—to focusing on all organisms. While the concept of ecosystem management goes back to the mid-1970s, there has recently been a greater shift towards this kind of environmental management, where maintaining whole-of-ecosystem function and health is a primary goal.

A number of values are implicit to the concept of biodiversity. One of the most important of these is the ecosystem services biodiversity provides. These can be described as the environmental processes that help sustain life on Earth—such as the role native vegetation remnants play in maintaining water quality or preventing fragile landscapes being degraded, the production of oxygen and the fixing of carbon by plants, or the role of wetlands in flood mitigation and nutrient stripping (the removal of harmful nutrients in sewage before it enters a waterway). Biodiversity values also contribute to the quality of our chemical and physical environment in ways that protect human health, for example through acting as the 'canary in the coal mine'—an indicator of risks to health.

Our natural biodiversity also contains productive and consumptive use values. Natural products commercially harvested in WA (with permits) include wildflowers, firewood, timber and kangaroos. WA's internationally significant flora may provide opportunities for new sustainable industries and genetic resources, the potential of which is hard to imagine.

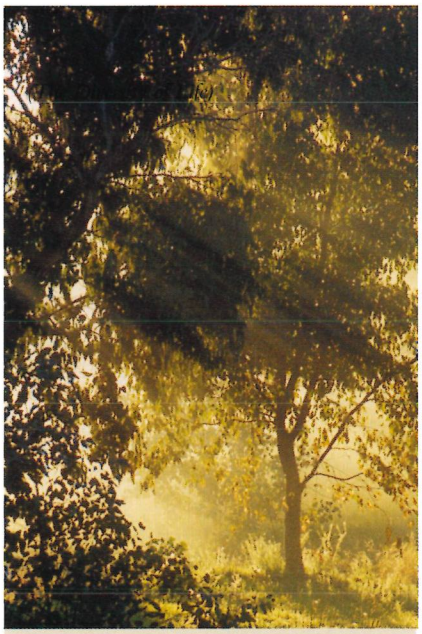
There are also significant scientific and educational values to our natural biodiversity. Understanding our land, how it works and how it has changed relies on being able to access remnants of native vegetation. Bushland is also a valuable educational resource for a wide range of research institutions as well as for school and university teachers, who aim to engender a love for the natural environment in their students.

Another feature of biodiversity is its amenity and aesthetic value. Remnant vegetation provides shade and shelter from wind. The inspiring view of a



Left A rich display of flowers from the family Asteraceae, the daisies, in Western Australia's Midwest Region. They include the pom pom everlasting (*Cephalipterum drummondii*), the Swan River daisy (*Brachycome iberidifolia*) and the everlasting daisy (*Hyalosperma cotula*). *Photo – Marie Lochman*

Below The bushland around Lake Gwelup, in Perth's City of Stirling, is home to many bird, frog and reptile species. *Photo – Andrew Davoll/Lochman Transparencies*



mountain range, or the local bushland in your suburb, has natural beauty and the capacity to inspire wonder and amazement. As Edward O Wilson, acclaimed American biologist and Pulitzer Prize winner, says in *The Diversity of Life:* "Wilderness settles peace on the soul because it needs no help; it is beyond human contrivance". Loss of biodiversity impacts in many ways on these almost indescribable values, which we often take for granted.

Natural spaces are also important places for people to be active and keep fit. As identified through the Department of Environment and Conservation's *Healthy Parks, Healthy People* program, tourism and recreation in the environment have positive connections with physical and mental health. Special places in the natural environment—especially ones which we return to time and time again—can become part of our cultural identities. In this way, the environment can become even more than a place for recreation: it can become a place with spiritual or philosophical value that is part of our moral framework and sense of self. In Wilson's words: "Signals abound that the loss of life's diversity endangers not just the body but the spirit".

Protecting biodiversity

Protecting our biodiversity is about protecting these wide-ranging values. Its importance also extends beyond the economic and instrumental criteria—the things that are beneficial to humans—to intrinsic ones. These might be called biocentric or ecocentric values. Nature-centered value systems such as these place equal worth with all wild plants and animals on the planet, regardless of their value to humankind. These areas of environmental philosophy consider every form of life as unique and worthy of protection and assert that lasting benefits from nature will only be possible if the complex and interrelated ecological processes life contains are maintained. Good environmental management is a key element of biocentric and ecocentric philosophies.

A closing thought from Wilson:

> "Humanity coevolved with the rest of life on this particular planet; other worlds are not in our genes... it is reckless to suppose that biodiversity can be diminished indefinitely without threatening humanity itself. Field studies show that as biodiversity is reduced, so is the quality of the services provided by ecosystems. Records of stressed ecosystems also demonstrate that the descent can be unpredictably abrupt. As extinction spreads, some of the lost forms prove to be keystone species, whose disappearance brings down other species and triggers a ripple effect through the demographies of the survivors.
>
> ... These services are important to human welfare. But they cannot form the whole foundation of an enduring environmental ethic. If a price can be put on something, that something can be devalued, sold, and discarded.
>
> ... Humanity is part of nature, a species that evolved among other species. The more closely we identify ourselves with the rest of life, the more quickly we will be able to discover the sources of human sensibility and acquire the knowledge on which an enduring ethic, a sense of preferred direction, can be built."

Joanna Moore is a DEC publications officer and *LANDSCOPE* editor. She can be contacted on (08) 9389 4003 or by email (joanna.moore@dec.wa.gov.au).

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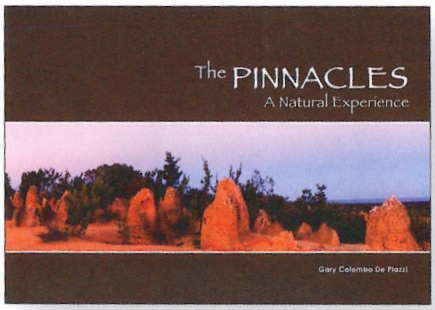
2010 International Year of Biodiversity

bookmarks by Joanna Moore

Feathered Dinosaurs: The Origin of Birds

Author: John Long
Illustrator: Peter Schouten
Publisher: CSIRO Publishing
www.publish.csiro.au
194 pages, hardback, full colour
ISBN: 978-0-6430943-4-5
RRP: $49.95

Dramatic colour illustrations by acclaimed natural history artist Peter Schouten bring this comprehensive book by palaeontologist and popular science author John Long to life. New understandings about the origins of birds and their links to certain predatory dinosaurs, discovered through recent fossil evidence, are explored in the easy-to-read text. Eighty imaginative full-colour paintings of all the known groups of dinosaurs that bore feathers match their peculiar physical traits with those of living creatures. A worthwhile read for any bird or dinosaur enthusiast.



The Pinnacles: A Natural Experience

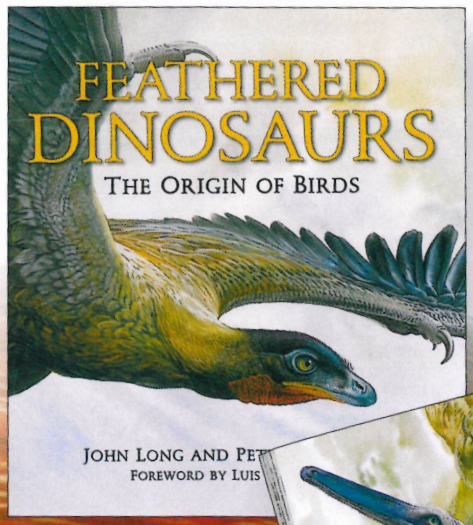
Author/photographer: Gary Colombo De Piazzi
Publisher: G and K De Piazzi
garydep@hotmail.com
76 pages, paperback, colour photographs
ISBN: 978-0-9805443-0-5
RRP: $24.95

Gary Colombo De Piazzi's first book investigates the role natural spaces play in our often-regimented and busy lives, meeting our needs for escape, contemplation or calmness. A combination of poetry, prose and photographs creates an exploratory journey through the Pinnacles Desert, an iconic tourist attraction in Nambung National Park.

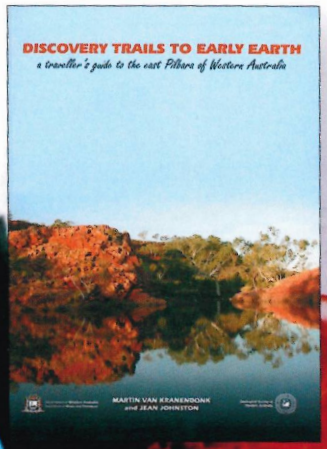
Discovery trails to early Earth: a traveller's guide to the east Pilbara of Western Australia

Authors: Martin J Van Kranendonk and JF Johnston
Publisher: Geological Survey of Western Australia, Department of Mines and Petroleum
www.dmp.wa.gov.au/bookshop
170 pages, paperback, full colour
ISBN: 978-1-7416824-5-8
RRP: $25

This roadside guidebook introduces travellers to the landforms, rocks and geological processes that helped shape the east Pilbara landscape. Branching out from Marble Bar, six discovery trails are described—with points of interest located with GPS coordinates—enabling the user to explore an ancient world of volcanoes, stromatolites, meteorites and glaciers. Additional information is provided about Deep Time and early Earth, rocks and minerals, the billion-year geological history of the east Pilbara and the history of the people of the region. There are also maps, diagrams and a glossary. A useful reference for tourists, students, teachers and those living in the area.








50

Giant steps:
industry and conservation make history through Gorgon

The Gorgon project—the largest natural gas development ever approved in Western Australia—is well under way. Managing the project's impact on island and marine environments, as well as the conservation programs being funded through the project's agreed environmental offsets, is no small undertaking either.

by Fran Stanley, Keith Morris, Tom Holmes and Joanna Moore



September 2009 marked an historic landmark for Western Australia. It was the month that the proposal to produce and export natural gas extracted from the massive Greater Gorgon area off the State's north-west, using nearby Barrow Island as a base, got the go-ahead. This came from both the Australian and State governments and from the project's financers, Joint Venture participants Chevron Australia and Australian subsidiaries of Shell and Exxon Mobil. Since then, Tokyo Gas, Osaka Gas and Chubu Electric Power have joined as participants in the project. Gorgon will be the biggest industrial development in Australia's history, and one of the largest such ventures in the world.

But industry is not the only superlative here. Barrow Island, which will host the onshore facilities to process, store and load the product, is Western Australia's second biggest island, and is recognised as one of the most important areas for native fauna conservation in Australia. Its geographic isolation has resulted in it being an important refuge for many species that have either declined in number or become extinct on the mainland. In addition, Australia's largest onshore oil field has been operated by Chevron Australia on Barrow Island for more than 40 years, producing more than 300 million barrels of oil since 1967.



Barrow Island was declared a nature reserve in 1908. In 1910, the reserve's status was changed to class 'A' in recognition of its significance for the conservation of a range of animal species. Any development proposals have to take these highly significant conservation values into account. The Gorgon proponents and the State Government have negotiated a program of environmental offsets to be funded by the Joint Venture, to ensure the project will contribute to improving Western Australia's biodiversity conservation values as well as its financial ledger. The offsets will take the form of a range of conservation programs to be led by the Department of Environment and Conservation (DEC).

The project

The Gorgon project will build and operate three 'gas trains' on Barrow Island—processing equipment to condense, compress and liquefy the natural gas—to produce 15 million tonnes each year of liquefied natural gas (LNG) for export to Japan, China, Korea and India. The project also involves building a marine wharf and jetty, with a large associated dredging program and a domestic gas plant. Construction for the project is now under way and will continue for the next three to five years. It is anticipated the plant will process natural gas for decades to come.

Island refuge

Barrow Island Nature Reserve is home to 23 threatened and four priority animal species. The smaller surrounding islands—Double, Middle, Pasco and Boodie—are also nature reserves. Adjacent to the island are Barrow Island Marine Park and Barrow Island Marine Management Area, which support a range of marine habitats and species including coral reefs, mangroves, algal and seagrass habitats, dugongs, whales and other cetaceans, marine turtles, fish and invertebrates. The islands are vested with the Conservation Commission of Western Australia, and the marine reserves with the Marine Parks and Reserves Authority. All are managed by DEC.

Environmental offsets

DEC is managing the Gorgon project's impact on island and marine conservation. This involves monitoring the effectiveness of quarantine systems on both Barrow Island and the mainland, and having a management and monitoring presence on Barrow



Previous page
Main DEC field staff monitoring near Barrow Island.
Photo – Tom Holmes/DEC
Inset A golden bandicoot captured on Barrow Island for translocation.

Left Lorna Glen is one of three sites chosen as a new home for species translocated from Barrow Island.
Photos – Judy Dunlop/DEC



Above DEC staff carry cage traps with animals for release on Hermite Island.
Photo – Ann Biasol/DEC



Right Brushtail possums trapped on Barrow Island have been translocated to Cape Range National Park.
Photo – Bill Muir/DEC

Island to ensure the protection of island and marine environments. DEC staff will be permanently based on Barrow Island to undertake these roles. In addition, as part of the environmental approvals for the Gorgon project, the Gorgon Joint Venture is also assisting with the funding of a number of new conservation programs.

These programs will extend knowledge and protection of threatened marine turtle species on the Northwest Shelf, provide information about key marine ecosystems and the potential impacts of human pressures (including dredging programs), and translocate mammals and birds to areas where these native fauna populations have been lost through introduced animals, weeds and changed land management practices. An important aspect to the programs on and around Barrow Island is the development of an ecological knowledge base, which will provide a baseline for monitoring during the development. There is also a contingency fund in place to support eradication if non-indigenous species become established on Barrow Island because of the project.

Mammals airlifted

One of the first offset programs to get under way has been the translocation of four mammal species from Barrow Island to three other locations. Before the Gorgon Joint Venture started clearing land on Barrow Island to build the gas treatment plant in early 2010, DEC trapped about 600 animals and airlifted them off the island to start new populations elsewhere. During February 2010, 325 golden bandicoots (*Isoodon auratus barrowensis*), 65 boodies (*Bettongia lesueur spp.*), 111 spectacled hare-wallabies (*Lagorchestes conspicillatus conspicillatus*) and 104 brushtail possums (*Trichosurus vulpecula*) were captured on Barrow Island and flown to their new homes. This represented only a small portion of the total populations of these animals on Barrow Island.

This program saw spectacled hare-wallabies and golden bandicoots travelling to Hermite Island, in the Montebello Islands group, to establish new populations as part of the Montebello Renewal project (see 'Montebello Renewal', *LANDSCOPE*, Summer 1996–97). Prior to the introduction of feral cats (*Felis catus*) and black rats (*Rattus rattus*), probably by pearlers or from shipwrecks in the early 1900s, the wallabies and bandicoots occurred naturally on Hermite Island. The feral cat and black rat became well established on the island, decimating the native animal populations. Intense efforts by DEC and volunteers in the 1990s led to the successful eradication of feral cats and black rats. This means the island can now once again become a refuge for the threatened species (see 'Moving mala', *LANDSCOPE*, Autumn 1999).

Fauna reconstruction

Golden bandicoots were also relocated to the former pastoral station Lorna Glen, 150 kilometres north-east of Wiluna, together with boodies, also

known as burrowing bettongs. Boodies and golden bandicoots once lived on Lorna Glen and across the arid region, but disappeared following European settlement. The reintroductions are part of Operation Rangelands Restoration, which is aimed at re-establishing ecosystem health and wildlife diversity to almost 600,000 hectares of rangelands in the north-eastern Goldfields by 2020.

Since 2001, DEC and the Wiluna Aboriginal community have carried out a range of activities to remove livestock and other introduced animals from Lorna Glen, manage bushfires and build a boundary fence with neighbouring landholders. Baiting and trapping has reduced feral cat numbers by about 75 per cent, and foxes are virtually non-existent at Lorna Glen. A 1,100-hectare predator-proof compound was also constructed in which reintroduced animals can acclimatise to their new surroundings and be totally protected from the few remaining feral cats. Once they have bred, their adapted offspring will be released outside the fenced enclosure, into the wild.

Previous mammal reintroductions into unfenced areas in Australia's arid interior have not been successful, mainly because of an inability to control feral cats that prey on small-to-medium-sized native mammals. But recent advances in feral cat control techniques mean the conservation of Australia's most threatened native animals and the restoration of the arid zone can successfully begin (see 'Controlling introduced predators in the rangelands: the conclusion' on page 17). During the next 10 years, re-establishment of 11 native animal species at Lorna Glen is planned, making it one of the world's largest wildlife reconstruction programs (see 'Into the wild: restoring rangelands fauna', *LANDSCOPE*, Winter 2009).

Brushtail possums have been transported from Barrow Island to Cape Range National Park near Exmouth. Fox control is under way here for rock wallaby conservation, and this is the start of another fauna reconstruction project in the arid zone, where most mammal declines have occurred. Interestingly, these possums are much smaller than their mainland relatives and have shorter tails, possibly because they are mainly ground-dwellers—there are very few trees on Barrow Island!



Left DEC research scientist Adrian Wayne releases a spectacled hare-wallaby on Hermite Island.
Photo – Sophie Arnall/DEC

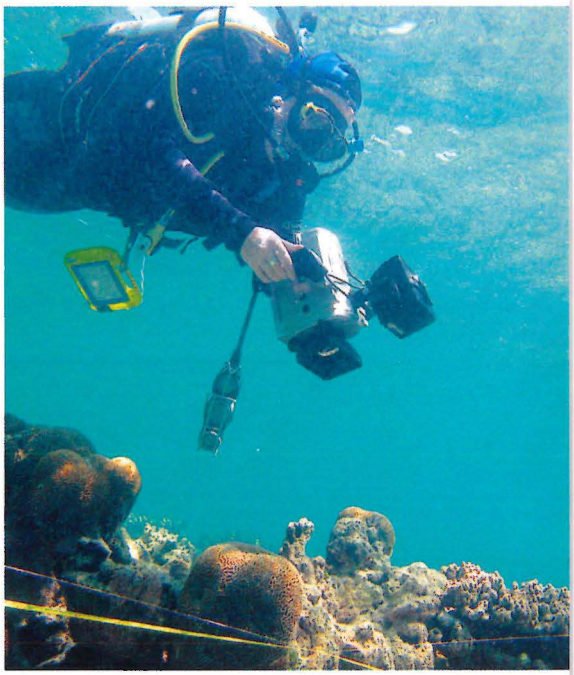


Below left A healthy translocated boodie at Lorna Glen.
Photo – Judy Dunlop/DEC



Below Radio tracking boodies to their warrens at Lorna Glen.
Photo – Joanna Moore/DEC





Above left Flatback turtle.
Photo – Jiri Lochman

Above Field staff conducting benthic video transects near Barrow Island.
Photo – Kevin Crane/DEC

The Threatened and Priority Species Translocation and Reintroduction Program will continue for the next decade. In the next part of this project, it is planned to translocate two bird species, the Barrow Island black and white fairy wren and the spinifex bird, to the Montebello Islands. Newly established populations will be monitored to check whether they are thriving in their new homes.

Turbid waters

Another offset program already under way is the Dredging Audit and Surveillance Program. This marine monitoring program aims to assess the potential impacts of marine construction, dredging and spoil disposal activities on the marine biodiversity of the adjacent Montebello and Barrow islands marine parks and reserves.

The program will also enable DEC to provide independent, informed and timely environmental management advice to assist in the management of dredging activities and is complementary to industry marine compliance monitoring programs. DEC established 23 permanent monitoring sites in 2006, resurveyed and established additional sites in 2009 and surveyed these sites again in April 2010. These surveys provided data on the condition of benthic and fish communities of the Montebello and Barrow islands marine parks and reserves before dredging started in earnest. The monitoring program will continue to monitor key marine communities during and beyond the timeframe of the dredging operations.

The 2009 survey consisted of two week-long field expeditions, involving 10 scientific and technical staff from DEC's Marine Science Program, Environmental Management Branch, Pilbara regional office and The University of Western Australia's Oceans Institute. Not only were the trips significant for the spatial scale over which surveys were conducted, but they also forged invaluable collaborations between the groups involved.

In total, 26 sites were intensively surveyed throughout the eastern Montebello and Barrow islands area, encompassing a wide range of locations and habitats. Although results are still being analysed, preliminary evidence indicates that both coral and reef fish communities throughout the islands are generally in excellent condition, highlighting the area's regional marine biodiversity significance within WA.

Information collected from these trips forms the baseline for DEC's monitoring of marine communities potentially affected by industrial activities in the Montebello and Barrow islands marine parks and reserves. Dredging on the eastern side of Barrow Island has now begun and is scheduled to continue for the next two years. The current monitoring program will continue during the next three years. Further field surveys will be conducted at regular intervals during this period and will be used in tandem with information collected by the private sector to monitor developmental impacts on the local ecosystem. This program will be integrated into the State-wide marine parks and reserves and threatened marine fauna monitoring programs currently being developed and implemented by DEC's Marine Science Program.

Marine turtles

The largest of the offset programs is the Northwest Shelf Flatback Turtle Conservation Program. One aspect of this program is the survey, monitoring and research into flatback turtle populations on the Northwest Shelf. Additionally, the project aims to minimise interference to key feeding



Left Oil storage tanks on the east coast of Barrow Island. This beach is one of the main flatback turtle nesting sites.
Photo – Fran Stanley/DEC

Below Lorna Glen project officer Judy Dunlop with a golden bandicoot, one of several species being reintroduced to parts of its former range in the rangelands.
Photo – Brent Johnson/DEC



and breeding locations. There are also plans for education and communication programs to support marine turtle protection. This long-term program will be developed during 2010, and will begin to be implemented in 2011.

Offset funding is also available for an intervention program which depends on the outcome of the flatback turtle conservation program on Barrow Island. If necessary, this intervention program will work to improve recruitment to this turtle population, through such measures as the establishment of a hatchery.

Net conservation benefits

The second set of conservation programs to be funded by the Gorgon Joint Venture are those that deliver 'net conservation benefits'. These are defined as demonstrable and sustainable additions to, or improvements in, biodiversity conservation values in WA.

Net conservation benefits for the Gorgon project also include the requirement to target, where possible, the biodiversity conservation values affected or occurring in similar bioregions to Barrow Island. Under the agreed biogeographical regionalisation for Australia, Barrow Island falls within the Cape Range subregion of the Carnarvon bioregion. The adjacent Gascoyne and Pilbara bioregions are considered to be similar to the Carnarvon bioregion. The $60 million being provided to fund net conservation benefits over about 30 years will enable at least two major projects to be undertaken, which could include the restoration of native fauna, habitat improvement and forging new partnerships with Aboriginal people and industry.

With many projects already well under way, and plans for some large and exciting ones still to come, managing the environmental offset and net conservation benefit projects for the Gorgon project is a mammoth undertaking. It is hoped the projects will help to maintain the biodiversity values of Barrow Island and its status as an island that has remained free of many of the processes that have threatened the Australian mainland. Additionally, they will enable some truly significant conservation projects to be undertaken elsewhere in the State.

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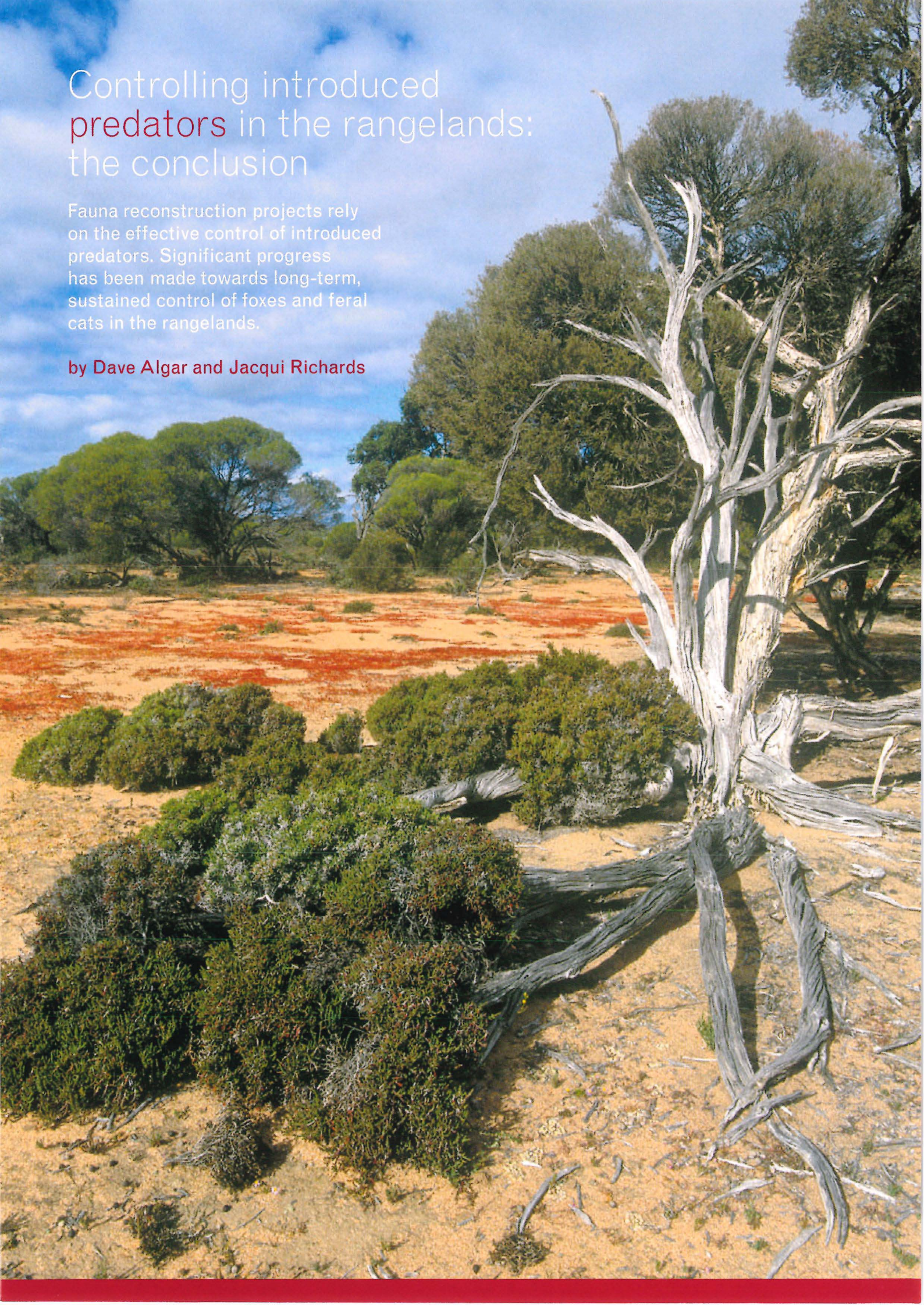
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Controlling introduced predators in the rangelands: the conclusion

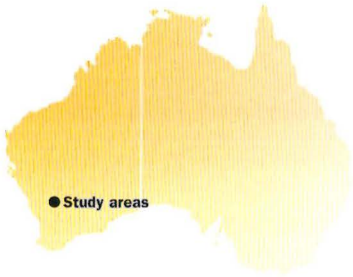
Fauna reconstruction projects rely on the effective control of introduced predators. Significant progress has been made towards long-term, sustained control of foxes and feral cats in the rangelands.

by Dave Algar and Jacqui Richards



Significant projects are under way to restore fauna diversity to reserves and former pastoral leases in Western Australia's rangelands, often involving the translocation of threatened native fauna species from other areas in the State (see 'Giant steps: industry and conservation make history through Gorgon' on page 10). The success of projects such as these relies on the control of introduced predators, particularly the feral cat and fox.

Initial successes were achieved during 2006 and 2007 in controlling feral cats and foxes in the southern rangelands of WA (see 'Controlling feral animals in the rangelands', *LANDSCOPE*, Autumn 2008). This was part of a collaborative project between the Department of Environment and Conservation (DEC) and the Australian Wildlife Conservancy (AWC), in partnership with the Invasive Animals Cooperative Research Centre (IA CRC).



The project undertook to develop an effective, landscape-scale and cost-efficient baiting strategy for introduced predators in this region, and its success could see DEC's *Western Shield* program aiming to achieve the successful reconstruction and conservation of biodiversity expand to the rangelands. Long-term, sustained control of introduced predators means fauna can be translocated. This project follows successful research programs and operational feral cat baiting trials conducted in the interior arid zone at the Gibson Desert Nature Reserve and more recently at Lorna Glen, a former pastoral lease station 150 kilometres north-east of Wiluna (see 'Into the wild: restoring rangelands fauna', *LANDSCOPE*, Winter 2009).

The feral problem

Feral cats and foxes have become widespread across the mainland of Australia since their arrival with European settlers. Cats are believed to have been introduced around 1800 and foxes in the 1870s. Predation by feral cats and foxes is recognised to be one of the major threats to the survival of many threatened mammal and bird species. Management of these introduced predators is now generally viewed as critical to successfully reintroduce, recover or maintain populations of small-to-medium-sized native fauna.

Previous page
Main Rangelands, Mt Gibson.
Photo – Marie Lochman

Below Former pastoral lease, Karara Station–one of the study sites.
Photo – Stefanie Hilmer/DEC



The field-based research project started in 2006 and was completed in mid-2009. It was conducted at DEC's reclaimed pastoral leases of Karara and Lochada, purchased for the creation of conservation reserves, and at AWC's nearby Mt Gibson Wildlife Sanctuary. The study sites are approximately 350 kilometres north-east of Perth. Karara and Lochada pastoral stations cover an area of about 2,000 square kilometres, while Mt Gibson is about 1,300 square kilometres.

For the first two years, Karara-Lochada was used as the 'control' or non-baited site and Mt Gibson was used as the 'treatment' site, where introduced predators were controlled with an annual aerial baiting. In 2008 and 2009, baiting was also implemented at Karara-Lochada, replicating the baiting regime conducted at Mt Gibson. While this meant removing the control site, it was hoped that this addition would determine whether the baiting strategy trialed at Mt Gibson was also effective at Karara-Lochada, where introduced predator numbers were far higher.

Taking the bait

Feral cats do not readily take the baits widely used to control foxes and wild dogs. However, foxes and wild dogs readily take feral cat baits (*Eradicat*®). This means cat baits could be used for controlling both feral cats and canids. *Eradicat*® baits used in this project and earlier baiting campaigns in the arid zone have been developed and produced by DEC specifically for the control of feral cats. The baits are made at DEC's bait manufacturing facility at Harvey and use the 1080 poison derived from the native poison pea plant.

The hypothesis tested was that effective and sustained introduced predator control was achievable using a feral cat baiting 'strategy'—a baiting approach based on specific timing, intensity and frequency. This strategy involves an annual baiting program, conducted in June to August, using *Eradicat*® baits distributed at a density of 50 baits per square kilometre. Previous research has shown that baiting programs for feral cats are most effective during the cool, dry winter periods. At this time, the abundance and activity of all prey types—in particular predator-vulnerable young mammals and reptiles—is at its lowest, and bait degradation due to rainfall, ants and hot, dry weather is significantly reduced.



Above Fox.
Photo – Stefanie Hilmer/DEC

The plan was to determine the impact of this baiting strategy on feral cat and fox numbers. Predator reinvasion and distribution was monitored to show how effective the strategy was over time and whether there was a need for additional control programs for individual species throughout the year.

Baiting successes

Surveys of introduced predator activity in 2006, before the start of the baiting strategy, indicated that both fox and feral cat activity were much greater at Karara-Lochada than Mt Gibson. At Mt Gibson, cat activity was much higher than for foxes, possibly due to previous fox baiting programs undertaken by AWC.

The first aerial baiting program was conducted across Mt Gibson in winter 2006. A comparison of introduced predator activity measured before and after baiting indicated a highly effective campaign with no fox tracks recorded immediately following baiting. A 95 per cent reduction in feral cat activity was also recorded. At the same time, activity indices for foxes and cats at the non-baited Karara-Lochada site remained relatively stable.

Successes recorded after the first baiting program were again demonstrated in the second year (2007) at Mt Gibson, with an 85 per cent reduction in fox activity and no records of feral cats. Interestingly, cat activity at Karara-Lochada also declined by 60 per cent in conjunction with an increase

Sand plots and sticky wickets—how the survey was done

Eight track survey transects were located at each of the two study areas, each comprising 11 sand plots located at one-kilometre intervals. The survey transects ran along existing tracks and provided a broad coverage of each area. The sand plots contained several lures to entice animals to cross the plot and thereby maximise the number of plot visits for each survey period. The plots containing lures were termed 'active plots'. Sand plots that contained no lures—'passive plots'—were located each half-kilometre in between. Each plot consisted of a metre-long patch of sand that extended the width of the track. Both ends of the plot were blocked by fallen brush or trees, thereby forcing animals to walk across the plot. At active plots, a channel was cleared into the vegetation at one end of the plot and the lures were located in the channel.

Each plot was examined for the presence or absence of feral cat and fox tracks, on four consecutive days during each survey period. The animal track activity information collected was used to calculate 'activity indices' for both species. The efficacy of the baiting program was then assessed by comparing these indices immediately before and following individual baiting programs.

Activity at the same sand plots was also measured at seasonal intervals (in October, December and April) in addition to the baiting period (June to August) to provide information on the rate and extent of reinvasion into the baited site. In 2008 and 2009, an additional survey was conducted at the end of summer or in early autumn to determine the best time to consider conducting an additional fox baiting program.

During the project, a new technique was developed which significantly increased the information available to researchers. The technique—known as the 'sticky wicket'—involves putting double-sided tape on posts at the entrance to the active sand plots which snags hair as animals brush past to reach the lures. DNA can then be extracted from the hair, without actually having to trap the animals.

Hair capture from foxes was conducted for the 2008 and 2009 survey periods at the Karara-Lochada site. The amount of hair collected enabled good DNA extraction back in the laboratory and the samples to be genotyped well. This technique now enables collection of data to identify specific individuals at plots, which can, in turn, provide estimates of population size in the region, a measurement that has proven nearly impossible for researchers to acquire in the past.

in fox activity. After examining the data, questions arose: Were the active plots being monopolised by foxes and therefore having reduced visits by feral cats? Or was this decrease in cat activity a real decline in abundance? Reduced cat track activity at the passive plots, which were only crossed as part of normal movement patterns, suggested that cat numbers had in fact declined.

In 2008, the third annual winter baiting program was conducted at Mt Gibson and, for the first time, at Karara-Lochada. Fox activity was substantially reduced at Mt Gibson and also at Karara-Lochada following the baiting program. The new technique of DNA analysis of collected hair samples from Karara-Lochada now made it possible to identify individual animals at sand plots and calculate more robust estimates of abundance (see box above). These estimates demonstrated a major reduction in fox numbers following the 1080 baiting program. Unlike the reductions observed in fox activity, the third baiting program appeared to have no significant impact on feral cat activity at either site.

Watching the weather

It is thought that a major rainfall event that occurred immediately after baiting in 2008, dumping more than 20 millimetres across both sites, may have caused the different response by foxes and feral cats to the baiting program. This rain would have made the baits unpalatable to cats. The foxes' propensity to eat any and all baits they encounter is likely to be the reason why major reductions in fox activity at both Mt Gibson and Karara-Lochada were achieved following baiting, despite the rain. Bait longevity in the field, baiting intensity and bait distribution therefore become critical components in developing successful baiting campaigns to target feral cats.

The final baiting program of the project was conducted in the winter of 2009 in the absence of any rainfall events. This baiting resulted in major reductions in activity of both feral cats and foxes, as displayed in the first two baiting programs at Mt Gibson.



Above A 'sticky wicket' set up at a monitoring plot.
Photo – Stefanie Hilmer/DEC

Reinvasion

The results of the project suggest that fox and feral cat activity could be substantially reduced for a number of months after each winter baiting. These predator indices, particularly for foxes, gradually increased during the late summer and autumn, the main dispersal period for juvenile foxes. But were these increases actually due to an increase in the number of foxes or was it just an increase in fox activity? Perhaps foxes were moving more throughout the landscape as vacant territories became available.

Analysis of DNA from the fox hair snagged at Karara-Lochada during the latter two years of the project confirmed that reinvasion was occurring principally during late summer and autumn. It also showed that these animals tended to range further than adult foxes resident in a non-baited area. The individual data suggested that fox numbers were increasing but, at the same time, those foxes were displaying an increase in activity as hair from individuals was being collected more widely.

Feral cat reinvasion following the baiting programs appeared to occur at a much slower rate. It remains unclear whether this is because the cat social structure is more complex than that of foxes, with juveniles often remaining within the natal home range for longer, or because feral cats do not disperse as far.

An effective control tool

Over its four-year duration, the project has demonstrated that the sustained control of foxes and feral cats in the rangelands can be achieved using a feral cat baiting strategy. Since the initial 2006 baiting program at Mt Gibson, feral cat activity has never



Above Feral cat.
Photo – Jiri Lochman



Left Baits being sweated–a process to make them most palatable to cats.
Photo – Dave Hawke/DEC

recovered to its original level. Indices of fox activity crashed following each baiting and their numbers remained low until late summer or autumn, when juvenile foxes disperse and reinvade, the extent of which varies annually.

The picture is less clear for feral cats at Karara-Lochada, where indices of activity decreased before the introduction of the baiting program. However, implementation of the baiting program during the latter two years of the project possibly prevented the population from increasing and, in fact, reduced cat activity to zero following the final 2009 baiting program. As at Mt Gibson, major declines in fox abundance at Karara-Lochada were achieved following baiting and limited increases in their numbers occurred during the juvenile dispersal period.

The project demonstrated the importance of using long-term weather forecasts to ensure baiting programs are conducted only when prolonged periods of fine weather are assured. An operational protocol has now been established within DEC and AWC to minimise the possibility of poor baiting outcomes due to adverse weather conditions.

It was also decided that predator control could potentially be enhanced with additional baiting using fox baits during autumn. The additional baiting would not only reduce fox numbers during the key dispersal period, but also suppress fox numbers until the subsequent *Eradicat*® baiting in winter. This would increase bait availability for feral cats and therefore bait effectiveness during the annual winter baiting. Ongoing monitoring of introduced predator abundance will determine the need to conduct individual baiting programs at each location. The impact of reinvasion by foxes and particularly feral cats can also be mitigated to some extent by increasing the size of the area baited. This will essentially provide a buffer zone around a core area of conservation significance.



Right Hair samples collected on a 'sticky wicket' helps in the identification of individual animals.
Photo – Neil Hamilton/DEC

The way forward

Routine monitoring of feral cat and fox abundance is a critical component of AWC's conservation programs, and in the operational management of DEC's *Western Shield* program. One of the major outcomes of this project was the development of the 'sticky wicket' technique. Trapping feral predators has always been a notoriously difficult task and so the ability to identify individual animals from DNA extracted from snagged hair is particularly significant. This data provides the ability to identify specific individuals at plots and provide more accurate estimates of population size and home ranges. Researchers can now examine how well indices of relative abundance—such as presence at sand plots—reflect true abundance. It is possible to use this information to help interpret sand plot data and improve the robustness of the technique.

This project has gone a long way towards demonstrating that long-term, sustained control of feral cats and foxes can be achieved in the rangelands. Some native species, such as mala (*Lagorchestes hirsutus*) and greater stick-nest rats (*Leporillus conditor*) may possibly survive only when introduced predators are completely absent—these species will need offshore and 'mainland islands' (fenced areas) to survive. However, a large number of native species can survive if the densities of predators are reduced (rather than their populations being totally eliminated). If it is possible to successfully control introduced predator densities over large areas, the door will be open for a number of fauna reintroductions, helping to build resilience in the populations of many native species. The integrated feral cat and fox baiting strategy and techniques developed by DEC, AWC and the IA CRC during this program will help make this vision a reality.

One of the next major challenges is to determine whether this integrated feral cat and fox baiting strategy can be extended to the south-west of WA.

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The Invasive Animals Cooperative Research Centre (IA CRC) aims to counteract the impact of invasive animals in Australia through the development and application of new technologies and by integrating approaches across agencies and jurisdictions. Its website (www.invasiveanimals.com) provides information about IA CRC programs.

The authors wish to thank the many staff from DEC, AWC and volunteers involved in the project during the past four years, particularly Neil Hamilton, Mike Onus, Jim Rolfe, Stefanie Hilmer, John Angus, Craig Stephens, Trish Gardner and Phil Boglio.

Manjimup and the Muirs



The Muir family name is intertwined with the history of Manjimup. From being the region's first European pioneers to the shaping roles their descendants have played in this farming and forestry town in the south-west of our State, they are the keepers of a wealth of knowledge. Held in the hearts and minds of people who have been living and working on the land for decades, this great store of wisdom goes beyond the limits of conventional science.



by Joanna Moore

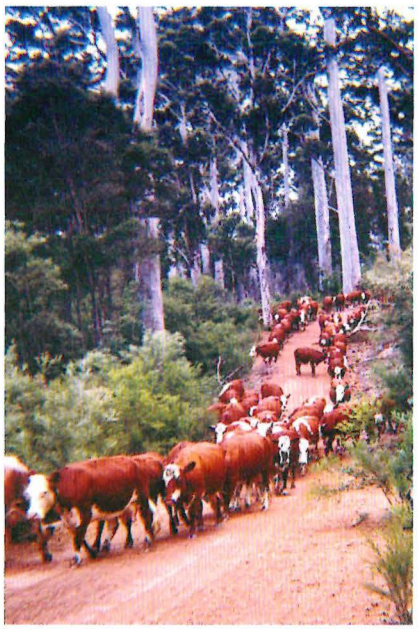
For long-time Western Australians, especially those of us from the south-west, the name 'Muir' is synonymous with knowledge and love of the natural environment. The members of this pioneering farming family were the first Europeans to settle in the Manjimup district. Today, their descendants continue to live in the area and their connection to the environment endures in both farming and conservation traditions.

Andrew and Elizabeth Muir and their four sons and two daughters arrived in Fremantle on 18 January 1844. The family eventually settled at 'Forest Hill', 30 kilometres west of Mount Barker in 1851. From Forest Hill, the Muir sons and their partners ventured north and west from Mount Barker in search of good sheep grazing and new challenges. Their properties—mostly located along the route they established which is now known as the Muir Highway—included Marbalup, Moolicup, Lake Muir and Deeside. Three sons even ventured as far away as Eucla–Moopina to try their luck at opening up this area in the 1870s (see 'Eucla pioneers: sand and salt water', *LANDSCOPE*, Autumn 1998.)



The Muir pioneers received invaluable help from local Aboriginal people in their explorations of the land. Lake Muir, for example, was 'discovered' by Andrew and Elizabeth's sons Thomas and John and named after the family, following the Aboriginal people's talk of the 'big water' to the west, towards what is now known as Manjimup. In 1856, members of the family established holdings and built a two-roomed paperbark hut on the edge of Lake Muir at Nabagup (an Aboriginal name that means 'place of the cobbler'). Thomas, the first European to settle in the Manjimup area, established a farm at Deeside in 1856, further down the Perup River.





Botany and bush tucker

The Muirs were keen explorers and observers of natural history and made some worthwhile contributions to botanical collections. In about 1872, Thomas Muir started corresponding with Government Botanist in Melbourne Baron von Mueller, to whom he sent local plant specimens. In August 1873, von Mueller named a rope rush found near Lake Muir *Lepyrodia muirii*, in recognition of the Muir's contribution to the botany of the area. When Thomas and Andrew Muir hosted von Mueller at Deeside and Lake Muir in 1877, they took him to the Nornalup coast where he could see the beautiful red-flowering gum (*Eucalyptus ficifolia*) in the location it was first collected.

The Muirs made good use of local plants. Marri gum was used to tan kangaroo skins for rugs, dingo and sheep skins for floor mats and cattle hides for leather from which to make boots and harnesses. Tea was often in short supply but a native tree made an acceptable substitute.

Their Aboriginal playmates taught the Lake Muir children how to find

Previous page
Main Andrew and Jim Muir drove cattle through what is now the Shannon and D'Entrecasteaux national parks.

Above Cattle near Squirts River.

Left Old hut.
Photos – Muir family collection



Right Balga (*Xanthorrhoea preissii*). *Photo – Brett Dennis/Lochman Transparencies*



Bottom right Bardi grubs were eaten by the local Aboriginal and Muir children. *Photo – Jiri Lochman*

honey. They would insert a down feather into the back end of a bee and then track the feathered bee back to its home. Balga rushes were used to make a fire to smoke out the bees so the honey could be retrieved. Native bees are harmless but they found that the introduced ones carried a painful sting.

According to Jim Muir, great grandson of the original settlers Andrew and Elizabeth Muir, who has farmed and lived in the Manjimup area for his entire 89 years:

> "They say that in the early settlement of the Swan River, people used to chop the green reeds out of a balga and the bottom of these reeds or the white part was used as a vegetable. They ate it raw. It was pretty tasteless really but that's what they did. There's a fat white grub that can be found in the balga called a bardi grub; and these taste good. My kids would eat them as fast as I could cook them—on burning balga rushes. They taste something like the fatty end of a chop and it is real good tucker! The Aborigines and the hunters ate them." (*Battlers, Bushmen and Drovers*)

Changing ways of being in the bush

Jim has some interesting recollections of how life in the bush, and the bush itself, has changed over the decades. He has seen the forest structure change dramatically since the 1930s. His understanding, developed over decades of living and working in the bush, is that regular fire over a long period of time shaped the ecology of the south-west. Historically, low-intensity fires lit by Aboriginal people or caused by lightning occurred as frequently as every three to four years, or as often as the bush would burn.

Regular burning developed a mosaic of burnt and unburnt country which stopped wildfires from developing. From what he observed, the small, low-intensity fires were beneficial to the







Left Horse riders greet the Southern Ocean.

Centre left Rustic accommodation on a horse riding tour through Shannon National Park.
Photos – Muir family collection

Below left Foxes were first seen near Lake Muir around 1932.
Photo – Jay Sarson/Lochman Transparencies

forest's ecology as they encouraged new growth and stimulated plants to flower and fruit. For example, Jim noticed that the balga (*Xanthorrhoea* sp.) would flower regularly when burnt, usually every three years, but not for 10 years without a burn. He also noted that:

> "... we don't get karri honey much these days. It is because of very little fire in the forest. It was regular fire that promoted the flowering of the karris... The emu bushes are the same. If they are burnt they will generally flower and have fruit the next year, but with no fire they will grow tall but you'll find no flowers or fruit."
> (*Battlers, Bushmen and Drovers*)

In Jim's view, Aboriginal people were near perfect ecologists. Fire was their primary form of land management, a technique that would shift dramatically with the arrival of European settlers and foresters, particularly after 1929 when a decision was made by foresters to ban burning of the bush. Decisions such as these were often based upon Eurocentric understandings of forest structure and function, not knowledge of the very different south-west forests. This understanding has improved significantly since those days and forest and fire management now reflect it.

Each summer between the 1860s and early 1980s, the Muir family drove cattle down to their holding on the coast, through land now in the Shannon and D'Entrecasteaux national parks. When this tradition ended with the declaration of the parks, two of old Thomas Muir's great grandsons, Thomas junior and Jeff Muir, started offering horse riding tours through the Shannon National Park—a business which still operates today, though no longer run by Muir descendants.



Above Brush-tailed phascogale—a threatened species which may benefit from the control of feral animals in the south-west.

Right Red-tailed black cockatoo—another threatened species in the State's south-west.
Photos – Jiri Lochman



Store of oral knowledge

Over the decades, Thomas has built up an understanding of environmental issues in the area and a rich knowledge of how things have changed.

It is important that the knowledge of local naturalists and 'bushmen' whose forebears have lived on the land for many decades is not lost. Conventional science rarely taps into these environmental credentials, but they can make an important contribution to conservation and also to the attitudes of future generations to the land and its careful management.

Farmers such as Thomas can also provide a historical perspective about the arrival and spread of new weed species, observed changes to salinity and water levels and changing populations of rare animals and birds. For example, a large population of the red-tailed black cockatoo lives on Thomas's property and in the surrounding forest and comes down to the water trough near the house in the evening to drink. The threatened Carnaby's black cockatoo also visits sometimes.

The recent decline of the woylie (*Bettongia penicillata*) is one conservation issue which is raising significant concern among scientists and conservationists (see 'Down but not out: solving the mystery of the woylie population crash', *LANDSCOPE*, Winter 2008). Thomas recalls stories of previous population crashes in the species, such as in the 1940s, which suggest there may be a cyclical nature to the phenomenon.

Meanwhile, 89-year-old Jim has some interesting recollections about feral animals in the Manjimup area. He describes how rabbits first came to Deeside in the early 1930s, increasing to plague proportions in just a few years. They caused massive damage—eating out both farming pastures and bushland grass—and farmers tried a range of methods to kill them including poisoning, fumigating, trapping, ripping burrows and fencing. He remembers the introduction of the myxomatosis disease in 1952, which dramatically reduced rabbit populations until they began to develop immunity. Jim also recalls that his brother Andy noted in his diary in 1932 that a fox had been caught at Nabagup near Lake Muir.

Jim's anecdotal evidence about animal populations also includes recollections of native species, such as bilbies and marron. Jim remembers that marron were plentiful in the 1920s and 1930s before their numbers declined through increased fishing and the introduction of perch and trout. Jim also remembers when kookaburras were introduced into WA from Victoria in about 1917 with the hope that they would reduce the number of snakes. Unfortunately, they had no natural enemies and he describes how populations of small birds, lizards, frogs and small mammals dropped, predated upon by the introduced kookaburras.



Above The numbat is one of several species which DEC's *Western Shield* program aims to help recover through feral animal control.
Photo – Jiri Lochman

In Jane Muir's book *Battlers, Bushmen and Drovers*, Andy Muir commented that in his youth you could catch 70 or 80 marron in an hour with a snare on a stick. He also notes that:

> "Over the last few years there have been kangaroos going blind—this was unknown in my younger years. I can remember snakes in their hundreds, mostly dugites. Tiger snakes were very rare in my younger days. There are plenty now especially around swamps and rivers."

Western Shield

Thomas describes the Department of Environment and Conservation's (DEC's) *Western Shield* program as highly successful. The *Western Shield* wildlife recovery program aims to bring native animals back from the brink of extinction through the control of pest species such as foxes and cats and, in some locations, the reintroduction of native animal populations. In the Manjimup area, poison baits for foxes and cats are regularly laid and Thomas can testify to their effect.

Before *Western Shield*, Thomas said foxes were catching dozens of small bird, reptile and mammal species in the Manjimup area. After the program started, Thomas increasingly saw animals and birds in the bush, including the numbat (*Myrmecobius fasciatus*), chuditch (*Dasyurus geoffroii*), white-breasted robin, brush-tailed phascogale (*Phascogale tapoatafa*), goannas and possums. During his lifetime, about 50 years, Thomas has gone from seeing these animals very rarely, to observing them frequently in the bush surrounding his farm, Wattle Glen, which is about 40 kilometres east of Manjimup.

A continuing tradition

The Muir forebears' concern for the environment has continued with a number of Muir descendants sharing their interest in nature with others through their careers and eco-tourism businesses. John Thomson, who married Ethel Muir from Deeside, was selected in 1917 as one of just two successful applicants for the first forestry apprenticeship ever offered by the WA Forests Department (one of DEC's predecessor departments). He devoted his life to the care of the south-west forests and, in his retirement, became an outspoken conservationist.

Raised in the south-west forestry settlements, Ethel (nee Muir) and John Thomson's son Andrew Thomson also contributed significantly to environmental causes. Following a career in teaching, he spent his retirement caring for the bush environment.

Ross and Gary Muir from the Lake Muir family take tourists on interpretive cruises in the Walpole and Nornalup Inlets Marine Park, surrounded by the magnificent Walpole-Nornalup National Park. Janine Liddelow, daughter of Prudence Liddelow (nee Muir) is a district flora officer at DEC's Walpole Office. Bill Muir is a senior technical officer at DEC's Woodvale Research Centre.

Remembering to get amongst it

How we value our bushland is tied up with how we experience it. While the way people live and work on the land has changed dramatically since the pioneering days, there's still much we can take from the old stories. Most of all, we can learn about the importance of getting amongst the bush to really appreciate and understand it. Turn off the engine, get out of the car, perhaps try to imagine you are one of the first pioneers arriving in our south-west. What an amazing place you've just arrived in.

Joanna Moore is a DEC publications officer and *LANDSCOPE* editor. She can be contacted on (08) 9389 4003 or by email (joanna.moore@dec.wa.gov.au).

The author would like to thank Thomas Muir of Wattle Glen and Jim and Alison Muir of Manjimup for sharing their knowledge and recollections as well as Carolyn Thomson-Dans, who is a DEC special projects officer and Muir family descendant. Information has also been sourced from *Settler Footprints from Star – Muir Family: Pioneers of the South West and Eucla, Western Australia 1844–2005* by Alison Muir and *Batters, Bushmen and Drovers* by Jane Muir.

Photos from the Muir family collection.

endangered

by Tim Gamblin, Carly Bishop, Matthew Williams and Andrew Williams



Graceful sun-moth

Unless you move in entomological circles or are an attentive autumnal bushwalker, it's unlikely you would have heard of the graceful sun-moth (*Synemon gratiosa*). And yet during 2010, the fate of this rare moth may be decided when decisions regarding land development will be made which will potentially have a significant impact on the species.

In March 2010, researchers, volunteers, environmental consultants and land managers prowled through a number of Perth's urban bushland remnants with butterfly nets poised, searching for this protected moth.

The graceful sun-moth can only be observed for a few weeks each year, from mid-February through March. This small, brightly coloured day-flying moth can then be seen darting along tracks on the western half of the Swan Coastal Plain from Perth's far northern suburbs south to Mandurah and Yalgorup National Park.

There are currently few known populations of this species, which is listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and as specially protected fauna under the Western Australian *Wildlife Conservation Act 1950*. This is largely due to habitat destruction and fragmentation from urbanisation of Perth and surrounds. The remaining populations in small, isolated bushland remnants are thought to be subject to a high risk of local extinction.

Diurnal and brightly coloured, sun-moths are often mistaken for butterflies. Whereas most moths are night-flying, with 'feathery' or pointed antennae, butterflies and sun-moths fly during the day and have slender, clubbed antennae. Moths usually rest holding their wings flat to their sides, while butterflies hold them up like a sail.

For most of the year the graceful sun-moth larvae (caterpillars) live underground where they feed on the subterranean parts of only two closely related mat rushes, *Lomandra maritima* and *L. hermaphrodita*. The distribution of these plants is the major determinant of potential graceful sun-moth habitat.

The habitat of the graceful sun-moth includes much of the greater Perth and Peel areas, including many areas zoned for future development. This has created an urgent need to determine habitat and distribution of the species to resolve any potential conflict between the species' conservation and urban development.

A Department of Environment and Conservation Specific Nature Conservation Project is conducting surveys of the graceful sun-moth and its habitat to better determine its distribution and habitat requirements. This will provide essential information for its conservation. For more information about the graceful sun-moth email carly.bishop@dec.wa.gov.au.

Habitat photo by Carly Bishop, graceful sun-moth photo by David Pike

Slaughter, seabirds and ocean life

at the Abrolhos



The Houtman Abrolhos Islands offer a wealth of species diversity—on the islands where birdlife feed and breed, as well as around them in the rich marine environment.
Add to this the intriguing past of the islands and there's plenty to discover.

by Samille Mitchell
and Anthony Desmond

Travel 60 kilometres west of the Midwest coast at Geraldton and an archipelago of 192 craggy, low-lying islands, islets and rocks rises from the windswept seas. At first sight, the islands appear stark, desolate, devoid of life: seemingly covered in nothing but scrub. But venture under the water and you'll discover riotously coloured coral gardens and fish. Or visit during the seabird breeding season in spring and summer and you'll see the skies come alive with a squawking, teeming, swirling mass of birdlife.

The Houtman Abrolhos Islands, often called simply 'the Abrolhos' or, locally, 'the islands', spread north-south across about 100 kilometres of ocean. They are clustered into three main groups: Wallabi, Easter and Pelsaert. The startling array of birds, fish, marine mammals and corals make the islands one of the State's most exciting diving and nature viewing hot spots. The Abrolhos Islands are also home to the State's most infamous maritime tale—the wreck of the *Batavia*.



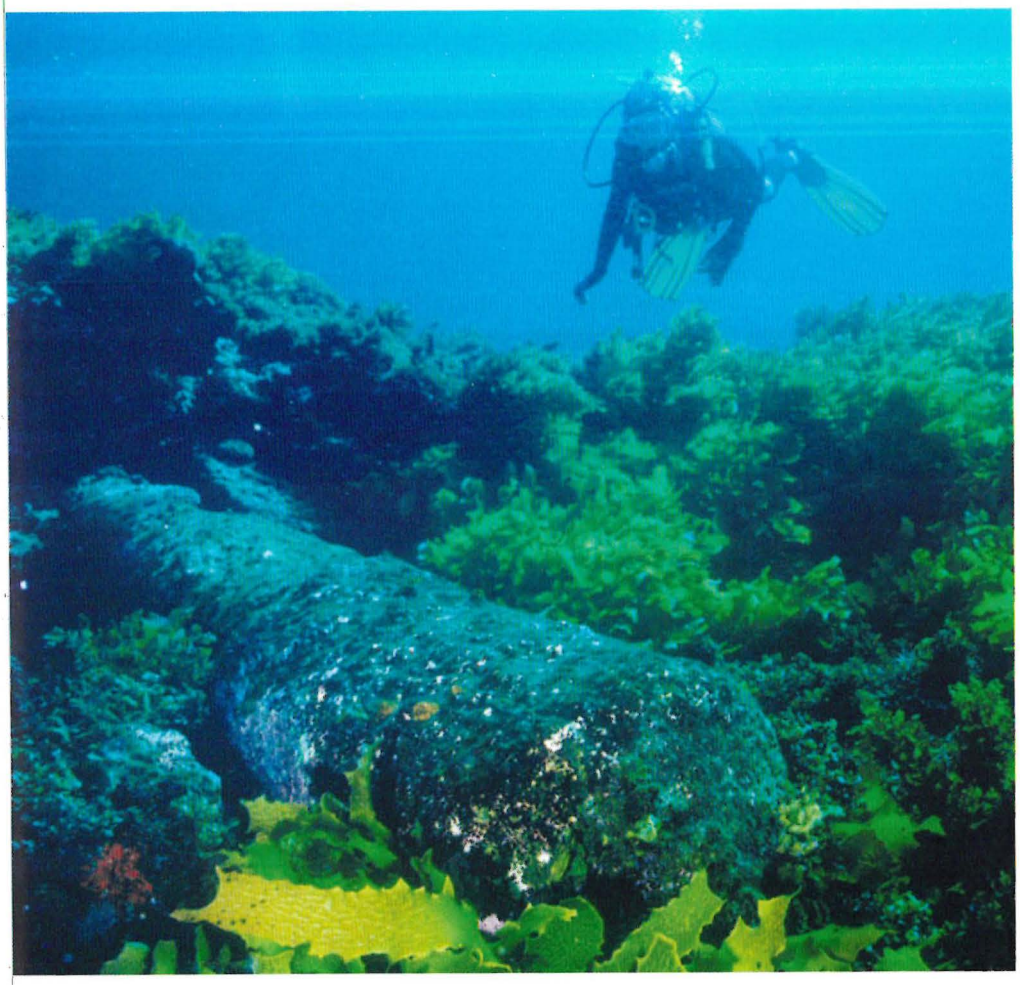
A gruesome past

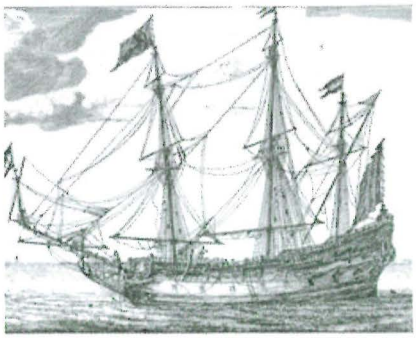
The Abrolhos is renowned as resting place of the *Batavia*, which met its demise on Morning Reef near Beacon Island in the Wallabi Group in 1629. Survivors from the Dutch East India Company sailing ship scrambled ashore the rocky isles, faced with no shelter and little fresh water or food. This was nothing compared to the horrors to come.

After ship commander Francisco Pelsaert and a small crew set sail for Batavia, now Jakarta, to seek rescue for the survivors, a group of mutineers embarked on a gruesome slaughter that resulted in the death of 125 men, women and children. Remarkably, Pelsaert returned from Batavia with a rescue team on the very day the mutineers faced a stand-off with a group of defenders, led by Wiebbe Hayes. Outraged at the slaughter, Pelsaert condemned chief mutineer Jeronimus Cornelius and several of his cronies to the gallows on the lonely isles. Two other mutineers were marooned on the mainland at a beach thought to be Wittecarra Creek in Kalbarri, making these men Australia's first European settlers.

Fast forward through the years to the 1960s and fishermen on Beacon Island in the Wallabi Group stumbled across a mass grave of the *Batavia* victims. More bodies were discovered in the 1990s—evidence of Australia's most horrific maritime tale. The wreckage of the ship, discovered in 1963, now forms a popular dive site.

Nearly 100 years after the *Batavia* tragedy, another Dutch East India Company sailing ship, the *Zeewijk*, met its demise at the Abrolhos. The ship struck Half Moon Reef in the Pelsaert Group during the night on 9 June 1727 but did not break up immediately, so many of the 208 crew were able to survive. The survivors built a second ship from wreckage and mangrove timber, enabling 82 of the crew to reach their intended destination, Batavia, on 30 April 1728.





Previous page
Main Moon wrasse.
Photo – Shannon Conway/Sallyanne Cousans Photography
Insert Lesser noddy tern
Photo – Chris Surman/Lochman Transparencies

Above Illustration of the *Batavia*.
Courtesy – WA Maritime Museum.

Left One of the encrusted cannons from the *Batavia* wreck site.
Photo – Glen Cowans



Above Western rock lobster fishing huts on Burnett Island.
Photo – Chris Surman/Lochman Transparencies



Right Western rock lobster.
Photo – Alex Steffe/Lochman Transparencies

Below Abrolhos spiny-tailed skink.
Photo – Jiri Lochman

Island isolation and livelihoods

Captain John Lort Stokes encountered artefacts from the *Zeewijk* wreckage on his journey aboard HMS *Beagle* in 1840, and the shipwreck was discovered in 1968. Stokes was also the first to note the Abrolhos's unique flora and fauna. His observations lead the endemic Abrolhos spiny-tailed skink (*Egernia stokesii stokesii*) to be named in his honour. As Darwin observed during his voyages on HMS *Beagle*, island environments cause evolutionary pressures on species, resulting in significant changes in the species' genetics, body shape and even physiology over time. The Abrolhos spiny-tailed skink is a good example of this, with differences in colour and size evident in comparison to the closely related mainland western spiny-tailed skink (*Egernia stokesii badia*).

Three years later John Gilbert, who worked for the famous naturalist John Gould, visited the Abrolhos and became the first to write of its extensive seabird population. Seabirds on the islands include several species of shearwater, tern and gull.

Much later, a guano industry started at the Abrolhos, followed by the western rock lobster (*Panulirus cygnus*) fishing industry. Today, lobster fishers and their families live on about 20 of the 192 islands during the Abrolhos fishing season from March to June each year. The Abrolhos lobster stock is regarded as highly important to the State fishery, with 40 to 50 per cent of the State's lobster spawning estimated to come from the area. The industry is worth an average of $300 million to the State each year with 15 per cent of this amount coming from the Abrolhos. Management of the rock lobster industry is based on counts of puerulus, a stage in the rock lobster life cycle. Counts undertaken during the last two years show unprecedented low numbers, indicating difficult times ahead for the industry. Scallop, finfish and black pearl industries also operate at the Abrolhos.



Natural riches

The remarkable marine life of the Abrolhos is brought about by the southward flowing waters of the Leeuwin Current which bathe the otherwise temperate zone in warmer waters. This results in an unusual mix of temperate and tropical species. The spectacular coral reefs of the Abrolhos are the southernmost significant coral reef system in the Indian Ocean. Unusually, the corals here grow in close association with temperate algae, and colourful tropical fish live alongside temperate water sea lions.



While renowned among Western Australians for its fishing and diving opportunities, the Abrolhos also has many land-based natural attractions. The seemingly uniform isles are home to a range of vegetation and landforms, including mangroves, dwarf eucalypt stands, salt lakes, saltbush flats and one priority flora species. The islands also provide refuge for an endemic bird sub-species: the Houtman Abrolhos painted button-quail (*Turnix varius scintillans*). Islands with long sandy beaches such as East and West Wallabi are important for wading birds that migrate from the northern hemisphere each year.

In addition to the Houtman Abrolhos spiny-tailed skink, the islands are home to 26 species of reptile. These include important populations of two species: the specially protected carpet python (*Morelia spilota imbricata*) and the endemic Abrolhos dwarf bearded dragon (*Pogona minor minima*).

The Abrolhos are also home to two native mammal species: the tammar wallaby (*Macropus eugenii derbianus*) and southern bush rat (*Rattus fuscipes*). The tammar wallaby once occurred over a large area of south-western Australia but is now known only from seven islands and some scattered mainland populations in the south-west of Western Australia. Survivors of the *Batavia* shipwreck recorded the wallabies on West Wallabi Island in 1629. The wallabies are thought to have survived on the islands after rising sea levels left the archipelago surrounded by sea. Abrolhos wallabies have been shown to be different morphologically and genetically between the different islands and more distinctly from populations on the mainland and islands elsewhere.

Tammar wallabies gain most of their water requirements from the foliage of the shrubs they eat, enabling them to survive on the often waterless isles. They have also been observed drinking sea water. The wallabies were introduced to North Island from the Wallabi Group of islands in 1985 and are adversely affecting the vegetation there. With few predators and food and water readily available from humans for part of the year, the population has grown beyond the capacity of what the island can support. Their grazing and trampling appear to have almost wiped out the population of the Abrolhos painted button-quail. Wallabies are being progressively removed from North Island to enable the island to regenerate.

The Abrolhos population of the southern bush rat was once found on two islands, East and West Wallabi. However, recent surveys on East Wallabi have failed to relocate the species, leading to the conclusion that this population is now extinct, though no cause is known.

Seabirds

Visit the Abrolhos during the seabird breeding season—as John

Above Tammar wallaby.
Photo – Dave Watts/Lochman Transparencies

Below Carpet python.

Below right Southern bush rat, one of the two species of native mammals found on the Abrolhos.
Photos – Jiri Lochman









Above left Lesser noddy tern.

Above Lesser noddy terns at dusk.

Below left Osprey with fish.
Photos – Chris Surman/Lochman Transparencies

Below Little tern sitting on eggs.
Photo – Dave Watts/Lochman Transparencies

Gilbert did back in 1843—and you may be overwhelmed by the sheer mass of birdlife. The Abrolhos is home to the biggest seabird breeding colony in the eastern Indian Ocean and one of the most important in the country. Pelsaert Island, in particular, comes alive with colour and sound as more than one million birds from 18 species construct more than 400,000 nests during the breeding season. There's a frenzy of activity as the birds build nests, incubate eggs, feed young and hunt in the adjacent ocean.

So significant are the bird populations that the Abrolhos is regarded as highly important to the conservation of several seabird species, including the wedge-tailed shearwater, little shearwater, roseate tern, sooty tern and fairy tern. Two tern species, the common noddy and the lesser noddy, are particularly significant, with the lesser noddy regarded as rare or likely to become extinct. In recent years growing numbers of common noddies and sooty terns have begun nesting on Lancelin Island, perhaps an indication of a changing marine environment for all tern species.

Most of the birds nest close to or on the ground, putting their nests at risk of the trampling feet of human visitors. Crested terns nest in sand in the open while roseate and fairy terns lay eggs on small stones among coral rock. Bridled terns build their nests under overhanging cliffs, low mangroves or under large slabs of coral; shearwaters dig burrows and ospreys and sea eagles build large stick nests. Common noddies nest on low shrubs and lesser noddies build on mangrove branches.

The seabirds of Rat Island were once described as numbering in their millions, but today only a handful of seabirds breed on the island. As its name suggests, the island was once infested by introduced black rats. These predators of eggs and young seabirds, along with the cats introduced to eat the rats, can be blamed for the destruction of one of the greatest seabird breeding populations in Australia. The rats were eradicated in 1991.

While boardwalks have been built on some islands to reduce trampling by visitors, the effects of disturbance of nesting birds also requires careful management. Disturbed birds vacating their nests allows silver gulls and other scavenging species the opportunity to predate eggs and young birds.

Intensive studies on terns by Dr Chris Surman have shown a close link between the breeding success of noddies and the El Nino-Southern Oscillation Index (a climatic pattern that occurs across the tropical Pacific Ocean). During 20 years of studies, there has been a progressive shift in the breeding time of the birds as their food items (small fish such as beaked salmon, black-spotted goatfish and Hawaiian bellowfish) arrive later. This climate change effect has grave implications for the future of these species, with later breeding demonstrated to be less successful.









Above left Australian sea lion.
Photo – Eva Boogaard/Lochman Transparencies

Above Clarks anemonefish.
Photo – Glen Cowans

Below left Aerial view of Beacon Island and reefs in the Wallabi Group.
Photo – Eva Boogaard/Lochman Transparencies

Underwater

Descend beneath the waters of the Abrolhos Islands and you'll be overwhelmed by a fantasia of marine life. Elaborate coral castles harbour colourful tropical fish such as clownfish, while deeper waters support many highly sought-after finfish including dhufish (*Glaucosoma hebraicum*), pink snapper (*Pagrus auratus*), coral trout (*Plectropomus leopardus*) and baldchin groper (*Choerodon rubescens*), also known locally as bluebone groper. Such species make the Abrolhos a highly desirable destination for fishers.

Recreational and commercial fishing pressure has led to the strict management of the Abrolhos's delicate marine environment. Waters here are a Fish Habitat Protection Area. Each island group also features one reef observation area—no-take zones to anyone except licensed lobster fishers. The 6,859 hectares of reef observation area are the site of long-term studies on populations of key fish species such as baldchin groper, dhufish, red throat emperor and coral trout. The studies have found that population numbers and mean lengths of these fish are in decline.



Marine mammals also abound at the Abrolhos. Migrating humpback whales (*Megaptera novaeangliae*) pass by in winter and spring, giant pods of common (*Delphinus delphis*) and bottlenose (*Tursiops aduncus*) dolphins cruise the seas and the rarely seen Bryde's whales (*Balaenoptera edeni*) make annual visits. Threatened Australian sea lions (*Neophoca cinerea*) frolic in the waters, haul out on the beaches and use the dense vegetation of the islands to raise their young.

The sea lions here form the northernmost breeding population of this species. Despite their popularity—many divers and swimmers have delighted in an encounter with an inquisitive Australian sea lion—the population is thought to number just 70 to 80 animals. The Abrolhos is estimated to have once been home to 500 to 600 of these creatures. Unfortunately, no pups have been observed in the Wallabi Group in the past 15 years. The reduced populations may be caused by entanglements in fishing gear and debris, as well as disturbance to breeding areas. The trapping of sea lions in lobster pots has been an issue in the Jurien Bay area with Sea Lion Exclusion Devices, or SLEDs, developed by the Department of Fisheries to prevent the juveniles from being caught. This issue is not known to exist in the Abrolhos.

Balancing act

An increasing number of people are attracted to the Houtman Abrolhos Islands each year, to dive among the rich fish life and coral formations, to explore the history, or to witness the beauty and birdlife. Commercial fishing brings further crowds of people whose livelihoods depend on the collection of islands, and they bring with them additional visitors.

Balancing the competing needs of a fragile yet highly important ecosystem with those of tourists and the fishing industry is no easy task. The Fisheries Minister receives advice on management from the Abrolhos Islands Management Advisory Committee (AIMAC), established in 1995. The Department of Fisheries manages the islands as a class 'A' reserve and the Department of Environment and Conservation provides advice to AIMAC on protection of the environment.



Anthony Desmond is the Department of Environment and Conservation's (DEC's) nature conservation regional leader for the Midwest, based in Geraldton. He can be contacted on (08) 9964 0912 or by email (anthony.desmond@dec.wa.gov.au).

Samille Mitchell is a DEC publications officer and *LANDSCOPE* editor.

Rare seaweed rediscovered

by John Huisman



Biologists from the Department of Environment and Conservation recently rediscovered one of the world's rarest seaweeds, ironically washed up at one of the State's most popular tourist destinations, Monkey Mia in Shark Bay. The event instigated an in-depth investigation involving taxonomists from around the world using modern forensic techniques. The results led to the recognition of the species as a new genus and finally completed a saga begun more than a century ago.



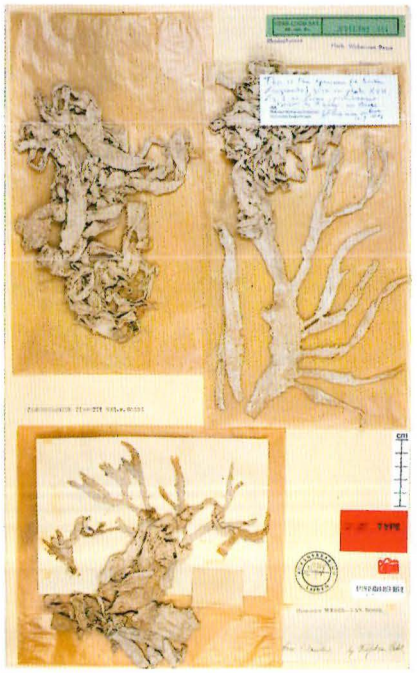
The beginning of this story about a rare red seaweed dates back 100 years, when the world and its biodiversity were markedly less well known than they are today. At the time, many countries embarked on scientific expeditions to far-flung territories, often those they governed from afar. One such voyage was the Dutch *Siboga* expedition to the Indonesian Archipelago, then known as the Dutch East Indies.

The trip spanned the years 1899 and 1900 and is rightly regarded as one of the great biological voyages of discovery. Led by the professor of Zoology at the University of Amsterdam Max Weber, the six scientific expeditioners also included his wife Anna Weber-van Bosse, who specialised in marine algae. The participation of women in such extended scientific voyages was virtually unheard of at the time, which makes Weber-van Bosse's achievements all the more remarkable.

Early seaweed discoveries

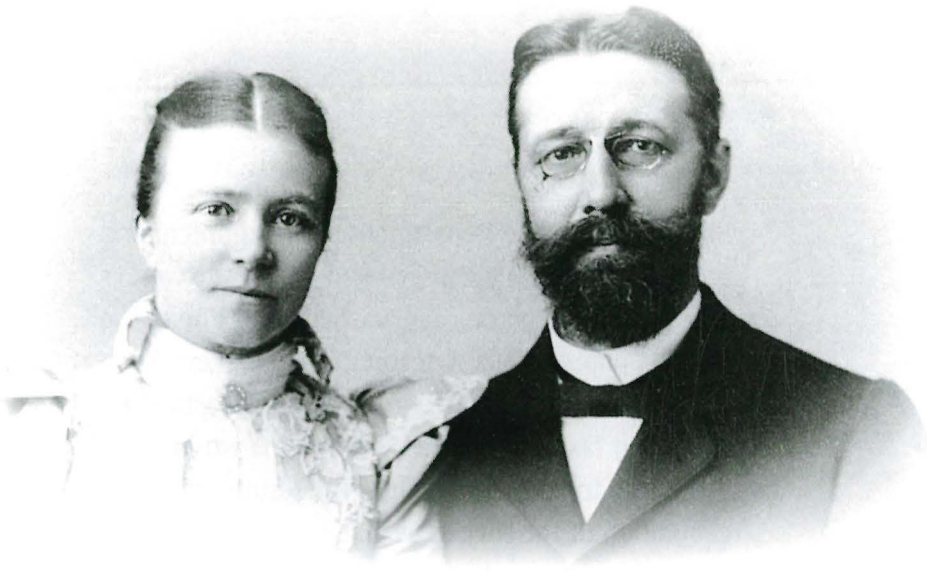
During the expedition, a large number of seaweeds was collected and these eventually formed the basis of eight monographs, recording some 555 species, of which many were new to science. In combination, these publications represent perhaps the greatest phycological (study of algae) contribution of the early 20th century. Anna Weber-van Bosse was subsequently awarded a doctorate from the University of Utrecht, the first Dutch woman to be so honoured.

Based partly on her *Siboga* collections, Weber-van Bosse described three new species of very unusual red seaweeds, which she named *Thamnoclonium treubii*, *T. tissotii* and *T. procumbens*, placing them in a genus previously known only from the colder waters of southern Australia. These species were unique in that they lived in a symbiotic relationship with a sponge, the seaweed itself not visible, hidden beneath the sponge coating. Coincidentally, some specimens of *T. tissotii* were collected from Dunk Island in Queensland in 1910 and sent to the Kew Herbarium in England, where, due to the plentiful and large size of the specimens, Kew botanist AD Cotton felt that the species "would appear to be frequent". This has not been borne out by subsequent collections, however, as *T. tissotii* has never again been seen in Queensland.



Naming dilemmas

For the next 90 or so years, Weber-van Bosse's species remained known only from these few collections. Questions were raised as to whether the species were correctly placed in the genus *Thamnoclonium*, but without



Previous page
Main Raising the trawl-net on the original research vessel *Siboga*.

Inset Dried seaweed specimen collected from Monkey Mia.

Photo – John Huisman

Top Max Weber and Anna Weber-van Bosse with local people on Boleoe Barang Island near Makassar, Indonesia.

Above The original specimen of *Thamnodonium tissotii* in the Leiden Herbarium (Netherlands).

Photo – Willem Prud'homme van Reine

Left Anna Weber-van Bosse and Max Weber, circa 1890.

Historical photos courtesy of Artis Library, Special Collections University of Amsterdam

new fertile material the issue could not be resolved. It is surprising to most people that seaweeds reproduce sexually, and in the red seaweeds the process is perhaps the most complex of all plants. It involves the nuclei of the fertilised egg cells being duplicated and transferred to numerous other cells in the female plant, from which the next generation develops. The taxonomy of red seaweeds is based primarily on the intricate details of this process, so it is often impossible to classify specimens that are reproductively immature.

Then, in the late 1980s, a population of *T. tissotii* was observed at Herald Bight in Shark Bay, many thousands of kilometres to the south of the original locations. The plants grew in drifting, entangled clusters and specimens were also commonly found washed up at nearby Monkey Mia. Unfortunately, none of the collections were reproductively mature and without these stages no new information could be added. After having not been seen for nearly a century, the rediscovery of this species was certainly welcome, but better specimens were needed.

Taxonomic investigation

Turn the clock forward to 2009 and, despite several expeditions in the interim, the all-important reproductive stages remained elusive. However, by this stage, a new tool had entered the taxonomist's kit: DNA sequencing. By comparing the unique pattern of nucleotide bases in fragments of DNA, taxonomists, much like forensic biologists matching the DNA of criminals, can establish how closely related each species is and, from that knowledge, propose how these species fit within a larger evolutionary history. Using this technique, the nagging questions about the taxonomic placement of these species of seaweed could potentially be answered. However, this procedure can only be undertaken with relatively fresh specimens. So, once again, the hunt was on.



Above One of the specimens collected from Monkey Mia.

Below right A transverse microscopic view of the seaweed's surface, showing the seaweed coated with sponge tissue.

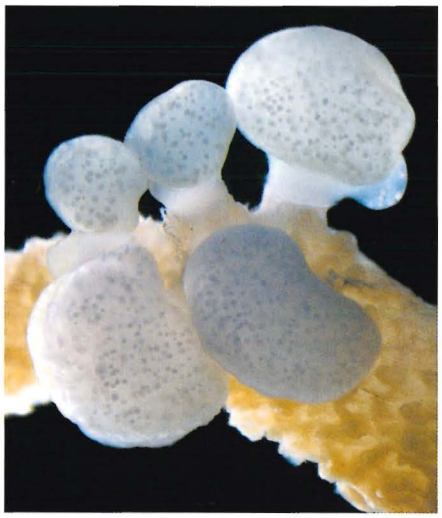
Below left The fertile branches of the seaweed, which penetrate through the sponge tissue.

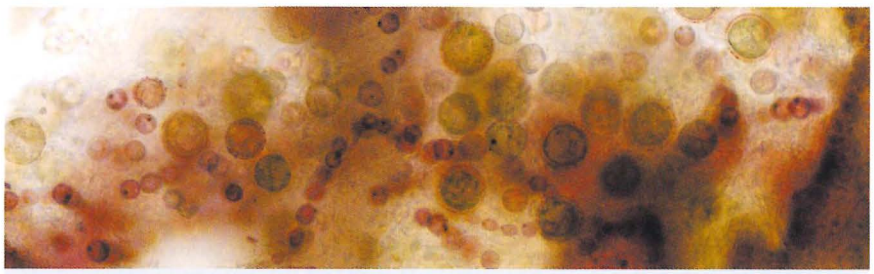
Photos – John Huisman

A fertile search

Fortunately, patience is often rewarded. In 2009, a Department of Environment and Conservation expedition to Shark Bay, primarily undertaken to study mangroves (see 'Marvellous Mangroves', *LANDSCOPE*, Summer 2009–10) provided an opportunity to search once again for the elusive seaweed. The first days proved fruitless, but, in perhaps the most unusual twist in this tale, a drift specimen was found on the Monkey Mia boat ramp, wedged under the wheel of the trailer as the boat was being pulled from the water! A walk along the beach yielded a further 10 specimens, including the much-needed fertile plants.

Some of the fertile plants were sent to Belgian botanist Olivier De Clerk, an expert in this group of seaweeds. There, their DNA was sequenced, ultimately proving that the species were only remotely related to true *Thamnoclonium* and that a new genus was needed to accommodate them. This genus is yet to be named, but, after more than a century, the book can finally be closed on Weber-van Bosse's enigmatic species.





John Huisman is a phycologist (seaweed specialist) who holds a joint appointment with the Department of Environment and Conservation's Western Australian Herbarium and Murdoch University. He is currently writing a book describing WA's tropical marine plants and also has interests in marine biosecurity. He can be contacted on (08) 9334 0585 or by email (john.huisman@dec.wa.gov.au).

The author thanks Jip Binsbergen, Willem Prud'homme van Reine and Michael Wynne for their assistance in obtaining historical photographs.



feature park by Samille Mitchell

Dryandra Woodland

Dryandra Woodland is one of the best places in the State to see rare native mammals. You can get up close to witness the little-seen antics of small marsupials at Dryandra's Barna Mia Animal Sanctuary interpretive facility and viewing enclosure.

Above Dryandra wandoo woodland.
Photo – Marie Lochman

Opposite page
Above top Numbats, Western Australia's faunal emblem.
Photo – Jiri Lochman

Above right Woodcutter's cottage.

Far right Cowslip orchids.

Right Blue beard orchid.
Photos – Sallyanne Cousans

Barna Mia Animal Sanctuary and surrounding Dryandra Woodland protects 28,066 hectares of native vegetation and threatened animals within a sea of agricultural landscape. The 17 blocks that make up the reserve provide islands of habitat for species that have been otherwise wiped out through land clearing and other pressures. Among these species is the State's faunal emblem—the numbat (*Myrmecobius fasciatus*).

Natural attractions

While clearing elsewhere in the area has resulted in the local disappearance of six mammal species and the presumed extinction of three mammal species, Dryandra continues to harbour 24 of the 46 species of native mammal that occur in the Wheatbelt.

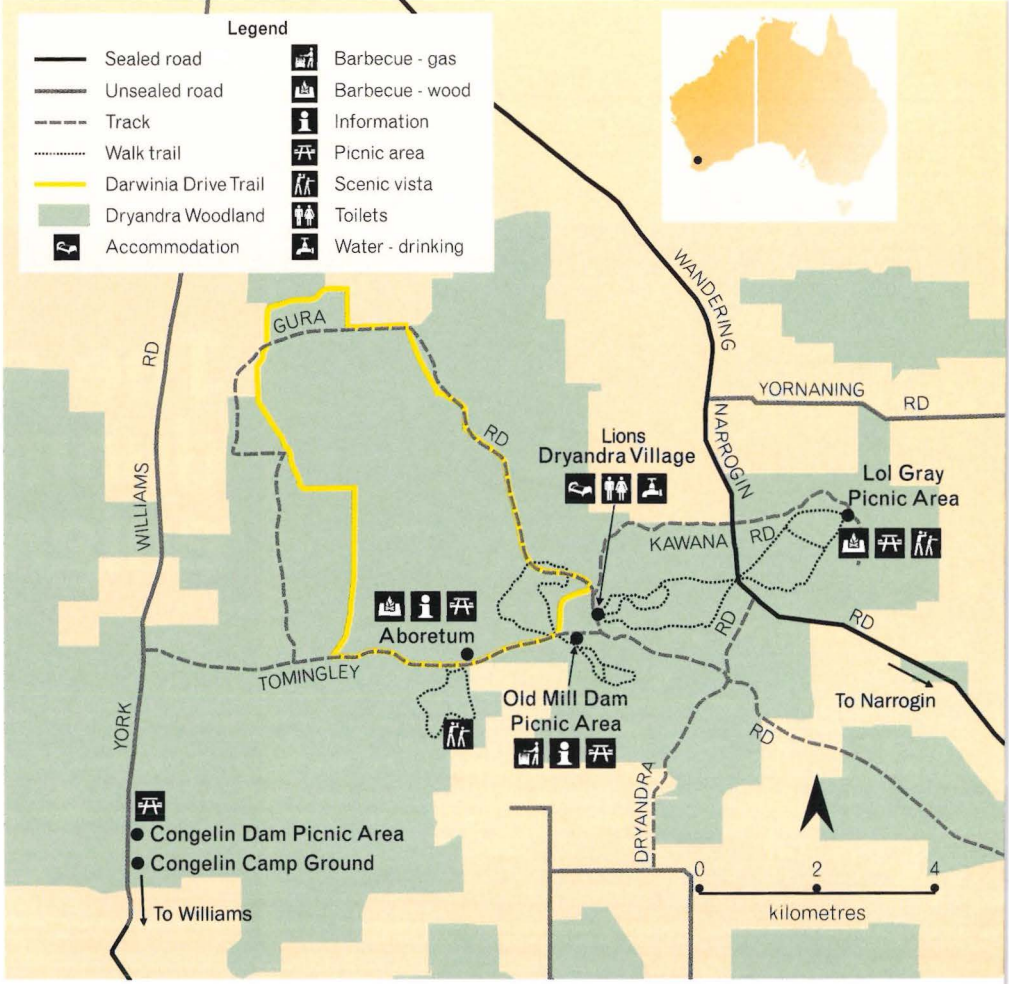
These populations are supported by the Department of Environment and Conservation's (DEC's) nature conservation project *Western Shield*, which involves baiting the area for foxes which prey on native animals. As a result of this work, threatened species such as the numbat, woylie (*Bettongia penicillata*), bilby (*Macrotis lagotis*), tammar wallaby (*Macropus eugenii*), chuditch (*Dasyurus geoffroii*) and red-tailed phascogale (*Phascogale calura*) survive here. Numbat populations here represent nearly half the total number of the species. The woodland also has populations of rarely seen species such as honey possums (*Tarsipes rostratus*) and western pygmy possums (*Cercartetus concinnus*).

A sub-program of *Western Shield*, *Return to Dryandra*, has also resulted in the construction of a predator-proof compound containing populations of western barred bandicoots (*Parameles bougainville*), boodies (*Bettongia lesueur*), bilbies and rufous hare-wallabies (*Lagorchestes hirsutus*). These animals can safely breed in the compound and their offspring are released into the wild at Dryandra and other DEC reserves in the south-west and further north, to help establish new populations.

In addition to the mammal species, 98 species of birds occur in the area,







including two species that are threatened and two others that are gazetted as specially protected. Carnaby's black cockatoo, the bush stone curlew and the rufous tree creeper are among them. There are also 51 species of reptile and eight frog species.

Exploring the park

The Barna Mia Animal Sanctuary's viewing enclosure enables you to see some of the State's rarest mammals, up close in a natural setting. The four-hectare sanctuary is fenced to exclude predators and is now home to populations of threatened marsupials.



You can join a night walk here in a natural setting to see these nocturnal mammals. A guide will lead you on the spotlight tour, scanning the heath and woodlands for sights of the captivating marsupials.

Visitors can also make use of picnic and barbecue facilities at Lol Gray, Lions Dryandra Village, the Old Mill Dam, the Arboretum, Giles Park, Congelin Dam and Contine Hill. Drivers can set out on the 25-kilometre radio drive trail, known as Sounds of Dryandra Woodland, which enables you to tune in your radio to hear voices from the past sharing tales of Aboriginal culture, forestry, railway history and wildlife.

Another 23-kilometre drive trail features interpretive signage along the way which reveals the wonders of the woodland's natural environment and the intricate relationships between species.

The energetic can set out on a series of walk and cycle trails that cater to all fitness levels. One of the most interesting walks is the five-kilometre Ochre Trail, which describes some of the modern and ancient Nyoongar culture of the Dryandra area and features an ochre pit used by Aboriginal people for decoration. Scarred trees and stone arrangements provide more clues about traditional Aboriginal lifestyles.



park facts

Where is it? 164 kilometres south-east of Perth and 22 kilometres north-west of Narrogin.

What to see and do: Picnicking, scenic driving, bushwalking, cycling, Barna Mia Animal Sanctuary guided tour, camping, group educational activities.

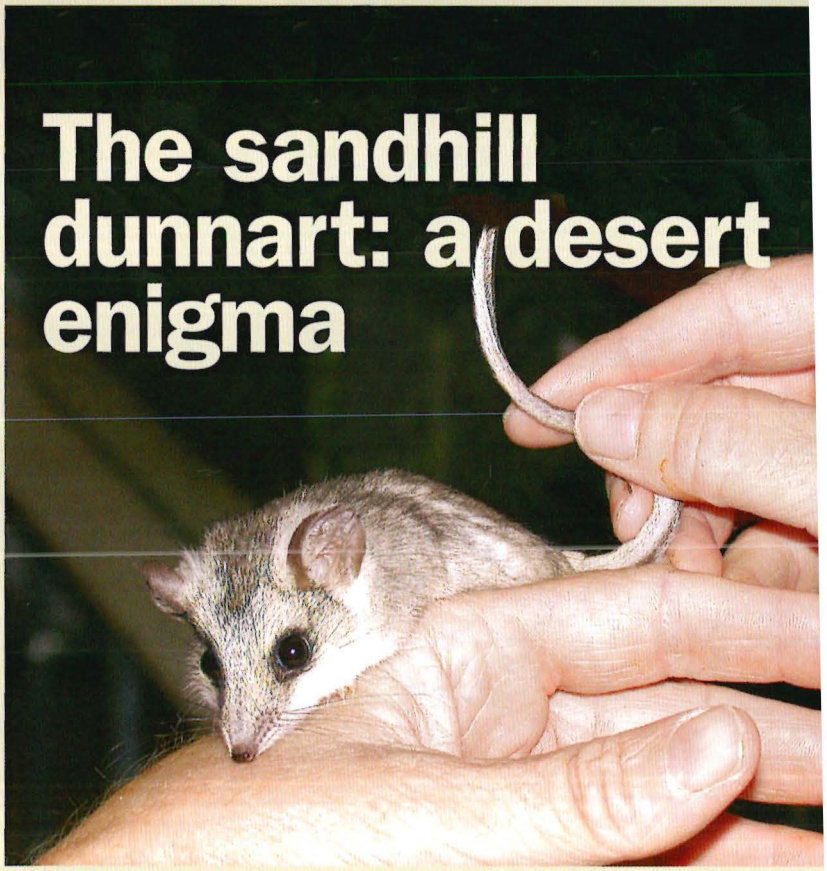
Facilities: Interpretive centre and animal sanctuary, toilets, picnic tables, barbecues, walk trails, drive trail, Lions Dryandra Village (08) 9884 5231.

Camping: Yes, fees apply.

Entry fees: No park entry fees apply but fees must be paid to enter Barna Mia Animal Sanctuary.

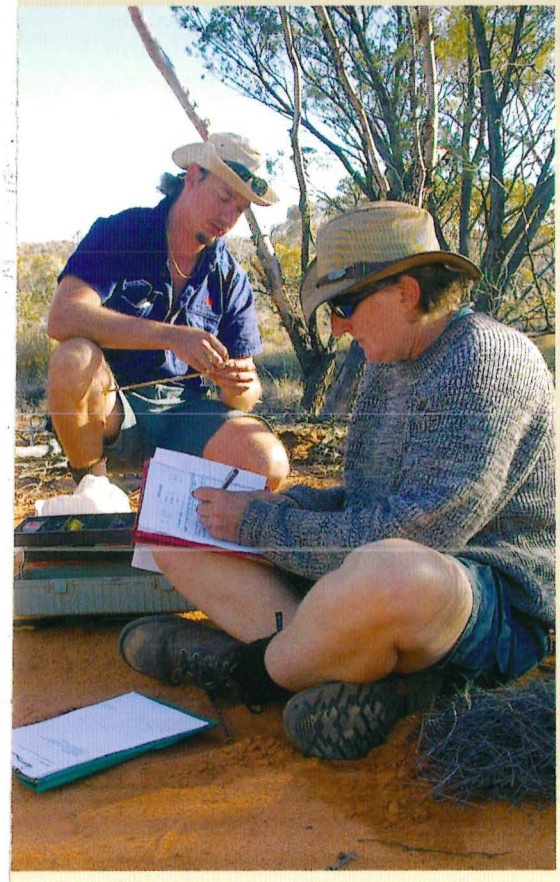
Nearest DEC office: Hough Street, Narrogin, phone (08) 9881 9200.

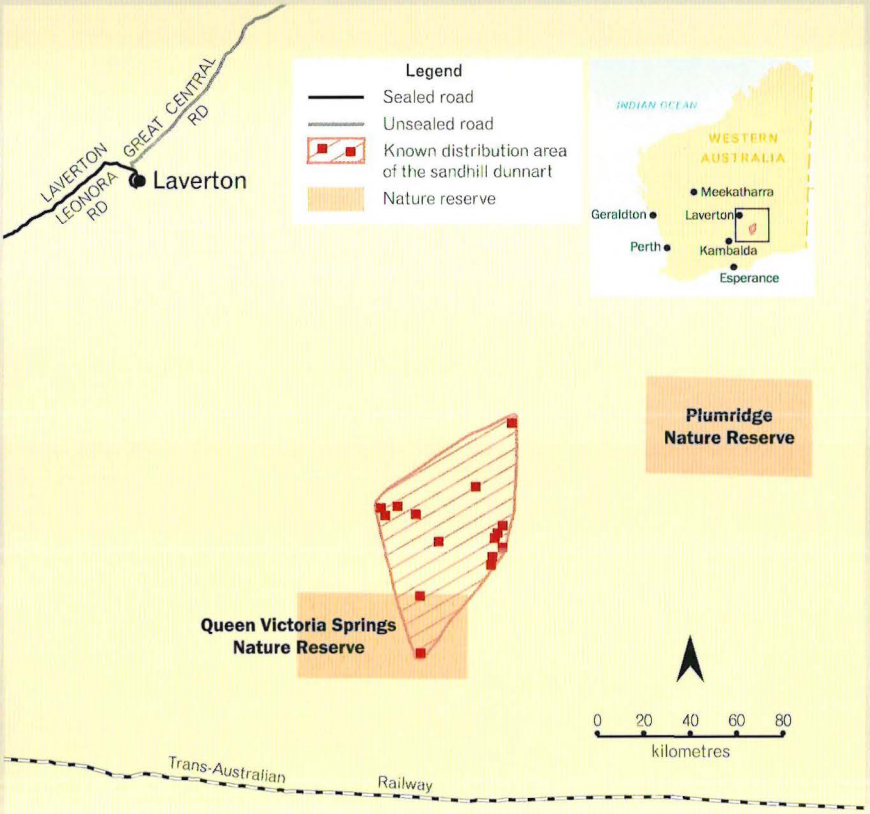
The sandhill dunnart: a desert enigma



The sandhill dunnart is an extremely rare marsupial which lives in scattered desert locations. Over many years, some curious researchers have roamed the Great Victoria Desert in search of this mysterious creature.

by Glen Gaikhorst and Cathy Lambert





The sandhill dunnart (*Sminthopsis psammophila*) is a small, endangered, carnivorous marsupial currently found in only a handful of isolated locations in arid and semi-arid Western and South Australia. In fact, in 2000, fewer than 30 individuals had ever been seen.

This tantalising rarity and lack of knowledge about the species captured the imaginations of two Perth Zoo staff members and led them on an eight-year quest to find out more. Volunteering their time with other keen naturalists, they trekked into Western Australia's Great Victoria Desert 11 times, spending up to two weeks at a stretch studying this elusive creature.

Rarely seen

Sandhill dunnarts were first discovered by European settlers when a single specimen was captured in 1894 near Lake Amadeus in the Northern Territory. Apart from this one individual, and a skull found in an owl pellet from a cave near Uluru, Rock, the animals have never been seen again in the Northern Territory. In fact, it was doubted that they would ever be seen anywhere again, until their rediscovery in 1969 on the Eyre Peninsula in South Australia, some 75 years later.

A population was also discovered in the south-western corner of Western Australia's Great Victoria Desert in 1985. Staff from the then Department of Conservation and Land Management, a predecessor to the Department of Environment and Conservation, located a population in Queen Victoria Springs Nature Reserve in 1987, with several individuals found over a few years, until the area was destroyed by fire (see 'Endangered', *LANDSCOPE*, Spring 1992). They have since been found very sporadically in other locations in both South Australia and WA. The total number of known captured individuals is probably about 100.

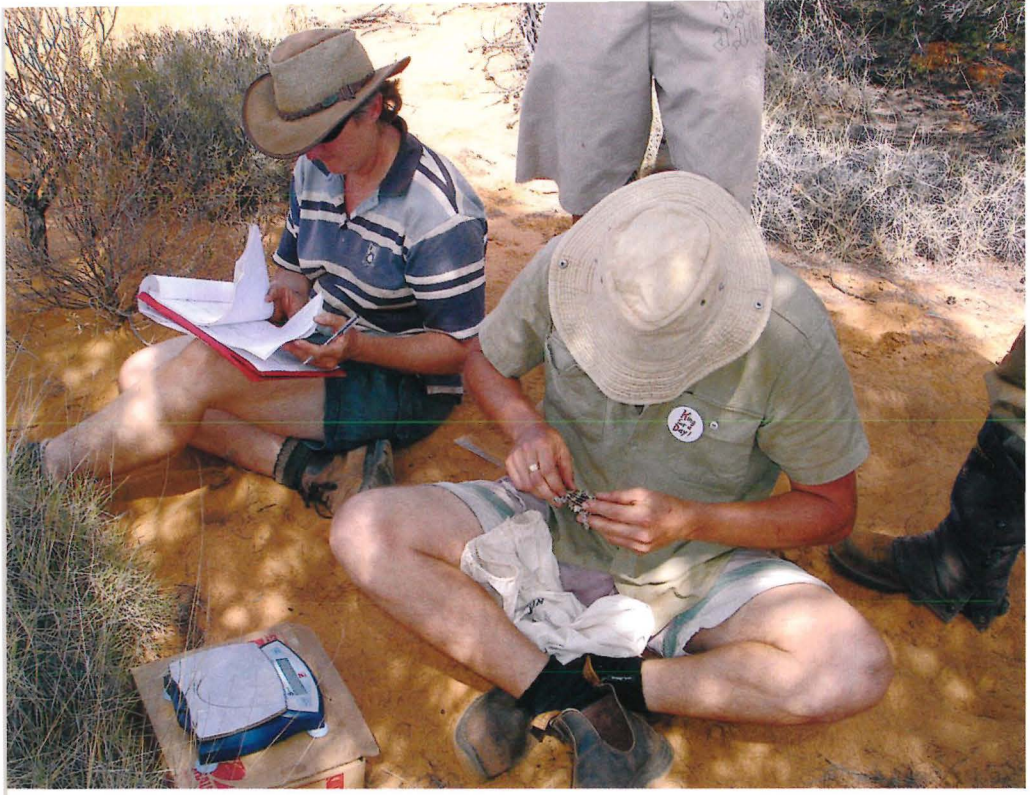
Why so special?

Apart from its rarity, the sandhill dunnart is quite large in comparison to other dunnart species, ranging in weight from 30 to 55 grams. Only one dunnart species is larger, the endangered Julia Creek dunnart (*S. douglasi*). The sandhill dunnart is also quite easy to distinguish from other dunnarts because it has a row of dark hairs on the underside of the tip of its tail, giving it a comb or feather-like appearance.

The sandhill dunnart seems to have quite specific habitat requirements which relate to the quality of the spinifex in which they live and the time since it was last burnt. The spinifex clumps must be old enough to have gained sufficient size to provide shelter from predators and probably the extremes of temperature, but not so old that they

Opposite page
Main Great Victoria Desert.
Photo – Jiri Lochman
Inset The unique tail of the sandhill dunnart.
Photo – Cathy Lambert

Above Recording captured specimens.
Photo – Glen Gaikhorst







have begun to deteriorate and become loose and open. The sandhill dunnart is also found most often where the mid- and over-storey are not too open and on yellow or yellow-orange dunes, undulating sandplain, or occasionally on flat sand-plain with dune systems nearby. Mallee (*Eucalyptus youngiana* and *E. concinna*) and marble gum (*Eucalyptus gongylocarpa*) are common over-storey species in sandhill dunnart habitat.

Roughing it in the Great Victoria Desert

Spending two weeks in the desert, hundreds of kilometres from the nearest town, television and shower, sleeping in swags and carrying all the food and water you need may not be everyone's cup of tea. But to others this is the description of heaven. Indeed there was no shortage of volunteers for the trip to research the sandhill dunnart, with some 50 people taking part in the study.

The desert is a beautiful place: peaceful, ancient and in most areas relatively untouched. The plants and wildlife are unique and specially adapted to the harsh conditions of the area, and discovering their many wonders far outweighs the chore of digging 60-centimetre-deep holes in the sand dunes to place traps.

The study area is located about 350 kilometres north-east of Kalgoorlie in the Great Victoria Desert. It is a hot and persistently dry desert with an average annual rainfall of between 150 and 250 millimetres. Rainfall across the region is largely unpredictable and highly variable from year to year, and may develop from summer storms coming down from the north, or from winter fronts coming up from the south. It can get very hot in summer with a mean maximum temperature range of 32 to

Top left Measuring and recording specimens.
Photo – Cathy Lambert

Centre left Bush camp for two weeks.
Photo – Steffi Kuckarzt

Left Sandhill dunnart habitat in the Great Victoria Desert.
Photo – Glen Gaikhorst



Above An adult male sandhill dunnart. *Photo – Cathy Lambert*

35 degrees Celsius, but with individual days much hotter. During winter, the night-time temperature commonly falls below zero.

There is no permanent surface water in the Great Victoria Desert, other than the occasional human-made reservoir. Pinjin Lake and Queen Victoria Springs are human-modified and periodically have water in them, while several gnamma holes and shallow rock pools provide the only ephemeral water to wildlife.

Desert diversity

The term 'desert' may conjure up images of barren, shifting sands, but the Great Victoria Desert is so ancient that life has found a way to colonise it in an amazing testament to evolution, diversity and survival. Instead of just bare sand, there is a spectacular array of mixed shrublands, woodlands and stretches of mallee and mulga country, often with an abundance of harsh spiky spinifex that provides not only food, but a safe haven from predation for an extraordinary diversity of reptiles and small mammals.

On more than one occasion, sandhill dunnarts were observed climbing up to the top of a spinifex clump before finding a good way in and then burrowing down and out of sight. Native rodents were seen chewing the more juicy bases of the needle-like leaves and two-lined dragons (*Diporiphora reginae*) sat perched among the spikes waiting for a spider or fly to come their way, before darting inside the clump for cover when startled. It was a surprise to many of the volunteers that the delicate-looking western pygmy possum (*Cercartetus concinnus*) was also found in the harsh conditions, but the desert in bloom is a wonderful sight and, along with supplying nectar for food, the blossoms sustain an insect population that these delightful creatures thrive on.

Changing goals

At the time the study began, both sites where sandhill dunnarts had previously been recorded in WA had been destroyed by fire. The first aim, therefore, was to establish whether the species was still present in the State. Then, if a stable population could be found, the plan was to study its ecology over a number of years.

Although it was found that fires in the region had been very frequent and extensive, within a couple of years two new populations had been found outside the previously known range of the species. Both populations appeared to be in good health, with pouch young and independent juveniles found. In 2005, these two sites became the core of a long-term ecological study, and permanent pitfall traps were established. These permanent traps were made of sturdy PVC tubing, rather than the thin flexible plastic ones routinely used, and so could be left in the ground for many years without deterioration, capped securely between visits.

Unfortunately, before this could be done, wildfires claimed these populations too. A massive fire burned both sites (which were 25 kilometres apart) and left a devastating burn scar of thousands of hectares. The study changed scope at this point and it was decided to extend the surveys further, focusing on the species' abundance and distribution in the region and also on the reproductive biology of the species in captivity.

Captive breeding

Between 2000 and 2008, 17 individual sandhill dunnarts were captured. Although this doesn't sound like many for the effort involved, it







Above Pouch-young, 39 days old.
Photo – Glen Gaikhorst

Above left Six-day-old pouch-young.
Photo – Bradie Durell

Left A juvenile female sandhill dunnart, 45 days old. Even at this young age it is possible to see her pouch.
Photo – Bradie Durell

was actually an immensely satisfying result, considering the rarity of the species. In October, one of the females was found to be carrying eight small pouch-young and another had active teats indicating she had young in a nest somewhere. These observations, along with a handful of others from similar studies, were all that was known from which to piece together a picture of the reproductive pattern of the sandhill dunnart. In 2005, permission was gained to bring two pairs into captivity to try to find out more.

A small breeding and research program operated at the Perth Zoo between 2005 and 2007 which aimed to fill in some of the gaps that existed in the knowledge of the sandhill dunnart's reproductive biology. Oestrus cycles were monitored and faecal samples were collected to assess hormonal changes associated with mating and birth. Understanding factors such as the time of year these animals breed, how many litters they can have in a season, their gestation period and how long young are dependent can help land managers preserve the species.

Six litters were produced over three seasons, and observations and measurements were taken of the growth and development of the young. The oestrus cycle of the females, the gestation period and the growth and development of the young were all determined.

Threats

The main threats to the survival of the sandhill dunnart in WA are fire frequency and size, introduced pests and, potentially, the recent establishment of mining in the area. Fires occur very frequently, mostly ignited by lightning strikes, with some destroying vast areas







Above Crested dragon *(Ctenophorus cristatus).*

Above right Black-naped snake *(Neelaps bimaculatus).*

Right Central military dragon *(Ctenophorus isolepis citrinus).*
Photos – Glen Gaikhorst

at a time. Often very little unburnt remnant habitat remains where animals can survive until the burned landscape returns to a useful age. In the case of sandhill dunnarts, this age is about eight to 10 years. Although fire is necessary to regenerate spinifex that has become old and sparse, the large scale and frequent nature of these fires is a concern and probably the most serious threat to the dunnarts.

Foxes and cats are present in the Great Victoria Desert and continue to be a threat to wildlife in the area. Traces of these introduced predators have been observed at all study sites and on occasions they have raided traps in an attempt to catch fauna. In recent years, natural resources have been discovered in the region with several exploration and mining programs being initiated in the area. As the known area that sandhill dunnarts occupy in WA is quite small, good management of these human impacts will be required to protect the species.

Other significant fauna

The Great Victoria Desert is an area where species from the south-west merge with those from desert complexes. As such, the area has become well known for its wildlife diversity. This includes vegetation and, to a greater degree, lizards and small mammals. Seventy-three reptile species, nine small mammals, one amphibian and 58 bird species were recorded during the study, including some interesting range extensions for some species and signs and sightings of some other quite rare animals.

Significant finds included a south-easterly extension of the known range of the desert mouse (*Pseudomys desertor*) and a southerly extension for a burrowing skink, *Lerista taeniatus*. There was also a rare sighting of a south-west woma (*Aspidites ramsayi*), identified by its unusual colour pattern.

The team also dug trenches on dunes and found signs that the elusive itjaritjari, or southern marsupial mole (*Notoryctes typhlops*), had been passing through. This quite bizarre-looking creature is blind, has well developed front legs with huge claws and 'swims' below the surface, back-filling its tunnel as it moves forward. It feeds mostly on underground invertebrates, but perhaps on reptiles as well (see 'Mysterious sand swimmers', *LANDSCOPE*, Winter 2003).

The southern marsupial mole rarely comes to the surface, so one of the best ways to know if it has been in an area is to dig a trench on the north side of a dune and a little way down from the crest, and then leave it for a day or two for the sun to dry it out. When looking at the smoothed sides of the trench, if

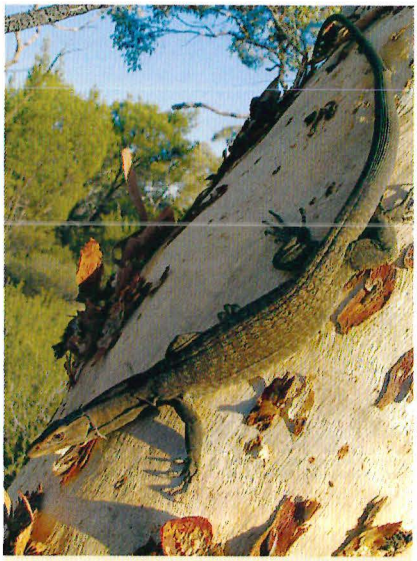


Left The team making pit traps.
Photo – Cathy Lambert

Below left A well-earned rest in the evening in the Great Victoria Desert.
Photo – Steffi Kuckarzt

Below Black-headed monitor *(Varanus tristis).*
Photo – Glen Gaikhorst





a mole has moved through in the past, loosened soil caused by its tunneling swill have dried out faster than the surrounding compact sand and a small telltale circle of lighter coloured sand can be seen. Trench digging can be hard, but the excitement of finding signs of a creature that most people will never see was well worth the effort.

An active mulgara (*Dasycercus cristicauda*) burrow, complete with scats and fresh footprints, was also found but despite surrounding the area with traps, the little beast eluded capture. There were also sightings of the scarlet-chested parrot, princess parrot and naretha blue bonnet which are now rare in parts of their former range.

Plans for recovery

Sandhill dunnarts are currently only known from Yellabinna Regional Reserve and the upper Eyre Peninsula in South Australia and in four relatively closely grouped locations within the Great Victoria Desert in WA. Following a year-long study of the species across South Australia and WA, a recovery plan was produced for the sandhill dunnart in 2001. More survey work is currently being carried out in South Australia by the Department of Environment and Heritage which will hopefully continue to increase the knowledge about this little-known and fascinating species.

Glen Gaikhorst is currently a zoologist with GHD Pty Ltd in the ecology and marine group, but at the time of these studies was the supervisor of Perth Zoo's Native Species Breeding Program. He can be contacted by email (glen.gaikhorst@ghd.com.au).

Cathy Lambert is a senior keeper in Perth Zoo's Native Species Breeding Program. She manages the dibbler captive breeding program, which provides animals for release to the wild as part of the Department of Environment and Conservation's (DEC's) Dibbler Recovery Plan. Cathy can be contacted by email (cathy.lambert@perthzoo.wa.gov.au).

The authors thank the volunteers who made this study possible, in particular Klaas Gaikhorst and Ian Butland. Sue Churchill, author of the *Sandhill Dunnart Recovery Plan* (2001), and David Pearson (DEC) also provided invaluable advice in the early days of the project. Monetary assistance towards equipment, fuel and food was provided through grants from Gerald Durrell Memorial Funds, Australian Academy of Science, *LANDSCOPE* and Perth Zoo, with the Perth Zoo assisting with resources and supporting the captive component of the study.

Triple test: recovering natural biodiversity at **Toolibin Lake** and **Lake Bryde**







Catchment management is a complex challenge facing land managers across southern Australia. Large-scale recovery actions at two natural diversity recovery catchments in the heart of the southern wheatbelt of Western Australia are taking a multi-pronged approach to protecting biodiversity from the threats of altered hydrology, particularly rising water tables and increasing salinity.

by Greg Durell, Natalie Nicholson and Ray McKnight

Wetland biodiversity managers in the low-to-medium rainfall zone of southern Australia face three main challenges. The first is a lack of knowledge about the complex interactions between natural biodiversity assets and the ecosystem processes, including altered hydrology, that will determine management success. The second is variability. Both the climate of these areas and their catchment landscapes are highly variable and often each situation requires site-specific research and actions. Finally, successful management in these variable areas requires a commitment, over decades, to active management.

Recovery catchments: managing altered hydrology

Altered hydrology refers to changes in the way water is stored and moves through the landscape. Broad-scale replacement of native perennial vegetation with annual crops and pastures has significantly altered hydrology in agricultural areas, with considerable impacts on natural resources.

There are various approaches to dealing with altered hydrology. These include surface water management, ground water management, the protection of remnant vegetation and revegetation. It has taken some 100 years for altered hydrology to develop to its current degraded condition in some areas; hence, it may require decades to address the issue effectively.

Western Australia is the Australian state most affected by altered hydrology. It has been estimated that about one million hectares of WA are affected by salinity and this is increasing at 14,000 hectares each year. The area with 'salinity hazard'—land at risk from salinity because groundwater is predicted to rise close to the surface—was estimated to be between 2.9 and 4.4 million hectares. While about 80 per cent of this is on cleared agricultural land, salinity also threatens important public assets such as water resources, infrastructure and biodiversity, particularly in the valley floors.

A threat to biodiversity

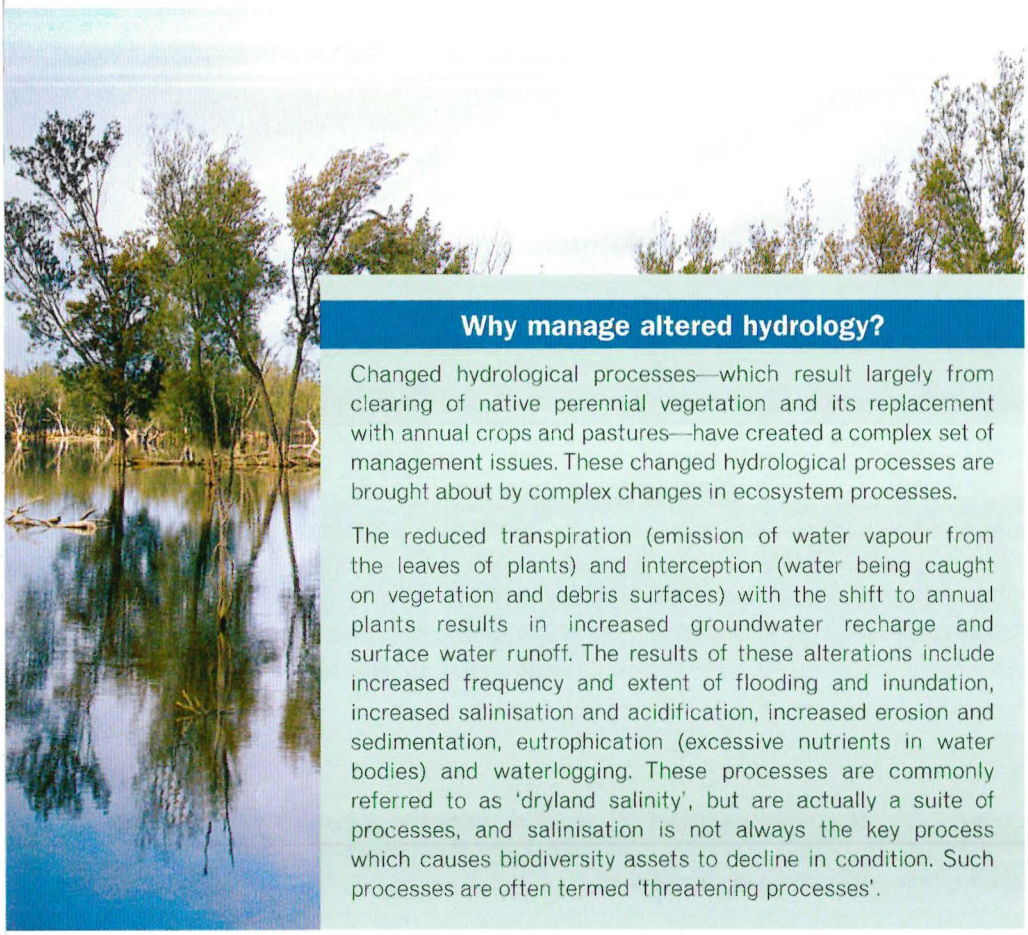
Altered hydrology is a major threat to the biodiversity of WA. Many of the State's wetlands and streams have become salty, and more continue to become so. *A Biodiversity Survey of the Western Australian Agricultural Zone* was an important project funded through the 1996 *Western Australian Salinity Action Plan* and carried out by the Department of Environment and Conservation (DEC) and its predecessors and the Western Australian Museum. This work documented biota in the inland south-west agricultural zone and the extent to which it was threatened by salinity. This survey revealed that salinity has already had a significant effect on the native plants and animals of this area, particularly those in wetlands. It estimated that 450 plant species were at risk of global extinction and 400 animal species were at risk of global or regional extinction.

The Natural Diversity Recovery Catchment (NDRC) Program also arose from the Salinity Action Plan. The program targets six key catchments to ensure that critical and regionally significant natural areas, particularly wetlands, are protected in perpetuity.

The great southern NDRCs

DEC is responsible for the recovery of biodiversity in six NDRCs in the south-west of WA. Toolibin Lake NDRC and Lake Bryde NDRC fall within DEC's Great Southern District, which forms the heart of the southern wheatbelt.

Toolibin Lake NDRC is 20 kilometres south-east of Wickepin and Lake Bryde NDRC sits 35 kilometres



Why manage altered hydrology?

Changed hydrological processes—which result largely from clearing of native perennial vegetation and its replacement with annual crops and pastures—have created a complex set of management issues. These changed hydrological processes are brought about by complex changes in ecosystem processes.

The reduced transpiration (emission of water vapour from the leaves of plants) and interception (water being caught on vegetation and debris surfaces) with the shift to annual plants results in increased groundwater recharge and surface water runoff. The results of these alterations include increased frequency and extent of flooding and inundation, increased salinisation and acidification, increased erosion and sedimentation, eutrophication (excessive nutrients in water bodies) and waterlogging. These processes are commonly referred to as 'dryland salinity', but are actually a suite of processes, and salinisation is not always the key process which causes biodiversity assets to decline in condition. Such processes are often termed 'threatening processes'.

Previous page
Main Yate Swamp, a small swamp in Lake Bryde Conservation Park, part of the Lake Bryde NDRC.
Photo – Natalie Nicholson/DEC
Insets (left to right) A waterway under construction at Toolibin; a waterway in use following a rainfall event in Toolibin NDRC; monitoring water flows at Toolibin.

Left background Water reflection on Toolibin Lake.
Photos – Sam MacWilliams/DEC



Above Taarblin Lake succumbed to altered hydrology particularly after a prolonged period of inundation in the 1950s and 1960s.
Photo – Jiri Lochman

south-east of Lake Grace. Both occur in broad, relatively flat valleys—Toolibin in the headwaters of the Blackwood River and Lake Bryde in the headwaters of the Avon-Swan river system. Both recovery catchments contain remnants of a once extremely rich natural landscape. They retain a significant proportion of their original values including threatened species, threatened ecological communities (TECs) and other high-value biodiversity assets.

Rich biodiversity

Lake Bryde NDRC covers an area of about 140,000 hectares and includes the Lake Bryde Conservation Park. It was formally selected as a recovery catchment in July 1999 to protect a TEC as well as threatened species and important wetland and terrestrial ecosystems.

Toolibin Lake is the largest remaining area representing a habitat of which only a handful survive today: inland, fresh water wooded wetlands. This critically endangered TEC was a relatively common lake community until the threat of too-frequent flooding and inundation and salinity began to take its toll from about the 1940s.

Both areas also provide habitat for a wide range of waterbirds. Lake Bryde has up to 23 waterbird species occurring, with up to seven species breeding. Toolibin Lake is well known for its waterbird richness, with up to 41 species of waterbirds being recorded there and as many as 24 species known to breed on the lake. The rare freckled duck (*Stictonetta naevosa*) has been recorded at Toolibin Lake, Lake Bryde, East Lake Bryde and Lake Walbyring, just south of Toolibin Lake.

Toolibin Lake is listed under the Ramsar Convention as a Wetland of International Importance and is also listed on the Register of the National Estate. Lake Bryde and East Lake Bryde are listed on the Directory of Important Wetlands at a State and Commonwealth level, hence they are considered to be of local, national and international significance.

The first main phase of agricultural development at Toolibin occurred in the period 1900–10, whereas clearing at Lake Bryde began much later, during the mid-1960s. This means that while the threats are similar at the two systems, the altered hydrology at Lake Toolibin is in a later, more advanced state.

Recovery actions

The primary aim of recovery catchments is to protect their biodiversity from threatening processes brought about by altered hydrology. To achieve this, long-term monitoring and research is required to determine optimal management strategies. Various techniques are being applied to tackle threats, including water diversion, upper catchment management, the creation of waterways and the pumping of saline groundwater.

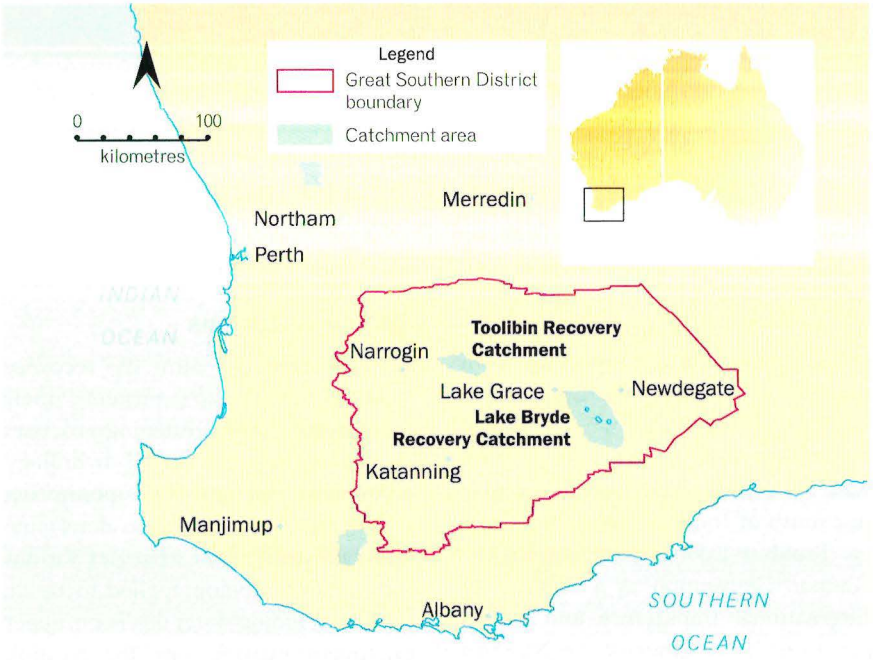
Groundwater pumping

Several threatening processes affect Toolibin Lake's health and condition, particularly excess groundwater. A groundwater pumping program began at Toolibin Lake in earnest in 1997 when six air displacement pumps were added to a trial pump already present on the lake floor. This system pumps an average of 230,000 litres of saline groundwater a day from beneath the lake. This water is transferred by a pipeline to Taarblin









Top left The pink-eared duck feeds in the shallow waters of the catchments.
Photo – Jiri Lochman

Top Constructing a waterway in Lake Bryde NDRC.
Photo – Natalie Nicholson/DEC

Above Water inflows at Toolibin NDRC.
Photo – Lance Mudgway/DEC

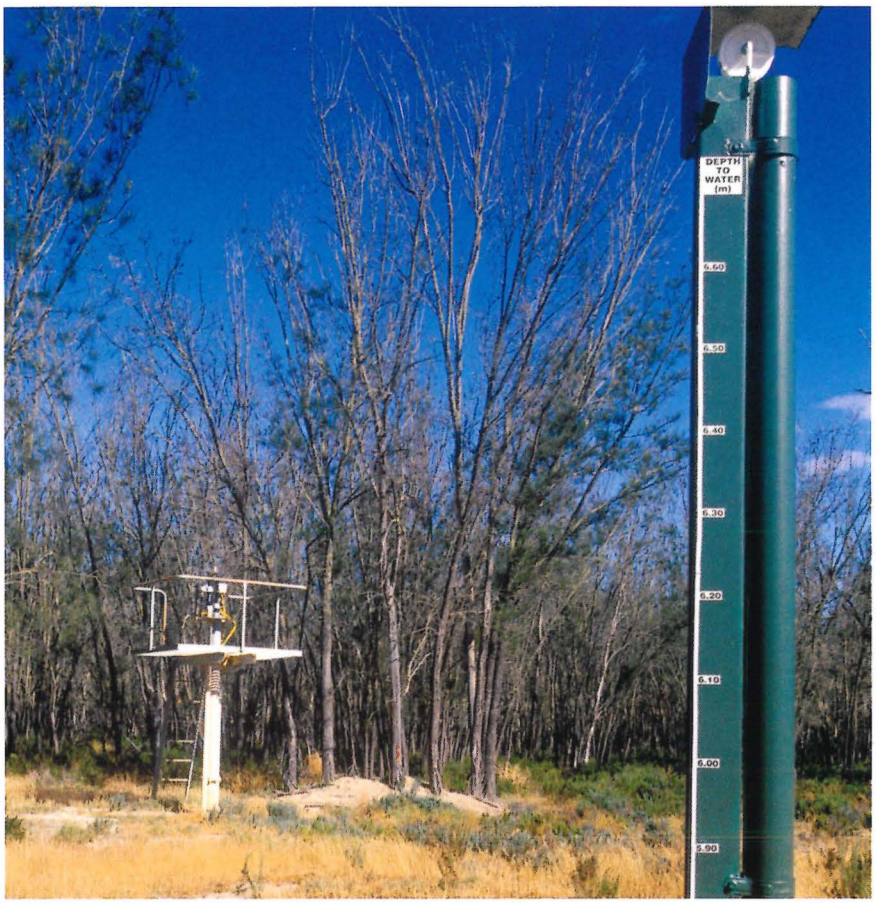
Lake, a large lake that had, unfortunately, already succumbed to salinity. One result of continued pumping is that in some areas around Toolibin Lake, vegetation is recovering.

Waterways

Major projects to manage surface water runoff are being implemented in each catchment. The main component of this is the installation of shallow waterways in the valley floors. The aim of these waterways is to relieve the immediate impacts of minor flooding on native vegetation. The waterway acts as a surface water conveyance through the valley floor to enable the typical smaller, annual water flows to pass through without causing ponding or waterlogging, preventing additional groundwater recharge and salinisation. Increasing surface flows is one of the outcomes from clearing native vegetation.

The waterways are 300 to 400 millimetres deep and up to 30 metres wide. These structures are designed to accommodate the water generated from an average runoff event (from a one-in-three-year rainfall event). In a large flood event (a one-in-25-year rainfall event), water volumes far exceed what the waterway is designed to handle and the fresh water will spill out into the surrounding vegetation as would normally occur. However, after flooding the waterway helps water levels recede more quickly, by accelerating water drainage to the disposal sites.

At Lake Bryde NDRC, 12 kilometres of a proposed 20-kilometre waterway is constructed, and design and construction of the remainder is under way. The waterways in both



Left A groundwater pump at Toolibin Lake.
Photo – Marie Lochman

Below Declared rare flora *Muehlenbeckia horrida* subsp. *abdita*.
Photo – DEC

catchments will also reduce the impacts of waterlogging on farmland and help protect the system of local roads.

Funding for the work on the two recovery catchments comes from a range of organisations including the State Government and the Australian Government's Natural Heritage Trust program through the South West Catchments Council and Wheatbelt Natural Resource Management (formerly the Avon Catchment Council). Construction work on stage four of the valley floor waterway began in 2007 and was completed in 2009. Design for construction of the final stages will occur in late 2010.

Other solutions

In addition to waterways, other surface water management techniques are required for upper catchment water management. These can include the construction of water storage dams higher in the catchment and graded contour banks to control flows from agricultural land into remnant vegetation and valley floors.

Improving the condition of existing vegetation remnants in reserves and on private property is also important, along with revegetation with perennial vegetation on both public and agricultural lands. Revegetation work usually has direct biodiversity conservation benefits and, in some cases, has potential commercial applications. For example, providing incentives for landowners to plant oil mallees will contribute to a resource base that may lead to a biofuels industry.

Working in partnership

Many operations in recovery catchments, such as waterways and revegetation, involve work on private land. Effective partnerships with land-holders are essential to achieving management success in recovery catchments. Their support, and that of a number of government agencies and other institutions, is integral to the overall success of these large-scale catchment projects.

Integrating a wide range of management actions with a variety of partners is a challenging but rewarding process. Funding for this work also presents difficulties due to the large scale of projects, long time frames and high cost of engineering and earth moving.

The future

Large-scale recovery actions are making a difference to managing the altered hydrology in recovery catchments. At Toolibin Lake and Lake Bryde, a complex set of actions are aimed at ensuring the long-term protection of the wetlands and their surrounding nature reserves. There is no quick or easy solution; managing altered hydrology will only be successful where an integrated package of recovery actions is implemented over decades.

Although the main objective of these two recovery catchments is to conserve the unique plants and animals that occur there, there are added benefits in protecting these areas. The development of new initiatives that work towards sustainable agricultural practices will also help enhance production in the catchments during the coming years. Both these projects offer a unique opportunity to develop new ideas to solve problems using a range of biological, engineering and agricultural solutions. Through the work being done at Toolibin Lake and Lake Bryde, as well as at the other four NDRCs, WA will continue to be a model for conservation and sustainable land use now and into the future.

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Wetland wonders

Imagine counting 33,000 waterbirds in one day and recording more than 60 species of waterbirds within an area of 1,115 hectares! These statistics – and more were required to nominate the Vasse-Wonnerup wetland system, which extends east from the main township of Busselton in the State's south-west, as a wetland of international importance.

by Ann Storrie



The term 'wetland' refers to naturally occurring lakes, swamps, marshes, mudflats and billabongs that are wet on a regular, semi-regular or occasional basis. They can be protected under State or Commonwealth law.

If a wetland is considered of international importance—for example, if it is an important habitat for migratory birds, or it supports large numbers of waterbirds—it can be listed under the international *Convention on Wetlands of International Importance*. This convention is known as the Ramsar Convention as it was signed in the Iranian city of Ramsar in 1971. It provides the framework to manage and conserve these wetlands at both a national and international level. In Australia, special Commonwealth laws apply to Ramsar wetlands.

Australia became a contracting party to the convention in 1975. By 2008, 158 countries had signed the treaty, making a total of 1,828 wetland sites in the world (169 million hectares) protected under the Ramsar agreement. The wetlands are selected on a number of criteria including their ecological, botanical, zoological and hydrological importance. Under the convention, there is an expectation that the contracting parties will at least maintain and, where possible, enhance the values for which those wetlands have been listed. Australia currently has 65 Ramsar wetlands with 12 occurring in Western Australia.



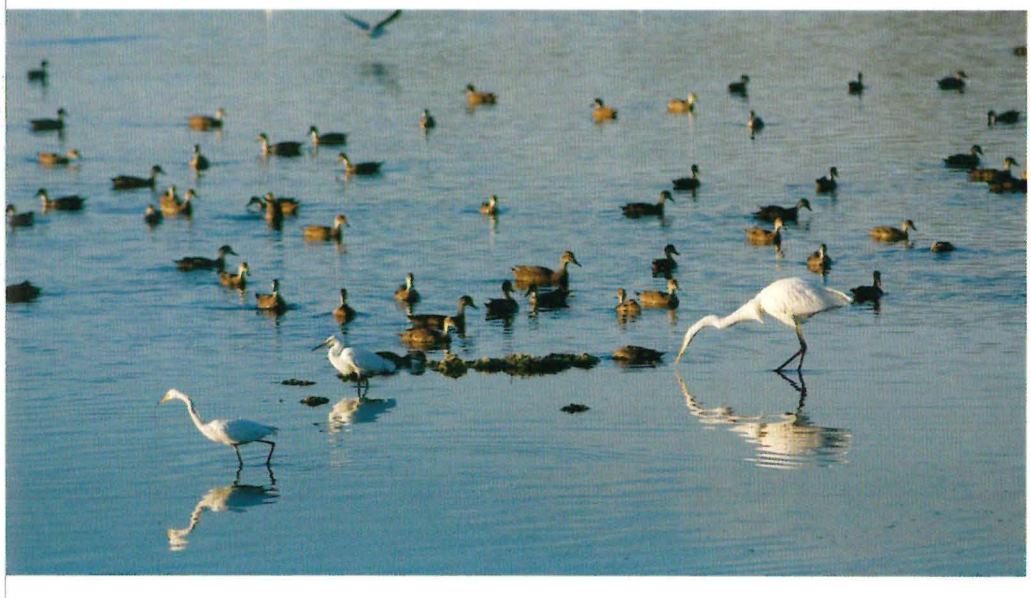
The Vasse-Wonnerup wetland system

The Vasse-Wonnerup wetland system was nominated as a Ramsar wetland in 1990. Two main criteria were met for its acceptance to the convention: the area regularly supports more than 20,000 waterbirds, and it supports at least one per cent of the individuals of a population of one species or subspecies. To fulfil the second criterion, the Vasse-Wonnerup system supports at least one per cent of the Australian population of black-winged stilts (*Himantopus himantopus*) and at least one per cent of the world's population of red-necked avocets (*Recurvirostra novaehollandiae*).

Monitoring of the wetlands and wildlife is carried out to comply with the regulations of the convention. The last survey was conducted during summer and autumn between 1998 and 2000. At the peak of this survey, the waterbird count totalled 37,000. In November 2000, the Ramsar site was extended in the Vasse-Wonnerup system to include all of one adjoining reserve, part of another and extra areas of Tuart Forest National Park.

Towns, tourists and tuart forest

This amazing wetland lies just over 200 kilometres south of Perth and is within one of WA's tourist hot spots. The main township of the rapidly expanding town of Busselton is just west of the wetlands. The new suburb of Port Geographe and the old town-site of Wonnerup are to the north of sections of the Vasse-Wonnerup wetlands, while farmlands skirt much of the system. Many birds benefit from the open pastures of the farms, especially ibis that regularly gather in their hundreds to feed on insects such



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Main Male musk ducks display a flamboyant courtship ritual of splashing water and loud whistles and emit a musky odour to attract females.
Photo – Ann Storrie

Above The Vasse-Wonnerup system is a Ramsar wetland of International Importance.
Photo – Dennis Sarson/Lochman Transparencies

Left Bird life at Vasse-Wonnerup.
Photo – Ann Storrie





Far left Quendas, or southern brown bandicoots, live in sedges close to the water's edge.

Left Western grey kangaroos from Tuart Forest National Park drink at Malbup Creek and are often seen close to the bird hide.

Below A great egret comes in to land on the Vasse-Wonnerup wetland.
Photos – Ann Storrie

as grasshoppers. Many frogs and snakes also thrive in both flooded and dry pastures, and provide valuable food for these birds.

East of the wetlands lies the last substantial area of tuart forest in the world. Two thousand hectares of magnificent tuart trees (*Eucalyptus gomphocephala*) are home to many birds and mammals, some of which rely on the wetlands for food and water. Hollows within the old tuarts provide important breeding sites for the Australian wood duck (*Chenonetta jubata*), Australian shelduck (*Tadorna tadornoides*) and others. Western grey kangaroos (*Macropus fuliginosus*) are abundant in the forest and the quenda, or southern brown bandicoot (*Isoodon obesulus*), thrives in the sedges that grow close to the water's edge.

It is easy to view many species of birds in this wetland. The Department of Environment and Conservation (DEC) installed a raised boardwalk and bird hide on a section of the wetland known as Malbup Creek, just north of Tuart Forest National Park. The boardwalk branches from the night-spotting possum walk off Layman Road in Wonnerup. The best times to visit the hide are in the early morning or late afternoon. Common species that you may see close-up from the hide include swans, ducks, grebes, coots, pelicans, spoonbills, ibis, herons, cormorants, sandpipers, stints, terns and egrets. Descriptions and photos of the most common birds are detailed in posters on the walls within the hide.

Breeding and migratory birds

The largest regular breeding colony of black swan (*Cygnus atratus*) in WA occurs in these wetlands. More than 150 pairs have been recorded. They nest on mounds of vegetation (samphire and introduced grasses) that are often used for several years, built up as an island surrounded by shallow water. Usually between three and nine eggs hatch in early spring after 40 days incubation and one or both parents care for the cygnets for several months. By November, several thousand swans may have gathered to feed in the Vasse-Wonnerup wetlands.

The area supports one of the largest breeding colonies of ibis in the State. Australian white ibis (*Threskiornis molucca*) and straw-necked ibis (*Threskiornis spinicollis*) breed in melaleuca paperbark trees that grow in











wetlands of the adjoining floodplain. Egrets and cormorants often join the ibis and the trees become a mass of large white and black birds, squabbling for position and weighing down the branches. During summer when the young mature, the early morning sky is filled with hundreds of ibis that fly in a 'V' formation to the surrounding paddocks to feed during the day. The sky is filled again in the evening as they return to roost in the paperbark trees.

Migratory wading birds from countries such as Siberia and China visit the wetlands during spring and summer. These tiny grey-brown birds, some of which weigh less than 30 grams, are protected under the China–Australia, Japan–Australia and Republic of Korea–Australia migratory bird agreements.

One of the earliest to arrive, in late August, is the curlew sandpiper (*Calidris ferruginea*). These have long, downward-curved bills that they insert fully into the mud or sand to find food. They eat mainly aquatic worms, crustaceans and molluscs. The curlew sandpiper is also one of the last to leave Australia, sometimes staying until the first week in May. They fly back to northern Siberia where they breed in June and July.

Some of the other species of migratory wading birds that visit the Vasse-Wonnerup wetlands include the wood sandpiper (*Tringa glareola*), sharp-tailed sandpiper (*Calidris acuminata*) and common greenshank (*Tringa nebularia*). One of the rarest waders to visit Australia, the long-toed stint (*Calidris subminuta*), is commonly seen in these wetlands.

Swamped by birds

Many Australian waders also visit in their thousands. Avocets fly in from lakes in the arid interior, some as far away as Lake Eyre. Pelicans fly

Top Vasse-Wonnerup wetlands.

Centre left Grey teal.
Photos – Jiri Lochman

Centre right Yellow-billed spoonbill.

Left Wonnerup wetlands at sunset.
Photos – Ann Storrie





Above The area supports one of the largest breeding colonies of straw-necked ibis in Western Australia.
Photo – Geoff Taylor/Lochman Transparencies

Above right Whistling kite.
Photo – Dave Watts/Lochman Transparencies

Below Migratory wading birds from as far away as Siberia visit the wetlands in summer.
Photo – Ann Storrie

from northern Australia and ducks congregate here from throughout the south-west region. Up to 14,000 grey teal ducks (*Anas gracilis*), 4,000 Pacific black ducks (*Anas superciliosa*) and more than 6,000 Australian shelducks (*Tadorna tadornoides*) have been recorded in the Vasse-Wonnerup wetlands.

As the waters of the wetlands dry out in summer, many birds congregate in the shallows to feast on invertebrates, algae and schools of stranded fish. Spoonbills sweep through the mud to sift out crustaceans, water insects, molluscs and small fish. Dabbling ducks, such as the grey teal, up-end for aquatic plants, seeds and plankton, while diving ducks such as the musk duck, dive for small fish and invertebrates. Heron stalk their prey such as fish and amphibians, jabbing and sometimes spearing them with their sharp, pointed beaks. Egrets hunt in a similar manner.

Flocks of pelicans swim in formation, herding fish into the shallows, then simultaneously dip their bills into the water to catch their prey. Not to be outdone, thousands of silver gulls noisily join in the fray. Raptors such as swamp harriers (*Circus approximans*), whistling kites (*Haliaster sphenurus*) and ospreys (*Pandion haliaetus*) cruise over the area, sending flocks of waterbirds into the sky. A pair of white-bellied sea eagles (*Haliaeetus leucogaster*) that nest nearby also come to watch and wait for an easy meal.

Conservation and the future

Conservation measures have and are being undertaken to preserve this important wetland. The waters of the Vasse-Wonnerup system are fresh in winter and saline in summer. Floodgates were installed on the outlet channels of the Vasse and Wonnerup estuaries to regulate the inflow of seawater and to minimise flooding. The Department of Water monitors water quality. Monitoring of fish behaviour and the waterbirds is undertaken by DEC.

Although the wetland does experience periods of very poor water quality, particularly when large algal blooms occur in summer and autumn, past management of water levels and salinity has proved to be satisfactory for the waterbirds. A monitoring program that aims to detect changes in the health of fringing vegetation has also been developed. Control of introduced animals such as foxes and rabbits is undertaken within the site.

Despite these efforts, a big question mark hangs over the future of these wetlands. Although waterbird counts increased from 1990 to the 1998–2000 studies, peak numbers of some species have declined. The blue-billed duck (*Oxyura australis*), great egret (*Ardea alba*), great cormorant (*Phalacrocorax carbo*) and curlew sandpiper (*Calidris ferruginea*) have all declined in number and the status of several other species is uncertain.

Further surveys are warranted and many questions remain unanswered. Is the problem local or regional? Are the curlew sandpipers' staging sites in east Asia threatened? Degradation of habitat appears to be the major contributing factor to all these birds' decline. Urban expansion and coastal development that is encroaching on the Vasse-Wonnerup wetlands causes local disturbance. Noise, general pollution and, of course, additional human presence is of prime concern. Action needs to be taken now to not only conserve the local populations of wildlife, but also those in regional and widespread areas of our planet. If these magnificent and internationally renowned wetlands are in danger, then so are we.



Ann Storrie is an accomplished underwater and land nature photographer. She has co-authored and photographed several of the Department of Environment and Conservation's publications including *Beneath Busselton Jetty* and *Wonders of Western Waters*. Ann can be contacted by email (naturescapes.au@hotmail.com).

urban antics

by John Hunter



Black dirt

Being human sometimes has its advantages. You can fantasise about owning that spare bit of bush nearby which you visit daily to either walk the dog or just escape from the barricades of the 'burbs'.

A remnant area of tall trees and native bush can be intoxicating. To sit quietly and be mesmerised by resident wildlife which come to you and carry on as if you weren't there is more entertaining than a keg of bourbon at a bikies' birthday. Here, the mind can drift back to green cubbies and children playing, or perhaps to the day the bull ant bit your bum, ahh... they were the days.

With it being the hottest summer since the 'seventies', I relax back in my favourite outdoor chair and see smoke atop the tuarts in the valley. Bushfire! Here in suburbia, how can that be?

Soon fast-rising black smoke and loud cracking awakes reality and a call to the fire service is made. The next 10 minutes are traumatic, as from only a few hundred metres I see the flames grip trunk and derelict timber and canopies explode as sap and leaf vaporise into conflagration and chaos.

It took a concerted effort from dedicated professionals and an array of very large and small fire units over the next four hours to save a new electricity sub-station and about five hectares of bush, while losing three hectares of bush habitat. The aftermath said it all.

Where the flames had been there was now an open area devoid of all undergrowth, leaving only the soft black powder of burnt quartz. On a nearby vehicle track were the tracks of a bungarra that had loped away dragging a burnt foot, while dozens of small lizard prints and the slither-marks of a dugite head away from the scene The area was now deathly silent. Only the dead grey trunks with high stagheads of former trees had survived unscathed, while rare for the area jarrah, bull banksia and wattles and small sheoaks resembled used sparklers on an odorous charcoal birthday cake. Grass trees now appeared naked without their skirts of grey and only large common banksias seemed saved. A solitary silent lorikeet was the only jewel in a landscape of simmering blackened stumps.

Apparently one of two things caused the fire: humans with matches or humans with rubbish.

Throughout the ash field one could now see the glittering glass of broken beer bottles liberally laced with ancient 1950-something coke bottles. Glass of any description can magnify the suns' rays and cause catastrophic combustion. What was thick bush, was now a graveyard of half-bales of fence wire, off-cuts of corrugated roof iron, half-burnt power cable drums, gutter down-pipes and partly melted bagging from a plant nursery.

I now know how our rangers and fire people feel, who are confronted with this every fire season.

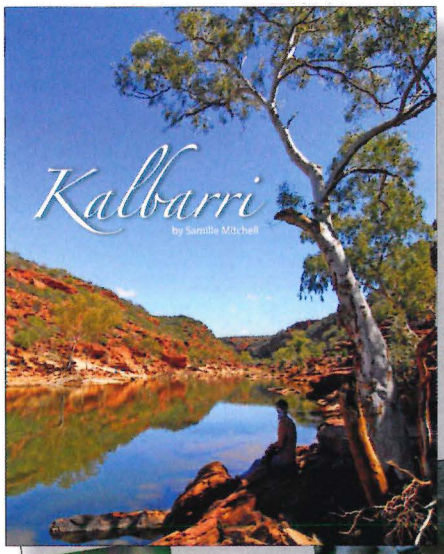
While some of the vegetation species will be lost in this fire, the bush generally will return. But I fear for special habitat and irreplaceable nesting holes of felled unsafe trees.

The Department of Environment and Conservation's Keep Australia Beautiful Council has a program for community members to dob in dumpers of rubbish... phone us or register online.

DID YOU KNOW?

- The department's saleable book *Leaf and branch: Trees and tall shrubs of Perth* has just been revised and reprinted. It is a wonderful reference on our urban vegetation and no home should be without one.
- The Keep Australia Beautiful Council office phone number is 6467 5129 or you can register at www.kabc.wa.gov.au. Call the illegal dumping hotline on 1300 766 541.

Drop something sport?







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

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

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

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

Kalbarri

RRP $29.95

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

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