

# Science Division annual research activity report and management implications

## 2009 – 2010



# DIRECTOR'S MESSAGE

This is the last *Annual Review of Research Activities Report* produced under my leadership of the Science Division. I step down after 14 years to continue my career in the Department of Environment and Conservation (DEC) focusing on fire and biodiversity policy, planning and research.

DEC's in-house applied research capability is one of the great strengths of the agency and is part of why DEC is recognised as a world leader in many areas including fire management, feral animal control, fauna and flora translocations and conservation, disease management and biological survey. It has also enabled DEC to build enduring and beneficial partnerships with other local, national and international scientific institutions.

DEC has maintained a significant research capability while many other similar organisations across the country have allowed their research capacity to decline. This is indicative of the strategic importance placed on science and scientists by successive leaders of DEC. However, this support is conditional – DEC's Science Division must continue to address the agencies science and information needs; the science we generate must be relevant and beneficial to the organisation; we must communicate and promote our science; and through partnerships, we must leverage DEC's investment in science.

The importance of science to conservation and land management is also enshrined in the Conservation and Land Management Act 1984 Sect. 33 – Functions of the CEO:

- to be responsible for the permanent preservation of the plant collections of the Western Australian Herbarium and to care for and extend those collections.
- to carry out or cause to be carried out such study or research of or into:
  - (i) the management of land to which this Act applies
  - (ii) the conservation and protection of flora and fauna
  - (iii) the taxonomy of flora and introduced plants
  - (iv) any other matter related to a function of the CEO, as the Minister may approve.

Having a core of in-house expertise also enables the provision of accurate and timely scientific, technical and policy advice to the Department, the Minister and the wider community and is a point of contact for engaging and communicating with external providers of science. On a number of occasions scientists from other institutions have told me they enjoy working with DEC because of the ease of science communication with the organisation.

Adaptive management requires a scientific approach to management activities so that answers to important questions can be learnt by doing. Not only does this enable DEC to do its job effectively and efficiently, but it enhances the Department's public standing and engenders confidence in the Government's policies and the Department's practices.

While the importance of science to delivering a "*healthy, diverse and well-managed Western Australian environment*" is generally appreciated, there are several models by which science can be delivered.

DEC's science and information needs could be delivered either via internal or external science capacity or, preferably, through strategic collaborations that utilise both internal and external capacities. The balance of internal, external and collaborative delivery will be different for short-term research, strategic/long-term research and monitoring because of the varying objectives, capacities, expertise and interests of external science providers and the institutional imperatives of DEC. For example, external science providers are generally more focused on, and structured for, short-term research rather than strategic or long-term research and monitoring.

Drivers for research institutions outside the state government sector are to attract funds and to produce scientific papers in peer-reviewed journals. This is because research, rather than management, is their primary focus. That is, their focus is scientific output rather than government policy outcomes. Therefore, research, monitoring, survey or other knowledge acquisition activities that require a medium or long-term commitment of people and other resources is probably most effectively and efficiently done in-house by agency scientists, whereas it may be more efficient for external providers such as CSIRO, local universities or consultants, to conduct short-term, one-off and highly specialised research.

Recognising this, the science delivery model in DEC utilises both internal and external science capacities because agencies with management responsibilities (like DEC) require an appropriate balance between the three areas of science (short term research, long term research, and monitoring and evaluation) to achieve their objectives. Within the research area, external science providers' interests relate more to pure or basic research than applied research often because a) it aligns better with their short term funding cycles and b) they are primarily interested in the process/prediction part of the knowledge continuum and are less interested in the biophysical and social inventories and baseline data that are 'core' knowledge for management agencies. Where DEC has a requirement for this process/prediction type of research, it may be more cost-effective to engage, or collaborate with external agencies such as CSIRO or tertiary institutions – the extent to which this is done is summarised in this report. Pure or basic research, rather than applied research, is also of greater professional interest to most scientists in external research institutions and is generally more amenable to scientific publications, which is a key performance measure in external research institutions.

In addition to problem solving, discovering new and better ways of doing things and carrying out relevant applied research necessary to underpin policies and operations, a vital role for DEC scientists is to ensure that new knowledge is transferred and taken up by policy makers and practitioners. Communication and knowledge transfer to improve the way we do things are key performance measures for scientists in DEC while recognising the need to have the quality of science assessed through the peer review publication process. Improving or changing policies and practices based on new information ('operationalising science') often requires a long term commitment by DEC scientists working alongside planners, policy makers and practitioners to up-skill and train them and to develop new or revised processes for incorporating changes. External science providers are generally unable or unwilling to make the significant, ongoing commitment that is needed to adequately communicate and transfer knowledge, train staff and develop new policies and operating procedures and to be 'on tap' to trouble shoot.

It has been an honour and a privilege to have served as DEC's Science Director and to have been part of DEC's Corporate Executive.



Dr Neil Burrows  
Director Science Division  
June 2010

# CONTENTS

VISION .....	7
FOCUS AND PURPOSE.....	7
ROLE .....	7
SERVICE DELIVERY STRUCTURE.....	8
PUBLICATIONS AND REPORTS .....	9
CURRENT COLLABORATION WITH ACADEMIA (STUDENT PROJECTS) .....	27
EXTERNAL PARTNERSHIPS.....	33
SUMMARY OF RESEARCH PROJECTS BY DEC, NRM, IBRA/IMCRA REGIONS .....	40
RESEARCH ACTIVITIES.....	49
<b>BIODIVERSITY AND CLIMATE CHANGE UNIT.....</b>	<b>49</b>
Collaborative research on biodiversity and climate change in megadiverse ecosystems .....	49
Assessing the combined effects of climate change and land transformation on the geographic ranges of keystone and iconic species in south-west Western Australia .....	50
Temperature thresholds for recruitment in south-west Western Australian flora .....	51
Climate change risks for biodiversity and ecosystem function in species-rich shrublands .....	51
Protecting the safe havens: will granite outcrop environments serve as refuges for flora threatened by anthropogenic climate change? .....	52
<b>BIOGEOGRAPHY .....</b>	<b>54</b>
Pilbara regional biological survey .....	54
Kimberley islands biological survey.....	55
Floristic surveys of the banded iron formation (BIF) and greenstone ranges of the Yilgarn .....	56
Biological survey of the Ravensthorpe Range .....	57
Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain.....	58
Ecomorphological clues to community structure; bat echolocation studies .....	58
Short range endemism of ground-dwelling Invertebrates in the central Pilbara.....	59
Development of ethically acceptable techniques for invertebrate wet-pit trapping .....	60
<b>FAUNA CONSERVATION.....</b>	<b>62</b>
Development of effective broadscale aerial baiting strategies for the control of feral cats .....	62
Sustained introduced predator control in the rangelands.....	63
Conservation of south coast threatened birds.....	64
Translocation outcomes and monitoring of naturally occurring populations of the western ringtail possum ( <i>Pseudocheirus occidentalis</i> ).....	65
The importance of fox, cat and native predator interactions to sustained fauna recovery in the northern jarrah forest – is there a mesopredator release effect? .....	66
Factors affecting establishment in the numbat ( <i>Myrmecobius fasciatus</i> ) Recovery Plan .....	67
An assessment of the effect of fox control on red-tailed phascogale ( <i>Phascogale calura</i> ) populations.....	68
Dibbler ( <i>Parantechinus apicalis</i> ) Recovery Plan .....	69
Gilbert's potoroo ( <i>Potorous gilbertii</i> ) Recovery Plan .....	70
Genetics and ecology of the western barred bandicoot ( <i>Perameles bougainville</i> ) .....	71
Disease screening and vectors of transmission in quokkas ( <i>Setonix brachyurus</i> ) on the	

mainland and Bald Island.....	72
Rapid survey of quokka ( <i>Setonix brachyurus</i> ) in the southern forests.....	73
Pro bait trials: phase 2.....	74
Sustained fauna recovery in a fragmented landscape (Dryandra Woodland and Tutanning Nature Reserve).....	74
Return to Dryandra.....	76
Implementation of the Recovery Plan for chuditch ( <i>Dasyurus geoffroii</i> ).....	77
Factors affecting fauna recovery in the Wheatbelt – Lake Magenta and Dunn Rock Nature Reserves.....	77
Rangelands Restoration – reintroduction of native mammals to Lorna Glen (Matuwa).....	78
Barrow Island fauna translocations.....	80
Ecology and conservation of threatened pythons in WA.....	81
Implementation of the Lancelin Island Skink Recovery Plan.....	81
Improving rock-wallaby conservation and management.....	82
Impact of cane toads on biodiversity in the Kimberley.....	83
Identifying the cause(s) of the recent declines of woylies in south-west Western Australia.....	84
Conservation of Western Australian butterflies.....	85
Conservation of the graceful sun-moth.....	86
<b>FLORA CONSERVATION AND HERBARIUM.....</b>	<b>88</b>
Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora.....	88
Genetic and ecological viability of plant populations in remnant vegetation.....	89
Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance.....	91
Assessment of genetic diversity, key population processes and evolutionary relationships in the Banded Ironstone endemic <i>Acacia woodmaniorum</i> and its close relatives.....	92
Seed biology, seedbank dynamics and collection and storage of seed of rare and threatened Western Australian taxa.....	93
Translocation of Critically Endangered plants.....	94
Ecophysiology of rare flora restricted to shallow-soil communities.....	95
Effects of pre-treatments, microhabitats and on-site management in the translocation success of threatened plant species: an ecophysiological approach.....	96
Integrated strategies for the control of <i>Phytophthora cinnamomi</i> using phosphite.....	97
Susceptibility of rare and endangered flora to <i>Phytophthora</i> .....	98
An investigation of the epidemiology and use of novel phosphite application techniques in <i>Phytophthora cinnamomi</i> infestations in National Parks of the south coast region of Western Australia.....	98
Selection, screening and field testing of jarrah resistant to <i>Phytophthora cinnamomi</i> .....	99
Dieback-resistant jarrah establishment in operational forest rehabilitation sites.....	100
Mundulla Yellows disease in Western Australia.....	101
Vegetation Health Service.....	102
The population ecology of Critically Endangered flora.....	103
Causes of rarity in four <i>Tetratheca</i> taxa in the Goldfields Ranges.....	104
Taxonomic studies on native and naturalised plants of Western Australia arising from biological survey.....	105
Wattles of the Pilbara.....	106
Conservation status and systematics of Western Australia <i>Acacia</i> .....	106
Wattles in the Shire of Dalwallinu.....	107
Understanding Mulga.....	107
Taxonomic review and conservation status of the members of the Myrtaceae tribe Chamelaucieae and miscellaneous other Western Australian plant groups.....	108
Taxonomic resolution and description of new plant species particularly Priority Flora and from those areas subject to mining interests in Western Australia.....	109
Taxonomy of selected families including legumes, grasses and lilies.....	110
Taxonomic studies in selected families, including Asteraceae, Celastraceae, Malvaceae, Proteaceae.....	111
Herbarium collections management.....	112
The Western Australian plant census and Australian plant census.....	114
The Western Australian Herbarium's specimen database.....	115



FloraBase – the Western Australian flora.....	116
Biodiversity Informatics at the Western Australian Herbarium .....	117
Taxonomic review and floristic studies of the benthic marine algae of north-western Western Australia and floristic surveys of Western Australian marine benthic algae .....	118
The Western Australian marine benthic algae online and an interactive key to the genera of Australian marine benthic algae.....	119
Perth Urban Bushland Fungi (PUBF) Project.....	119
Improving the comprehensiveness, accuracy and availability of taxonomic data about WA's fungi in DEC biological datasets and biodiversity collections .....	120
Taxonomic studies in Epacridaceae, Rafflesiaceae, Rhamnaceae and Violaceae .....	121
Development of interactive identification platforms and content .....	122
Surveys, systematics and genetic diversity of granitic vernal pools flora.....	123
New tools to uncover a <i>Eucalyptus</i> phylogeny and evaluate conservation priority species ....	124
Systematics of the triggerplant genus <i>Stylidium</i> .....	125
Comparison of plant canker disease impact and climatic variables in Proteaceae on the south coast of Western Australia and evaluation of selected fungicides as a management tool for canker control in the declared rare flora <i>Banksia verticillata</i> and <i>Lambertia orbifolia</i> .....	126
Taxonomy of <i>Ptilotus</i> and <i>Gomphrena</i> (Amaranthaceae) and <i>Swainsona</i> (Fabaceae).....	127
Taxonomy of undescribed conservation taxa in the <i>Ericaceae</i> subfamily <i>Styphelioideae</i> .....	128
<b>LANDSCAPE CONSERVATION .....</b>	<b>130</b>
FORESTCHECK – Integrated site-based monitoring of the effects of timber harvesting and silviculture in the jarrah forest .....	130
Monitoring long-term effects of various fire regimes on species richness and composition of southern jarrah forest understory.....	131
Project Rangelands Restoration: Developing sustainable management systems for the conservation of biodiversity at the landscape scale in the Gibson Desert and Gascoyne bioregions.....	131
Burning for biodiversity: Walpole fine grain mosaic burning trial.....	133
Genetic analysis for the development of vegetation services and sustainable environmental management .....	134
Identification of seed collection zones for rehabilitation .....	135
Management of environmental risk in perennial landuse systems.....	135
State Salinity Strategy wetland monitoring .....	136
Monitoring stream biodiversity (KPI 20 for Forest Management Plan).....	138
Bushfire CRC Project 1.4: Improved methods for the assessment and prediction of grassland curing.....	139
Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the jarrah forest .....	139
Management of the Vasse-Wonnerup wetlands .....	140
Monitoring post-fire effects of the 2001 Nuyts wildfire.....	141
Long-term monitoring of timber harvesting on bird populations in south-west forest areas.....	142
Project Vesta – prediction of high intensity fire behaviour in dry eucalypt forest .....	143
Increasing productivity of karri regrowth stands by thinning and fertilising .....	144
Espacement effects on the development and form of regrowth karri stands .....	144
Fire induced mosaics in semi-arid shrublands and woodlands.....	145
Fire regimes and biodiversity decline in the Kimberley .....	146
Armillaria spread in karri ( <i>Eucalyptus diversicolor</i> ) forest .....	147
The effect of wildfire on forest fungi.....	148
Forest health and vitality surveillance and monitoring.....	149
Aspects of dieback behaviour relevant to the formulation of jarrah silviculture guidelines .....	149
The impact of wildfire in old growth forest of the Walpole-Nornalup National Park on short-range endemic invertebrates and their forest floor communities .....	150
Effects of timber harvesting on terrestrial vertebrates in medium rainfall jarrah forest.....	151
Characteristics of hollow-bearing jarrah ( <i>Eucalyptus marginata</i> ) and marri ( <i>Corymbia calophylla</i> ) trees and coarse woody debris (CWD), their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them.....	152
Evaluation of key soil indicators of sustainability in Australian Mediterranean forests (Indicators 4.1d, 4.1e) .....	153

Effect of stand density and fertilising on seed-fall. Exp. B. Establishment of jarrah ( <i>Eucalyptus marginata</i> ) in shelterwood areas and on dieback 'graveyard' sites .....	154
Control of jarrah leafminer: selective retention of JLM resistant trees and ground coppice in a demonstration forest plot.....	155
Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity .....	155
Monitoring northern extent of jarrah leafminer outbreak .....	156
Bushfire CRC Project B1.1: Managing fires in forested landscapes in south-west WA .....	157
Fire, fragmentation, weeds and the conservation of plant biodiversity in wheatbelt nature reserves.....	157
<b>MARINE SCIENCE.....</b>	<b>160</b>
WAMSI Node 3: Science administration, coordination and integration.....	160
Conservation of marine turtles in Western Australia .....	162
Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015 .....	163
Strategic plan for the development and implementation of the Western Australian Marine Monitoring Program (WAMMP) .....	163
WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation.....	164
WAMMP Sub-project 2: Historical time-series development .....	165
WAMMP Sub-project 3: 'Fit to Park' .....	166
WAMMP Sub-project 4: MPRA/DEC audit support .....	168
WAMMP Sub-project 5: Community participation .....	169
WAMMP Sub-project 6: MSP Data management and presentation .....	170
Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park .....	170
Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater and Marmion marine parks .....	171
Interactive effects of fishing and climate change on coral reef fish populations .....	172
Preliminary assessment of diseases affecting Western Australian corals .....	173
The biogeography of Shark Bay Marine Park mangrove communities .....	174
<b>SCIENCE APPLICATIONS.....</b>	<b>176</b>
Development of biodiversity indices .....	176
Provision of authoritative names of WA taxa.....	176
Online GIS biodiversity mapping (NatureMap).....	177
Species database management software (Max).....	178
Baselining the Avon NRM Region (terrestrial).....	178
Baselining the Avon NRM Region (wetlands) .....	180
<b>PERTH OBSERVATORY .....</b>	<b>181</b>
Astronomical Outreach and Education .....	181
Astronomical Information Services .....	182
Variable star observations .....	183
Imaging and spectrophotometry of comets .....	184
Imaging and CCD photometry of transient and variable sources.....	184
Astrometry of minor planets, comets and targets of opportunity .....	185
Monitoring gravitational microlenses .....	185
Supernova search.....	186
Astronomical evaluation of sites in Western Australia.....	187
<b>STUDENT PROJECTS – PROGRESS REPORTS.....</b>	<b>189</b>

# VISION

We envisage a society where scientific enquiry is highly respected and forms an objective basis for environmental decision making and policy development.

# FOCUS AND PURPOSE

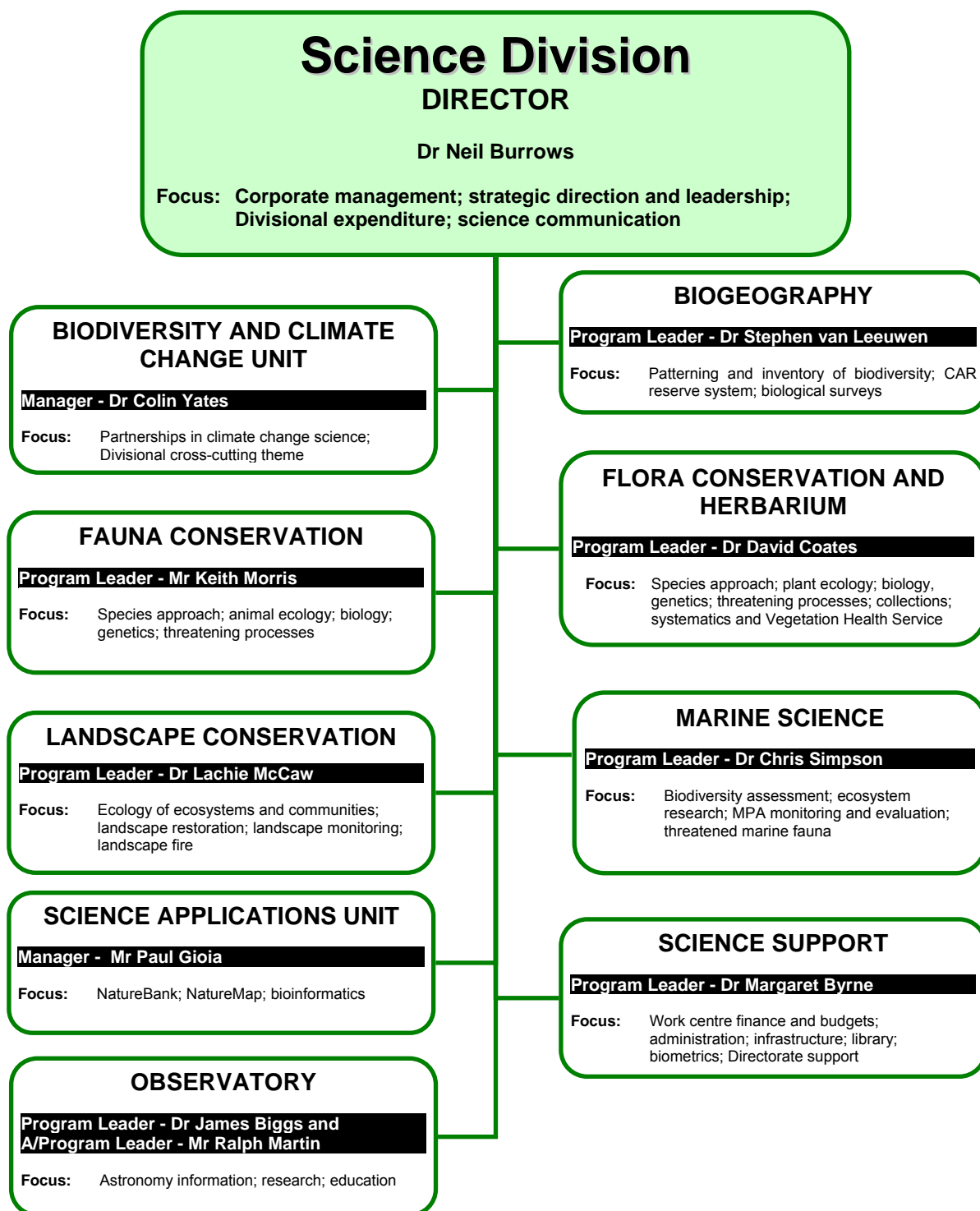
Provision of up-to-date and scientifically sound information to uphold effective conservation of biodiversity and sustainable natural resource management in Western Australia. We strive to provide excellence in science and technology based on internationally recognised best practice. We operate research centres that foster, promote and reward creativity and innovation.

# ROLE

- To provide a scientifically objective and independent source of reliable knowledge and understanding about conserving species and ecological communities in Western Australia, managing the public lands and waters entrusted to the Department of Environment and Conservation (DEC), and carrying out DEC's other legislative responsibilities.
- To ensure that Science Division is responsive to the needs of policy makers and end users in DEC by bringing science to bear on the solution of the State's most pressing problems relating to conservation and land management.
- To work in partnership with DEC managers, research institutions and the broader community to increase knowledge underpinning conservation and land management in WA.
- To advise DEC on sustainable resource development opportunities and to promote the conservation of biological resources through their sustainable utilisation.
- To communicate and transfer to managers in DEC, and to the broader community, knowledge, information and other insights obtained through scientific investigation in Western Australia and elsewhere.
- To attain a worldwide reputation for excellence in science by publishing knowledge obtained through scientific research in premier national and international scientific journals and through electronic means.
- To contribute, as an integrated part of DEC, to meeting the need for knowledge on conservation and land management matters by the public of Western Australia.
- To undertake and participate in astronomy research, information and education for the benefit of local, national and international communities.



# SERVICE DELIVERY STRUCTURE



# PUBLICATIONS and REPORTS

1. Abbott I (2009) Aboriginal names of bird species in south-west Western Australia, with suggestions for their adoption into common usage. *Conservation Science Western Australia* **7**, 213-278.
2. Abbott I (2009) Faunal extinctions: where and how have populations disappeared? Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3690/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3690/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **21/2009**, DEC, Kensington, WA. 2 p.
3. Abbott I (2009) Faunal extinctions: where and why?. *Bushland News* **72**, p. 10.
4. Abbott I, le Maitre D (2010) Monitoring the impact of climate change on biodiversity: the challenge of megadiverse Mediterranean climate ecosystems. *Austral Ecology* **35**, 406-422.
5. Abbott I, Liddel G, Vellios C, Mellican A, Williams M (2009) Monitoring bird populations after logging in forests of south-west Western Australia: an update from two long-term experimental research case studies. *Conservation Science Western Australia* **7**, 301-347.
6. Albrow MD, Horne K, Bramich DM, Fouqué P, Miller VR, Beaulieu J-P et al. [Williams A] (2009) Difference imaging photometry of blended gravitational microlensing events with a numerical kernel. *Monthly Notices of the Royal Astronomical Society* **397**, 2099-2105.
7. Algar D, Hamilton N, Johnston M, Lindeman M (2010) New tools for fighting ferals. *Landscape* **25(3)**, 24-29.
8. Algar D, Johnston M, Hilmer S (2010) A pilot study for the proposed eradication of feral cats on Dirk Hartog Island, Western Australia (ABSTRACT). In *Island Invasives: Eradication and Management: a Conference at Tamaki Campus, the University of Auckland, 8 to 12 February 2010: Programme, Abstracts and List of Participants* (comp D Veitch), p. 17. Centre for Biodiversity and Biosecurity, Auckland.
9. Algar D, Richards J (2010) Controlling introduced predators in the rangelands: the conclusion. *Landscape* **25(4)**, 17-23.
10. Anderson P, Brundrett M, Grierson P, Robinson R (2010) Impact of severe forest dieback caused by *Phytophthora cinnamomi* on macrofungal diversity in the northern jarrah forest of Western Australia. *Forest Ecology and Management* **259**, 1033-1040.
11. Austen JM, Jefferies R, Friend JA, Ryan U, Adams P, Reid SA (2009) Morphological and molecular characterization of *Trypanosoma copemani* n.sp. (Trypanosomatidae) isolated from Gilbert's potoroo (*Potorous gilbertii*) and quokka (*Setonix brachyurus*). *Parasitology* **136**, 783-792.
12. Averis S, Thompson RCS, Lymbery AJ, Wayne AF, Morris KD, Smith A (2009) The diversity, distribution and host-parasite associations of trypanosomes in Western Australian wildlife. *Parasitology* **136**, 1269-1279.
13. Bain K, Bencini R, Morris K, Liddel G, Wayne A (2009) Quantitative determination of the abundance of quokka (*Setonix brachyurus*) populations in the southern forests of Western Australia using relative abundance indices (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 35.
14. Bancroft K (2009) Constructing historical timelines: is it worth the trouble? (ABSTRACT). In *Monitoring for Action: Symposium Abstracts, 24 November 2009: Understanding Western Australia's Changing Marine and Coastal Environment* p. 31. Symposium Organising Committee, Perth.
15. Batista V, Dong S, Gould A, Beaulieu JP, Cassan A, Christie GW et al. [Martin R, Williams A] (2009) Mass measurement of a single unseen star and planetary detection efficiency for OGLE 2007-BLG-050. *Astronomy and Astrophysics* **508**, 467-478.
16. Beatty P, McCaw L (2009) Bushfire control and salvage tactics in the west. *Australian*

*Forest Grower* **32**(2), 27-28.

17. Bennett MD, Reiss A, Stevens H, Heylen E, van Ranst M, Wayne A et al. (2010) The first complete papillomavirus genome characterized from a marsupial host: a novel isolate from *Bettongia penicillata*. *Journal of Virology* **84**, 5448-5453.
18. Berryman A (2009) Western ground parrot project: 2008 review. *South Coast Threatened Birds News* **13**, 2, 12.
19. Bishop C, Wardell-Johnson G, Williams M (2009) How does *Phytophthora cinnamomi* change *Banksia* woodland alpha and beta diversity in the southwest Australian global biodiversity hotspot? (ABSTRACT). In *SERI 2009: World Conference on Ecological Restoration: Making Change in a Changing World: 19th Conference of the Society for Ecological Restoration International, Perth, Western Australia, Australia, Sunday 23 August to Thursday 27 August 2009: Conference Abstracts* p. 80. Conference Organising Committee, Perth.
20. Bishop C, Williams M, Gamblin T (2009) Graceful sun-moth: information kit and survey methods. Department of Environment and Conservation, Kensington, WA. 16 p.
21. Boer MM, Sadler RJ, Wittkuhn RS, McCaw L, Grierson PF (2009) Long term impacts of prescribed burning on regional extent and incidence of wildfires: evidence from 50 years of active fire management in SW Australian forests. *Forest Ecology and Management* **259**, 132-142.
22. Boer M, Sadler R, Wittkuhn R, McCaw L, Grierson P (2009) Long-term impacts of prescribed burning on regional extent and incidence of wildfires: evidence from fifty years of active fire management in SW-WA: poster presented at AFAC09, Conference of the Australasian Fire and Emergency Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). University of Western Australia, Crawley.
23. Bougher N (2009) Assessing the conservation status and nomination for formal listing of fungi species in Western Australia: a discussion document provided for the FungiMap V workshop, 2009, Threat status listing of Australian fungi. Department of Environment and Conservation, Kensington, WA. 4 p.
24. Bougher NL (2009) A flora, fauna and fungi doctrine in Western Australia (ABSTRACT). In *Fungimap V Conference, 21-26 May 2009, Wallerawang, New South Wales: Conference Programme* p. 9. Sydney Fungal Studies Group, Sydney.
25. Bougher NL (2009) Fungi survey 2009, and historical account of fungi studies and names: Kings Park and Botanic Garden. Department of Environment and Conservation, Kensington, WA. 27 p.
26. Bougher NL (2009) Fungi survey: Bold Park 2009. Department of Environment and Conservation, Kensington, WA. 24 p.
27. Bougher N (2009) New science information sheets from Western Australia fly the flag for fungi. *Fungimap Newsletter* **37**, p. 11.
28. Bougher NL (2009) Status of the genera *Hymenangium* and *Descomyces*. *Mycotaxon* **108**, 313-318.
29. Bougher NL (2009) Two intimately co-occurring species of *Mycena* section *Sacchariferae* in south-west Australia. *Mycotaxon* **108**, 159-174.
30. Bougher NL (2010) First record for Australia of the wood-inhabiting fungus, *Hemimycena cephalotricha*: from urban bushland in Perth, Western Australia. *Western Australian Naturalist* **27**, 91-98.
31. Bougher NL (2010) Fungi manual for 2009 Bush Skills for the Hills Workshop. Department of Environment and Conservation, Kensington, WA. 22 p.
32. Bougher NL (2010) History of the study of fungi at Kings Park, Perth, Western Australia. *Western Australian Naturalist* **27**, 61-90.
33. Bougher NL, Friend JA (2009) Fungi consumed by translocated Gilbert's potoroos (*Potorous gilbertii*) at two sites with contrasting vegetation, south coastal Western Australia. *Australian Mammalogy* **31**, 97-105.
34. Bougher N, Hart R, Jayasekera A (2009) Flora, fauna and fungi. *Bushland News* **71**, p. 1.
35. Bougher NL, Hart R, Jayasekera A, Glossop B (2009) Bushland fungi of Ellis Brook Valley Reserve. Department of Environment and Conservation, Kensington, WA. 24 p.
36. Bougher NL, Hart R, Jayasekera A, Glossop B (2009) Bushland fungi of FR Berry Reserve. Department of Environment and Conservation,

- Kensington, WA. 20 p.
37. Bougher NL, Hart R, Jayasekera A, Glossop B (2009) Bushland fungi of Paruna Wildlife Sanctuary. Department of Environment and Conservation, Kensington, WA. 22 p.
  38. Bougher NL, Hart R, Jayasekera A, Glossop B (2009) Fungi of John Forrest National Park. Department of Environment and Conservation, Kensington, WA. 27 p.
  39. Bougher NL, Hart R, Jayasekera A, Ruthrof K, Glossop B (2009) Bushland fungi of the Busselton area. Department of Environment and Conservation, Kensington, WA. 43 p.
  40. Bullen RD, McKenzie NL, Bullen KE, Williams MR (2009) Bat heart mass: correlation with foraging niche and roost preference. *Australian Journal of Zoology* **57**, 399-408.
  41. Burbidge AA (2009) Box 3.11: South-western Australia: a global biodiversity hotspot under stress. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), pp. 55-56. CSIRO Pub, Collingwood.
  42. Burbidge A (2009) Box 3.4: An example of biodiversity vulnerability to mining in Western Australia. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 37. CSIRO Pub, Collingwood.
  43. Burbidge A (2009) Box 3.6 Australia's extinction record for terrestrial mammals. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 42. CSIRO Pub, Collingwood.
  44. Burbidge A (2009) Box 3.7: What does threatened mean?. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 43. CSIRO Pub, Collingwood.
  45. Burbidge A (2009) Box 5.6 Australia's islands and sea-level rise: Houtman Abrolhos example. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 90. CSIRO Pub, Collingwood.
  46. Burbidge A (2009) Box 6.5: Trans-equatorial migrating shorebirds. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 136. CSIRO Pub, Collingwood.
  47. Burbidge A (2009) Extinction, decline and recovery in Australia's terrestrial mammal fauna. In *Art, Science and the Environment: a Festschrift in Honour of Emeritus Professor Don Bradshaw, Chair of Zoology 1976-2004*, the University of Western Australia pp. 277-293. University of Western Australia Press, Crawley.
  48. Burbidge A (ed) (2009) Carnaby's Black-Cockatoo Symposium: Monday 1st December, 2008, Department of Environment and Conservation, Kensington: proceedings, September 2009. WWF-Australia, Sydney. 56 p.
  49. Burbidge A (2009) Western ground parrot in dire straits. *Western Australian Bird Notes* **130**, 1-2.
  50. Burbidge AH (2009) Western ground parrots distinct from eastern ground parrots. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **13(3)**, p. 17.
  51. Burbidge A, Berryman A, Comer S, Bondin A, Newbey B, Blyth J (2009) Volunteers are a key component in research and management of the critically endangered western ground parrot (ABSTRACT). In *Fifth Biennial Australasian Ornithological Conference, Armidale, NSW, 29 November-4 December 2009: Program, Timetable & Abstracts* p. 29. Birds Australia (Northern NSW), Armidale.
  52. Burbidge A, Mather S (eds) (2009) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. No. 131, September 2009. 32 p.
  53. Burbidge A, Mather S (eds) (2009) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. No. 132, December 2009. 36 p.
  54. Burbidge A, Mather S (eds) (2010) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia. No. 133, March 2010. 36 p.
  55. Burbidge A, Mather S (eds) (2010) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia. No. 134, June 2010. 40 p.
  56. Burbidge A, Mitchell D, Roache M (2009) Overview of the Carnaby's Black-Cockatoo Symposium. In *Carnaby's Black-Cockatoo Symposium: Monday 1st December, 2008, Department of Environment and Conservation, Kensington: Proceedings, September 2009* (ed A Burbidge), p. 5.

WWF-Australia, Sydney.

57. Burgess TI, Stukely M, Jung T, White D, Huberli D, Hardy GE St (2010) Molecular characterisation of a *Phytophthora* hybrid swarm in native ecosystems and waterways in Western Australia (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 6. Conference Organising Committee, Auckland.
58. Burmej HI, Wayne A, Abdad Y, Smith A, Lymbery A, Morris K et al. (2009) Ectoparasites and the woylie (*Bettongia penicillata ogilbyi*): biodiversity and ectoparasite burden (POSTER ABSTRACT). In *The Australian Mammal Society: Semi-Centenary and 55th Meeting in Perth, July 5-9, 2009: Scientific Programme* p. 54. Conference Organising Committee, Perth.
59. Burrows N (2009) Big bad fires threaten rock outcrops (ABSTRACT). In *Biodiversity Under Fire: the Nature Conservation Council of NSW Presents its 17th Biennial Bushfire Management Conference: NSW Teachers Federation Conference Centre, Sydney, 22nd June-23rd June* pp. 13-14. Nature Conservation Council of NSW, Sydney.
60. Burrows N (2010) How much fuel reduction burning is needed to prevent wildfires?. *Biomass Smoke Newsletter* 5, p. 3.
61. Burrows N, Ward B, Robinson A (2010) Fire regimes and tree growth in low rainfall jarrah forest of south-west Australia. *Environmental Management* 45, 1332-1343.
62. Byrne M (2009) Box 5.2: Did Australian species stay or move when climate changed in the past?. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), p. 75. CSIRO Pub, Collingwood.
63. Byrne M, Hankinson M, McArthur S (2009) Characterization of microsatellite markers isolated from *Bossiaea ornata* (Lindl.) Benth. (Papilionaceae). *Conservation Genetics* 10, 1985-1987.
64. Byrne M, Stone L (2009) The need for duty of care when introducing new crops for agriculture (ABSTRACT). In *Biosecurity in the New Bioeconomy: Canberra, ACT, Australia, 19-21 November 2009* p. 9. CSIRO, Canberra.
65. Byrne M, Stone L, Millar M (2009) Environmental risk in agroforestry. In *Agroforestry for Natural Resource Management* (eds I Nuberg, B George, R Reid), pp. 107-126. CSIRO Pub, Collingwood.
66. Cale D, Lyons M, McCormick C, Pinder A, Walker C (2010) State Salinity Strategy wetland biodiversity monitoring report: Lake Eganu 1998-2007. Department of Environment and Conservation, Woodvale, WA. 44 p.
67. Campbell KJ, Hanson CC, Algar D, Keitt BS, Robinson S, Harper GA et al. (2010) Updated review of feral cat eradications on islands (ABSTRACT). In *Island Invasives: Eradication and Management: a Conference at Tamaki Campus, the University of Auckland, 8 to 12 February 2010: Programme, Abstracts and List of Participants* (comp D Veitch), p. 27. Centre for Biodiversity and Biosecurity, Auckland.
68. Chambers JM, Clarke A, Paling EI (2009) Snapshot survey of the distribution and abundance of the macrophytes, macroalgae, phytoplankton and macroinvertebrates of the Vasse-Wonnerup lagoons, February 2009. Murdoch University, Murdoch. 42 p.
69. Coates DJ, McArthur S (2009) Assessing the taxonomic status of *Banksia brownii* and patterns of genetic diversity in extinct and extant populations: Bankwest Landscape Project final report. Department of Environment and Conservation, Kensington, WA. 8 p.
70. Cochrane A (2009) Millennium Seed Bank Project. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3413/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3413/task,doc_download/). Biodiversity Case Study 3, p. 3. Department of Environment and Conservation, Kensington, WA.
71. Cochrane A (2009) Saving plant diversity, one seed at a time. *Landscape* 25(2), 6-8.
72. Cochrane A (2009) Saving the Western Australian flora: conserving genetic diversity under the international Millennium Seed Bank Project partnership 2001-2009. Department of Environment and Conservation, Kensington, WA. 2 p.
73. Cochrane A (2009) Threatened Flora Seed Centre, 2010: seeding our future. Threatened Flora Seed Centre Calendar 2010, Department of Environment and

- Conservation, Kensington, WA.
74. Cochrane A, Barrett S, Watson J (2009) Responses to threats and impacts on the outstanding biodiversity values of low-altitude mountains in south Western Australia. *Mountain Forum Bulletin* **9**(2), 8-10.
  75. Cochrane A, Crawford AD, Offord CA (2009) Seed and vegetative material collection. In *Plant Germplasm Conservation in Australia: Strategies and Guidelines for Developing, Managing and Utilising Ex Situ Collections*. Fully revised (eds CA Offord, PF Meagher), pp. 35-62. Australian Network for Plant Conservation, Canberra.
  76. Cochrane A, Monks L, Crawford A (2009) Lessons learnt from linking *ex situ* to *in situ* conservation of threatened plant species (ABSTRACT). In *SERI 2009: World Conference on Ecological Restoration: Making Change in a Changing World: 19th Conference of the Society for Ecological Restoration International, Perth, Western Australia, Australia, Sunday 23 August to Thursday 27 August 2009: Conference Abstracts* p. 162. Conference Organising Committee, Perth.
  77. Cochrane A, Schreck S (2009) Assessing temperature thresholds for germination: final report. Department of Environment and Conservation, Albany. 17 p.
  78. Colquhoun IJ, Thomas L, Rakela N, Pearson L, Dunne C, Witham D et al. (2010) A new approach to changing the behaviours of users of remnant woodlands in the Perth region (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 9. Conference Organising Committee, Auckland.
  79. Colquhoun IJ, Williams N, Rakela N, Dunne C, Witham D, Pez M (2010) Best practice management framework for *Phytophthora* dieback in southwest Western Australia (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 10. Conference Organising Committee, Auckland.
  80. Comer S, Burbidge A, Tiller C, Berryman A, Danks A, McNee S (2009) Monitoring to inform adaptive management of threatened birds on the south coast of Western Australia (ABSTRACT). In *Abstracts, 10th International Congress of Ecology (INTECOL): Ecology in a Changing Climate: Two Hemispheres-One Globe, Brisbane, August 2009* p. 1. Conference Organising Committee, Brisbane.
  81. Comer S, Newbey B, Burbidge A (2010) New western ground parrot recovery actions under way. *Western Australian Bird Notes* **133**, p. 3.
  82. Cruz J, Sutherland DR, Leung LKP, Marlow NJ, de Tores PJ (2009) Behavioural responses of Australian species to invasive predators (ABSTRACT). In *Abstracts: IMC 10, 10th International Mammalogical Congress: Mendoza, Argentina, 9-14 August 2009* p. 273. Conference Organising Committee, Mendoza.
  83. Daniel G, Kern S, Pinder A (2009) Resource condition report for a significant Western Australian wetland: Marglu Billabong, Parry Lagoons. Department of Environment and Conservation, Kensington, WA. 9 p.
  84. Daniel G, Kern S, Pinder A, Nowicki A (2008) Resource condition report for a significant Western Australian wetland: Airfield Swamp (Nguyarri). Department of Environment and Conservation, Kensington, WA. 26 p.
  85. Daniel G, Kern S, Pinder A, Nowicki A (2009) Resource condition report for a significant Western Australian wetland: Lake Eda. Department of Environment and Conservation, Kensington, WA. 27 p.
  86. Daniel G, Kern S, Pinder A, Nowicki A (2009) Resource condition report for a significant Western Australian wetland: Lake Gregory (Paraku) system. Department of Environment and Conservation, Kensington, WA. 35 p.
  87. Daniel G, Kern S, Pinder A, Nowicki A (2009) Resource condition report for a significant Western Australian wetland: Lake MacLeod system. Department of Environment and Conservation, Kensington, WA. 28 p.
  88. Daniel G, Kern S, Pinder A, Nowicki A (2009) Resource condition report for a significant Western Australian wetland: Ngallagunda Swamp. Department of Environment and Conservation, Kensington, WA. 21 p.
  89. Daniel G, Kern S, Pinder A, Nowicki A



- (2009) Resource condition report for a significant Western Australian wetland: Saunders Spring. Department of Environment and Conservation, Kensington, WA. 30 p.
90. Davis RW (2009) *Ptilotus luteolus*, a new combination in *Ptilotus* (Amaranthaceae). *Nuytsia* **19**, 311-312.
  91. De Tores PJ (2009) A summary of research by Department of Environment and Conservation (DEC), Murdoch University and Curtin University on the western ringtail possum (*Pseudocheirus occidentalis*) on the southern Swan Coastal Plain and recommendations relevant to current research proposals. Department of Environment and Conservation, Woodvale, WA. 10 p.
  92. DEC, Science Division (2009) Science Division annual research activity report and management implications, 2008-2009. Department of Environment and Conservation, Kensington, WA. 212 p.
  93. Dunlop J, Morris K, Withnell B, Withnell K (2009) Fauna reconstruction in the WA rangelands (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 40.
  94. Dunne C, Crane C, Shearer B (2010) Containment and eradication of *Phytophthora cinnamomi* in the Fitzgerald River National Park in Western Australia (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 13. Conference Organising Committee, Auckland.
  95. Dunne C, Crane C, Shearer B (2010) Stem application of phosphite controls *Phytophthora cinnamomi* in native plant communities from south-west Western Australia (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 13. Conference Organising Committee, Auckland.
  96. Dunstan W, Paap T, Williams N, Dunne C, Sibbel N, Hardy G (2010) Progress in developing containment and eradication methods for *Phytophthora cinnamomi* in natural ecosystems (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* p. 14. Conference Organising Committee, Auckland.
  97. Dunstan WA, Rudman T, Shearer BL, Moore NA, Paap T, Calver MC et al. (2010) Containment and spot eradication of a highly destructive, invasive plant pathogen (*Phytophthora cinnamomi*) in natural ecosystems. *Biological Invasions* **12**, 913-925.
  98. Durrant B (2009) Christmas spiders: bush decorations. *Bushland News* **72**, p. 4.
  99. Edgar G, Barrett BJ, Crane K, Bancroft K (2009) Ecosystem monitoring of subtidal reefs in different management zones in the Jurien Bay Marine Park 1999-2007. Tasmanian Aquaculture and Fisheries Institute, Hobart. 57 p.
  100. Enright N, Yates C (2009) Predicting the impacts of climate change on biodiversity and ecosystem function in biodiverse shrublands. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3413/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3413/task,doc_download/). Biodiversity Case Study **2**, p. 2. Department of Environment and Conservation, Kensington, WA.
  101. Franks AJ, Yates CJ, Hobbs RJ (2009) Defining plant functional groups to guide rare plant management. *Plant Ecology* **204**, 207-216.
  102. Freeman K, Keighery B, Keighery G, Longman V, Black A, Molloy S (2009) The flora and vegetation of the Dawesville to Binningup region (Swan Coastal Plain): a report for the Environmental Protection Authority as part of the Swan Bioplan Project. Department of Environment and Conservation, Perth. 244 p.
  103. Friedman KJ (2009) State outlook for marine monitoring, evaluation and reporting: a Department of Environment and Conservation perspective (ABSTRACT). In *Monitoring for Action: Symposium Abstracts, 24 November 2009: Understanding Western Australia's Changing Marine and Coastal Environment* pp. 10-11. Symposium Organising Committee, Perth.
  104. Friend T (2009) Foreword. In *Mammals of the Avon Region* (by M Bamford, R Inglis, K Watson), pp. 6-7. Department of Environment and Conservation, Kensington, WA.
  105. Friend T (2010) The numbat: back by popular appeal. *Landscape* **25(3)**, 40-45.
  106. Friend JA, Bennison CH, Button TA, Bencini R, Mills HR, Lambert C (2009) Preliminary assessment of non-target risk

- associated with poison baiting for introduced house mice on Boullanger and Whitlock islands, Western Australia (POSTER ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 57.
107. Friend JA, Bougher NL, Hill SJE, Button TA, Bell LA (2009) Establishment of an island population of the world's rarest marsupial, Gilbert's potoroo, *Potorous gilbertii* (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 41.
  108. Gaikhorst G, Lambert C, Morris K (2009) Sandhill dunnarts WA: survey, ecology and conservation biology. *Watsnu* **15(1)**, p. 2.
  109. Gamblin T, Bishop C, Williams M, Williams A (2009) Sun-moth fact sheet (POSTER). Department of Environment and Conservation, Kensington, WA.
  110. Gamblin T, Bishop C, Williams M, Williams A (2010) Graceful sun-moth. *Landscape* **25(4)**, p. 31.
  111. Gamblin T, Williams M, Williams A (2010) The ant, the butterfly, the leafhopper and the bulldozer. *Landscape* **25(3)**, 54-58.
  112. Gamblin T, Williams MR, Williams AAE, Richardson J (2009) The ant, the butterfly and the bulldozer: a summary of baseline data for the pale form of the sand-dwelling sugar ant *Camponotus terebrans* associated with the critically endangered arid bronze azure butterfly (*Ogyris subterrestris petrina*) and recommendations for recovery. Department of Environment and Conservation, Kensington, WA. 16 p.
  113. Gamblin T, Williams MR, Williams AAE, Richardson J (2009) The ant, the butterfly and the bulldozer (POSTER). Department of Environment and Conservation, Kensington, WA.
  114. Gibson LA, McKenzie NL (2009) Environmental associations of small ground-dwelling mammals in the Pilbara region, Western Australia. *Records of the Western Australian Museum Supplement* **78**, 91-122.
  115. Gibson N (2009) Floristic surveys of the banded ironstone ranges. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3741/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3741/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **23/2009**, DEC, Kensington, WA. 2 p.
  116. Gibson N (2009) Ravensthorpe Range biological survey. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3982/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3982/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **30/2009**, DEC, Kensington, WA. 2 p.
  117. Gibson N (2010) Ephemeral clay-based wetlands of the south west Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,4121/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,4121/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **32/2010**, DEC, Kensington, WA. 2 p.
  118. Gioia P (2009) NatureMap: mapping Western Australia's biodiversity. Available at: <http://www.dec.wa.gov.au/images/stories/nature/science/sdis/sdis026.pdf>. Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **26/2009**, DEC, Kensington, WA. 2 p.
  119. Gioia P (2009) NatureMap: mapping Western Australia's biodiversity. No. 1, December 2009. Department of Environment and Conservation, Kensington, WA. 2 p.
  120. Gioia P (2010) Managing biodiversity data within the context of climate change: towards best practice. *Austral Ecology* **35**, 392-405.
  121. Glen A (2009) Introduced predator control and the response of native marsupial carnivores in south-western Australia (ABSTRACT). In *Abstracts: IMC 10, 10th International Mammalogical Congress: Mendoza, Argentina, 9-14 August 2009* p. 48. Conference Organising Committee, Mendoza.
  122. Glen A (2009) Why are endangered marsupial carnivores still abundant in some parts of eastern Australia? (ABSTRACT). In *Abstracts: IMC 10, 10th International Mammalogical Congress: Mendoza, Argentina, 9-14 August 2009* pp. 72-73. Conference Organising Committee, Mendoza.
  123. Glen AS (2010) Hybridisation between dingoes and domestic dogs: a comment on Jones (2009). *Australian Mammalogy* **32**, 76-77.
  124. Glen AS, Berry O, Sutherland DR, Garretson S, Robinson T, de Tores PJ (2010) Forensic DNA confirms intraguild

- killing of a chuditch (*Dasyurus geoffroii*) by a feral cat (*Felis catus*). *Conservation Genetics* **11**, 1099-1101.
125. Glen A, Cruz J, Sutherland D (2009) Predators and prey in the northern jarrah forest. *Australian Wildlife* **4**, p. 24.
  126. Glen AS, de Tores PJ, Sutherland DR, Morris KD (2009) Interactions between chuditch (*Dasyurus geoffroii*) and introduced predators: a review. *Australian Journal of Zoology* **57**, 347-356.
  127. Glen AS, Pennay M, Dickman CR, Firestone KB (2009) Dietary overlap between native and introduced carnivores in eastern Australia (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 42.
  128. Glen AS, Sutherland DR, Cruz J (2010) An improved method of microhabitat assessment relevant to predation risk. *Ecological Research* **25**, 311-314.
  129. Glen M, Bougher NL, Francis AA, Nigg SQ, Lee SS, Irianto R et al. (2009) *Ganoderma* and *Amauroderma* species associated with root-rot disease of *Acacia mangium* plantation trees in Indonesia and Malaysia. *Australasian Plant Pathology* **38**, 345-356.
  130. Gosper CR, Prober SM, Yates CJ (2010) Repeated disturbance through chaining and burning differentially affects recruitment among plant functional types in fire-prone heathlands. *International Journal of Wildland Fire* **19**, 52-62.
  131. Gosper CR, Prober SM, Yates CJ, Parsons BC (2009) Changes in vegetation structure and composition after fire in two Australian Mediterranean-climate plant communities: poster presented at the 2009 Fire Ecology and Management Congress (POSTER). Department of Environment and Conservation, Kensington, WA.
  132. Gosper C, Yates C, Prober S (2009) Ecological effects of creating fuel-modified zones by chaining and burning. Available at: <http://www.dec.wa.gov.au/images/stories/nature/science/sdis/sdis027.pdf>. Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **27/2009**, DEC, Kensington, WA. 2 p.
  133. Gosper C, Yates C, Prober S (2009) Restoring an appropriate fire regime to fragmented remnants: a vital attributes approach (ABSTRACT). In *SERI 2009: World Conference on Ecological Restoration: Making Change in a Changing World: 19th Conference of the Society for Ecological Restoration International, Perth, Western Australia, Australia, Sunday 23 August to Thursday 27 August 2009: Conference Abstracts* p. 84. Conference Organising Committee, Perth.
  134. Gosper C, Yates C, Prober S (2009) Restoring an appropriate fire regime to fragmented vegetation: a vital attributes approach: paper presented at the 2009 Fire Ecology and Management Congress. Department of Environment and Conservation, Kensington, WA. 24 p.
  135. Gosper C, Yates C, Prober S, Parsons B (2010) Changes in plant diversity and vegetation structure with time-since-fire in mallee and mallee-heath. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,4403/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,4403/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **33/2010**, DEC, Kensington, WA. 2 p.
  136. Grimm HL, de Tores PJ (2009) Some aspects of the biology of the common brushtail possum (*Trichosurus vulpecula*) and the threatened western ringtail possum (*Pseudocheirus occidentalis*) in a pine plantation scheduled for harvesting and in adjacent tuart and peppermint woodland near Busselton, Western Australia. Department of Environment and Conservation, Woodvale, WA. 28 p.
  137. Hamilton T, Wittkuhn RS, Carpenter C (2009) Creation of a fire history database for southwestern Australia: giving old maps new life in a geographic information system. *Conservation Science Western Australia* **7**, 429-450.
  138. Han C, Hwang K-H, Kim D, Udalski A, Abe F, Monard LAB et al. [Martin R, Williams A] (2009) Interpretation of strong short-term central perturbations in the light curves of moderate-magnification microlens events. *Astrophysical Journal* **705**, 1116-1121.
  139. Harding C, Williams M (2010) Designing a monitoring program for significant native flora. Department of Environment and Conservation, Kensington, WA. 38 p.
  140. Harding D (ed) (2009) Conservation science Western Australia. Volume seven, number two, December 2009. pp. 207-450. Department of Environment and Conservation, Kensington, WA.

141. Hart R (2010) Winter fungi surveys: enroll now. *Bushland News* **73**, p. 8.
142. Harvey J, Keighery G (2009) Avon baseline project: benchmarking wheatbelt vegetation communities: eucalypt woodlands. Department of Environment and Conservation, Kensington, WA. 56 p.
143. Heterick BE, Durrant B, Gunawardene NR (2010) The ant fauna of the Pilbara Bioregion, Western Australia. *Records of the Western Australian Museum Supplement* **78**, 157-167.
144. Hilmer SS (2010) Ecophysiology of feral cats (*Felis catus*) in Australia. Thesis (PhD) - Johann Wolfgang Goethe Universität. 166 p.
145. Hilmer S, Algar D, Neck D, Schleucher E (2010) Remote sensing of physiological data: impact of long-term captivity on body temperature variation of the feral cat (*Felis catus*) in Australia, recorded via Thermochron iButtons. *Journal of Thermal Biology* **35**, 205-210.
146. Hislop M (2009) New taxa in the *Leucopogon gracilis* group (Ericaceae: Styphelioideae: Styphelieae). *Nuytsia* **19**, 211-228.
147. Hollis JJ, McCaw WL (2009) Behind the flaming zone: woody fuel consumption and fireline intensity in the changing climate of Australia: poster presented at AFAC09, Conference of the Australasian Fire and Emergency Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). University of New South Wales, Canberra.
148. Hollis JJ, McCaw WL (2010) Woody fuel consumption and carbon in the changing climate of Australia: paper presented at the Conference of the Institute of Foresters of Australia, Caloundra, Qld, September 2009. Department of Environment and Conservation, Manjimup. 13 p.
149. Houston TF, Bougher NL (2010) Records of hypogeous mycorrhizal fungi in the diet of some Western Australian bolboceratine beetles (Coleoptera: Geotrupidae: Bolboceratinae). *Australian Journal of Entomology* **49**, 49-55.
150. Huisman JM (2010) (Common) seaweeds of India (BOOK REVIEW). *Journal of Applied Phycology* **22**, 381-383.
151. Huisman J (2010) Rare seaweed rediscovered. *Landscape* **25(4)**, 39-41.
152. Huisman JM, Leliaert F, Verbruggen H, Townsend RA (2009) Marine benthic plants of Western Australia's shelf-edge atolls. *Records of the Western Australian Museum Supplement* **77**, 50-87.
153. Huisman JM (2010) More marine algae (BOOK REVIEW). *Australian Systematic Botany Newsletter* **142**, 15-16.
154. Jackson J, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Desert Queens Baths. Department of Environment and Conservation, Kensington, WA. 19 p.
155. Jackson J, Kern S, Pinder A, Nowicki A, Daniel G (2009) Resource condition report for significant Western Australian wetland: wetlands of the Fortescue River system. Department of Environment and Conservation, Kensington, WA. 68 p.
156. Jaensch R, Clarke A, Lane J (2009) Surveys of waterbirds in selected wetlands of south-western Australia in spring-summer 2008-9, with an assessment of changes in habitat and waterbird usage over 2-3 decades. Department of Environment and Conservation, Busselton. 79 p.
157. Johnson B, Mitchell S (2009) Spotted surprise: the chuditch comeback. *Landscape* **25(2)**, 9-13.
158. Johnson B, Morris K (2010) Eradication of exotic rodents off six high conservation value Western Australian islands (ABSTRACT). In *Island Invasives: Eradication and Management: a Conference at Tamaki Campus, the University of Auckland, 8 to 12 February 2010: Programme, Abstracts and List of Participants* (comp D Veitch), p. 39. Centre for Biodiversity and Biosecurity, Auckland.
159. Johnston M, Algar D, Hamilton N, Lindeman M (2010) A bait efficacy trial for the management of feral cats on Christmas Island. Arthur Rylah Institute for Environmental Research, Technical Report Series **200**, Arthur Rylah Institute for Environmental Research, Heidelberg. 16 p.
160. Johnston M, Algar D, O'Donoghue M, Morris J. (2010) Field efficacy of the Curiosity® feral cat bait on three Australian islands (ABSTRACT). In *Island Invasives: Eradication and Management: a Conference at Tamaki Campus, the University of Auckland, 8 to 12 February 2010: Programme, Abstracts and List of*

- Participants* (comp D Veitch), p. 40. Centre for Biodiversity and Biosecurity, Auckland.
161. Johnston M, Algar D, Onus M, Hamilton N, Hilmer S, Withnell B et al. [Koch K] (2009) A bait efficacy trial for the management of feral cats on Dirk Hartog Island. Arthur Rylah Institute for Environmental Research, Technical Report Series **205**, Arthur Rylah Institute for Environmental Research, Heidelberg. 42 p.
  162. Jones CG, Plummer JA, Barbour EL, Byrne M (2009) Genetic diversity of an Australian *Santalum album* collection: implications for tree improvement potential. *Silvae Genetica* **58**, 279-286.
  163. Jones S, Francis C, Leung A, Pinder A (2009) Aquatic invertebrates and waterbirds of wetlands in the Avon region. Department of Environment and Conservation, Kensington, WA. 156 p.
  164. Keighery G (2009) Aloe in Western Australia. *Australian Systematic Botany Newsletter* **141**, 28-29.
  165. Keighery G (2009) Another Paradise lost? (BOOK REVIEW). *Australian Systematic Botany Newsletter* **141**, p. 33.
  166. Keighery GJ (2009) Fifty years after Cold Spring; what has been the contribution of cytogenetics to the systematics of Australian plants? (ABSTRACT). In *Australian Systematic Botany Society Conference, 1-3 December 2009: Systematic Botany: From Science to Society: Conference Booklet* p. 49. Conference Organising Team, Armidale.
  167. Keighery G (2009) Weeds: new, emerging, fading and gone: the dynamic weed flora of Western Australia (ABSTRACT). In *Western Australian Weeds Conference, 2009: Fostering Solutions for the Future: Western Australian Ecology Centre, Bold Park, Floreat, Western Australia* p. 12. Weeds Society of Western Australia, Victoria Park.
  168. Keighery G (2010) Grosvenor Selk: Kings Park Herbarium Curator and volunteer. *Australian Systematic Botany Society Newsletter* **142**, 6-8.
  169. Keighery G (2010) A new subspecies of *Grevillea brachystylis* (Proteaceae) from the Whicher Range. *Western Australian Naturalist* **27**, 11-17.
  170. Keighery G, Keighery B (2009) The identity of the Westview Beach *Atriplex*. Department of Environment and Conservation, Woodvale, WA. 7 p.
  171. Keighery GJ, Keighery BJ, Longman VM (2009) A preliminary list of the flora and significant flora of the Yalgorup National Park. Department of Environment and Conservation, Woodvale, WA. 43 p.
  172. Kendrick A, Huisman J, Rule M (2009) Marvellous mangroves. *Landscape* **25(2)**, 50-56.
  173. Kern S, Pinder A, Daniel G, Nowicki A (2009) Resource condition report for a significant Western Australian wetland: Le Lievre Swamp (Iljamalkarda). Department of Environment and Conservation, Kensington, WA. 26 p.
  174. Kinal J (2009) Hydrological impacts of timber harvesting. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3728/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3728/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **22/2009**, DEC, Kensington, WA. 2 p.
  175. Koan C, Kilkenny D, Pretorius ML, Frew D (2010) Two new variable sdB stars, HE 0218-3437 and LB 1516. *Monthly Notices of the Royal Astronomical Society* **401**, 1850-1856.
  176. Köhler F (2009) Phylogeny and evolution of the Camaenidae in north-western Australia: a model case for the study of speciation and radiation (ABSTRACT). In *Program and Abstracts of the Triennial Conference of the Malacological Society of Australasia, Molluscs 2009. Brisbane, 25-27 November 2009*
  177. Köhler F (2010) Three new species and two new genera of land snails from the Bonaparte Archipelago in the Kimberley, Western Australia (Pulmonata: Camaenidae). *Molluscan Research* **30**, 1-16.
  178. Köhler F, Gibson L (2009) Exploring the diversity of camaenid land snails in the Kimberley, Western Australia. *Newsletter of the Malacological Society of Australasia* **136**, 1-3.
  179. Köhler F, Gibson L (2009) Hidden treasures: land snails of the Kimberley. *Explore: the Australian Museum Magazine* **31(4)**, 10-11.
  180. Kroiss L, Moody M, Barker SJ, Byrne M, Ryan MH (2009) Development, characterization and transferability of microsatellite markers for *Cullen australasicum* (Leguminosae). *Conservation Genetics* **10**, 1803-1805.

181. Lane J (2009) Management of the Ramsar-listed Vasse-Wonnerup wetlands. Available at: <http://www.dec.wa.gov.au/images/stories/nature/science/sdis/sdis028.pdf>. Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **28/2009**, DEC, Kensington, WA. 2 p.
182. Lane J (2010) A list of the waterbirds of the Vasse-Wonnerup wetlands. Rev. (PAMPHLET). p. 2. Department of Environment and Conservation, Como, WA.
183. Lane JAK, Clarke AG, Winchcombe YC, Pearson GB, Muir WP, Johnson BW, Elscot SV (2009) South west wetlands monitoring program report, 1977-2008. Department of Environment and Conservation, Busselton. 143 p.
184. Llorens T, Nistelberger H, Byrne M, Coates D, Yates C (2009) Fine scale genetic structure and gene flow in *Banksia sphaerocarpa* var. *caesia* in the fragmented agricultural landscape of south-western Australia (ABSTRACT). In *GSA 2009: Brisbane, 7-10 July: Programme and Abstracts* p. 19. Genetics Society of AustralAsia, Brisbane.
185. Lonsdale CJ, Cappallo RJ, Morales MF, Briggs FH, Benkevitch L, Bowman JD et al. [Williams A] (2009) The Murchison Widefield Array: design overview. *Proceedings of the IEEE* **97**, 1497-1506.
186. Lyons MN, Dunlop JA (eds) (2009) Data appendices: a biodiversity survey of the Western Australian agricultural zone. Department of Environment and Conservation, Woodvale, WA. 624 p.
187. Maher D, McCaw L, Yates C (2009) Vulnerability of forests in south-west Western Australia to timber harvesting under the influence of climate change: expert panel report. Department of Environment and Conservation, Kensington, WA. 55 p.
188. Maher KA, Hobbs RJ, Yates CJ (2010) Woody shrubs and herbivory influence tree encroachment in the sandplain heathlands of southwestern Australia. *Journal of Applied Ecology* **47**, 441-450.
189. Malkovich T (2009) Burning the bush: to prevent big fires. Available at: [http://www.sciencewa.net.au/index.php?option=com\\_content&view=article&id=2631:burning-the-bush-to-prevent-big-fires](http://www.sciencewa.net.au/index.php?option=com_content&view=article&id=2631:burning-the-bush-to-prevent-big-fires) [Accessed 22 Sep 2009]. 1-2. ScienceNetwork Western Australia, Perth.
190. Markey AS, Dillon SJ (2009) Flora and vegetation of the banded iron formations of the Yilgarn Craton: Herbert Lukin Ridge (Wiluna). *Conservation Science Western Australia* **7**, 391-412.
191. Markey A, Wilkins C, Allen J (2009) Report on the conservation status of 40 taxa from the Ravensthorpe Range. Part 1. Department of Environment and Conservation, Woodvale, WA. 119 p.
192. Marks CA, Gigliotti F, McPhee S, Piggott MP, Taylor A, Glen AS (2009) DNA genotypes reveal red fox (*Vulpes vulpes*) abundance, response to lethal control and limitations of contemporary survey techniques. *Wildlife Research* **36**, 647-658.
193. Martin R (2010) Supernova 2010e in ESO 13-G28. Central Bureau for Astronomical Telegrams, Electronic Telegram **2121**, p. 1.
194. Martin R, Jacques C, Pimentel E (2009) Supernova 2009jy in NGC 320. *Central Bureau for Astronomical Telegrams, Electronic Telegram* **1983**, p. 1.
195. Maslin B, Reid J (2009) Understanding mulga. Available at: <http://www.dec.wa.gov.au/images/stories/nature/science/sdis/sdis025.pdf>. Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **25/2009**, DEC, Kensington, WA. 2 p.
196. Matthews S, Gould J, McCaw L (2010) Simple models for predicting dead fuel moisture in *Eucalyptus* forests. *International Journal of Wildland Fire* **19**, 459-467.
197. McClanahan TR, Graham NAJ, Wilson S, Letourner Y, Fisher R (2009) Effects of fisheries closure size, age and history of compliance on coral reef fish communities in the western Indian Ocean. *Marine Ecology Progress Series* **396**, 99-109.
198. McDougall A, Porter G, Mostert M, Cupitt R, Cupitt S, Joseph L et al. [Burbidge A] (2009) Another piece in an Australian ornithological puzzle: a second night parrot is found dead in Queensland. *Emu* **109**, 198-203.
199. McKellar R, Midgley GF, Yates CJ, Abbott I, Gioia P, le Maitre D (2010) The need to develop a coherent research approach for climate change vulnerability impact



- assessment and adaptation in high-biodiversity terrestrial ecosystems. *Austral Ecology* **35**, 371-373.
200. McKenzie NL, Bullen RD (2009) The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum Supplement* **78**, 123-155.
  201. McKenzie NL, van Leeuwen S, Pinder AM (2009) Introduction to the Pilbara Biodiversity Survey, 2002-2007. *Records of the Western Australian Museum Supplement* **78**, 3-89.
  202. Mead-Hunter D, Hart R (2010) First records of *Poderseerpula pusio*, the pagoda fungus in the Perth metropolitan region, Western Australia. *Western Australian Naturalist* **27**, 25-26.
  203. Meissner RA (2010) Biodiversity values of basic raw material sites within Cape Range National Park. Department of Environment and Conservation, Kensington, WA. 51 p.
  204. Meissner R, Owen G, Bayliss B (2009) Flora and vegetation of banded iron formations of the Yilgarn Craton: Cashmere Downs range. *Conservation Science Western Australia* **7**, 349-361.
  205. Meissner R, Owen G, Bayliss B (2009) Flora and vegetation of banded iron formations of the Yilgarn Craton: Mount Forrest-Mount Richardson Range. *Conservation Science Western Australia* **7**, 377-389.
  206. Meissner R, Owen G, Bayliss B (2009) Flora and vegetation of the banded iron formation of the Yilgarn Craton: Robinson Ranges and Mount Gould. *Conservation Science Western Australia* **7**, 363-376.
  207. Millar MA (2009) Characterisation of microsatellite DNA markers for the rare *Acacia woodmaniorum* (Leguminosae: Mimosaceae). *Conservation Genetics Resources* **1**, 441-445.
  208. Millar M (2010) Seed collection for revegetation: guidelines for determining the requirement for local seed. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **14(1)**, 6-8.
  209. Millar MA, Byrne M, Coates D (2009) Disparate patterns of population genetic diversity, structure and clonality in a critically endangered *Banksia* species (ABSTRACT). In *GSA 2009: Brisbane, 7-10 July: Programme and Abstracts* p. 46.
  - Genetics Society of AustralAsia, Brisbane.
  210. Millar MA, Coates D (2009) Assessment of population genetic variation and structure of *Acacia woodmaniorum*, and its phylogenetic relationship to other *Acacia* species: twelve monthly report to Karara Mining Ltd by the Department of Environment and Conservation, October 2009. Department of Environment and Conservation, Kensington, WA. 12 p.
  211. Millar MA, Coates DJ (2010) Assessment of population genetic variation and structure of *Acacia woodmaniorum*, and its phylogenetic relationship to other *Acacia* species: eighteen month report to Karara Mining Ltd by the Department of Environment and Conservation, April 2010. Department of Environment and Conservation, Kensington, WA. 27 p.
  212. Miller EJ, Eldridge MDB, Thomas N, Marlow N, Herbert CA (2010) The genetic mating system, male reproductive success and lack of selection on male traits in the greater bilby. *Australian Journal of Zoology* **38**, 113-120.
  213. Mills G, McCaw L (2009) Atmospheric stability environments and fire weather 1, an extended Haines Index: poster presented at AFAC09, Conference of the Australasian Fire and Emergency Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). Centre for Australian Weather and Climate Research, Melbourne.
  214. Mills G, McCaw L (2009) Atmospheric stability environments and fire weather 2, a case study of the Hovea fire: poster presented at AFAC09, Conference of the Australasian Fire and Emergency Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). In *AFAC09 Conference of the Australasian Fire and Emergency Services Authorities Council and the Bushfire CRC, Gold Coast, QLD, September 2009* Centre for Australian Weather and Climate Research, Melbourne.
  215. Mills GA, McCaw L (2010) Atmospheric stability environments and fire weather in Australia: extending the Haines Index. CAWCR Technical Report **20**, Centre for Australian Weather and Climate Research, Melbourne. 151 p.
  216. Moody ML, Les DH (2010) Systematics of the aquatic angiosperm genus *Myriophyllum* (Haloragaceae). *Systematic Botany* **35**, 121-139.

217. Moore T, de Tores P, Fleming PA (2010) Detecting, but not affecting, nest box occupancy. *Wildlife Research* **37**, 240-248.
218. Murphy S, Austin J, Burbidge A, Joseph L, Berryman A (2009) Systematics and population history of ground parrots suggest we are dealing with a critically endangered species (ABSTRACT). In *Fifth Biennial Australasian Ornithological Conference, Armidale, NSW, 29 November-4 December 2009: Program, Timetable & Abstracts* p. 44. Birds Australia (Northern NSW), Armidale.
219. Murphy S, Berryman A, Burbidge A, Joseph L, Austin J (2009) Raising the stakes: ancient and modern population history of western ground parrots combine to suggest a new addition to Australia's critically endangered species list. *Wingspan* **19**(2), p. 19.
220. Murphy S, Burbidge A, Joseph L, McAllan I, Venables W, King E (2009) Wanted: a bigger needle or a smaller haystack. explaining and predicting the occurrence of night parrots in a vast landscape (ABSTRACT). In *Fifth Biennial Australasian Ornithological Conference, Armidale, NSW, 29 November-4 December 2009: Program, Timetable & Abstracts* p. 83. Birds Australia (Northern NSW), Armidale.
221. Neaves LE, Zenger KR, Prince RIT, Eldridge MDB, Cooper DW (2009) Landscape discontinuities influence gene flow and genetic structure in a large, vagile Australian mammal, *Macropus fuliginosus*. *Molecular Ecology* **18**, 3363-3378.
222. Nield AP, Ladd PG, Yates CJ (2009) Reproductive biology, post-fire succession dynamics and population viability analysis of the critically endangered Western Australian shrub *Calytrix breviseta* subsp. *breviseta* (Myrtaceae). *Australian Journal of Botany* **57**, 451-464.
223. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Lake Ballard. Department of Environment and Conservation, Kensington, WA. 30 p.
224. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Lindsay Gordon Lagoon. Department of Environment and Conservation, Kensington, WA. 38 p.
225. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Mungilli Claypan. Department of Environment and Conservation, Kensington, WA. 22 p.
226. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Rowles Lagoon. Department of Environment and Conservation, Kensington, WA. 31 p.
227. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Yeo Lake. Department of Environment and Conservation, Kensington, WA. 26 p.
228. Nowicki A, Kern S, Pinder A, Daniel G (2009) Resource condition report for significant Western Australian wetland: Coyrecup Lake. Department of Environment and Conservation, Kensington, WA. 32 p.
229. Nowicki A, Pinder A, Kern S, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Balicup Lake. Department of Environment and Conservation, Kensington, WA. 25 p.
230. Nowicki A, Pinder A, Kern S, Daniel G (2009) Resource condition report for a significant Western Australian wetland: Hutt Lagoon. Department of Environment and Conservation, Kensington, WA. 35 p.
231. O'Donnell AJ, Cullen LE, McCaw WL, Boer MM, Grierson PF (2010) Dendroecological potential of *Callitris preissii* for dating historical fires in semi-arid shrublands of southern Western Australia. *Dendrochronologia* **28**, 37-48.
232. Onton K (2009) Community based monitoring (ABSTRACT). In *Monitoring for Action: Symposium Abstracts*, 24 November 2009: Understanding Western Australia's Changing Marine and Coastal Environment p. 18. Symposium Organising Committee, Perth.
233. Pacioni C, Spencer PBS (2010) Capturing genetic information using non-target species markers in a species that has undergone a population crash. *Australian Mammalogy* **32**, 33-38.
234. Pan S, Thompson A, Lymbery A, Smith A, Morris K, Wayne A et al. (2009) Atypical *Toxoplasma gondii* genotypes in Western Australian wildlife species (ABSTRACT). In *World Association for the Advancement of Veterinary Parasitology, 2009: Abstract*

- Volume p. 110. Conference Organising Committee, Calgary.
235. Parameswaran N, O'Handley RM, Grigg ME, Wayne A, Thompson RCA (2009) Vertical transmission of *Toxoplasma gondii* in Australian marsupials. *Parasitology* **136**, 939-944.
  236. Parkar U, Traub R, Wayne AF, Morris K, Thompson RCA (2009) The prevalence and molecular characterization of *Blastocystis* isolates from wild Australian native fauna (ABSTRACT). In *ASP/NHMRC Research Network for Parasitology Annual Conference, University of Sydney, New South Wales*
  237. Parsons RF, Gibson N (2009) The cushion plants of lowland southern Australia. *Cunninghamia* **11**, 177-184.
  238. Pastorello A, Crockett RM, Martin R, Smartt SJ, Altavilla G, Benetti S et al. (2009) SN 1999ga: a low-luminosity linear type II supernova?. *Astronomy and Astrophysics* **500**, 1013-1023.
  239. Pearson D, Greenlees M, Ward-Fear G, Shine R (2009) Predicting the ecological impact of cane toads (*Bufo marinus*) on threatened camaenid land snails in north-western Australia. *Wildlife Research* **36**, 533-540.
  240. Phillips JC, Huisman JM (2009) Influence of the Leeuwin Current on the marine flora of the Houtman Abrolhos. *Journal of the Royal Society of Western Australia* **92**, 139-146.
  241. Pinder A (2009) Aquatic invertebrate communities in Avon and Dale River pools. Department of Environment and Conservation, Woodvale, WA. 19 p.
  242. Pinder A (2009) Up and down: aquatic annelid diversity in surface wetlands and groundwater of the arid Pilbara region of Western Australia (ABSTRACT). In *11th International Symposium on Aquatic Oligochaeta, 5-12 October, Türkiye/Alanya* p. 23. Eskisehir Osmangazi University, Eskisehir, Turkey.
  243. Pinder A (2010) Tools for identifying selected Australian aquatic oligochaetes (Clitellata: Annelida). *Museum Victoria Science Reports* **13**, 1-26.
  244. Pinder A, Leung A (2009) Conservation status and habitat associations of aquatic invertebrates in Pilbara coastal river pools. Department of Environment and Conservation, Woodvale, WA. 106 p.
  245. Pinder A, Timms B, Campagna V (2009) Salt-loving shrimps threatened by salinisation? Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3689/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3689/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **20/2009**, DEC, Kensington, WA. 2 p.
  246. Pinder J (2009) Radio-tracking western ground parrots in Cape Arid. *South Coast Threatened Birds News* **13**, 8-9.
  247. Poeschel CM, Huisman JM (2010) Observations of *Pihiella liagoraciphila* (Pihellales: Rhodophyta). *Phycologia* **49**, 42-47.
  248. Radford IJ, Dickinson KJM, Lord JM (2009) Does the invader *Hieracium lepidulum* have a comparative growth advantage over co-occurring plants? High leaf area and low metabolic costs as invasive traits. *New Zealand Journal of Botany* **47**, 395-403.
  249. Radford IJ, Dickinson KJM, Lord JM (2010) Does disturbance, competition or resource limitation underlie *Hieracium lepidulum* invasion in New Zealand? Mechanisms of establishment and persistence, and functional differentiation among invasive and native species. *Austral Ecology* **35**, 282-293.
  250. Randles JW, Hanold D, Stukely M, Thompson N (2010) Investigating eucalypt diseases of unknown etiology: the Mundulla Yellows experience. *Acta Horticulturae* **849**, 325-329.
  251. Rea AJ, Jung T, Stukely MJC, Burgess TI, Hardy GE St J (2010) Three undescribed pathogenic *Phytophthora* taxa from the south-west of Western Australia (ABSTRACT). In *Abstracts: 5th IUFRO Phytophthoras in Forests and Natural Ecosystems: Auckland and Rotorua, New Zealand, 7-12 March 2010* pp. 32-33. Conference Organising Committee, Auckland.
  252. Reid JE, Wardell-Johnson G, Maslin BR (2009) A new subspecies of *Acacia pentadenia* (Leguminosae: Mimosoideae) from south-western Australia. *Nuytsia* **19**, 245-252.
  253. Reisen F, Meyer M, Powell J, Keywood M, McCaw L, Tolhurst K (2009) Impact of smoke from prescribed burning and wildfires on rural communities in southern Australia: poster presented at AFAC09,

- Conference of the Australasian Fire and Emergency Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). CSIRO Marine and Atmospheric Research, Aspendale.
254. Reiss A, Vitali S, Eden P, Wayne AF (2009) Perth Zoo vet involvement in conservation programs: recent developments (ABSTRACT). In *Wildlife Disease Association (Australasian Section) Annual Conference, New Zealand*
  255. Richardson B (2009) The TDWG life sciences identifiers applicability statement (ABSTRACT). In *The Proceedings of TDWG: Provisional Abstracts of the 2009 Annual Conference of the Taxonomic Databases Working Group: 9-13 November 2009, Montpellier, France* (ed AL Weitzman), p. 11. Biodiversity Information Standards (TDWG), Montpellier.
  256. Roberts AE, Radford IJ, Orlovich DA (2009) Do alterations of arbuscular mycorrhizal fungal communities change interactions between invader *Hieracium lepidulum* and two co-occurring species? A glasshouse study. *Australasian Mycologist* **28**, 29-35.
  257. Robinson R (2009) Bushfires, fungi and biodiversity. *Landscape* **25**(1), 16-21.
  258. Rye BL (2009) An interim key to the Western Australian tribes and genera of Myrtaceae. *Nuytsia* **19**, 313-323.
  259. Science Division, DEC (2010) ForestCheck: report of progress, 2008-09. Department of Environment and Conservation, Kensington, WA. 126 p.
  260. Shearer BL, Dillon MJ, Kinal J, Buehrig RM (2010) Temporal and spatial soil inoculum dynamics following *Phytophthora cinnamomi* invasion of *Banksia* woodland and *Eucalyptus marginata* forest biomes of south-western Australia. *Australasian Plant Pathology* **39**, 293-311.
  261. Shepherd K (2010) Targeted survey of *Tecticornia* (Chenopodiaceae) in the Nelson Point to Bing Siding rail duplication project area, Port Hedland. Department of Environment and Conservation, Kensington, WA. 29 p.
  262. Shepherd KA, Barker RM (2009) A new species of *Hakea* (Proteaceae) from the Swan Coastal Plain, Western Australia. *Nuytsia* **19**, 253-258.
  263. Sirisena UM, Conran JG, Macfarlane TD (2009) Phylogeny of *Thysanotus* R.Br. (Laxmanniaceae) inferred from molecular and morphological data (ABSTRACT). In *Australian Systematic Botany Society Conference, 1-3 December 2009: Systematic Botany: From Science to Society: Conference Booklet* p. 68. Conference Organising Team, Armidale.
  264. Sirisena UM, Macfarlane TD, Conran JG (2009) *Thysanotus unicus* (Laxmanniaceae), a new species discovered in Unicup Nature Reserve, south-west Western Australia. *Nuytsia* **19**, 259-263.
  265. Smith A, Averis S, Wayne A, Morris K, Thompson A (2009) Low host specificity in trypanosomes associated with native Australian wildlife (ABSTRACT). In *World Association for the Advancement of Veterinary Parasitology, 2009: Abstract Volume* pp. 91-92. Conference Organising Committee, Calgary.
  266. Stanley F, Morris K, Holmes T, Moore J (2010) Giant steps: industry and conservation make history through Gorgon. *Landscape* **25**(4), 10-16.
  267. Stannard HJ, Caton W, Old JM (2010) The diet of red-tailed phascogales in a trial translocation at Alice Springs Desert Park, Northern Territory, Australia. *Journal of Zoology* **280**, 326-331.
  268. Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmayer D, Mulgrave W et al. (2009) Australia's Biodiversity and Climate Change. CSIRO Pub, Collingwood. 236 p.
  269. Stojanovic D, le Souef A, Burbidge A, Warren K (2009) Satellite and radio transmitters can be successfully borne by black-cockatoos (ABSTRACT). In *Fifth Biennial Australasian Ornithological Conference, Armidale, NSW, 29 November-4 December 2009: Program, Timetable & Abstracts* p. 34. Birds Australia (Northern NSW), Armidale.
  270. Stukely MJC, Barbour L (2009) Grafting is not feasible for propagating jarrah (*Eucalyptus marginata*) selected for resistance to *Phytophthora* dieback caused by *Phytophthora cinnamomi*. *Conservation Science Western Australia* **7**, 207-211.
  271. Stukely M, Webster J, Ciampini J (2009) Vegetation Health Service: annual report 2008-2009, *Phytophthora* detection. Department of Environment and

- Conservation, Kensington, WA. 13 p.
272. Sumi T, Bennet D, Bond I, Udalski A, Batista V, Dominik M et al. [Martin R, Williams A] (2010) A cold Neptune-mass planet OGLE-2007-BLG-368Lb: cold Neptunes are common. *Astrophysical Journal* **710**, 1641-1653.
  273. Sutherland DR, Kearney MR, Glen AS, Hilmer S, Schmidt S, de Tores PJ (2009) Mammalian and reptilian predators: niche overlap and competitive interactions (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, 50-51.
  274. Taggart DA, Schultz DJ, Fletcher TP, Friend JA, Smith IG, Breed WG et al. (2010) Cross-fostering and short-term pouch young isolation in macropodoid marsupials: implications for conservation and species management. In *Macropods: the Biology of Kangaroos, Wallabies and Rat-Kangaroos* (eds G Coulson, M Eldridge), pp. 263-278. CSIRO Pub, Collingwood.
  275. Thiele KR (2009) *Banksia recurvistyliis* (Proteaceae), a new species from Western Australia. *Nuytsia* **19**, 277-281.
  276. Thiele KR (2009) A new circumscription for *Lysinema ciliatum* (Ericaceae: Styphelioideae: Epacrideae) and reinstatement of *L. pentapetalum*. *Nuytsia* **19**, 265-275.
  277. Thiele KR (2009) Three new species of *Hibbertia* (Dilleniaceae) from Western Australia. *Nuytsia* **19**, 283-293.
  278. Thompson RCA, Smith A, Lymbery AJ, Averis S, Morris KD, Wayne AF (2010) *Giardia* in Western Australian Wildlife. *Veterinary Parasitology* **170**, 207-211.
  279. Thomson-Dans C, Johnson B (2009) Mammals of north-western Australia. Department of Environment and Conservation, Western Australia, Bush Books Department of Environment and Conservation, Kensington, WA. 72 p.
  280. Timms BV, Pinder AM, Campagna VS (2009) The biogeography and conservation status of the Australian endemic brine shrimp *Parartemia* (Crustacea: Anostraca: Parartemiidae). *Conservation Science Western Australia* **7**, 413-427.
  281. Trimming EM, Chambers BK, Grillo D, de Tores PJ, Bencini R (2009) Road kills of the western ringtail possum (*Pseudocheirus occidentalis*) occur at specific hotspots (ABSTRACT). In *The Australian Mammal Society: Semi-Centenary and 55th Meeting in Perth, July 5-9, 2009: Scientific Programme* p. 24. Conference Organising Committee, Perth.
  282. Van Leeuwen S (2009) Biodiversity of an economic hotspot: the Pilbara biological survey. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **13(3)**, 6-8.
  283. Verveer A, Frew D (2009) [Eta] Carinae. *International Astronomical Union, Circular* **9103**, p. 1.
  284. Ward BG (2009) A broad scale aerial survey of the feral camel population in the south Kimberley region of WA. Department of Environment and Conservation, Manjimup. 10 p.
  285. Waters C, Murray BG, Melville G, Coates D, Young A, Virgona J (2010) Polyploidy and possible implications for the evolutionary history of some Australian Danthonieae. *Australian Journal of Botany* **58**, 23-34.
  286. Wayne A (2010) Woylie conservation research: fact sheet. South Coast Natural Resource Management, Albany. 2 p.
  287. Wayne A, Maxwell M (2009) Examples of woylie skin and fur conditions associated with declines in the Upper Warren populations. Department of Environment and Conservation, Kensington, WA. 19 p.
  288. Wayne A, Thompson A, Reiss A, Page M, van Weenen J, Maxwell M et al. [Ward C, Vellios C] (2009) A wildlife pandemic? Are introduced predators and disease the causes of the collapse of woylie (brush-tailed bettong) populations? (ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 53.
  289. Webb A, Keighery B, Keighery G, Longman V, Black A, O'Connor A (2009) The flora and vegetation of the Busselton Plain (Swan Coastal Plain). Department of Environment and Conservation, Perth. 326 p.
  290. Wege JA, Gibson N (2009) A new, rare *Marianthus* (Pittosporaceae) from the Bremer Range in Western Australia. *Nuytsia* **19**, 295-302.
  291. Wege J, Markey A (2009) A new, rare *Hibbertia* discovered on Bandalup Hill. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,4037/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,4037/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet

- 31/2009**, DEC, Kensington, WA. 2 p.
292. Wege JA, Thiele KR (2009) Two new species of *Hibbertia* (Dilleniaceae) from near Ravensthorpe in Western Australia. *Nuytsia* **19**, 303-310.
  293. Wege JA (2009) Naming *Stylidium* (Stylidiaceae): an historical account, with specific reference to *S. graminifolium* and *S. lineare*. *Telopea* **12**, 321-332.
  294. Westera MB, Phillips JC, Coupland GT, Grochowski AJ, Harvey ES, Huisman JM (2009) Sea surface temperatures of the Leeuwin Current in the Capes region of Western Australia: potential effects on the marine biota of shallow reefs. *Journal of the Royal Society of Western Australia* **92**, 197-210.
  295. White DA, Battaglia M, Mendham DS, Crombie DS, Kinal J, McGrath JF (2010) Observed and modelled leaf area index in *Eucalyptus globulus* plantations: tests of optimality and equilibrium hypotheses. *Tree Physiology* **30**, 831-844.
  296. White DA, Crombie DS, Kinal J, Battaglia M, McGrath JF, Mendham DS et al. (2009) Managing productivity and drought risk in *Eucalyptus globulus* plantations in south-western Australia. *Forest Ecology and Management* **259**, 33-44.
  297. Whitford K (2009) Reducing soil disturbance during timber harvesting. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3624/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3624/task,doc_download/). Department of Environment and Conservation, Western Australia, Science Division, Information Sheet **19/2009**, DEC, Kensington, WA. 2 p.
  298. Whitford KR, Manning EJ, Wills AJ (2009) Wandoo crown condition 2009: report of wandoo crown decline surveys, 2009. Department of Environment and Conservation, Kensington, WA. 11 p.
  299. Williams M (2009) Butterflies in urban bushlands around Perth. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **13(4)**, 8-9.
  300. Williams M (2009) Conservation of the graceful sun-moth. *Bushland News* **72**, p. 9.
  301. Williams MR (2009) Diversity of butterflies and day-flying moths in urban habitat fragments, south-western Australia. Thesis (PhD) - Curtin University of Technology. 184 p.
  302. Williams M (2010) The butterflies & moths of Yalgorup. In *Yalgorup: Place of Lakes: an Ecological Wonderland* (comps H Wheater, J Norton), p. 31. FRAGYLE, Yalgorup.
  303. Williams MR, Lamont BB, Henstridge JD (2009) Species-area functions revisited. *Journal of Biogeography* **36**, 1994-2004.
  304. Williams M, Williams A (2009) Butterflies of the south-west. *Landscape* **25(1)**, 22-28.
  305. Williers N, Bencini R, Matson P, Martin GB, Morris K, Mawson P (2009) Use of contraceptive deslorelin implants to manage reproduction in black-flanked rock-wallabies (*Petrogale lateralis lateralis*) in Western Australia (ABSTRACT). In *Abstracts: IMC 10, 10th International Mammalogical Congress: Mendoza, Argentina, 9-14 August 2009* p. 22. Conference Organising Committee, Mendoza.
  306. Wills A (2009) Earthworms on the Maret Islands and adjacent islands, north-west Kimberley region, Western Australia. Department of Environment and Conservation, Kensington, WA. 31 p.
  307. Wilson K, de Tores P, Spencer PBS (2009) Isolation and characterisation of polymorphic microsatellite markers in the western ringtail possum, *Pseudocheirus occidentalis*. *Conservation Genetics Resources* **1**, 123-125.
  308. Wilson SK, Adjeroud M, Bellwood DR, Berumen ML, Booth D, Bozec Y-M et al. (2010) Crucial knowledge gaps in current understanding of climate change impacts on coral reef fishes. *Journal of Experimental Biology* **213**, 894-900.
  309. Wilson SK, Fisher R, Pratchett MS, Graham NAJ, Dulvy NK, Turner RA et al. (2010) Habitat degradation and fishing effects on the size structure of coral reef fish communities. *Ecological Applications* **20**, 442-451.
  310. Wittkuhn R, McCaw L (2010) Project B1.1: Managing fires in forested landscapes in southern Western Australia: final report. Department of Environment and Conservation, Kensington, WA. 41 p.
  311. Wittkuhn R, McCaw L, Robinson R, Farr J, van Heurck P, Wills A, Liddelow G, Cranfield R, Andersen A (2009) Planning fire intervals for biodiversity conservation. Poster presented to AFAC09, Conference of the Australasian Fire and Emergency



- Services Authority Council and Bushfire CRC, Gold Coast, Qld, September 2009 (POSTER). Department of Environment and Conservation, Manjimup.
312. Woolford L, Bennet MD, Sims C, Thomas N, Friend JA, Nicholls PK et al. (2009) Prevalence, emergence and factors associated with a viral papillomatosis and carcinomatosis syndrome in wild, reintroduced and captive western barred bandicoots (*Perameles bougainville*). *Ecohealth* **6**, 414-425.
  313. Yates C (2009) Box 5.8 Vulnerability of biodiversity in Western Australia to climate change. In *Australia's Biodiversity and Climate Change* (by W Steffen, AA Burbidge, L Hughes et al.), 102-104. CSIRO Pub, Collingwood.
  314. Yates C (2009) Climate change, seed sourcing and ecological restoration: implications for Mediterranean climate south-west Western Australia (ABSTRACT). In *SERI 2009: World Conference on Ecological Restoration: Making Change in a Changing World: 19th Conference of the Society for Ecological Restoration International, Perth, Western Australia, Australia, Sunday 23 August to Thursday 27 August 2009: Conference Abstracts* p. 49. Conference Organising Committee, Perth.
  315. Yates C, Byrne M, Gibson N, Langley M, Newman B, Sampson J, Stankowski S, Thavornkanlapachai R (2009) Assessing the long-term viability of the locally restricted species *Calothamnus* sp. *Whicher* and *Hakea oldfieldii* in a threatened ecological community near Busselton. Department of Environment and Conservation, Kensington, WA. 54 p.
  316. Yates CJ, Elith J, Latimer AM, le Maitre D, Midgley GF, Schurr FM, West AG (2010) Projecting climate change impacts on species distributions in megadiverse South African cape and southwest Australian floristic regions: opportunities and challenges. *Austral Ecology* **35**, 374-391.
  317. Yates CJ, McNeill A, Elith J, Midgley GF (2009) Assessing the impacts of climate change and land transformation on *Banksia* in the South West Australian Floristic Region. *Diversity and Distributions* **16**, 187-201.
  318. Yates C, Midgley G (2009) Collaborative research on climate change and biodiversity in megadiverse ecosystems. Available at: [http://www.dec.wa.gov.au/component/option,com\\_docman/Itemid,1/gid,3413/task,doc\\_download/](http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3413/task,doc_download/). Biodiversity Case Study **1**, p. 1. Department of Environment and Conservation, Kensington, WA.
  319. Yee JC, Udalski A, Sumi T, Dong S, Kozlowski S, Bird JC, et al. [Martin R., Williams A.] (2009) Extreme magnification microlensing event OGLE-2008-BLG-279: strong limits on planetary companions to the lens star. *Astrophysical Journal* **703**, 2082-2090.
  320. Young A, Broadhurst L, Elliot C, Field D, Coates D, Byrne M et al. [Yates C, Llorens T, Nistleberger H] (2009) Land & Water Australia project CPI 13: Molecular analysis of vegetation function in fragmented Australian biomes. CSIRO Plant Industry, Canberra. 36 p.
  321. Zosky K, Wayne A, Bryant K, Calver M (2009) Variation in the diet of the woylie, *Bettongia penicillata* (POSTER ABSTRACT). *Newsletter of the Australian Mammal Society* **Oct**, p. 62.

# CURRENT COLLABORATION WITH ACADEMIA (Student Projects)

DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
Abbott, Ian	P Van Heurck	The compositional, structural, and functional succession of beetle communities in habitat mosaics created by three different fire regimes in the southern forests of Western Australia	PhD	2005-2011	Prof J Majer	Curtin University of Technology
Algar, David	S Hilmer	Ecophysiology of the feral cat in Australia	PhD	2006-2009	Dr E Schieuecher	Johan Wolfgang Gothe University
Algar, David	K Koch	Genetic diversity and phylogeography of Australian cats	PhD	2009-2011	Dr K Schwenk	Johan Wolfgang Gothe University
Burbidge, Allan	R Scott	Can vocal recognition be used to discern population spatial structure and dispersal in Carnaby's Black-Cockatoo?	MSc	2010-2012	Dr R Davis	Edith Cowan University
Burrows, Neil	J Reid	Factors influencing stand structure, distribution and recruitment of <i>Acacia burrowsiana</i>	Hons	2008-2009	Dr P Groom, Dr P Grierson	Curtin University of Technology/ University of Western Australia
Burrows, Neil	C Bishop	Impacts of fire regimes and <i>Phytophthora</i> on vegetation communities of the southern forests	PhD	2005-2009	Dr G Wardell-Johnson	University of Queensland
Burrows, Neil	P Langlands	Interactions between fire and spiders in arid zone rangelands	PhD	2005-2009	Dr K Brennan	University of Western Australia
Burrows, Neil	J Fissioli	Predicting the distribution of tingle associations in south-west Australia	PhD	2005-2009	Dr G Wardell-Johnson	University of Queensland
Byrne, Margaret	R Thavornkanlapachai	Understanding the importance of gene flow for conservation of rare plants in fragmented landscapes	Hons	2009	Dr P Ladd	Murdoch University
Byrne, Margaret	A Shah	Genetic diversity and differentiation in <i>Banksia nivea</i>	Hons	2009	Dr M Moody	University of Western Australia

DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
Cochrane, Anne	B Vincent	Germination physiology and ecology of the priority and significant flora on RNO tenements at Bandalup Hill Nickel mine in relation to recruitment and regeneration	PhD	2005-2009	Dr J Plummer	University of Western Australia
de Tores, Paul	H Grimm	Possum ecology and health on the Geographe Coastal Plain	PhD	2006-2010	Dr K Warren, Prof I Robertson, Assoc Prof M Calver	Murdoch University
de Tores, Paul	G Bryant	The ecology and thermal biology of the south-west carpet python <i>Morelia spilota imbricata</i> in fox-controlled and uncontrolled areas of the swan coastal plain and northern jarrah forest of Western Australia	PhD	2006-2010	Dr T Fleming, Dr K Warren	Murdoch University
de Tores, Paul	K Yokochi	The efficacy of rope bridges in mitigating negative effects of roads on populations of possums in south-west Western Australia	PhD	2009-2012	Assoc Prof R Bencini, J Kennington	University of Western Australia
de Tores, Paul	L Zimmermann	Population density estimate of western ringtail possums ( <i>Pseudocheirus occidentalis</i> ) at Karakamia Wildlife Sanctuary	Hons	2010	Asst Prof H Mills	University of Western Australia
de Tores, Paul; Marlow, Nicky	J Cruz	Ecology of the Common brushtail possum in the northern jarrah forest in relation to predation and resource availability	PhD	2007-2010	Dr L Leung	University of Queensland
Farr, Janet	K Ironside	Trophic dynamics of predatory invertebrates in jarrah forests of differing fire history	MSc	2006-2011	Dr J Prince, Dr P Grierson	University of Western Australia
Friend, Tony	J Austen	Trypanosomes of some Western Australian mammals: phylogenetics and ecology	PhD	2006-2011	Dr U Ryan	Murdoch University
Friend, Tony	J Pridham	Finding a dietary surrogate for Gilbert's potoroo ( <i>Potorous gilbertii</i> )	Hons	2009-2010	Dr G Luck	Charles Sturt University, NSW
Huisman, John	F Hart	Systematics and pest potential of <i>Codium</i> (Chlorophyta) in Western Australia	Hons	2010	Dr J Huisman	Murdoch University
Huisman, John	R Dixon	Systematics of <i>Sargassum</i> (Phaeophyceae) in Australia	PhD	2008-2010	Dr J Huisman	Murdoch University
Kendrick, Alan; Rule, Mike	various	Marine and Coastal Management Course	3 <sup>rd</sup> yr	2010	Assoc Prof G Hyndes, Prof P Lavery	Edith Cowan University

DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
Lane, Jim	S Davies	An investigation of the cause and effects of increased salinity in a freshwater coastal wetland: Lake Davies, Western Australia	B Env Sc	2009-10	Dr J Chambers	Murdoch University
Macfarlane, Terry	IA Raheem	Systematic and evolutionary studies of the eastern and southern Australian clade of the genus <i>Hibbertia</i> Andrews subgenus <i>Hemistema</i> (Thouars) JW Horn	PhD	2009-2012	Dr JG Conran	University of Adelaide
McCaw, Lachie	F Metcalfe	Spatially explicit modelling of fire severity in south-west forest ecosystems, Western Australia	PhD	2007-2010	Prof B Veenendaal, Dr W Anderson (UNSW)	Curtin University of Technology
McCaw, Lachie	J Cargill	Fate of <i>Eucalyptus marginata</i> seed from canopy store to emergence in the northern jarrah forests of Western Australia	PhD	2006-2009	Prof W Stock, Dr E van Etten	Edith Cowan University
McCaw, Lachie	J Hollis	Coarse woody fuel availability and consumption in Australian forests fires	PhD	2007-2010	Dr W Anderson, Dr J Chapman, Dr P Ellis, Dr S Matthews	University of New South Wales
McCaw, Lachie	A O'Donnell	Fire patterns and vegetation structure in semi-arid woodlands and shrublands in southern Western Australia	PhD	2006-2009	Dr P Grierson, Dr M Boer	University of Western Australia
McKenzie, Norm; Wayne, Adrian	P Webala	Bat community structure and habitat use across disturbance regimes in jarrah forests, south-west Western Australia	PhD	2007-2010	Prof S Bradley, Dr M Craig	Murdoch University
Moody, Michael	J Stingemore	The effect of plant density on dispersal mechanisms and genetic variation for two co-occurring <i>Persoonia</i> species	PhD	2009-2011	Asst Prof M Moody	University of Western Australia
Moody, Michael	T Hevroy	Molecular taxonomy, phylogeography and population genetics of the <i>Grevillea thelemanniana</i> complex	PhD	2010-2012	Asst Prof M Moody	University of Western Australia
Moody, Michael; Poot, Peter	Y Smythe	Determining population health, viability and resilience to natural threats in the DRF <i>Banksia verticillata</i>	Hons	2010	Asst Prof M Moody, Asst Prof P Poot	University of Western Australia
Moody, Michael	S Battaliana	Molecular systematics and phylogeography of the <i>Myriophyllum callitrichoides</i> complex in the Kimberley Region	Hons	2010	Asst Prof M Moody	University of Western Australia
Moody, Michael	P Macintyre	Molecular taxonomy of <i>Laxmannia jamesii</i> : a disjunct species of	Hons	2009	Asst Prof M Moody	University of Western Australia

DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
		conservation concern				
Morris, Keith	N Willers	The use of the contraceptive deslorelin to manage overabundant rock-wallaby populations	PhD	2007-2010	Dr R Bencini	University of Western Australia
Morris, Keith; Johnson, Brent	K Rayner	Ecology of chuditch in the western woodlands of the Goldfields	Hons	2009	Dr H Mills	University of Western Australia
Morris, Keith; Johnson, Brent	C Smart	The relationship between water rat ( <i>Hydromys chrysogaster</i> ) distribution and water quality on the Swan Coastal Plain	Hons	2009	Dr H Mills	University of Western Australia
Radford, Ian	A Cook	Can we protect threatened mammals from severe wildfires in the north Kimberley?	MSc	2008-2010	Dr R Bencini, Dr H Mills	University of Western Australia
Robinson, Richard	F (Paco) Tovar	Fungi causing decay in coppiced bluegum stumps	PhD	2006-2009	Dr T Burgess, Dr G St J Hardy	Murdoch University
Rye, Barbara	C Motsi	Molecular systematics of <i>Pimelea</i> (Thymelaeaceae)	PhD	2005-2009	Dr M Van der Bank	University of Johannesburg
Shearer, Bryan	P Barua	Distribution of phosphite	PhD	2008-2011	Dr G Hardy	Murdoch University
Shearer, Bryan	P Barua	Use of <i>Lambertia</i> spp. as a model system to study pathogenicity of <i>Phytophthora cinnamomi</i>	PhD	2008-2011	Dr G Hardy	Murdoch University
Shearer, Bryan	L Eshraghi	Use of <i>Arabidopsis</i> as a model system to study mechanisms of action of phosphite	PhD	2008-2011	Dr G Hardy	Murdoch University
Shearer, Bryan	P Scott	Tuart decline	PhD	2004-2010	Dr G Hardy	Murdoch University
Shearer, Bryan	R Hooper	Wandoo decline	PhD	2004-2010	Prof K Sivasithamparam	University of Western Australia
Shearer, Bryan	P Staskowski	Mechanisms of phosphite action	PhD	2006-2010	Dr G Hardy	Murdoch University
Simpson, Chris	A Hill	Factors influencing the establishment of marine protected areas in Western Australia	PhD	2007-2009	Dr S Shea	Notre Dame University
Simpson, Chris; Kendrick, Alan; Wilson, Shaun; Waples, Kelly	Various	Science Connections: Marine Science Mentoring Program	U/grad	2009	Dr M van Keulen	Murdoch University
Smith, Andrew; Morris, Keith	J Dunop	Improving the success of threatened species translocation projects	PhD	2009-2012	Prof A Thompson	Murdoch University
Smith, Andrew	C Thomas	Trypanosomes of woylies from western Australia: vector identification, in vitro cultivation and	PhD	2010-2013	Prof A Thompson	Murdoch University

DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
		phylogenetic analysis.				
Smith, Andrew; Morris, Keith	L Pertuisel	Reintroduction of bilbies <i>Macrotis lagotis</i> (family Thylacomyidae) in the rangelands of Western Australia: background and future prospects	MSc	2010	Prof A Charpentier	University of Montpellier
Stukely, Mike	A Rea	Classical and molecular taxonomy and pathogenicity testing of <i>Phytophthora</i> species	PhD	2007-2010	Dr G Hardy	Murdoch University
van Leeuwen, Stephen	G Page	Ecology and physiology of Mulga types at West Angelas, Pilbara, Western Australia	PhD	2005-2010	Dr P Grierson	University of Western Australia
Wayne, Adrian	K Bain	Ecological study of the quokka ( <i>Setonix brachyurus</i> ) in the southern forests of south-west WA	PhD	2006-2012	Dr R Bencini	University of Western Australia
Wayne, Adrian; Smith, Andrew; Morris, Keith	H Burmej	Ectoparasites of threatened mammals in Western Australia: Biodiversity and impact	PhD	2007-2010	Prof A Thompson, Dr A Smith	Murdoch University
Wayne, Adrian	C Pacioni	A conservation conundrum: the population and epidemiological dynamics associated with recent decline of woylies ( <i>Bettongia penicillata</i> ) in Australia	PhD	2006-2010	Prof I Robertson, Dr P Spencer, Dr K Warren	Murdoch University
Wayne, Adrian	K Zosky (nee Rodda)	Resource availability and woylie declines in south-west Western Australia	PhD	2007-2010	Dr K Bryant Dr M. Calver	Murdoch University
Wayne, Adrian; Morris, Keith	U Parkar	Blasocystis and other protozoa in humans and wildlife	PhD	2006-2010	Prof A Thompson	Murdoch University
Wayne, Adrian	G Kaewmongkol	Bartonella infections in wildlife and domestic animals in Western Australia	PhD	2010-2012	Dr S Fenwick	Murdoch University
Wayne, Adrian	Y Abdad	Rickettsial infections in wildlife and humans in Western Australia	PhD	2006-2010	Dr S Fenwick	Murdoch University
Wayne, Adrian	G Yeatman	Population demographics of a fenced population of woylie	Hons	2010	Dr H Mills	University of Western Australia
Wayne, Adrian	P Webala	Bat community structure and habitat use across disturbance regimes in jarrah forests, south-west Western Australia	PhD	2007-2010	Dr S Bradley Dr M Craig	Murdoch University
Wayne, Adrian	H Hunt	A temporal assessment investigating the effects of population declines on genetic diversity, in the critically endangered woylie ( <i>Bettongia</i>	Hons	2009-2010	Dr M Bunce	Murdoch University



DEC Officer	Student	Project Title	Degree /level	Duration (yr - yr)	University Academic	University
		<i>penicillata ogilbyi</i> )				
Wayne, Adrian; Morris, Keith	S Pan	<i>Toxoplasma gondii</i> infection and atypical genotypes in Western Australian wildlife species.	PhD	2008-2011	Prof A Thompson	Murdoch University
Wayne, Adrian	P Roger	Predator profiling as a tool for the conservation of the woylie ( <i>Bettongia penicillata ogilbyi</i> )	Hon	2008-2009	Dr J Meyer	University of Western Australia
Wayne, Adrian	R McCracken	The status of key south-west Australian brush-tailed phascogale ( <i>Phascogale tapoatafa tapoatafa</i> ) populations and the role of animal health and disease in the absence of recovery from population decline	Hon	2009	Dr K Robert	University of Western Australia
Wittkuhn, Roy	B Pekin	Influence of fire frequency and resource gradients on the structure and diversity of the jarrah ( <i>Eucalyptus marginata</i> Donn ex Sm.) forest of south-west Australia	PhD	2006-2009	Dr P Grierson, Dr M Boer, Dr C Macfarlane	University of Western Australia

# EXTERNAL PARTNERSHIPS

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	External funding and source 2009/2010 (\$)	DEC Involvement (in kind and \$)
ABRS via Adelaide and Murdoch Universities	Marine Benthic Algae of the Great Barrier Reef	ABRS (to Murdoch) \$14k per annum 2009-2011	J Huisman (0.25)
ANZEC/CRC for Australian Weed Management	Technical Group for weeds of conservation significance	Nil	G Keighery (0.05)
ARC Linkage, Curtin University, University of Western Australia, Saskatchewan University, Royal Botanic Gardens Kew, AAMHatch	Protecting the safe havens: will granite outcrop environments serve as refuges for flora threatened by anthropogenic climate change?	\$330K 2009-2012	C Yates (0.2), M Byrne (0.1)
ARC Linkage, University of Queensland, University of Western Australia	Broadening the spatio- temporal scope of ecological studies to anticipate change in Australian forested ecosystems	\$120k for three years	N Burrows (0.05), B Ward (0.2), G Liddelow (0.2), R Cranfield (0.1), J Farr (0.1), A Wills (0.1), P Van Heurck (0.1), R Robinson (0.1), B Smith (0.1), K Bain (0.05), D Green (0.05), T Middleton (0.05), L Shu (0.05)
ARC Linkage, University of Sydney, Department of Environment and Water, Australian Reptile Park	Predicting the ecological impact of cane toads on native fauna of north western Australia	\$503k for three years	D Pearson (0.5). \$20k cash for three years; \$112k in kind
ARC Linkage, University of Western Australia	Fire management of complex rehabilitated forests – quantifying and understanding spatial variability of forest structure and fuels	\$465k for three years	L McCaw (0.05)
Aust Marine Science Assoc. (WA)	Rottneest Young Scientist Workshop	Nil	T Holmes (0.01). \$500 sponsorship
Australia's Virtual Herbarium Trust	AVH: Australia's Virtual Herbarium: Databasing of cryptogam collections	2007-2008 (\$48.5k)	C Parker (0.1), S Carroll (0.1)
Australian Biological Resources Study	Bush Blitz: reserve surveys and tactical taxonomy	\$8k for 2009-2010; \$5k for 2010-2011	T Macfarlane (0.1)
Australian Institute of Marine Science	Coral reef fish recruitment study	AIMS funded field trip	S Wilson (0.1), T Holmes (0.1)
Australian Museum	Kimberley islands biodiversity asset identification	\$5k in kind	L Gibson (0.7), F Koehler (1.0), V Kessner (0.75)
Australasian Wildlife Conservancy, The University of Western Australia	Population density estimate of western ringtail possums ( <i>Pseudocheirus occidentalis</i> ) at Karakamia Wildlife Sanctuary	Nil (AWC) \$2,000 (UWA)	P de Tores (0.1)
Australian Wildlife Conservancy	Establishment of translocated populations of critically endangered <i>Acacia imitans</i> and <i>A. unguicula</i>	AWC provides ongoing care and maintenance	R Dillon (0.08). \$15k in kind for translocation establishment (including fencing)
Australian Wildlife Conservancy	Integrated management of introduced predators in the rangelands	\$45k per annum 2006-2009	D Algar (0.5), M Onus (0.5), H Hamilton (0.5)

<b>Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)</b>	<b>Project</b>	<b>External funding and source 2009/2010 (\$)</b>	<b>DEC Involvement (in kind and \$)</b>
Australian Wildlife Conservancy	Woylie Conservation Research Project	Nil	A Wayne (0.6), C Vellios (0.6), C Ward (0.6), M Maxwell (0.6)
BHP Billiton (Iron Ore and Nickel West)	Understanding Mulga Project	\$64k	B Maslin (0.75), J Reid (1.0)
BHP Billiton Iron Ore	Identification Botanist position at the Western Australian Herbarium	\$105k	S Dillon (1.0)
BHP Billiton Iron Ore	SRE invertebrates in the Central Pilbara	\$157k until early 2011 (BHPBIO)	B Durrant (0.3). DEC contribution of \$20k
Birds Australia	Shark Bay Shorebird Survey	\$2k	K Onton (0.03). \$6 500 in kind DEC Shark Bay District
Bushfire CRC	Managing fires in forest landscapes in SW Australia	2006-2010 \$150k	L McCaw (0.4), R Robinson (0.2), J Farr (0.2), B Ward (0.1), G Liddelow (0.2), P Van Heurck (0.1), A Wills (0.2)
Caring For Our Country	Eradication of exotic rodents from six islands of high conservation value	\$890k 2010-2014	K Morris (0.3), B Johnson (0.3), B Muir (0.3)
Chevron Australia	Translocations of mammals from Barrow Island – offset program	ca. \$1.4M pa 2009-2014, \$500k pa 2015-2019	K Morris (0.10), A Smith (0.50), K Rusten (1.0), J Dunlop (1.0), E Miller (1.0), B Johnson 0.3), B Muir (0.3), S Garretson (1.0)
Clarion U and Oil Region Astronomical Society	Internet telescope	\$1k	R Martin (0.02), A Verveer (0.1)
Commonwealth Department of Environment and Water Resources (DEW)	Preparation of a recovery plan for the quokka, <i>Setonix brachyurus</i>	\$38k	P de Tores (0.05)
Commonwealth Department of Environment and Water Resources (DEW), (formerly DEH), Murdoch University	The uptake of cat baits by non-target fauna in the south-west of WA	\$ 42k	K Morris (0.1), P deTores (0.2)
Crosslands Resources	Idiosoma nigrum assessment	\$40k	B Durrant (0.4), M Davis (0.1)
CSIRO Entomology, ESPM Dept. & Essig Museum of Entomology, University of California, Berkeley, CA	Pilbara Biological Survey: Australian National Insect Collection curation and identification of Coleoptera	Nil	N Guthrie (0.1)
CSIRO Marine and Atmospheric research	What is the role of predators at Ningaloo and how are they impacted by human use?	\$55K in kind	S Wilson (0.1), T Holmes (0.1). DEC contribution \$10K
CSIRO Sustainable Ecosystems	Fire regimes and biodiversity decline in the Kimberley	\$101.4k for three years, 2006-2009	I Radford
CSIRO Sustainable Ecosystems	Fire, fragmentation, weeds and the conservation of plant biodiversity in Wheatbelt nature reserves	CSIRO \$180k for three years, 2006-2009	C Yates, C Gosper
CSIRO, Australian Wildlife Conservancy	Explaining and predicting the occurrence of Night Parrots ( <i>Pezoporus occidentalis</i> ) using GIS and ecological modelling	\$38k	AH Burbidge (0.05)
CSIRO, Australian Wildlife Conservancy	Systematics and population history of Ground Parrots	\$11k	AH Burbidge (0.05)
Curtin University of Technology	Gamma ray burst – optical follow up	Nil	R Martin (0.05)

<b>Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)</b>	<b>Project</b>	<b>External funding and source 2009/2010 (\$)</b>	<b>DEC Involvement (in kind and \$)</b>
Curtin University of Technology, Department of Environmental and Aquatic Sciences	Pilbara Biological Survey: Ant identifications	Nil	B Durrant (0.05)
Department of Agriculture and Food Western Australia, BHP, CSIRO, NHT, University of WA	Genetic purity and movements of dingos/wild dogs in the rangelands and deserts	\$25k per year for two years 2008-2009	K Morris (0.05), N Burrows (0.05)
Department of Fisheries	Introduced Marine Pests	\$28k for 2006-2007	J Huisman (0.3)
Department of Fisheries	Resource Condition Monitoring of Mangroves in Northwest Australia	Nil	K Friedman (0.02)
DSE (Victoria) and Department DEWHA (Commonwealth)	PAPP toxicosis and cat bait pellet development	\$100k per year from DEWHA	D Algar (0.05), K Morris (0.02)
Edith Cowan University	Monitoring movement patterns of marine fauna using Vemco VRAP Acoustic tracking system	Nil	A Kendrick (0.01) S Wilson (0.01)
Edith Cowan University	Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park	Nil	A Kendrick (0.05), M Rule (0.05)
Flinders University South Australia	A satellite tracking study of feral camels in WA	\$40k from Flinders University	B Ward (0.1). \$25k from DEC
Forest Products Commission, Integrated Tree Cropping	Genetic analysis of <i>Santalum spicatum</i>	\$10.7k	M Byrne (0.05), B Macdonald (0.1)
Fortescue Metals Group	Understanding Mulga Project	\$64k	B Maslin (0.75), J Reid (1.0)
Future Farm Industries CRC	Biodiversity Program Project - Management of weed and genetic risk in perennial landuse systems	\$322k for three years (2008-2011)	M Byrne (0.3), B Macdonald (0.2)
GCN (Gamma Ray Burst Communication Network), USA	Supernova search	Nil	R Martin (0.05)
Griffith University	Land & Water Australia funded TraCK project - examining bioregionalisation of northern Australian riverine fauna	Nil	A Pinder (0.05)
IAU Minor Planet Center, Harvard University	Asteroid tracking - Astrometry of minor planets, comets and targets of opportunity	Nil	A Williams (0.03), A Verveer (0.02)
International Science Linkages	Resolving determinants of plant diversity and vegetation structure at different spatial scales for the conservation of high rainfall mediterranean-climate ecosystems	\$5k one off	Access to databases

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	External funding and source 2009/2010 (\$)	DEC Involvement (in kind and \$)
Invasive Animals CRC	Demonstration site – mesopredator release	\$1.1k for four years (2006- 2009)	K Morris (0.3), P de Tores (0.75), N Marlow (0.75), D Algar (0.5), B Johnson (1.0), W Muir (0.25), J Angus (0.5), M Onus (0.5), N Thomas (1.0), A Williams (0.9)
James Cook University	Monitoring fish and coral communities at Trunk reef	\$ 2k	S Wilson (0.05)
Karrara Mining Ltd	An assessment of population genetic variation and structure of <i>Acacia woodmaniorum</i> , and its phylogenetic relationship to other acacia species	\$499k for three years	D Coates (0.1), M Millar (1.0)
Kimberley Land Council	Kimberley islands biological survey – indigenous liaison and participation	Nil	L Gibson (0.7), N McKenzie (0.3). NHT2 contributed \$95 500
Kimberley Land Council	Movement behaviours and habitat usage of West Kimberley dugongs: A community based approach	\$129,990 (Australian Marine Mammal Centre-AMMC for two years 2009-10, \$30,000 Woodside Energy	S Wilson (0.05), Holley (0.1). \$5500 in kind –vessel use
Lotteries West	Insect databasing - DEC's insect collection	\$7.4k final funding	1 database person (0.05)
Lowell Observatory, USA University of Maryland, USA	SPP# 1998-010 - Imaging and spectrophotometry of comets	\$2k from Lowell Observatory	A Williams (0.01), A Verveer (0.05)
Millennium Seedbank Project	Seed collection, storage and biology	\$210k per year to 2009	A Cochrane (0.8), D Coates (0.1)
Murdoch University	An ecosystem approach to estimating the viability of dolphin populations exposed to industrial/port activities	Nil	C Simpson. DEC contribution \$10k pa for three years (2007- 2009)
Murdoch University	Epidemiology of marri canker	Nil	B Shearer (0.4)
Murdoch University	Little Penguin Study: Development of a monitoring protocol	Nil	C Simpson. DEC contribution \$27.5k for three years (2006- 2008)
Murdoch University	Macrophytes, macroalgae, phytoplankton and macroinvertebrates of Vasse-Wonnerup	\$80k in 2009-2010	A Clarke (0.05)
Murdoch University (CPSM)	Molecular investigation of <i>Phytophthora</i> hyrids	Nil (to DEC) \$5k pa (VHS)	M Stukely (0.05)
Murdoch University	Monitoring management effectiveness: Monkey Mia dolphins	Nil	C Simpson. DEC contribution \$15k-\$25k pa for six years
Murdoch University	Taxonomic Studies of Western Australian Marine Plants	Murdoch University, \$50k per annum 2008-2010	J Huisman (0.5), \$50k per annum 2008-2010
Murdoch University	Woylie Conservation Research Project	Nil	A Wayne (0.6), C Vellios (0.6), C Ward (0.6), M Maxwell (0.6)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	External funding and source 2009/2010 (\$)	DEC Involvement (in kind and \$)
Murdoch University (CPSM)	Classical and molecular taxonomy and pathogenicity testing of <i>Phytophthora</i> species	\$5k pa (VHS)	M Stukely (0.05)
National Climate Change Adaptation Research Facility	Network case study: Marine biodiversity and resources network	\$900	T Holmes (0.03)
National Heritage Trust	Western ground parrot recovery	\$200k	AH Burbidge (0.1), South Coast Region
National Heritage Trust	Seed conservation program	\$85k p.a. to 2008 (SCRIPT)	A Cochrane (0.5)
National Heritage Trust (Kimberley Land Council)	Kimberley islands biodiversity asset identification – Phase 1 (incl. indigenous liaison and participation)	\$2.7m for 2006-2010 (incl. \$165k for two years)	L Gibson (0.7), N McKenzie (0.3), F Koehler (1.0), R Palmer (1.0), M Lyons (0.4), G Keighery (0.15), D Pearson (0.05), P Handasyde (0.75), V Kessner (0.75), B Muir (0.4), J Rolfe (0.05), W Caton (1.0)
Perth Zoo	Numbat juvenile survival monitoring	\$8.45k Wildlife Conservation Action	T Friend (0.1)
Perth Zoo	Woylie Conservation Research Project	\$10.5k Wildlife Conservation Action	A Wayne (0.6), C Vellios (0.6), C Ward (0.6), M Maxwell (0.6)
Perth Zoo, Wildlife Conservation Association	Fauna reconstruction in the rangelands	\$5k	K Morris (0.3), J Dunlop (1.0) Goldfields Region
Ravensthorpe Nickel	Determination of hybrid status of <i>Eucalyptus</i> <i>stoataptera</i>	\$28k	M Byrne (0.1), B Macdonald (0.1)
Rio Tinto	Identification Botanist position at the Western Australian Herbarium	\$47K	G Guerin – J Hurter (1.0)
Rio Tinto (West Angelas Coondewanna West Environmental Offsets)	Pilbara Wattle	Nil	B Maslin (0.1), S van Leeuwen (0.05)
Rio Tinto Iron Ore (West Angelas Coondewanna West Environmental Offsets)	Fire-Mulga study: post burn monitoring & Tussock Grassland Survey of the Hamersley Range	\$20k	S van Leeuwen (0.01)
SciTech Planetarium, UWA, STAWA	Astronomy education	Nil	A Williams (0.05)
Satterley Property Group	Factors associated with western ringtail possum ( <i>Pseudocheirus occidentalis</i> ) persistence within retained habitat at development sites	\$400k (inclusive of rope bridges study) 2009/2010 to 2012/2013	P de Tores (0.5)
SCNRM	Gilbert's potoroo recovery program	\$43.7 in 2009/2010, Caring for Our Country	T Friend (0.75), S. Hill (1.0)
SCNRM	Numbat recovery program, South Coast	\$43.7 in 2009/2010, Caring for Our Country	T Friend (0.05)
SCNRM	Dibbler distribution and ecology in Fitzgerald River National Park	\$28.1 in 2009/2010, Caring for Our Country	T Friend (0.05)
South African National Biodiversity Institute	Guidelines for bioclimatic modelling, monitoring and data management	Australian Department of Climate Change \$100k	C Yates (0.2)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	External funding and source 2009/2010 (\$)	DEC Involvement (in kind and \$)
South Australian Dept Environment and Heritage	Woylie Conservation Research Project	Nil	A Wayne (0.6), C Vellios (0.6), C Ward (0.6), M Maxwell (0.6)
South West NRM	Genetic and ecological viability of Busselton Ironstone communities	\$102.7k for four years (2005-2009)	M Byrne (0.1), B Macdonald (0.1), C Yates (0.1), N Gibson (0.1), M Langley (0.1)
Space Telescope Science Institute, USA; Sth Afri Astronomical Observatory; Institut d' Astrophysique, France; U Potsdam, Germany; University of St Andrews, Scotland; University of Tasmania	PLANET - Monitoring gravitational microlenses	Nil	R Martin (0.2), A Williams (0.25), A Verveer (0.06)
University of Adelaide	Wetland monitoring program – rotifer and cladoceran identifications	Nil	A Pinder (0.05), D Cale (0.05). DEC contribution \$400
University of California, Berkeley and Lawrence Hall of Science	Hands on Universe - Internet telescope	\$1k	R Martin (0.01), A Verveer (0.05)
University of Nebraska, Omaha USA	Fire ecology of hummock grasslands	Nil	B Ward (0.1)
University of Northern Arizona	Pilbara biological survey diatom identifications	Nil	A Pinder (0.05) , M Lyons (0.05)
University of Tasmania	Understanding the health effects of landscape burning and biomass smoke in Australian towns and cities	Nil	L McCaw (0.05). DEC contribution \$10K for three years
University of Tasmania	Using tree rings of an Australian conifer as a bioindicator of decadal-scale environmental change	Nil	L McCaw (0.1)
University of Western Australia	Assessing fish communities in Marmion Marine Park	Nil	K Friedman (.01). DEC contribution \$4k
University of Western Australia	Assessing fish communities in Shoalwater Islands Marine Park	Nil	K Friedman (.01 ) A Kendrick (.01) S Wilson (0.01) M Rule (.05) K Bancroft (0.01) T Holmes (0.05). DEC contribution \$12k
University of Western Australia	Mode of action of phosphonate in native hosts to <i>Phytophthora cinnamomi</i>	Ni	B Shearer (0.04)
University of Western Australia	New tools to uncover a <i>Eucalyptus</i> phylogeny and evaluate conservation priority species	\$28K – UWA Research Development Award	M Moody (0.2)
University of Western Australia, SWCC, SCRIPT	Aboriginal landscape transformations in south- west Western Australia	ARC Linkage	N Burrows (0.01). DEC \$6k for three years
WA Naturalists Club, Lotteries West	PUBF: Perth Urban Bushland Fungi project	\$14k for 2007-2008	N Bougher (0.05), R Hart (0.5), S de Bueger (0.2), B Glossop (0.2)
Walpole - Nornalup National Parks Association; Walpole Wilderness Eco-Cruises	The impact of wildfire on invertebrate communities in old growth forests	Nuyts Wilderness Community Trust funds annual collection curation	P Van Heurck (0.1), T Middleton (0.1), WNNPA volunteers (2 x 0.2 = 0.4)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	External funding and source 2009/2010 (\$)	DEC Involvement (in kind and \$)
Western Areas NL	Ecology of chuditch in the western woodlands	\$38k	K Morris (0.1), B. Johnson (0.2)
Western Australian Museum	Kimberley island biodiversity asset identification	Nil	L Gibson (0.7), R Palmer (1.0)
Western Australian Museum	NatureMap – data sharing and joint custodianship	Nil	P Gioia (0.45)
Western Australian Museum	Pilbara Biological Survey	\$500k in-kind in 2005-2010	N McKenzie (0.6), AH Burbidge (0.9), L Gibson (0.1)
Western Australian Museum	Systematic revision of the endemic Australian scorpion genus <i>Urodacus</i> (Scorpiones, Urodacidae)	ABRS and WAM for three years	B Durrant (0.2). DEC contribution of \$18k
Wheatbelt NRM	Genetic analysis of <i>Eucalyptus cupraea</i> and <i>Grevillea phanerophleba</i>	\$34.7k	M Byrne (0.1)
Wheatbelt NRM	Terrestrial Baselineing of natural diversity data in Wheatbelt NRM Region	ACC funding	B Bayliss (0.5), P Gioia (0.05), J Harvey (0.5), A Rick (Consultant)
Woodside Energy	Taxonomic Studies on Burrup Flora	\$120k	R Butcher (0.25), K Shepherd (0.25), J Wege (0.25)

Note: 1k = \$1 000



# SUMMARY OF RESEARCH PROJECTS by REGIONS (DEC, IBRA/IMCRA and NRM)

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
<b>BIODIVERSITY AND CLIMATE CHANGE UNIT: COLIN YATES</b>				
South Coast, Warren, Wheatbelt, Swan, Midwest	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Northern Agricultural, South West, South Coast, Swan	Collaborative research on biodiversity and climate change in megadiverse ecosystems	49
South Coast, Warren, Wheatbelt, Swan, Midwest	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Northern Agricultural, South Coast, South West, Swan	Assessing the combined effects of climate change and land transformation on the geographic ranges of keystone and iconic species in the south-west Western Australia	50
South Coast, Warren, Wheatbelt, Swan, Midwest	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Northern Agricultural, South Coast, South West, Swan	Temperature thresholds for recruitment in south-west Western Australian flora	51
Midwest	Geraldton Sandplains	Northern Agricultural	Climate change risks for biodiversity and ecosystem function in species-rich shrublands	52
South Coast, Warren, Wheatbelt	Avon Wheatbelt, Esperance Plains, Jarrah Forest, Mallee, Warren	Avon, South Coast, South West	Protecting the safe havens: will granite outcrop environments serve as refuges for flora threatened by anthropogenic climate change?	52
<b>BIOGEOGRAPHY PROGRAM: STEPHEN VAN LEEUWEN</b>				
Pilbara	Pilbara	Rangelands	Pilbara regional biological survey	54
Kimberley	Victoria Bonaparte, North Kimberley, Dampierland	Rangelands	Kimberley islands biological survey	55
Goldfields, Midwest	Avon Wheatbelt, Coolgardie, Murchison, Gascoyne, Yalgoo	Rangelands, Northern Agricultural	Floristic surveys of the banded iron formation (BIF) and greenstone ranges of the Yilgarn	56
South Coast	Esperance Plains, Mallee	South Coast	Biological survey of the Ravensthorpe Range	57
Swan, South West	Swan Coastal Plain	Swan, South West	Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain	58
All	All	All	Ecomorphological clues to community structure, bat echolocation studies	58
Pilbara	Pilbara	Rangelands	Short range endemism of ground-dwelling invertebrates in the central Pilbara	59

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
All	All	All	Development of ethically acceptable techniques for invertebrate wet-pit trapping	60
<b>FAUNA CONSERVATION PROGRAM: KEITH MORRIS</b>				
Midwest, Goldfields	Carnarvon, Gascoyne, Murchison, Gibson Desert	Rangelands	Development of effective broadscale aerial baiting strategies for the control of feral cats	62
Midwest	Avon Wheatbelt, Yalgoo	Northern Agricultural, Rangelands	Sustained introduced predator control in the Rangelands	63
South Coast, Warren	Esperance Plains, Jarrah Forest, Warren	South Coast, South West	Conservation of south coast threatened birds	64
Swan, South West	Swan Coastal Plain	South West	Translocation outcomes and monitoring of naturally occurring populations of the western ringtail possum, <i>Pseudocheirus occidentalis</i>	65
Swan, South West	Jarrah Forest	South West, Swan, Avon	The importance of fox, cat and native predator interactions to sustained fauna recovery in the northern jarrah forest – is there a mesopredator release effect?	66
Swan, South Coast, Wheatbelt, Warren	Avon Wheatbelt, Jarrah Forest, Mallee, Swan Coastal Plain, Warren, Yalgoo	South West, Swan, Avon, South Coast	Factors affecting establishment in the numbat ( <i>Myrmecobius fasciatus</i> ) Recovery Plan	67
Wheatbelt	Avon Wheatbelt	South West, Avon	An assessment of the effect of fox control on <i>Phascogale calura</i> (red-tailed phascogale) populations	68
Midwest, South Coast	Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain	Northern Agricultural, South Coast	Dibbler ( <i>Parantechinus apicalis</i> ) Recovery Plan	69
South Coast	Jarrah Forest	South Coast	Gilbert's potoroo ( <i>Potorous gilbertii</i> ) Recovery Plan	70
Midwest	Carnarvon, Geraldton Sandplains	Rangelands, Avon	Genetics and ecology of the western barred bandicoot ( <i>Perameles bougainville</i> )	71
South Coast	Jarrah Forest	South Coast	Disease screening and vectors of transmission in quokkas ( <i>Setonix brachyurus</i> ) on the mainland and Bald Island	72
South West, Swan, Warren	Jarrah Forest, Warren	South West, South Coast	Rapid survey of quokka ( <i>Setonix brachyurus</i> ) in the southern forests	73
Goldfields, South West, Wheatbelt, Warren	Avon Wheatbelt, Coolgardie, Jarrah Forest, Warren	Avon, South West, Rangelands	Pro bait trials: phase 2	74
Wheatbelt	Avon Wheatbelt	Avon, South West	Sustained fauna recovery in a fragmented landscape (Dryandra Woodland and Tutanning Nature Reserve)	74
Wheatbelt	Avon Wheatbelt	South West, Avon	Return to Dryandra	76
South Coast, Swan, South West, Warren, Wheatbelt	Avon Wheatbelt, Esperance Plains, Jarrah Forest, Mallee	South West, Swan, Avon, South Coast	Implementation of the Recovery Plan for the chuditch, <i>Dasyurus geoffroii</i>	77

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
Wheatbelt, Katanning work centre	Mallee	Avon Catchment	Factors affecting fauna recovery in the Wheatbelt – Lake Magenta and Dunn Rock Nature Reserves	77
Goldfields	Murchison, Gascoyne	Rangelands	Rangelands Restoration – reintroduction of native mammals to Lorna Glen	78
Pilbara	Pilbara	Rangelands	Barrow Island fauna translocations	80
Midwest	Swan Coastal Plain	Northern Agricultural	Ecology and conservation of threatened pythons in WA	81
Midwest	Swan Coastal Plain	Northern Agricultural	Implementation of the Lancelin Island Skink Recovery Plan	81
All except South West	All	State wide	Improving rock-wallaby conservation and management	82
Kimberley	Northern Kimberley, Central Kimberley, Ord Victoria Plains, Victoria Bonaparte	Rangelands	Impact of cane toads on biodiversity in the Kimberley	83
Warren	Jarrah Forest	South West	Identifying the cause(s) of the recent declines of woylies in south western Australia	84
Swan, Goldfields	Coolgardie, Swan Coastal Plain	Swan, Rangelands	Conservation of Western Australian butterflies	85
Swan, Goldfields	Coolgardie, Swan Coastal Plain	Swan, Rangelands	Conservation of the graceful sun-moth	86
<b>FLORA CONSERVATION PROGRAM: DAVID COATES</b>				
South Coast, Midwest, Swan, Wheatbelt, Goldfields	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Mallee, Murchison, Swan Coastal Plain, Yalgoo	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora	88
Wheatbelt	Avon Wheatbelt, Swan Coastal Plain	Avon, Northern Agricultural, South Coast, Swan	Genetic and ecological viability of plant populations in remnant vegetation	89
Wheatbelt, Midwest, Swan, South West, South Coast, Warren	Avon Wheatbelt, Esperance Plains, Jarrah Forest, Mallee, Swan Coastal Plain, Nullabor, Swan Coastal Plain, Warren, Yalgoo	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance	91
Midwest	Yalgoo	Northern Agricultural	Assessment of genetic diversity, key population processes and evolutionary relationships in the Banded ironstone endemic <i>Acacia woodmaniorum</i> and its close relatives	92
All	Avon Wheatbelt, Carnarvon, Coolgardie, Esperance Plains, Gascoyne, Geraldton Sandplains, Great Sandy Desert, Hampton, Jarrah Forest, Mallee, Murchison, Nullabor, Swan Coastal Plain, Warren, Yalgoo	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Seed biology, seedbank dynamics and collection and storage of seed of rare and threatened Western Australian taxa	93
Midwest, South Coast, South West, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Northern Agricultural, South Coast, South West, Swan	Translocation of Critically Endangered plants	94

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
Midwest, Wheatbelt, South Coast, Swan, South West, Warren	Avon Wheatbelt, Esperance Plains, Jarrah Forest, Swan Coastal Plain, Warren	Avon, South Coast, South West, Swan	Ecophysiology of rare flora restricted to shallow-soil communities	95
South Coast	Warren, Esperance Plains	South Coast	Effects of pre-treatments, microhabitats and on-site management in the translocation success of threatened plant species: an ecophysiological approach.	96
South West, South Coast	Esperance Plains, Jarrah Forest, Swan Coastal Plain	Avon, South Coast, South West, Swan	Integrated strategies for the control of <i>Phytophthora cinnamomi</i> using phosphite	97
Midwest, Swan, Wheatbelt, South West, Warren, South Coast	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren	Avon, South Coast, South West, Swan	Susceptibility of rare and endangered flora to <i>Phytophthora</i>	98
South West, South Coast	Esperance Plains, Jarrah Forest, Swan Coastal Plain	Avon, South Coast, South West, Swan	An investigation of the epidemiology and use of novel phosphite application techniques in <i>Phytophthora cinnamomi</i> infestations in the National Parks from the South Coast of Western Australia	98
Warren, South West, Swan, Wheatbelt	Avon Wheatbelt, Jarrah Forest, Swan Coastal Plain, Warren	Avon, South Coast, South West, Swan	Selection, screening and field testing of jarrah resistant to <i>Phytophthora cinnamomi</i>	99
South West, Swan	Jarrah Forest	Avon, South Coast, South West, Swan	Dieback-resistant jarrah establishment in operational forest rehabilitation sites	100
Swan, South West, Midwest, Wheatbelt, South Coast, Warren	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren	Northern Agricultural, Swan, Avon, South West, South Coast, Rangelands	Mundulla Yellows disease in Western Australia	101
Midwest, Swan, South West, Warren, South Coast, Wheatbelt	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren	Northern Agricultural, Swan, Avon, South West, South Coast	Vegetation Health Service	102
Goldfields, Midwest, South West, South Coast, Swan, Wheatbelt	Avon Wheatbelt, Esperance Plains, Jarrah Forest	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	The population ecology of Critically Endangered flora	103
Goldfields	Coolgardie	Rangelands	Causes of rarity in four <i>Tetratheca</i> taxa in the goldfields ranges	104
Wheatbelt, Midwest, Swan, South Coast	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Mallee, Swan Coastal Plain	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Taxonomic studies on native and naturalised plants of Western Australia arising from biological survey	105
Pilbara	Pilbara	Rangelands	Wattles of the Pilbara	106
All	All	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Conservation status and systematics of Western Australia <i>Acacia</i>	106

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
Wheatbelt	Avon Wheatbelt	Northern Agricultural	Wattles in the Shire of Dalwallinu	107
Pilbara, Midwest, Goldfields	Central Ranges, Coolgardie, Gascoyne, Gibson Desert, Great Victoria Desert, Little Sandy Desert, Murchison, Nullabor, Pilbara, Yalgoo	Rangelands	Understanding Mulga	107
All	All	All	Taxonomic review and conservation status of the members of the Myrtaceae tribe Chamelaucieae and miscellaneous other Western Australian plant groups	108
All	All	All	Taxonomic resolution and description of new plant species particularly Priority Flora and those areas subject to mining interests in Western Australia	109
All	All	All	Taxonomy of selected families including legumes, grasses and lilies	110
All	All	All	Taxonomic studies in selected families, including Asteraceae, Celastraceae Malvaceae, Proteaceae	111
All	All	All	Herbarium collections management	112
All	All	All	The Western Australian plant census and Australian plant census	114
All	All	All	The Western Australian Herbarium's specimen database	115
All	All	All	FloraBase – the Western Australian Flora	116
All	All	All	Biodiversity Informatics at the Western Australian Herbarium	117
Kimberley, Pilbara, Swan, South West, Warren, South Coast	Central Kimberley, Dampierland, Esperance Plains, Gascoyne, Geraldton Sandplains, Jarrah Forest, Northern Kimberley, Swan Coastal Plain, Victoria Bonaparte, Warren	Rangelands, Northern Agriculture, Swan, South West, South Coast	Taxonomic review and floristic studies of the benthic marine algae of north-western Western Australian and floristic surveys of Western Australian marine benthic algae	118
Kimberley, Pilbara, Midwest, Swan, South West, Warren, South Coast	Central Kimberley, Dampierland, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Northern Kimberley, Swan Coastal Plain, Victoria Bonaparte, Warren	Rangelands, Northern Agriculture, Swan, South West, South Coast	The Western Australian marine benthic algae online and an interactive key to the genera of Australian marine benthic algae	119
Swan	Swan Coastal Plain	Swan	Perth Urban Bushland Fungi (PBUF) Project	119
All	All	All	Improving the comprehensiveness, accuracy and availability of taxonomic data about WA's fungi in DEC biological datasets and biodiversity collections	120
South Coast, South West, Swan, Warren,	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal	Northern Agricultural, Swan, South West, South Coast	Taxonomic studies in Epacridaceae, Rafflesiaceae, Rhamnaceae and Violaceae	121

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
Wheatbelt	Plain, Warren			
All	All	All	Development of interactive identification platforms and content	122
South Coast, South West, Warren, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Jarrah Forest, Mallee.	Avon, South Coast, South West	Surveys, systematics and genetic diversity of granitic vernal pools flora	123
All	All	All	New tools to uncover a <i>Eucalyptus</i> phylogeny and evaluate conservation priority species	124
All	All	All	Systematics of the triggerplant genus <i>Stylidium</i>	125
South Coast	Warren, Esperance Plains	South Coast	Comparison of plant canker disease impact and climatic variables in Proteaceae on the south coast of Western Australia and evaluation of selected fungicides as a management tool for canker control in the Declared Rare flora <i>Banksia verticillata</i> and <i>Lambertia orbifolia</i>	126
All	All	All	Taxonomy of <i>Ptilotus</i> and <i>Gomphrena</i> (Amaranthaceae) and <i>Swainsona</i> (Fabaceae)	127
All	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	All	Taxonomy of undescribed conservation taxa in the Ericaceae subfamily Styphelioideae	128
<b>LANDSCAPE CONSERVATION PROGRAM: LACHIE MCCAW</b>				
Warren, South West, Swan	Jarrah Forest, Warren	South West, Swan	FORESTCHECK – Integrated site-based monitoring of the effects of timber harvesting and silviculture in the jarrah forest	130
South West, Warren	Jarrah Forest	South West	Monitoring long-term effects of various fire regimes on species richness and composition of southern jarrah forest	131
Goldfields	Gascoyne, Murchison	Rangelands	Project Rangelands Restoration: Developing sustainable management systems for the conservation of biodiversity at the landscape scale in rangelands of the Murchison and Gascoyne bioregions	131
Warren	Jarrah Forest	South West	Burning for biodiversity: Walpole fine grain mosaic burning trial	133
Goldfields, South Coast, Midwest, Wheatbelt, South West, Warren	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Murchison, Swan Coastal Plain	Avon, Northern Agricultural, Rangelands, South West, South Coast	Genetic analysis for the development of vegetation services and sustainable environmental management	134
South West, Warren	Jarrah Forest	Avon, South West	Identification of seed collection zones for rehabilitation	135
Midwest, Wheatbelt, South Coast	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains	Avon, Northern Agricultural, South Coast	Management of environmental risk in perennial landuse systems	135

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
Midwest, South Coast, Wheatbelt, South West, Swan, Warren	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee	Avon, Northern Agricultural, South West, South Coast	State Salinity Strategy wetland monitoring	136
South West, Swan, Warren	Jarrah Forest, Warren	Swan, South West, South Coast	Monitoring stream biodiversity (KPI 20 for Forest Management Plan)	138
Kimberley, Goldfields, Wheatbelt, Warren	Central Kimberley, Gascoyne, Jarrah Forest, Victoria Bonaparte	Avon, Rangelands, South West	Bushfire CRC Project B1.4: Improved methods for the assessment and prediction of grassland curing	139
Swan	Jarrah Forest	South West, Swan	Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the jarrah forest	139
South West	Swan Coastal Plain	South West	Management of the Vasse - Wonnerup wetlands	140
Warren	Warren	South Coast, South West	Monitoring post-fire effects from the 2001 Nuyts wildfire	141
Warren	Jarrah Forest, Warren	South West	Long-term monitoring of timber harvesting on bird populations in south-west forest areas	142
South West, Swan, Warren	Jarrah Forest, Warren	South Coast, South West, Swan	Project Vesta – prediction of high intensity fire behaviour in dry eucalypt forest	143
Warren	Warren	South West	Increasing productivity of karri regrowth stands by thinning and fertilising	144
Warren	Warren	South West	Espacement effects on the development and form of regrowth karri stands	144
Goldfields, South Coast, Wheatbelt	Coolgardie, Esperance Plains, Mallee	Rangelands, South Coast	Fire induced mosaics in semi-arid shrublands and woodlands	145
Kimberley	Northern Kimberley	Rangelands	Fire regimes and biodiversity decline in the Kimberley	146
Warren	Warren	South West	Armilaria spread in karri forest	147
Warren	Warren	South West	The effect of wildfire on forest fungi	148
South West, Warren	Jarrah Forest, Warren	South Coast, South West	Forest health and vitality surveillance and monitoring	149
South West, Swan	Jarrah Forest	South West, Swan	Aspects of dieback behaviour relevant to the formulation of jarrah silviculture guidelines	149
Warren	Warren	South Coast, South West	The impact of wildfire in old growth forest of the Walpole-Nornalup National Park, on short-range endemic invertebrates and their forest floor communities	150
Warren	Jarrah Forest	South West	Effects of timber harvesting on terrestrial vertebrates in medium rainfall jarrah forest	151
South West, Warren	Jarrah Forest	South West, Swan	Characteristics of hollow-bearing jarrah ( <i>Eucalyptus marginata</i> ) and marri ( <i>Corymbia calophylla</i> ) trees and coarse woody debris (CWD), their use by selected species of fauna, and the effect of logging-	152

DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
			and-burning jarrah forest on them	
South West, Warren	Jarrah Forest, Warren	South West, Swan	Evaluation of key soil indicators of sustainability in Australian Mediterranean forests (Indicators 4.1d, 4.1e)	153
South West, Swan	Jarrah Forest	South West, Swan	Effect of stand density and fertilising on seed-fall. Exp B. Establishment of jarrah ( <i>Eucalyptus marginata</i> ) in shelterwood areas and on dieback 'graveyard' sites	154
South West	Jarrah Forest	South West	Control of jarrah leafminer: selective retention of JLM resistant trees and ground coppice in a demonstration forest plot	155
Swan	Jarrah Forest	Swan	Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity	155
Swan	Jarrah Forest	Swan	Monitoring northern extent of jarrah leafminer outbreak	156
Warren	Jarrah Forest, Warren	South Coast, South West	Bushfire CRC Project B1.1: Managing fires in forested landscapes in south-west WA	157
South Coast, Wheatbelt	Avon Wheatbelt, Esperance Plains, Mallee	Avon, South Coast, Rangelands	Fire, fragmentation, weeds and the conservation of plant biodiversity in Wheatbelt nature reserves	157
<b>MARINE SCIENCE PROGRAM: CHRIS SIMPSON</b>				
Pilbara	Ningaloo	Rangelands	WAMSI Node 3: Science administration, coordination and integration	160
Midwest, Pilbara, Kimberley,	Carnarvon, Geraldton Sandplains, Pilbara, North Kimberley	Rangelands,	Conservation of marine turtles in Western Australia	162
Pilbara, Kimberley, Midwest, Swan, South West, Warren, South Coast	Ningaloo, Pilbara Inshore, Pilbara Offshore, Offshore Oceanic atolls, Central West Coast, Shark Bay, WA South Coast	Rangelands, Perth, South west	Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015	163
All	All	All	Strategic plan for the development and implementation of the Western Australian Marine Monitoring Program (WAMMP)	163
All	All	All	WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation	164
All	All	All	WAMMP Sub-project 2: Historical time-series development	165
All	All	All	WAMMP Sub-project 3: 'Fit to Park'	166
All	All	All	WAMMP Sub-project 4: MPRA/DEC audit support	168
All	All	All	WAMMP Sub-project 5: community participation	169



DEC Region	IBRA/IMCRA	NRM Region	Project Title	Page
All	All	All	WAMMP Sub-project 6: MSP Data management and presentation	170
Warren	WA South Coast	South Coast	Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park	170
Swan	Central West Coast	Perth	Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater and Marmion marine parks	171
Pilbara	Ningaloo	Rangelands	Interactive effects of fishing and climate change on reef fish populations	172
Pilbara	Ningaloo	Rangelands	Preliminary assessment of diseases affecting Western Australian corals	173
Midwest	Shark Bay	Rangelands	The biogeography of Shark Bay Marine Park mangrove communities	174
<b>SCIENCE APPLICATIONS UNIT: PAUL GIOIA</b>				
All	All	All	Development of biodiversity indices	176
All	All	All	Provision of authoritative names of WA taxa	176
All	All	All	Online GIS biodiversity mapping (NatureMap)	177
All	All	All	Species database management software (Max)	178
Wheatbelt, Swan, Goldfields	Avon Wheatbelt, Jarrah Forest (northern), Swan Coastal Plain, Coolgardie (Southern Cross), Mallee (Western), Yalgoo, Esperance Plains	Avon	Baselining the Avon NRM region	178
Wheatbelt, Swan, Goldfields	Avon Wheatbelt, Jarrah Forest (northern), Swan Coastal Plain, Coolgardie (Southern Cross), Mallee (Western), Yalgoo, Esperance Plains	Avon, Jarrah Forest, Swan Coastal Plain, Coolgardie, mallee, Yalgoo Esperance	Baselining the Avon NRM region (Wetlands)	180

# RESEARCH ACTIVITIES

## BIODIVERSITY AND CLIMATE CHANGE UNIT

**Unit Manager: Dr Colin Yates**

Climate is a fundamental influence on where plants and animals flourish, what communities and ecosystems develop in a location and what habitat is available there. Climate affects plants and animals directly by determining the temperature regimes and water availability in an area. Climate indirectly affects plants and animals by impacting on many of the most significant forces they experience, including fire, diseases, invasive species and salinity. Climate change has the potential to significantly impact on Western Australia's natural biological diversity.

Climate research through the Indian Ocean Climate Initiative program has demonstrated that climate conditions in south-west Western Australia have changed significantly during the past 40 years; in particular, the climate is becoming warmer and drier. Climate projections indicate that Western Australia faces ongoing climate changes. Managing the potential impacts of climate change on Western Australia's biodiversity requires sound knowledge of the vulnerability of species and communities to direct and indirect impacts.

The Biodiversity and Climate Change Unit (BCCU) focuses on research to develop an understanding of these impacts, especially the impacts on the potentially 'at risk' species, communities and ecosystems of Western Australia. This understanding provides the basis on which management responses to climate change are formulated and undertaken.

The BCCU includes research scientists from all Science Division programs. It includes strengths in ecology, modelling, surveys, phylogeography, genetics, and fire science.

---

### **Collaborative research on biodiversity and climate change in megadiverse ecosystems**

SPP # to be allocated

*Team members*

C Yates (0.2), P Gioia (0.1), I Abbott (0.05). (External Collaborators G Midgley, South African National Biodiversity Institute, D Le Maitre CSIR, J Scott, B Webber CSIRO (Climate Change Adaptation Flagship).

*Context*

The south-west Australian Floristic Region (SWAFR) and Cape Floristic Region (CFR) of South Africa have a shared evolutionary history and many ecological characteristics that make them ideal for comparative studies investigating the impacts of climate change on biodiversity. Such studies may yield insights that might not be gained if activities were restricted to one region alone. Species and ecosystems in both regions are already under threat from a range of threatening processes and projected warming and drying of climates is expected to place biodiversity under further stress. Tools for assessing the vulnerability of biodiversity to climate change in both regions and informing response planning are urgently needed.

*Aims*

- Review methods for modelling the impacts of climate change on biodiversity and assess their suitability for application in the SWAFR and CFR.
- Review the critical role of monitoring in detecting the impacts of climate change on biodiversity, validating model projections and measuring adaptive responses.
- Review the role of information management in science planning for climate change.

#### *Summary of progress and main findings*

- Completed Phase 1 of the DEC-SANBI collaboration - four manuscripts published in the scientific journal *Austral Ecology*.
- Implemented Phase 2 of the DEC-SANBI collaboration investigating the potential for climate change to facilitate weed invasions especially mutually exchanged WA and South African plants.
- Completed modelling the influence of climate change on the distributions of mutually exchanged WA and South African plant species that have become invasive in their alien ranges.

#### *Management implications*

Climate change is likely to have implications for all DEC activities including reserve design, fire management, fauna and flora transactions, disease management, and forest management.

#### *Future directions (next 12-18 months)*

- Prepare two manuscripts describing modelling research for scientific journals.
- Prepare a review paper on invasive alien species and climate change in the South West Australian Floristic Region and Cape Floristic Region global biodiversity hotspots.
- Continue to work with SANBI and other South African collaborators, CSIRO and the Australian Government Department of Climate Change in developing Phase 3 of the research.

---

### **Assessing the combined effects of climate change and land transformation on the geographic ranges of keystone and iconic species in south-west Western Australia**

SPP # to be allocated

#### *Team members*

C Yates (0.2), A McNeill (0.75), L Gibson (0.1), P de Tores (0.05), A Wayne (0.05).

#### *Context*

The climate in south-west Western Australia (SWWA) is projected to become warmer and drier. Present species and ecosystem distributions in SWWA are correlated with climate at macro-ecological scales. It is therefore expected that projected warming and drying of the climate will affect most species and ecosystems. If the geographic ranges of species change under projected climate change, as has been predicted and observed elsewhere, then spatially explicit information describing the new geographic ranges of species and taking into account land-use will be essential for conservation planning.

#### *Aim*

To model the combined effects of land transformation and projected climate change on the geographic ranges of keystone and iconic species in SWWA.

#### *Summary of progress and main findings*

- Manuscript describing the potential impacts of climate change and land transformation on *Banksia* published in scientific journal *Diversity and Distributions*.
- Manuscript describing the potential impacts of climate change and land transformation on quokka distribution accepted for publication in scientific journal *Biological Conservation*.

#### *Management implications*

Spatially explicit information on the relative sensitivities of different species and ecosystems to the impacts of climate change will be required for response planning.

#### *Future directions (next 12-18 months)*

- Use emerging dynamic species distribution modelling methods to further understanding of risks posed by combined effects of climate change and land transformation.

---

## Temperature thresholds for recruitment in south-west Western Australian flora

SPP# 2010-003

*Team members*

A Cochrane (0.2), S Schreck (0.2), A Crawford (0.1).

### *Context*

Germination is one of the fundamental biological activities vital to persistence in obligate seeding species. Climate directly influences germination and seedling growth, with temperature arguably the most important climatic variable after moisture since it synchronises germination to environmental conditions most suitable for seedling establishment. Although species have climate preferences, our knowledge of basic physiological tolerances is lacking for most native species. Assessing direct physiological constraints on recruitment (e.g. upper and lower germination temperature limits for germination) may assist our understanding of the impact of warming temperatures on the persistence of plant species at the limits of their geographic range.

### *Aims*

- Determine temperature thresholds for germination in SWWA flora.
- Identify potentially 'at risk' plant species and incorporate this data in modelling impacts of climate change on 'at risk' species.
- Utilise this data as a basis for developing management response options including fire management and flora translocations.

### *Summary of progress and main findings*

- Scientific paper on germination and early seedling growth temperature thresholds for Stirling Range species submitted to *Austral Ecology*.
- Completion of temperature profiling of 40 WA *Banksia* species, predominantly obligate seeding species. Results indicate that many species confined to the southern coastal areas of WA have a wide physiological tolerance for high temperatures during germination, although average temperatures for optimum germination (mean of high and low temperature alternations) for all species fall between 10 and 19°C.
- Temperature profiling completed for a number of endemic WA species, including *Calothamnus rosea*, *Beaufortia orbifolia*, *Xyris maxima* and *Carex tereticaulis*. Of the species tested, the conservation-listed *Xyris maxima* displayed pronounced photoperiod sensitivity with a relatively narrow germination temperature range.
- Temperature probes on Bluff Knoll have provided a full year's data on the relationship between soil and air temperatures. Data will continue to be logged to obtain comprehensive temperature data to direct germination studies.

### *Management implications*

Development of a seed-based framework for assessing seed viability under environmental change will assist in restoration. Incorporation of seed biology into threatened species reintroductions will improve recovery success.

### *Future directions (next 12-18 months)*

- Research aimed at determining the influence of projected climate change on seed and seedling traits in species, population and range dynamics along an E-W climate gradient in WA.
- Submit manuscript for publication on *Banksia* germination temperature thresholds and relationship between current climate envelopes.

---

## Climate change risks for biodiversity and ecosystem function in species-rich shrublands

SPP # to be allocated

### *Team members*

C Yates (0.2). (External collaborators N Enright, Murdoch University; K Smettem University of Western Australia; R Froend, Edith Cowan University; G Midgley, South African National Biodiversity Institute).

### *Context*

Correlative bioclimatic models are the primary tool for predicting the impacts of projected climate change on south-west Western Australia's (SWWA) globally renowned species-rich shrublands (kwongan). These models have many untested and limiting assumptions. Empirical and experimental studies investigating the relationship between climate, ecohydrology and population dynamics are needed to develop better and more realistic mechanistic models for predicting the impacts of climate change on kwongan.

### *Aims*

- Quantify seasonal patterns of water input, storage and distribution in the soil profile for shrubland sites of contrasting soil depth in relation to rainfall and plant water use.
- Quantify diurnal and seasonal patterns of plant water use among selected species from two major woody plant guilds (surface-water dependent sub-shrubs; groundwater-dependent shrubs and small trees) for shrubland sites of contrasting soil depth.
- Quantify the effects of decreased rainfall and increased air temperature on plant species ecophysiology and demography, identifying potentially lethal thresholds.
- Quantify plant demographic behaviour (survivorship, growth, fecundity) among selected species from two woody plant guilds for shrubland sites of contrasting soil depth.
- Apply a simulation modelling framework that links climate, soil water dynamics, plant water use and demographic response to investigate potential impacts of climate change on plant species and communities.

### *Summary of progress and main findings*

- Continued measurement of climate and soil moisture across the soil depth gradient on the Eneabba sandplain.
- Continued measurement of plant water use and demography in two woody plant guilds across the soil depth gradient.
- Initiated two PhD projects.

### *Management implications*

The project will provide projections of the likely risks of adverse effects of unavoidable climate change on plant species and communities in the Mid-West Region and more generally for SWWA.

### *Future directions (next 12-18 months)*

- Continue ecohydrology and demographic studies.
- Establish experiments simulating climate change through manipulating rainfall and temperature.

---

## **Protecting the safe havens: will granite outcrop environments serve as refuges for flora threatened by anthropogenic climate change?**

SPP # to be allocated

### *Team members*

C Yates (0.2), M Byrne (0.1). (External collaborators G Wardell-Johnson, L Mucina, Curtin University; K van Niel, University of Western Australia; S Franklin, University of Saskatchewan; S Hopper, Royal Botanic Gardens Kew, AAMHatch).

### *Context*

Many plant and animal species have survived previous climate change by contracting to dispersed

refuges where local climate conditions ameliorate regional changes. Such refuges will likely contribute to the persistence of biodiversity under projected climate change. In south-west Western Australia (SWWA) the old, highly weathered and flat landscape offers little scope for the biota to migrate to altitudinal refuges during climate change. However, the many granite outcrops (GOs) scattered across the region provide a suite of habitats and conditions not found in the wider landscape and these may ameliorate the impacts of regional climate change.

#### *Aims*

- Investigate the potential of GOs and their associated environments to act as refuges in the face of anthropogenic climate change across SWWA.
- Determine whether topographic and micro-habitat features of GOs designate them as refugia.
- Use phylogeographic patterns to determine whether GOs have acted as refuges in the past and are important reservoirs of genetic diversity.
- Determine whether particular environments at the base of GOs are more productive, and whether individual plants in these environments are under less stress than those in the intervening matrix.
- Determine whether plant communities of GOs are more resilient to anthropogenic climate change disturbances than the communities of the surrounding landscape matrix.

#### *Summary of progress and main findings*

- Scoped key hypotheses, data and equipment requirements, and field program.
- Commenced literature review on refugia concepts and drafted outline for a review manuscript.
- Commenced databasing Hopper GO species occurrence records.
- Obtained LiDAR and other multi-spectral remote sensed data for 28 GOs field sites.

#### *Management implications*

By identifying areas that can act as refuges under projected climate change, adaptation and conservation activities can be focused where they will provide greatest benefit.

#### *Future directions (next 12-18 months)*

- Complete literature review and submit to scientific journal.
  - Continue entering Hopper GO data into database.
  - Commence modeling LiDAR and multi-spectral remote sensed data.
  - Establish weather stations and micro-climate stations on GOs and their surrounding environments.
  - Begin measuring species diversity and traits on GOs and their surrounding environments.
  - Begin phylogeographic studies.
-

# BIOGEOGRAPHY

**Program Leader: Stephen van Leeuwen**

The Biogeography Program undertakes biological surveys to provide information on the biodiversity and nature conservation priorities within Western Australia. Surveys provide data on the distribution of plants and animals and enable an understanding of regional patterns in their composition and distribution. Targeted surveys of specific regions, broad habitat types or selected plant and animal groups are also undertaken. Knowledge obtained from surveys complements the site-specific studies commissioned by other land managers, such as resource companies, and is used to provide the foundation for biodiversity planning and natural resource management across Western Australia.

These activities are aligned with the information needs of the Department of Environment and Conservation. Collaborative associations are strong with the Western Australian Museum, Australian Museum, herbaria throughout Australia and with universities, cooperative research centres, CSIRO and other research institutions. Partnerships also exist with traditional owners, resource companies and the environmental consulting industry.

---

## **Pilbara regional biological survey**

SPP# 2002-004; SPP# 2004-002

### *Team members*

N McKenzie (0.6), N Guthrie (0.1), B Durrant (0.1), AH Burbidge (0.5), S van Leeuwen (0.2), M Lyons (0.4), A Pinder (0.25), M Langley (0.9), J Rolfe (0.4). (External collaborations - S Halse, P Doherty, M Harvey, R Johnstone, A Baynes, B Heterick, T Weir, D Blinn, N Gunawardene, E Volschenk).

### *Context*

The Pilbara is an economically important region in Western Australia, with major and expanding mineral extraction industries and pastoral industries. Effective biodiversity conservation is needed to minimise the adverse impacts of these activities and other threatening processes such as altered fire regimes. This survey addresses problems of incomplete knowledge of biodiversity (composition, patterns, status, trend) for nature conservation planning, including conservation reserve system gaps and weed invasions. Sampling includes reptiles, frogs, small ground mammals, bats, birds, arachnids, beetles, ants and aquatic invertebrates including stygofauna, wetland and terrestrial flora and soils to overcome low cross-taxon congruence in biodiversity models.

### *Aim*

To provide a regional perspective on biodiversity and nature conservation priorities, provide data on the distribution of the biota, identify gradients in community composition and the environmental factors related to these gradients, and complement site-specific studies being undertaken by mining companies and others.

### *Summary of progress (2009/2010) and main findings*

- All sampling and sorting completed.
- Introductory paper detailing aims, context, funding, design, milestones and staffing of the project refereed and published, including the physical environment matrix for terrestrial biodiversity sites.
- Small ground-dwelling mammal, microbat, ant, beetle, spider, aquatic invertebrate, bird and scorpion papers accepted for publication, and the first four of these published.
- Weed paper is in review.
- Drafts of the sub-fossil mammal, diatoms, reptile and frog, and historical bird papers completed.
- Drafts of the stygofauna, wetland aquatic flora and riparian flora papers are in preparation.
- Terrestrial flora identifications complete.

### *Management implications*

- Survey information forms the basis for systematic regional nature conservation planning for conservation reserve system development, and distribution and conservation status of species (indigenous and weeds) and ecological communities.
- Long-term ecological monitoring of region.

### *Future directions (next 12-18 months)*

- Compile and analyse terrestrial flora matrices then draft and submit the flora paper for publication.
- Submit, referee and publish all papers cited above.
- Compile terrestrial plant and zoological data-sets, contract a specialist modeller to carry out reserve system gap analyses, then analyse, interpret and write conservation and reserve system papers on the region's terrestrial and wetland communities.
- Undertake road show to update Pilbara communities on survey findings and outputs.

---

## **Kimberley islands biological survey**

SPP# 2007-001

### *Team members*

L Gibson (0.7), F Köhler (1.0), R Palmer (1.0), M Lyons (0.3), G Keighery (0.15), N McKenzie (0.15), D Pearson (0.1), W Caton (1.0), P Handasyde (0.75), V Kessner (0.75), M Cowan (0.1), J Rolfe (0.1).

### *Context*

Archipelagos along the Kimberley coast present an opportunity to conserve intact examples of ecosystems that have been modified or affected by various threatening processes on the Kimberley mainland. Knowledge is rudimentary about island distributions of species and ecological communities, including those that are endemic to the Kimberley and those that are threatened on the mainland. Consequently, a comprehensive biological survey of the islands off the north Kimberley coast is required. This survey focuses on sampling vertebrate and selected groups of invertebrate fauna that are most likely to be affected by the cane toad as well as by changes to other mainland selection processes. It will also sample the terrestrial flora, soil and other environmental attributes that are indicators of biogeographical patterning, environmental health, and provide a basis for condition monitoring of the targeted survey islands.

### *Aims*

- Provide the knowledge base that will enable better decision making for conservation given the imminent arrival of the cane toad on the adjacent mainland and potentially on some of the islands.
- Inform development proposals by the resources and tourism industries and to provide information for community-based natural resource management and biodiversity planning.

### *Summary of progress (2009/2010) and main findings*

- Dry and wet season surveys completed on Storr, Un-named (Doubtful Bay), Kingfisher, Wulalam, NW Molema, Hidden, Long, Lachlan and Sunday islands.
- Vertebrate identifications (bats - ongoing) completed for all islands above and species lists tabulated.
- The survey has continued to reveal the presence of additional island populations of many vertebrates (particularly snakes and frogs).
- An estimated 91 of the 178 reptile species and 22 of the 42 frog species in the entire Kimberley region are now known to have island populations. Some new finds among the vertebrates include:
  - the threatened (EPBC Act) golden-backed tree-rat (*Mesembriomys macrurus*), now restricted to the north-west Kimberley, was recorded for the first time on Lachlan Island
  - another threatened species, the golden bandicoot (*Isoodon auratus*), was recorded for the first time on Lachlan Island and Storr Island



- a new population of the endangered northern quoll (*Dasyurus hallucatus*), a species particularly vulnerable to cane toad invasion, was recorded on Storr Island
- the collection of a blind snake from Storr Island appears to be *Ramphotyphlops micromma* if correct, is the second record ever for this species.
- To date, 90 camaenid species have been identified on the islands (72 new species and five new genera) with almost all of them being endemic to their respective island. Up to 12 sympatric species have been recorded on a single island.
- The survey has revealed 21 species of non-camaenid snails from both terrestrial (16 species) and freshwater (five species) habitats.
- Identifications of plant material are ongoing with the first two survey years almost complete.
- So far, collections have added significantly to the known flora for the surveyed islands including those that have seen previous botanical collecting.
- Species not previously collected from the Kimberley islands include *Eucalyptus bigalerita* (Northern Salmon Gum) and *Syzygium angophoroides* (Kingfisher Island and Storr Island, respectively).
- Submitted final report to NHT for Phase 1 of the project.
- Two popular science articles have been published describing diversity of land snails in the Kimberley and a further article will be published in the next edition of *LANDSCOPE*.
- Three scientific papers have been published on taxonomic descriptions of the land snails.
- One conference paper has been given on taxonomy of Kimberley land snails.

#### *Management implications*

- Survey information provides a systematic foundation supporting nature conservation planning for reserve system design, development and management, and for understanding the distribution and conservation status of species (indigenous and introduced) and ecological communities as a basis for their management.
- Survey information provides a baseline for long-term ecological monitoring of region.

#### *Future directions (next 12-18 months)*

- Conduct dry season survey of two additional islands; Mary Island and Wargul Wargul Island in Vansittart Bay.
- Complete all species identifications from all sites sampled.
- Compile, analyse and interpret all data-sets.
- Complete and submit final report.

---

### **Floristic surveys of the banded iron formation (BIF) and greenstone ranges of the Yilgarn**

SPP# 2007-005

#### *Team members*

W Thompson (1.0), J Allen (1.0), N Gibson (0.6), R Jasper (0.3), N Sheehy (0.25).

#### *Context*

Assessment of the conservation significance of the flora and vegetation of the banded iron formation (BIF) and greenstone ranges of the Yilgarn is required as they are little studied and under increasing pressure from the rapidly expanding mining interests south of the Pilbara. These land system and geological units are highly prospective for mineral exploration and resource development but are inadequately documented in respect to botanical diversity and are poorly reserved.

#### *Aim*

To undertake a detailed floristic survey of the banded iron formation and greenstone ranges of the Yilgarn to identify gaps in the present reserve network and to determine areas of high biological significance.

#### *Summary of progress (2009/2010) and main findings*

- 17 papers published or in press the last six BIF manuscripts are in review.
- 24 finalised BIF datasets released.
- Contributed to several Public Environmental Reviews (PER) relating to proposed iron ore mines.
- Updated taxonomy in BIF database.
- Uploaded BIF database onto NatureMap site.
- Produced factsheets for 1217 BIF quadrats and 134 BIF community types for webpages for NatureMap site.
- Submitted two papers on meta analysis of the complete BIF dataset outlining extremely high beta diversity in the ranges and identified two hotspots of specialist BIF taxa.
- 150 quadrats established and sampled in 2009, covering three greenstone areas.

#### *Management implications*

BIF and greenstone surveys provide a regional context for the assessment of the impacts of proposed developments on conservation values on flora and vegetation of these banded iron formation ranges.

#### *Future directions (next 12-18 months)*

- Submit manuscripts on the three greenstone surveys for review and publication.
- Launch BIF webpages on NatureMap site.

---

### **Biological survey of the Ravensthorpe Range**

SPP# 2007-006

#### *Team members*

N Sheehy (0.25), N Gibson (0.2).

#### *Context*

The biodiversity values of the Ravensthorpe Range, an area of high prospectivity for mineral exploration and mining, are poorly documented and understood. The Range is known for possessing high numbers of both threatened and/or locally endemic plant species and distinctive and/or threatened ecological communities. Recent and historical resource developments on the Range and in the near vicinity have had significant threatened flora and vegetation management issues. This project's principal aim is to acquire additional knowledge on the floristics of the Ravensthorpe Range and to provide a comprehensive dataset, from site base plots, on the distribution of species and floristic communities across the range and to investigate the relationship between the floristic communities and mapped vegetation units.

#### *Aim*

To identify the botanical and invertebrate biodiversity values of the Ravensthorpe Range.

#### *Summary of progress (2009/2010) and main findings*

- Updated taxonomy on the Ravensthorpe Range database.
- Uploaded Ravensthorpe Range database onto NatureMap site.
- Produced factsheets for 267 quadrats and 21 community types for webpages for NatureMap site.
- Draft report on Ravensthorpe Range vegetation communities finalised.
- Draft report on correlation between floristic communities and vegetation mapping finalised.
- Report on the description and conservation assessment of 40 threatened endemic and near-endemic plant taxa published.

#### *Management implications*

This survey information will provide a regional context for the assessment of impacts from proposed

resource developments on the conservation values of flora and vegetation of the Ravensthorpe Range.

*Future directions (next 12-18 months)*

- Launch BIF webpages on NatureMap site.
- Submit paper on vegetation of the Ravensthorpe Range.
- Submit paper on the correlation between floristic communities and vegetation mapping.

---

**Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain**

SPP# 1993-038

*Team members*

G Keighery (0.2); (External collaborations with OEPA).

*Context*

The Swan Coastal Plain (SCP) is highly fragmented and impacted by settlement, urbanisation and industry. Detailed biological data at various levels is required to inform complex decisions on land use to conserve and protect biodiversity. This project delivers data from new surveys, via the Swan Coastal Plain Floristic and Reserve Survey, to relevant authorities including NGO's, local government authorities, statutory planning authorities and the Environmental Protection Authority.

*Aim*

To undertake studies into the classification, distribution, patterning and conservation status of vascular plant communities and taxa of the SCP at a local and regional level. This will result in the preparation of flora lists for the region and individual conservation reserves. Elucidation of taxonomy of significant flora and weeds will occur as part of this process.

*Summary of progress (2009/2010) and main findings*

- Whicher Range Floristic Study completed and report released. Expert working group convened by Deputy Director General - Parks and Conservation to review implementation, report completed. EPA assessment of Dawesville to Binninup area completed and technical papers on EPA website.
- Scientific paper published on flora and vegetation of Harvey and Mandurah Deltaic and Estuarine islands.
- Report on Vegetation and Flora of Capel to Dunsborough area published.
- New taxa of *Grevillea* and *Petrophile* from Whicher described.

*Management implications*

A better understanding of the conservation values of the area forms the basis for improved land use planning and decision making for biodiversity conservation on the Swan Coastal Plain.

*Future directions (next 12-18 months)*

- Complete report on Vegetation and Flora of Bunbury area.
- Continue to prepare and publish taxonomic, area and floristic papers.
- Conclude work on Dandaragan Plateau (if funded).
- Publish paper on national parks of the adjacent Margaret Plateau and Leeuwin-Naturaliste Ridge.

---

**Ecomorphological clues to community structure; bat echolocation studies**

SPP# 1993-028

*Team members*

N McKenzie (0.1). (External collaborator R Bullen).

### *Context*

This project underpins components of the Pilbara and Kimberley islands biodiversity surveys (SPP# 2004-002 and SPP# 2007-001, respectively).

### *Aims*

- Extend the strategies and sampling methods used in wildlife surveys to extend knowledge of the community structuring processes (including disturbances) that affect the composition and richness of faunal assemblages within Western Australia.
- Compile a dictionary of sonar signatures for automatically recording the composition of bat assemblages on survey sites.
- Develop ecomorphological and spectral measures of potential niche (relate them to community structuring mechanisms and species' realised foraging niches).
- Investigate metapopulation, environmental factors including disturbances and species energetic requirements, controlling the occurrence and conservation vulnerabilities of bats.

### *Summary of progress (2009/2010) and main findings*

- Paper published on assemblage composition, habitat relationships and echolocation characteristics of Pilbara bats.
- Paper published on the heart and lung mass ratios of WA bats and their relationships to species aerobic/anaerobic flight performance and energy costs, foraging strategies and roost preferences.

### *Management implications*

More biodiverse surveys and better understanding of guild and fauna structure in WA ecological communities as a basis for informed resource development decisions and conservation reserve design. Better understanding of bat distributions, energetics and nature conservation status as a basis for determining appropriate management actions and priorities.

### *Future directions (next 12-18 months)*

- Write and submit journal paper on echolocation ecology of Kimberley and Pilbara bats.
- Finalise the reference library of echolocation calls for the 21 microbat species in the Kimberley by documenting variation in *Macroderma* search-mode calls.
- Finalise identification of species in recordings from 19 islands surveyed during the Kimberley islands survey (see SPP# 2007-001), compile data on their foraging strategies, microhabitat use and airframe attributes, analyse guild relationships and write paper for Kimberley island report.
- Finalise and submit journal paper on characteristic flight speeds in WA bats.

---

## **Short Range Endemism of ground-dwelling Invertebrates in the central Pilbara**

SPP# 2009-012

*Team member*

B Durrant (0.6).

### *Context*

Short range endemic (SRE) invertebrates have been a focus of environmental impact assessments (EIAs) for the past decade. This focus has provided an insight into the occurrence of SRE taxa throughout the State and in so doing has highlighted considerable deficiencies in our understanding of this biota. In particular, our understanding of the habitats to which these biota are restricted, is poor. This lack of understanding impacts directly on two aspects of SRE surveys: site selection and risk assessment. This project will assist resource development companies and their consultants in determining suitable survey protocols for targeted biological surveys that are designed to document the presence of SRE taxa and inform the environmental approvals process. This project will also assist in determining the significance of isolated habitat patches and provide greater confidence for decisions made during risk assessments and the environmental impacts approval process.

### *Aims*

- Determine which characteristics define the most common SRE habitats in the Central Pilbara.
- Provide quantitative data to determine habitats that are unlikely to contain SRE taxa.
- Determine which distances and/or changes in the landscape represent significant barriers to dispersal for SRE taxa.
- Assess the extent and limits of distributions for SRE taxa in the Central Pilbara and gain an understanding of what aspects of the landscape may represent significant barriers to dispersal.

### *Summary of progress (2009/2010) and main findings*

- First sampling trip completed in April/May.
- Specimens being prepared for identification by taxonomic experts (40% completed).
- Soil samples collected for analysis.
- Photographs being collated and analysed for habitat assessment (20% completed).

### *Management implications*

The data and knowledge gained will be used by industry and regulators (DEC, OEPA) as part of the ongoing EIA process. Our increased understanding will also inform regional land managers about the significance of particular habitats and SRE taxa, and the external factors that can influence their distribution.

### *Future directions (next 12-18 months)*

- Carry out second sampling trip (July/August).
- Complete identifications with taxonomic experts.
- Contract out and complete soil analysis.
- Complete habitat analysis.
- Carry out analysis of data.
- Complete manuscript(s) for publication in peer reviewed journal.

---

## **Development of ethically acceptable techniques for invertebrate wet-pit trapping**

SCP# 2010-004

### *Team members*

M Cowan (0.3). (External assistance - D Harris, K Ho, T Oldfield).

### *Context*

Over the last 15 years the technique of invertebrate wet pit trapping has become a standard practice in the Division's biogeographic research programs. Relatively small aperture pits with a preserving fluid are buried flush with the ground and left in situ for extended periods (several months) to sample terrestrial invertebrates. This has enabled an unprecedented insight into the temporal and spatial structuring of invertebrate communities - a highly significant but comparatively poorly understood component of the States biota.

However, a consequence of this surveying technique is the inadvertent capture of vertebrates, which creates ethical issue. The combination of glycol and formalin used in these pits is likely to result in a distressing demise for vertebrates as they are able to swim and stay afloat in the solution for some time but the chemical solution is likely to act as an irritant. Also, the quality of the preserved material is of limited use beyond initial species identifications.

### *Aims*

- Establish wet pit trapping chemistry that ensures rapid death to both target and non-target fauna with the least distress possible.

- Achieve a level of preservation in captured organisms suitable not only for species identification, but also for morphological and molecular taxonomic research.

#### *Summary of progress (2009/2010) and main findings*

- Commenced research to examine suitable chemical solutions with WA ChemCentre.
- Obtained advice on animal ethics of proposed solutions.
- Preliminary trials of paraffin oil/ethanol combinations have been undertaken with the following results:
  - Low specific gravity paraffin oil will sit over solutions of ethanol with concentrations as high as 90%.
  - Paraffin oil appears to be an effective barrier against ethanol evaporation over short term (two weeks) trials.
  - Boundary layer between the two chemicals may obstruct the movement of specimens from the paraffin oil into the ethanol.
  - Boundary effect can be mediated to some extent by altering specific gravity of oils and ethanol concentrations.

#### *Management implications*

Continued use of invertebrate wet pit sampling is essential for a number of broad scale biodiversity monitoring programs underway as well as for environmental impact assessment and conservation planning through regional and local scale biological survey.

#### *Future directions (next six months)*

- Continue with background research and laboratory trials to achieve the stated chemistry goals.
  - Present findings to DEC's Animal Ethics Committee (AEC).
  - Seek approval from the AEC for preliminary field trials of any identified solutions.
  - Undertake preliminary field trials and report on the overall results.
-

# FAUNA CONSERVATION

## Program Leader: Keith Morris

Applied research undertaken by the Fauna Conservation Program seeks to understand the factors and processes that are critical for the conservation of Western Australia's rich and unique native fauna diversity. Ensuring the persistence of threatened species through local and landscape-scale management actions including ameliorating key threats such as predation by foxes and feral cats, inappropriate fire regimes, competition and predation by introduced rodents on islands, assessing cane toad impacts and reconstructing the fauna of rangeland and arid areas are major objectives of the Program.

---

### Development of effective broadscale aerial baiting strategies for the control of feral cats

SPP# 2003-005

*Team members*

D Algar (0.5), N Hamilton (0.5), M Onus (0.5).

#### *Context*

Control of feral cats is as one of the most important native fauna conservation issues in Australia. Development of an effective broadscale baiting technique, and the incorporation of a suitable toxin for feral cats, is cited as a high priority in the National Threat Abatement Plan for Predation of Feral Cats, as it is most likely to yield a practical, cost-effective method to control feral cat numbers in strategic areas.

#### *Aims*

- Design and develop a bait medium that is readily consumed by feral cats.
- Examine bait uptake in relation to the time of year to enable baiting programs to be conducted when bait uptake is at its peak and therefore maximise efficiency.
- Examine baiting intensity (number of baits laid/km<sup>2</sup>) in relation to baiting efficiency to optimise control.
- Examine baiting frequency required to provide long-term sustained effective control.
- Assess the potential impact of baiting programs on non-target species populations and devise methods to reduce the potential risk where possible.
- Provide a technique for the reliable estimation of cat abundance.

#### *Summary of progress (2009/2010) and main findings*

- Ongoing research to optimise baiting programs was undertaken at Lorna Glen, north east of Wiluna. Annual aerial cat baiting has maintained cat activity at 5-8 cats per 100km of track, which is about 15% of the activity level prior to baiting. Data collection and analysis has now been completed and is being compiled into a manuscript for publication.
- The final island trial of the feral cat bait (Eradicat) was undertaken at the tropical site of Christmas Island at the end of the dry season in 2009 and resulted in an 87% reduction in cat activity across the study site following baiting. The results of the trials on French Island (Vic), Dirk Hartog Island (WA) and Christmas Island have been published. Mainland trials will commence in autumn of 2011.
- A new hair capture technique that reliably samples all individuals was developed. This now enables collection of data, through DNA analysis, that will be used to identify specific individuals at plots. This will provide valuable information for teasing out the abundance/activity issues that confound the indices of relative abundance and assist in the development of a more robust monitoring technique. A description of this technique has been submitted for publication.

#### *Management implications*

- Research into the development of baiting strategies to provide sustained and effective feral cat

control over time can now extend operational introduced predator control and wildlife reintroductions to the arid and semi-arid interior.

- Research into the effectiveness of the baiting strategy is now also being assessed under the temperate climatic conditions of the south-west.

#### *Future directions (next 12-18 months)*

- Conduct further research to optimise the various parameters of baiting strategies, particularly on Dirk Hartog Island.
- A comprehensive risk assessment of the potential impact of feral cat baiting programs on populations of non-target species is continuing in collaboration with DEWHA and Victoria DSE, and where necessary, methods devised to reduce this risk.

---

### **Sustained introduced predator control in the rangelands**

SPP# 2007-004

#### *Team members*

D Algar (0.5), M Onus (0.5), N Hamilton (0.5).

#### *Context*

The project will provide for the successful reconstruction and conservation of biodiversity as part of future expansion of the Western Shield program into this region. The program builds on the successful research programs and operational trials conducted in the interior arid zone at the Gibson Desert Nature Reserve and more recently at Lorna Glen. This is a collaborative project involving DEC and Australian Wildlife Conservancy (AWC). The research was undertaken at AWC's Mt Gibson Sanctuary and at the nearby DEC acquired pastoral leases of Karara/Lochada. Mt Gibson Sanctuary is the treatment (baited) site and Karara/Lochada is the control or non-baited site, some 50km distant. Feral cat bait and baiting methodologies (i.e. timing of baiting, baiting intensity and frequency) are being employed to assess an integrated introduced predator (feral cat, fox and wild dog) control strategy. This strategy involves an annual baiting program, conducted in winter, with baits distributed at a density of 50 baits km<sup>-2</sup>.

#### *Aim*

Develop operational-scale introduced predator control techniques for the semi-arid bioregions in the lower rangelands.

#### *Summary of progress (2009/2010) and main findings*

- Over its four-year life 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, indices of feral cat activity have never recovered to their original level with the continuation of the annual baiting regime. Indices of fox activity crashed following each baiting and their numbers remained low until late summer/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 prior to 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.
- This project demonstrated that the impact of baiting, particularly on feral cat populations, is substantially reduced if significant rainfall occurs immediately following the baiting program. Baiting outcomes could be improved if long-term weather forecasts are used to ensure that baiting programs are only conducted 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.
- The predator control could potentially be enhanced with additional baiting using fox baits during the



autumn. The additional baiting would not only reduce fox numbers during the key dispersal period, but suppress fox numbers until the subsequent *Eradicat*<sup>®</sup> 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 necessity for conducting individual baiting programs at each location. The impact of reinvasion by both 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.

- 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 is the development of the 'sticky wicket' technique, which identifies individual animals by removing hair for the extraction of DNA without having to trap them; trapping feral predators has always been a notoriously difficult task. Using this data, we now have the ability to identify specific individuals at plots and provide more accurate estimates of population size and home ranges. We can now examine how well indices of relative abundance, such as presence at sand plots, perform at reflecting true abundance and use this information to help interpret sand plot data, and possibly improve the robustness of the technique.

#### *Management implications*

Research into the development of baiting strategies to provide sustained and effective integrated introduced predator control over time will extend operational introduced predator control and wildlife reintroductions to the Rangelands. This project demonstrated that long-term, sustained control of feral cats and foxes can be achieved in the rangelands. Some native species (like mala, *Lagorchestes hirsutus*, and greater stick-nest rats, *Leporillus conditor*;) may possibly only survive when introduced predators are completely absent - these species will need offshore and 'mainland islands' (i.e. fenced areas) to survive. However, a large number of native species can survive if introduced predator densities are reduced (rather than eliminated).

#### *Future directions (next 12-18 months)*

This project has been completed and is being published.

---

### **Conservation of south coast threatened birds**

SPP# to be allocated

#### *Team members*

AH Burbidge (0.15); South Coast Region staff (subject to ongoing funding).

#### *Context*

Identifying the conservation requirements of threatened south coast birds such as the Critically Endangered Western Ground Parrot, and the Vulnerable Western Bristlebird and western subspecies of the Western Whipbird will aid *in situ* management of these taxa. Understanding responses to fire, biological and behavioural characteristics such as vulnerability to predation and nesting site requirements are essential knowledge for the conservation of these WA endemics. A high community involvement is maintained with over 40 volunteers per survey season. Community education and information assimilation is achieved through local and internationally focused media. Since Western Ground Parrots are declining, this species is a high priority, but solutions will come from holistic management of the landscape as a whole.

#### *Aims*

- Develop an understanding of the biological and ecological factors that limit the distribution and numbers of Western Ground Parrots and Western Bristlebirds, including interactions with predators, habitat requirements, and response to fire.
- Increase the survival chances of the Western Ground Parrot, Western Bristlebird and Western Whipbird and increase their total population size, through creation of management prescriptions that will benefit all threatened south coast animals.

#### *Summary of progress (2009/2010) and main findings*

- Commenced integrated predator management on the south coast in an adaptive management framework.
- Genetic analysis indicated that the Western Ground parrot is a separate species from the Eastern Ground Parrot, indicating that its conservation status is critical.
- In collaboration with DEC South Coast Region, set up a captive management program for the Critically Endangered Western Ground Parrot.

#### *Management implications*

The project is providing a basis for decision-making and management actions for the recovery of threatened (and other) fauna, especially in respect of introduced predators and fire, in important conservation reserves on the south coast.

#### *Future directions (next 12-18 months)*

- Finalise writing up of data on response to fire by bristlebirds.
- Implement feral cat control (with monitoring) in key Ground Parrot habitat.
- Establish a captive breeding program for Western Ground Parrots.
- Continue writing popular and scientific articles on fauna reconstruction on the south coast.

---

### **Translocation outcomes and monitoring of naturally occurring populations of the western ringtail possum (*Pseudocheirus occidentalis*)**

SPP# 2006-006

#### *Team members*

P de Tores (0.25). (PhD Students – J Clarke, H Grimm, G Bryant, Murdoch University, K Yokochi, UWA, Honours L Zimmerman, UWA).

#### *Context*

The western ringtail possum translocation program commenced in 1991 and by 1998 appeared to have met the criteria for success. The primary translocation release site, Leschenault Peninsula Conservation Park, subsequently suffered a population decline. Low density populations have persisted at three translocation release sites within Yalgorup National Park. Possible causes for the decline at Leschenault are being investigated and are: factors influencing survivorship of naturally occurring (non translocated) populations; the health of naturally occurring and translocated populations; the role of predation by pythons in translocation outcomes; the genetics of western ringtail possums; and techniques for determining population density at sites within the Busselton area thought to be at relatively high density.

#### *Aim*

To determine translocation success at Leschenault Peninsula Conservation Park and Yalgorup National Park.

#### *Summary of progress (2009/2010) and main findings*

- Although no causal link has been identified, survivorship of translocated western ringtail possums was negatively associated with high numbers of the sympatric common brushtail possum (*Trichosurus vulpecula hypoleucus*) and negatively associated with high pre-translocation lymphocyte counts.
- Reference values and baseline information on the haematological and biochemical profiles have now been established for coastal populations.
- Cat presence has been confirmed at Leschenault Peninsula Conservation Park and fox and cat

trapping has commenced to assess the effectiveness of DEC's cat bait in south-west WA

- Results from Distance Sampling have shown previously relied upon *ad hoc* techniques used to estimate population size are unreliable.
- Genetic studies have revealed no evidence of historic or contemporary mixing of *in situ* (naturally occurring) populations separated by as little as 30km and with no physical barriers to dispersal or movement.
- Research has commenced on determining the factors associated with western ringtail possum persistence at retained habitat within development sites.

#### *Management implications*

- Translocation is yet to be shown to be a viable management strategy for rehabilitated western ringtail possums (ex wildlife carers) or for western ringtail possums displaced by urban developments. In the absence of demonstrated translocation success, there is a need to examine other options to deal with displaced or rehabilitated western ringtail possums.
- Translocation of western ringtail possums has largely been driven by the need to relocate possums from development sites where habitat is destroyed and the resident possum populations displaced. There will be a continued need for translocation of these displaced possums and an additional requirement to release orphaned and injured possums which have been nurtured and/or rehabilitated by wildlife carers. In order to meet conservation and community expectations, the current high rate of loss of animals to predation by cats needs to be addressed at translocation sites.

#### *Future directions (next 12-18 months)*

The factors determining persistence at retained habitat within development sites will be continue to be examined.

---

### **The importance of fox, cat and native predator interactions to sustained fauna recovery in the northern jarrah forest – is there a mesopredator release effect?**

SPP# 2006-005

#### *Team members*

P de Tores (0.75), R Hill (0.5), S Garretson (0.5), A Glen (0.5), D Sutherland (0.5). (PhD students - G Bryant, J Cruz).

#### *Context*

Fauna recovery within Western Australia is largely dependent upon the effectiveness of localised and large scale introduced predator control programs. However, recent research and monitoring by DEC has demonstrated the abundance, distribution and recovery of some species is unlikely to be a function of a single causal factor such as predation. Consistent with this hypothesis, some of DEC's Western Shield projects have not been able to demonstrate a response to fox control. In most of these cases there is insufficient information to determine why some programs have been unable to demonstrate a response to baiting programs or to determine why translocation programs have been unable to demonstrate success.

Various hypotheses have been proposed to explain these declines but none is universally accepted and a combination of causal factors is likely. However, there was strong evidence that predation by cats increased when fox density was reduced. This phenomenon is well documented in ecological theory and is known as mesopredator release. This project was established in collaboration with the Invasive Animals Cooperative Research Centre (IA CRC) to assess whether cats have shown a mesopredator release in the presence of fox control within the northern jarrah forest.

#### *Aims*

- Test the mesopredator release hypothesis at the landscape and local scale.
- Assess the importance of other factors to fauna recovery and translocation success.

#### *Summary of progress (2009/2010) and main findings*

- Refined sandplotting techniques now allow estimation of fox and cat density instead of relying on simplistic unquantified 'indices of activity'.
- Hair collection devices have been developed and enable collection of fox and cat hair from a single device.
- Genotyping of the DNA recovered from hair and scat samples has shown fox populations are being 'turned over' (i.e. individual foxes are successfully removed by baiting, but are replaced by immigration).
- Mesopredator release of cats in the presence of fox control has been confirmed.
- Complex predator interactions have been identified at George Forest Block, on the eastern margin of the northern jarrah forest. We hypothesised the level of fox density reduction achieved by 1080 baiting is insufficient to enable cats to respond, yet sufficient to enable relatively high native predator (chuditch and goanna) density which coincides with a higher diversity of native prey species. The woylie population at George Forest Block is of particular interest. It is possibly the only woylie population to have shown an increase over the past decade.
- We developed a technique for detection of the biomarker Rhodamine B in reptiles.
- Non-target trials of DEC's 'Curiosity' cat bait have indicated the current method for encapsulation of a toxin is not suitable for introduced predator control.

#### *Management implications*

- Fox and cat control will need to be integrated through strategic control programs for both species.
- Broadscale cat control in the south-west is not possible until a suitable bait is developed.
- The effectiveness of integrated baiting programs will need to be monitored through techniques suitable for the targeted species.

#### *Future directions (next 12-18 months)*

- Complete all analyses.
- Provide a final report to DEC and the IA CRC.
- Submit manuscripts for publication.

---

### **Factors affecting establishment in the numbat (*Myrmecobius fasciatus*) Recovery Plan**

SPP# 1993-145

#### *Team members*

T Friend (0.1), K Rusten (0.25).

#### *Context*

The numbat is Western Australia's State mammal emblem is now listed as Endangered in 2008 IUCN Red List. After a vigorous reintroduction campaign led by DEC, there are now eight self-sustaining populations but probably less than 1000 animals in existence. Continued recovery relies partly on private conservation organisations and this project is now orientated towards monitoring populations on DEC-managed estate.

#### *Aims*

- Measure the success of establishment of numbat populations through reintroduction and introduced predator control and attribute mortality to specific causes.
- Assess population abundance and trends. If population growth is zero or negative, remove one of the factors causing mortality, and assess the effect of removing the cause of mortality on the growth of the population.

#### *Summary of progress (2009/2010) and main findings*

- Monitoring of 13 captive-bred numbats that were radio-collared and released at Cocanarup Timber Reserve in December 2009 provided location, survival, breeding and habitat data as well as forensic data at death.
- Data reveals predation of most animals by fox, cats, birds of prey, carpet python and Goulds goannas.
- The annual numbat abundance survey was carried out at Dryandra in November 2009. The results of this survey showed that numbat numbers are lower than at any time since fox control commenced in 1983.
- A workshop to instruct Project Numbat community group members and Australian Wildlife Conservancy staff in techniques to assess numbat release sites was held at Mt Gibson Sanctuary.
- A small group of the members of the Friends of the Fitzgerald River National Park community group have been trained in monitoring radio-collared numbats and check the animals at Cocanarup between visits by DEC staff.

#### *Management implications*

- Management of numbat habitat requires ongoing fox control and application of appropriate fire regimes, including protection from large and intense wildfires.
- Rapid implementation of control of feral cats at Dryandra is a high priority if extinction of this critically important numbat population is to be averted.

#### *Future directions (next 12-18 months)*

- Monitoring of known numbat populations will be continued by involving district staff and community members and handing over monitoring responsibility to districts. Regular monitoring surveys will be essential in Dragon Rocks, Karroun Hill, and the northern jarrah forest east of Mundaring, Dryandra and Boyagin. Other areas will be included if possible.
- No further releases of numbats will be carried out at Cocanarup until the success of the translocation is determined by continued intensive monitoring.
- The small group of captive-bred numbats at Perth Zoo will be released in top-ups at Boyagin, Dragon Rocks and Batalling.
- A survey for numbats and feral cats at Dragon Rocks is proposed in 2010/2011, with Great Southern District involvement. A survey for numbats will also be carried out at Karroun Hill NR.

---

### **An assessment of the effect of fox control on *Phascogale calura* (red-tailed phascogale) populations**

SPP# 1993-149

*Team member*

T Friend (0.05).

#### *Context*

The red-tailed phascogale (RTP) is ranked Endangered on State, Commonwealth and IUCN threatened species lists, although a recent IUCN review recommended a downlisting to Vulnerable. This species is present in many small reserves and on private property in the Upper Great Southern and sporadically on the south coast and eastern wheatbelt and thus offers umbrella status as a threatened species for which landholders can provide habitat.

#### *Aims*

- Assess the effect of fox control on populations of the red-tailed phascogale.
- Determine distribution and habitat preferences of the red-tailed phascogale in the South Coast Region.

#### *Summary of progress (2009/2010) and main findings*

- Wildfires in the western Fitzgerald River National Park (FRNP) in January 2008 burnt the only two known sites for red-tailed phascogales, at which radio-tracking work was proposed during this year. Further searches will be carried out in 2010/11 for surviving populations.
- Trapping was carried out in four of the nine study sites under the fox control research program.
- A desktop habitat mapping exercise was carried out under the Fitzgerald Biosphere threatened species and communities' recovery planning project, focusing on stands of moort, swamp she-oak and rock she-oak to facilitate future targeted survey for red-tailed phascogales.

#### *Management implications*

At this stage there is little evidence that fox control is an important requirement for the persistence of remnant RTP populations, although recovery after dry seasons is more rapid under fox control. It is likely that movement between habitat patches and along corridors between reserves is inhibited by fox presence.

#### *Future directions (next 12-18 months)*

- Hair funnel surveys will be carried out in the FRNP in 2010/11 under the auspices of the Integrated Predator Management Program in likely RTP locations.
- Results of the effects of fox control project to date will be written up during 2010/11.
- A recovery plan for the RTP is currently being completed involving community input. The plan recommends the continuation of this study and the strong involvement of landholders and local community members.

---

### **Dibbler (*Parantechinus apicalis*) Recovery Plan**

SPP# 1995-011

#### *Team members*

T Friend (0.05), T Button (0.1).

#### *Context*

The *Dibbler Recovery Plan 2003-2013* identifies actions to improve the conservation status of this small marsupial, ranked Endangered in State, Commonwealth and IUCN threatened species lists.

#### *Aims*

To implement the *Dibbler Recovery Plan*, and thereby improve the conservation status of the dibbler by:

- Protecting and monitoring existing populations.
- Increasing the number of known populations by searching for undiscovered populations and re-establishing dibblers in areas where they have become extinct.
- Documenting and explaining dibbler distribution in the Fitzgerald River National Park (FRNP).

#### *Summary of progress (2009/2010) and main findings*

- The population study in the eastern FRNP continued in 2009/10, with three monitoring sessions at the study site. Numbers were very low following the dry winter of 2008 but increased significantly in March 2010 with new recruitment from spring 2009.
- A new series of releases of dibblers commenced at the Peniup translocation site in October 2008, with the release of 40 dibblers from the Perth Zoo colony. This was followed by a release of 30 more in October 2009.
- Monitoring of the Peniup trapping grids in September 2009 resulted in the capture of four dibblers including young, indicating that breeding had occurred on-site in spring 2009. Trapping after the October release resulted in capture of six dibblers in December 2009 and of six again in February 2010. These results are promising and another release is scheduled for October 2010.

- The Boullanger and Whitlock island populations were monitored in October 2009 and May 2010. The Whitlock Island population is small but very stable. While the Boullanger population has declined steadily over the last four years, the May trapping indicated a minor recovery.

#### *Management implications*

- Appropriate management for threatened fauna conservation depends on adequate knowledge of species distributions and habitat preferences.
- Results from both Peniup and SRNP indicate strongly that monthly ground baiting is necessary to maintain dibbler populations, at least in small isolated remnants and in large areas adjacent to farmland.
- Large and intense wildfires diminish dibbler habitat.

#### *Future directions (next 12-18 months)*

- Monitoring of the Peniup and Stirling Range translocations and the existing FRNP and Jurien Bay island populations will continue.
- Building on the results of the 2008-2009 mouse baiting investigations, further rhodamine B trials to test improved bait tube designs will be carried out on the Jurien Bay islands.
- The study of dibbler distribution in the FRNP will continue in 2010-2011, with survey activity focused on spring-early summer period.

---

### **Gilbert's potoroo (*Potorous gilbertii*) Recovery Plan**

SPP# 1996-008

#### *Team members*

T Friend (0.7), S Hill (1.0), T Button (0.9), V Hack (0.5), S Schreck (0.5).

#### *Context*

Gilbert's potoroo is the world's rarest marsupial. The *Gilbert's potoroo Recovery Plan 2003-2008* provides a list of actions to improve the conservation status of this Critically Endangered species. This project involves collaborative arrangements with South Coast NRM, universities, the Royal Zoological Society of South Australia, the Foundation for Australia's Most Endangered Species (FAME), private sponsors and the Albany-based Gilbert's Potoroo Action Group.

#### *Aims*

- Implement the Gilbert's potoroo Recovery Plan.
- Increase the numbers of individual Gilbert's potoroos known to be alive in the wild and increase the number of locations in which they occur.

#### *Summary of progress (2009/2010) and main findings*

- A census of the Mount Gardner population of Gilbert's potoroos is conducted three times a year. Numbers have remained stable since 2001 when this regime was introduced. Numbers captured were 21 in June/July 2009, 22 in November 2009 and 19 in March 2010.
- Intensive captive husbandry methods have not produced reliable breeding, so an experiment has been carried out to determine whether holding animals in a free range situation, with or without the captive diet, will stimulate non-reproducing animals to become reproductive. In the latest trial, a hand-reared female that had produced no young from numerous pairings in close captivity was held in a 14-hectare enclosure in remnant bushland at Ryedene farm with a male taken from the wild. From December 2008 until July 2009 these animals were supplied daily with the artificial diet and radio-tracking and motion-activated cameras showed that they fed on the diet every day and spent most of their time near the feeding enclosure. The potoroos were clearly accessing fungi, but no pouch young were recorded during this time. Provision of supplemental food ceased in early July 2009. Radio-tracking of both potoroos revealed a significant increase in movement throughout the

enclosure when artificial food was unavailable. This experiment was concluded in March 2010 when the pair were translocated to the Waychinicup enclosure. At this stage the female had still not produced young.

- The translocated population on Bald Island has grown rapidly from the founder number of ten. Twenty-nine independent potoroos, including eight of the ten founders, were captured in the most recent field trip in November 2009, despite the removal of seven potoroos in September 2008 and January 2009.
- In February and March 2010, nine Gilbert's potoroos (including seven from Bald Island) were released into a 380-ha fox- and cat-free enclosure in Waychinicup National Park. As well as aiming to establish a new population, this project is structured as an experiment to compare the potoroos' use of the different vegetation types within the enclosure. All animals were released into an area of about 50ha of *Melaleuca striata* heathland identical to potoroo habitat at Two Peoples Bay. The potoroos were radio-tracked on several days each week for two months, by which time tail-mounted transmitters had fallen off. At the end of this time, about half of the animals had moved out of the heathland into adjacent woodland. One had died but the other eight were alive when last tracked.
- A manuscript describing fungal diet of potoroos on Bald Island and Ryedene has been published in *Australian Mammalogy*.

#### *Management implications*

Results of the Bald Island translocation and subsequent monitoring indicate that a new self-sustaining population has been established at a site unaffected by introduced predators and lacking most native predators. This new population will provide better security for the species in the face of the greatest threat to its survival, wildfire at Two Peoples Bay.

#### *Future directions (next 12-18 months).*

- Continue to monitor the Mount Gardner population and the Bald Island translocation.
- Support cat trapping efforts at Two Peoples Bay, and initiate a study of fox bait consumption at Two Peoples Bay using motion-activated cameras.
- Continue the cross-fostering trial while funding is available.
- Monitor the progress of a male and a female potoroo in the 14ha fenced enclosure during and after the removal of supplemental feeding.
- Monitor establishment of Gilbert's potoroos within the Waychinicup National Park enclosure. Continue to monitor the enclosure for incursion by cats or foxes. Implement structured trapping to determine habitat use.
- Evaluate further translocation sites, both on the mainland and on other islands.
- A paper on the dynamics of the Two Peoples Bay population of Gilbert's potoroos will be submitted for publication.

---

### **Genetics and ecology of the western barred bandicoot (*Perameles bougainville*)**

SPP# 1993-163

*Team member*

T Friend (0.05).

#### *Context*

Bernier Island and Dorre Island are of extremely high conservation value because they have retained populations of several mammals that are extinct on the mainland. Recovery of those species relies on reintroductions but for successful outcomes it is vitally important to understand and manage genetic, ecological and disease characteristics that are a result of the long isolation of island populations.

#### *Aims*

- Achieve an understanding of the habitat requirements, habitat use, breeding biology and spatial



organisation of the western barred bandicoot.

- Assess genetic difference between populations of western barred bandicoots on Bernier Island and Dorre Islands using PCR and DNA sequencing.
- Assess the viability and fertility of progeny from matings between Dorre Island and Bernier Island individuals.
- Investigate the conservation ramifications of disease issues in western barred bandicoots and to support veterinary investigations into pathological conditions.

#### *Summary of progress (2009/2010) and main findings*

A collaborative paper on the 'wart-like syndrome' has been published.

#### *Management implications*

The results of these studies, particularly relating to disease and genetics, will be of great value in managing diseases in wild populations and with translocations of western barred bandicoots and other mammals surviving on islands.

#### *Future directions (next 12-18 months)*

- The results of the cross-breeding experiment conducted at Kanyana Wildlife Rehabilitation Centre will be written up.
- A paper on home range activity and nest use by western barred bandicoots on Dorre Island is near completion and will be submitted for publication.

---

### **Disease screening and vectors of transmission in quokkas (*Setonix brachyurus*) on the mainland and Bald Island**

SPP# to be allocated

*Team member*

T Friend (0.05).

#### *Context*

During studies of blood parasites of Gilbert's potoroos, trypanosomes (*Trypanosoma copemanii* n. sp.) and piroplasms (*Theileria* sp.) were discovered both in potoroos and in quokkas. This led to a PhD project by J Austen to examine epidemiology of trypanosomes in geographically dispersed populations of quokkas. This will include the determination of the vectors involved in transmission. In conjunction with this study, quokkas will be radio-tracked on Bald Island and the mainland to determine patterns of movement and juvenile dispersal in the context of disease transmission and dissemination. Salmonellosis has been shown to have a profound effect on the biology of the Rottnest quokka. *Salmonella* spp. been recorded in Bald Island quokkas but little is known about the species present or their prevalence throughout the year. Quokkas are swabbed when captured and the samples plated out in Albany and sent to Perth for identification.

#### *Aims*

- Determine the infection rates and vectors of trypanosomes in quokkas on Bald Island, Rottnest Island and mainland populations and to identify vectors and possible rates of transmission.
- Determine infection rates, seasonality and species composition of *Salmonella* in quokkas on Bald Island and the south coast mainland.

#### *Summary of progress (2009/2010) and main findings*

- Nesting home ranges of quokkas on Bald Island have been mapped and 347 individual quokkas captured. Dispersal of young away from their natal area has not been recorded and it appears that quokkas remain faithful to their natal or family home ranges on Bald Island as on Rottnest.

- Samples (rectal swabs) from Bald Island quokkas taken over three years have been cultured and *Salmonella* strain identified where present. Results have been collated for preparation of a publication on the influence of seasonal and demographic factors on *Salmonella* in Bald Island quokkas.
- Three trips to Bald Island were carried out during 2009/10 and a total of 177 individual quokkas captured. Data concerning location of capture, reproductive and physical parameters were recorded and ectoparasites were collected. Blood samples were taken from 14 quokkas. Ticks are present but fleas appear to be absent from the island.
- A field trip to Rottnest Island was carried out in January 2010. Forty-three quokkas were captured from Barker Swamp, the West End, the railway siding and the old salt works site in order to collect blood and ectoparasites from quokkas. Blood samples were taken from all but two of the quokkas. Fleas and ticks were absent and most interestingly, no trypanosomes were found in the blood samples.

#### *Management implications*

Understanding disease dynamics, especially modes of transmission, in wild populations is an important precursor to intensive management actions such as reintroductions and top-up translocations.

#### *Future directions (next 12-18 months)*

- Continue to trap, sample and radio-track quokkas on Bald Island, Rottnest Island and Mount Gardner and Two Peoples Bay.
- Work with Murdoch University collaborators to further studies of blood parasites in quokkas.

---

### **Rapid survey of quokka (*Setonix brachyurus*) in the southern forests**

SCP# in preparation

*Team member*

G Liddelow (0.1).

#### *Context*

Research on quokka populations in the northern jarrah forest has shown an alarming decline in quokka (*Setonix brachyurus*) populations in this part of their range. A rapid survey of the distribution and relative abundance of quokka populations in the southern forests was undertaken to understand their current distribution, promote their protection and conservation, and to guide decision-making with respect to fire management and timber harvesting.

#### *Aims*

- Survey quokka activity and distribution within the southern forest.
- Map quokka distribution.
- Provide management guidelines for district/region fire management plans.
- Provide management guidelines for areas subject to timber harvesting with known populations of quokka in timber harvesting coupes.

#### *Summary of progress (2009/2010) and main findings*

- Surveys of some gaps in the survey area of the southern forest have been filled
- Further surveys of the northern jarrah forest have been carried out by district staff
- A total of 2045 sites have been inspected for presence of quokka from Mundaring in the north to Walpole in the south and quokka activity was found in 932 or 45.5% of these sites.
- Pigs were found to be active in 283 or 13.8% of these 2045 sites.

### *Management implications*

Application of interim guidelines for fire management to protect and/or regenerate quokka habitat.

### *Future Directions (next 12/18 months)*

- Complete northern forests survey.
- Complete data analysis.

---

## **Probait trials: phase 2**

SPP# 2000-014 (incorporates SPP# 1999-018)

*Team member*

N Marlow (0.05).

### *Context*

Fox control at Dryandra has been found to be less effective than predicted. A possible reason for this may be a loss of 1080 from baits. Trials are needed to assess whether the 1080 content of baits decreases to non-lethal levels between baiting sessions.

### *Aim*

To ensure that Probait trials contain a lethal dose of 1080 for fox control between baiting sessions.

### *Summary of progress (2009/2010) and main findings*

- Toxic baits with known initial concentrations (hand injected) were placed in the field and samples of baits with varying amounts of 1080 (3mg, 4.5mg and 6mg) were collected each week for 12 consecutive weeks in each of four seasons.
- A sample of 32 baits with known concentrations of 1080 (hand injected) were sent to two different laboratories (Alan Fletcher Institute in Queensland and Landcare in New Zealand) for analysis of their 1080 content. Due to the salami process used in the manufacture of the Probait trials, both laboratories found it challenging to obtain reliable estimates of the 1080 content of each bait. These analyses were expensive and yielded no useful results. As a consequence none of the baits collected from the field were sent for analysis.

### *Management implications*

At present we are unable to say how long fox baits remain toxic and lethal to foxes in the field. However given that up-take trials indicated that baits in Dryandra Woodland rarely last more than 72 hours, the probability of them becoming non-toxic in this time is unlikely though this may not be the case in more mesic areas.

### *Future directions (next 12-18 months).*

Develop the protocols necessary to be able to accurately determine the concentration of 1080 in meat baits manufactured using the salami process.

---

## **Sustained fauna recovery in a fragmented landscape (Dryandra Woodland and Tutanning Nature Reserve)**

SPP# 2006-007

*Team members*

N Marlow (0.85), A Williams (0.90), N Thomas (0.9), B Macmahon (1.0), J Lawson (0.1).

### *Context*

The factors responsible for decreased survival and recruitment of woylies (*Bettongia penicillata*) in wheatbelt reserves in Western Australia (i.e. Dryandra Woodland and Tutanning Nature Reserve) were investigated in a four-year study which has now concluded. Woylies were radio-collared and monitored intensively to directly identify factors responsible for their demise. These were considered to include predation from pythons or raptors, or ineffective fox control (1080 loading too low, unsustainable non-target bait uptake, or bait shy foxes).

#### *Aims*

- Test the mesopredator release hypothesis at the landscape and local scale.
- Determine the causes of woylie decline.
- Test the effectiveness of current baiting regimes and to identify if resident foxes are present.

#### *Summary of progress (2009/2010) and main findings*

- A total of 252 woylies were captured in Dryandra Woodland and Tutanning Nature Reserve during 2006-2010. Of these 146 were radio-collared. Ninety nine of the radio-collared individuals died, eight went missing and 39 had their radio-collars removed at the end of the study. The results of autopsies and DNA analysis of saliva on collars have indicated that cat predation accounted for approximately 67% of the woylie deaths. Foxes were identified as the predator in 18% of the woylie deaths despite ongoing monthly hand baiting for foxes in both reserves. Predation by raptors, pythons and chuditch was relatively insignificant.
- Sandplots have been monitored in Tutanning (75 plots), Dryandra (129 plots) Highbury block (unbaited 31 plots) and Quinns block (unbaited 32 plots). Results indicate foxes are constantly present in all sites despite repeated baiting in Dryandra Woodland and Tutanning Nature Reserve. DNA samples from hair collected at sandplots revealed that at least six foxes (four in Dryandra and two in Tutanning) survived at least one fox baiting event, if not longer. This suggests there may be some resident foxes which are either not finding, not eating, or are not being killed by the baits. However, 19 fox carcasses of individuals killed by 1080 were found which indicates most foxes are not residents and that most of those immigrating into the reserves are killed by baits.
- Regular cage trapping of woylies in Dryandra Woodland and Tutanning Nature Reserve revealed a noticeable decrease in trap success as the project progressed. This appeared to be more noticeable in Tutanning Nature Reserve but analysis of survival of radio-collared woylies using the known fate model of Program MARK indicated that woylies in Dryandra actually survive less well than those in Tutanning Nature Reserve. This indicates both populations are struggling for survival.
- Bait uptake (Probaits) by foxes and non-target species was investigated using remote cameras. Bait uptake by possums and birds is extremely high and may preclude foxes from finding baits. Even at a simulated baiting rate of 50 baits per km<sup>2</sup>, most baits were removed within 72 hours. The baiting regime in the northern half of Dryandra Woodland was increased in intensity and frequency. The 1080 loading of baits is being increased from 3mg to 4.5mg. Fifty baits per km<sup>2</sup> were delivered in the northern half of Dryandra commencing November 2008. Analysis of Western Shield trapping data from 2006-2010 using a robust model in Program MARK has indicated increased woylie survival in the area with the increased baiting intensity.

#### *Management implications*

- The baiting regime at Dryandra Woodland needs to be maintained at 50 baits per square kilometre at least until the next Western Shield monitoring in April 2011. The Western Shield monitoring of Tutanning needs to be undertaken in April 2011. The cost of maintaining the increased baiting regime in Dryandra Woodland is \$11,700pa.
- The development of an operational cat bait which is effective in killing cats throughout the year and in sites where non-target species are present is of paramount importance.

#### *Future directions (next 6 months)*

- Continue with the increased fox baiting intensity (50 baits per km<sup>2</sup>) in Dryandra Woodland.
- Facilitate the annual monitoring of woylies at Tutanning.

- Encourage the development of an effective cat bait which can be used in both Dryandra Woodland and Tutaning Nature Reserve.
- Complete analysis of all data from the mesopredator project, complete a report to the Director General, and complete all relevant manuscripts.

---

## **Return to Dryandra**

SPP# 2003-002

*Team members*

N Thomas (0.1), N Marlow (0.05).

### *Context*

Developing cost effective captive breeding techniques and an understanding of effective reintroduction methodologies that can be implemented at an operational regional level is a priority of the Western Shield program. In 1998 the Return to Dryandra (RTD) project was established to investigate the best methodology to captively breed and maintain five locally extinct wheatbelt mammalian species within large enclosures (two x 10 ha) at Dryandra, to investigate a range of reintroduction techniques and to provide animals for reintroduction to Western Shield fauna reconstruction sites where fox control is in place at a regional level.

### *Aims*

- Provide a scientific basis for the establishment and maintenance of breeding populations of at least five critical weight range (CWR) threatened marsupial species (bilby, boodie, marl, mala and merrnine) from remote areas in large enclosures at Dryandra.
- Establish self-sustaining populations of these CWR threatened marsupial species within enclosures at Dryandra.
- Compare the success of different release and reintroduction methodologies and to develop optimal strategies for these CWR threatened marsupial species within Dryandra Woodland.
- Establish self-sustaining populations of these re-introduced CWR threatened marsupial species within Dryandra Woodland.

### *Summary of progress (2009/2010) and main findings*

- Bilbies and boodies continue to breed very well and more releases are needed in the near future to reduce overcrowding in the enclosures.
- Four marl have been caught in the RTD facility, indicating that they have persisted within the facility despite nine being removed in 2008.
- A release of 13 male bilbies to Lorna Glen was undertaken and this has alleviated the male bilby bias within the RTD enclosure.
- A release of 20 boodies (15 males and five females) to Lorna Glen was undertaken in 2009, this has also alleviated the male boodie bias within the RTD enclosure.
- Bilbies are still persisting within Dryandra Woodland but at extremely low numbers.
- Mala numbers within the RTD facility have increased from 17 to 20.

### *Management implications*

- New sites for the translocation of bilby and boodies need to be found to prevent overcrowding of the breeding facility.
- The ongoing future of the breeding facility needs to be considered by the Department, taking into account translocation proposals over the next few years.

### *Future directions (next 12-18 months)*

- Undertake a proposed translocation bilby to Perup, Spring 2010.

- Continue with translocation of boodies to Lorna Glen.
- Undertake a proposed translocation of mala to Lorna Glen, Spring 2010.

---

### **Implementation of the recovery plan for the chuditch (*Dasyurus geoffroi*)**

SPP# 1993-053

#### *Team members*

K Morris (0.20), B Johnson (0.40).

#### *Context*

The chuditch is currently listed as a threatened species under both the Wildlife Conservation Act 1950, and the Commonwealth EPBC Act 1999 (Vulnerable). A recovery plan was prepared for the species in 1994 and many of the recovery actions have been completed. Translocations have been undertaken to five sites and monitoring of chuditch at other sites has been undertaken as part of the Western Shield fauna recovery program. Translocations are considered to have been successful at three of the five sites, and chuditch abundance appears to have increased at 76% of the Western Shield monitoring sites. Anecdotal sightings also suggest that this species may now no longer meet the IUCN criteria for Vulnerable, and should be downlisted. However, a more detailed analysis of the distribution, abundance and population trend is required before this assessment is made.

#### *Aims*

- Ensure that chuditch persist within its present range at existing or increased population densities.
- Increase population numbers through the establishment of at least one population outside the present distribution.
- Review the conservation status of the chuditch using IUCN criteria, and revise the recovery plan if necessary.

#### *Summary of progress (2009/2010) and main findings*

- Ongoing monitoring at key recovery/translocation sites of Lake Magenta, Julimar and Kalbarri.
- Six chuditch removed from an area to be cleared east of Collie for a coal mine, and used to supplement the population at Kalbarri.
- Recovery plan revision forwarded to DEC's Species and Communities Branch.
- Several range expansion records received e.g. Swan Coastal Plan, Geraldton.

#### *Management implications*

Review of conservation status recommended that the chuditch remain listed as Vulnerable, and the recovery plan was revised.

#### *Future directions (next 12-18 months)*

- Continue monitoring at key sites – Kalbarri, Julimar, Lake Magenta and jarrah forest sites.
- Obtain State and Commonwealth approvals for recovery plan.

---

### **Factors affecting fauna recovery in the Wheatbelt - Lake Magenta and Dunn Rock Nature Reserves**

SPP# 2006-009

#### *Team Members*

K Morris 0.40, B Johnson 0.60, B Muir 0.25. (External - Prof A Thompson and volunteers).

#### *Context*

This project is a component of the investigation into introduced predator control and sustained fauna recovery in WA. It comprises part of DEC's contribution to the Invasive Animals CRC mesopredator release study and commenced in January 2006.

The project is part of a larger program examining introduced predator control and sustained fauna recovery in the rangelands and south-west of WA. In particular, this project will be examining whether there has been a mesopredator release effect after several years of fox control i.e. have other introduced/native predators increased in abundance and become a threatening process for fauna survival.

#### *Aims*

- Determine the causal factors responsible for the medium-sized mammal declines at Lake Magenta Nature Reserve.
- Identify the management required to ameliorate these declines.
- Develop adequate introduced and native mammal monitoring protocols that will enable future changes in population abundances to be quantified and explained.

#### *Summary of progress (2009/2010) and main findings*

- Last field work was undertaken in November 2009.
- The modified simultaneous ground and aerial baiting continued to reduce fox activity at Lake Magenta by 50%.
- Ongoing estimates of fox and feral cat activity were derived from sand pads at Lake Magenta and Dunn Rock Nature Reserves. Relationship between fox activity and fox numbers was established. Cat activity remains higher at Lake Magenta.
- 'Sticky wicket' hair traps were deployed at Lake Magenta and Dunn Rock and foxes were successfully identified and genotyped.
- Quenda were reintroduced to Lake Magenta in October 2009 and have successfully established.
- *LANDSCOPE* article prepared.
- Final milestone reports were submitted to the Invasive Animals CRC.

#### *Management implications*

This project has now been completed. It has demonstrated that a simultaneous ground and aerial baiting regime is more effective at controlling foxes than one where ground and aerial baits are laid at different times. It has also demonstrated the value of sand plots as an operational tool to assess fox and cat activity and relative abundance. It was intended to be able to deploy a cat bait at Lake Magenta to further improve fauna conservation, however non-target uptake issues have not been resolved and an operational cat bait is not yet available for use in the south-west of WA. It would be extremely desirable for the district to continue monitoring the native fauna, and fox and cat activity at Lake Magenta, at least annually.

#### *Future directions*

- Publish results and prepare final report for the Director General, DEC.
- Facilitate the annual monitoring of Lake Magenta by the District.
- Operationalise the simultaneous ground and aerial fox baiting at Lake Magenta.

---

### **Rangelands Restoration – reintroduction of native mammals to Lorna Glen (Matuwa)**

SPP# to be allocated

#### *Team members*

K Morris (0.35), J Dunlop (1.00), E Miller (1.00), A Smith (0.30). Kalgoorlie Regional staff.

#### *Context*

Operation Rangelands Restoration commenced in 2000 with the acquisition of Lorna Glen and Earahedy pastoral leases by the Western Australian Government. This 600 000ha area lying across the Gascoyne and Murchison IBRA regions is now the site for an ecologically integrated project to restore rangeland natural ecosystem function and biodiversity. An important component of this is the reintroduction of 11 arid zone mammal species following the successful control of feral cats and foxes.

The area now comprising Lorna Glen once supported a diverse mammal fauna that was representative of the rangelands and deserts to the north and east. These areas have suffered the greatest in terms of mammal declines in Western Australia. The original vision for the Western Shield fauna recovery program was to expand introduced predator control and translocations beyond the south-west once an operational feral cat control program had been developed, and this was also recommended by the independent review of Western Shield in 2003.

Potentially Lorna Glen could support one of the most diverse mammal assemblages in arid Australia, and contribute significantly to the long-term conservation of several threatened species. Mammal reconstruction in this area will also contribute significantly to the restoration of rangeland ecosystems through activities such as digging the soil and grazing/browsing vegetation, and assist in the return of fire regimes that are more beneficial to the maintenance of biodiversity in the arid zone.

The first of the mammal reintroductions commenced in August 2007 with the release of bilby (*Macrotis lagotis*) and wayurta (*Trichosurus vulpecula*). Another nine species of mammal are proposed for reintroduction over the next ten years.

#### *Aims*

- Reintroduce 11 native mammal species to Lorna Glen over the next 11 years.
- Re-establish ecosystem processes and improve the condition of a rangeland property.
- Improve the conservation status of some threatened species.
- Develop and refine protocols for fauna translocation and monitoring.

#### *Summary of progress (2009/2010) and main findings*

- An 1100ha acclimatisation pen has been constructed as part of the strategy to improve survivorship of translocation fauna.
- 65 boodies from Barrow Island and 20 from RTD, plus 135 golden bandicoots from Barrow Island were released into the pen in February/ March 2010 as part of the Gorgon funded fauna translocation offset program. These are being monitored every six weeks.
- Trapping in the acclimatisation pen has also revealed the presence of the mulgara and brushtail possums.
- Monitoring of bilbies released 2007-2009 was undertaken and PVA models were used to assist in predicting the fate of the translocated bilbies. This work has indicated that a large initial founder size (>100) has a better chance of long term persistence compared with regular translocations of smaller numbers of founders (e.g. 20 founders/year for five years).
- A 2009/2010 progress report has been prepared.

#### *Management implications*

- Arid zone rangelands fauna reconstruction and conservation techniques developed by this project will have broad state and national application.
- The outcomes of the project will contribute to the management of DEC's rangeland properties and provide guidance for future fauna reconstruction, e.g. Dirk Hartog Island. It will also demonstrate effective partnership models with traditional owners.

#### *Future directions (next 12-18 months)*

- Ongoing monitoring of bilbies and possums outside the enclosure, bandicoots and boodies inside the enclosure.
- Additional boodies from RTD to be released into the pen, mala from RTD to be released into the pen.
- Continued monitoring inside and outside the enclosure for breaches/presence of feral cats, foxes and



dogs.

- Develop a strategy for releases of boodies and bandicoots outside the enclosure, using the progeny of the founders.

---

## **Barrow Island fauna translocations**

SPP# to be allocated

*Team members*

K Morris (0.35), B Johnson (0.20), B Muir (0.20), K Rusten (1.00), J Dunlop, E Miller, A Smith (0.70), N Thomas (0.10), N Hamilton (0.10), A Burbidge (0.10), W Caton (0.10). Exmouth, Karratha and Kalgoorlie staff.

*Context*

Following WA Government approval for the Gorgon gas plant to be developed on Barrow Island in 2003, a series of Ministerial environmental conditions were imposed on the operator Chevron to ensure the unique conservation values of Barrow Island were maintained. These conditions included a 'Threatened and priority species translocation and reintroduction program' which was aimed at establishing populations of selected Barrow Island fauna on other island and mainland sites, to improve the security of these species.

*Aims*

- Successfully translocate selected mammal and bird species from Barrow Island to other island and mainland sites.
- Contribute to improving the conservation status of some of these species.
- Ensure ongoing appropriate management at the translocation sites.
- Develop and refine protocols for fauna translocation and monitoring.

*Summary of progress (2009/2010) and main findings*

- A mammal trapping program in the proposed gas plant site on Barrow Island was commenced in late January 2010, and ran for six weeks.
- Re-introductions were undertaken for 65 boodies and 135 golden bandicoots to Lorna Glen, 104 spectacled hare-wallabies and 130 golden bandicoots to Hermite Island, and 111 brushtail possums to Cape Range National Park.
- In May 2010, 38 white-winged fairy-wrens and 31 spinifexbirds were reintroduced from Barrow Island to Hermite Island.
- Twenty seven of the 111 possums translocated from Barrow Island to Cape Range National Park were radio-collared. Nineteen of the 27 have died, with seven of that 19 having fox DNA on them, indicating they could have been killed by foxes. The cause of death of the remainder is unknown, but potentially could be through raptor predation or natural causes.
- A small number of mortalities of both mammals and birds has been recorded since these fauna were translocated from Barrow Island. The vast majority of these occurred very soon after translocation.
- Monitoring of translocated mammal populations indicates that all recaptured animals are in good to excellent physical condition, many females are pregnant and animals are actively exploring and moving away from the translocation sites.
- Regular updates on progress have been provided to the Minister via Contentious Items Briefing Notes.

*Management implications*

Arid zone rangelands fauna reconstruction and conservation techniques developed by this project will have broad state and national application. The outcomes of the project will contribute to the management of DEC's rangeland properties and provide guidance for future fauna reconstruction, e.g. Dirk Hartog Island.

*Future directions (next 12-18 months)*

- Ongoing monitoring of the translocated mammals and birds at all the release sites.
- Planning underway for 2010/2011 translocations, workshop in Karratha in July 2010.
- Annual Report to be prepared as part of agreed governance arrangements

---

**Ecology and conservation of threatened pythons in WA**

SPP# 1993-159

*Team member*

D Pearson (0.1)

*Context*

Four of WA's 11 taxa of pythons are listed as threatened or in need of special protection. This project has undertaken ecological studies of three species thus far (south-west carpet python, Pilbara olive python and woma python) to provide basic information on their habitat requirements, diet, reproduction, distribution and conservation status. The fieldwork component of studies on the Pilbara olive and woma pythons are now complete and data are being prepared for publication. A long term mark-recapture study of carpet pythons is continuing on Garden Island.

*Aims*

- Document the ecology, distribution and conservation status of threatened and listed pythons in WA.
- Identify conservation threats to pythons and make recommendations on the management of populations.
- Collect material for future genetic work to aid wildlife forensics.
- Publish and disseminate research data to aid python conservation.

*Summary of progress (2009/2010) and main findings*

- Woma and Pilbara olive python radio-telemetry data has been collated, entered on databases and checked in readiness for analysis.
- Road-kills collected over the study have had necropsies performed for dietary and reproductive data and specimens prepared for lodging at the WA Museum.
- The mark-recapture study of carpet pythons on Garden Island has continued at a reduced rate of visitation. Around 40 pythons were captured over the year, providing further data on growth rates and survivorship of individuals.

*Management implications*

- Information on the basic biology and conservation status has been obtained for three threatened species. This will guide any future considerations of their status, the possible impacts of developments or other factors and efforts to mitigate these impacts.
- The ongoing mark-recapture study on Garden Island provides a baseline for comparison with other snake populations both in Australia and worldwide.

*Future directions (next 12-18 months)*

- Write up telemetry studies of woma and Pilbara olive pythons and conservation status of carpet pythons.
- Continue a long-term mark recapture study on carpet pythons on Garden Island.

---

**Implementation of the Lancelin Island Skink Recovery Plan**

SPP# 1999-011

*Team member*

D Pearson (0.1).

#### *Context*

The only wild population of the Lancelin Island skink is found on Lancelin Island. A translocated population was established on Favorite Island in Jurien Bay in 2002. This project continues the actions identified in the *Lancelin Island skink Recovery Plan* to improve the conservation status of the species.

#### *Aims*

- Implement the *Lancelin Island skink Recovery Plan*, especially the establishment of a translocated population on Favorite Island.
- Revise the recovery plan in conjunction with the Lancelin Island skink recovery team to reflect research work over the last five years and plan future actions.

#### *Summary of progress (2009/2010) and main findings*

- Monitoring of the translocated population on Favorite Island was undertaken in March 2010. Traps were removed from Favorite Island.
- Continuing capture of adult skinks in breeding condition indicates that breeding is occurring.

#### *Management implications*

- Monitoring has shown that the translocation of Lancelin Island skinks to Favorite Island has been successful. This action in the recovery plan has reduced its vulnerability to a natural or anthropogenic disturbance that might threaten the Lancelin Island population.
- The project has identified how the skinks can be bred and translocated if this action is required in the future.

#### *Future directions (next 12-18 months)*

- Write up of captive breeding data for Lancelin Island skinks.
- Production of a paper on the successful translocation to Favorite Island.
- Assist regional staff as required to conduct periodic monitoring of the Lancelin and Favorite Island populations.

---

### **Improving rock-wallaby conservation and management**

SPP# 2006-003

*Team member*

D Pearson (0.1).

#### *Context*

Five species of rock-wallabies occur in Western Australia. There are also a number of distinct subspecies and chromosomal races. Many taxa are threatened, primarily by feral animal predation, but inappropriate fire and introduced grazers also impact upon populations. This project seeks to improve management and monitoring of rock-wallaby populations.

#### *Aims*

- Prepare a recovery plan for the five species of rock-wallabies that occur in WA.
- Survey and monitor black-footed rock-wallaby populations.

#### *Summary of progress (2009/2010) and main findings*

- A draft recovery plan has been prepared and was circulated for comment within DEC but also amongst state conservation agencies in the NT, SA and Federal national parks such as Uluru and Kakadu.
- Support provided for surveys conducted in Cape Range National Park and neighbouring Ningaloo Station by the Cape Conservation Group.
- Assistance was provided for goat control operations in Kalbarri National Park, and the monitoring of goat exclosure plots to assess their impact on rock-wallaby populations and guide future translocation efforts.

#### *Management implications*

The recovery plan will allow the prioritisation of actions to improve the conservation status of rock-wallabies in WA and adjoining regions. It will also assist Aboriginal ranger and IPA groups to manage their wildlife and to seek funds to undertake conservation work. Surveys provide information on the current distribution and conservation status of the various taxa.

#### *Future directions (next 12-18 months)*

- Complete recovery plan incorporating comments received to date and those from the rock-wallaby symposium in July in Canberra.
- Write-up of paper on the distribution and conservation status of the West Kimberley race of *Petrogale lateralis*.

---

### **Impact of cane toads on biodiversity in the Kimberley**

SPP# 2006-004

#### *Team members*

D Pearson (0.7) and B Stewart (0.6 casual).

#### *Context*

Cane toads arrived in Western Australia during the 2009 wet season and have penetrated to Kununurra. An ARC-linkage project with the University of Sydney has identified taxa most at risk from the toad invasion. Monitoring of species at risk is continuing. Research is now focussing on potential techniques to reduce the impact of cane toads on predatory native species in the Kimberley.

#### *Aims*

- Field-test the results of lab trials looking at the susceptibility of species to cane toad toxins.
- Monitor the impact of invading cane toads on populations of frogs, snakes and goannas in the field in the East Kimberley.
- Test conditioned taste aversion (CTA) therapy as a means to prevent the loss of native predators.
- Make recommendations for management actions to reduce the impact of cane toads on biodiversity.

#### *Summary of progress (2009/2010) and main findings*

- Laboratory trials examining the responses of a range of snakes, goannas, lizards and small mammal species to cane toads were completed in March 2010. This has led to further surprising results with a range of observed responses from rapid learning to avoid toads, flipping toads and eating the less toxic underbelly, while in some goannas and snakes a high proportion of individuals die.
- Frog survey sites radiating along sealed roads from Kununurra were sampled regularly during the wet season to record presence/ absence based on calling males. A good baseline dataset will allow assessment of the response of native frogs to the invasion of toads.
- Ongoing benchmark monitoring of vertebrate communities in a number of conservation reserves in the Kununurra area.
- Publication of a paper in Wildlife Research on the impact of cane toads on threatened species of

Camaenid snails based on laboratory trials and field observations.

#### *Management implications*

The project has identified several species at significant risk from cane toads, and others that are not at risk based on their ability to learn or for other behavioural reasons. Continuing field-monitoring of susceptible species will occur. The information derived from this first part of the project will now be used in lab and field trials to see if CTA therapy can be used to preserve populations of susceptible predators (goannas, large snakes and blue tongue lizards) across the Kimberley landscape.

#### *Future directions (next 12-18 months)*

- Development and testing of a bait to teach naïve Kimberley predators to avoid toads. Potentially, this could be deployed in advance of the arrival of toads and so reduce the impact on predator populations.
- Resampling of frog survey sites at regular intervals during the 2010-11 wet season to document the impact of toads which are beginning to invade these sites.
- Undertake pre- and post-cane toad vertebrate and land snail surveys in reserves and other land tenures in the East Kimberley with DEC regional staff.
- Implantation of transmitters in some species of snakes and goannas to determine how these predators cope with the arrival of toads.

---

### **Identifying the cause(s) of the recent declines of woylies in south-west Western Australia**

SPP# 2007-002

#### *Team Members*

A Wayne (0.6), C Ward (0.6), C Vellios (0.6), M Maxwell (0.6).

#### *Context*

The woylie (*Bettongia penicillata*) has declined by about 80% since 2001. The declines by affected populations in Western Australia and South Australia have been rapid (<95% per annum), substantial (>90% lost) and apparently biased toward the largest and most important populations. The declines are continuing in some areas and as yet there have been no clear signs of a sustained post decline recovery. Most of the remaining unaffected populations are small (<300 individuals), isolated and inherently vulnerable. The woylie has been relisted as Endangered at the State and Federal level (Wildlife Conservation Act 1950 and EPBC Act 1999 respectively). The cause(s) for these declines remains unknown.

#### *Aims*

- Determine the causal factor(s) responsible for the recent woylie declines in the Upper Warren region of south-western Australia.
- Identify the management required to ameliorate these declines.
- Develop adequate mammal monitoring protocols that will enable future changes in population abundances to be quantified and explained.

#### *Summary of progress (2009/2010) and main findings*

- Ongoing Upper Warren monitoring indicates continued overall decline in woylies throughout the region (92% - 97% by the end of 2009 from 2002 peak). Keninup and Warrup were the largest remaining wild woylie populations in WA and have been foci for research within the Upper Warren. Declines in Keninup continued (>80% decline from March 2007 to April 2010). Previously stable since 2005, Warrup (southern Kingston) has begun declining again (a 61% decline in the last 12 months to March 2010).
- Monitoring of predator activity within the Upper Warren was limited to one survey at six sites in March

2010. Predator activity remains variable (spatially and temporally) throughout the region, however, at a regional level results continue to indicate an increasing trend in fox activity over time, particularly in northern Perup, and relatively stable cat activity. Fox-bait uptake trials indicate that <2% baits were confirmed taken by foxes and >37% of baits were partially consumed. Trials to improve the effectiveness of cat trapping in forest areas were conducted in Keninup.

- Evidence indicates that the woylie declines have been mortality driven, principally due to the predation (particularly by cats) of individuals thought to have become increasingly vulnerable due to disease.
- Collaborative disease investigations continue particularly into the key associations with the declines including *Toxoplasma*, *Typanosoma penicillata*, and poor skin and fur conditions and leads arising from recent pathology cases.
- 11 papers in peer-reviewed scientific journals and three articles in *LANDSCOPE* are amongst the publications produced from the research so far.

#### *Management Implications*

- Information from this work is reported directly to the woylie recovery team, which is currently drafting an interim recovery plan.
- The risk of local extinction of some indigenous and important populations remains high including Batalling, Tutanning and Perup.
- Effective predator control for feral cats and foxes is critical for sustaining important woylie populations.
- Wildlife diseases and the associated monitoring, risk assessment, management and hygiene protocols are important for conservation of this species and other wildlife.
- The outcomes of this work are directly relevant to determining the causes of declines in other species that may be more difficult to study directly (e.g. ngwayir, wambenger, quokka, numbat, etc).

#### *Future directions*

- Continued publication of results to date.
- Determine the success of the insurance populations through ongoing monitoring and continue the identification of causes of the declines/limitations to recovery.

---

### **Conservation of Western Australian butterflies**

SPP# 1993-022

#### *Team members*

M Williams (0.05), A Williams (0.05), T Gamblin (0.25).

#### *Context*

Invertebrates constitute a major part of the State's biodiversity. This project focuses on a high-profile group of terrestrial invertebrates (butterflies and day-flying moths) that are not sampled using traditional biological survey techniques. By involving community organisations, it extends co-operative partnerships with the community.

#### *Aims*

- Undertake research to enhance our ecological knowledge of threatened butterfly and day-flying moth taxa, and identify management strategies to enable effective conservation.
- Develop survey techniques to accurately assess butterfly biodiversity and use these to assess the abundance and species richness of butterflies in remnant bushland areas.
- Determine what factors may be causing loss of butterfly diversity.
- Review the taxonomic status of those taxa where systematics is uncertain, using genetic methods to better delimit those taxa.

#### *Summary of progress (2009/2010) and main findings*

- Scientific paper submitted – Habitat resources determine distribution patterns and abundance of butterflies and day-flying moths in a fragmented urban landscape, south-west Western Australia.
- Bush Book completed – *Rare and Endangered Butterflies of the south-West*.
- Further surveys of endangered arid bronze azure completed.
- Paper drafted on ecology of the arid bronze azure

#### *Management implications*

- Knowledge of butterfly populations is required for the assessment of impacts of proposed developments on conservation values of listed endangered invertebrates of the Wheatbelt and Swan Regions.
- More than ten butterfly species are now locally extinct in the highly disturbed bushland remnants on the Swan Coastal Plain (SCP), and therefore some reserves are likely to be of critical importance in maintaining landscape biodiversity.
- It is becoming apparent that a translocation approach, currently used successfully for threatened vertebrates, will be necessary to maintain butterfly biodiversity of the SCP.

#### *Future directions (next 12-18 months)*

- Undertake ecological studies of arid bronze azure to provide basic information on its habitat requirements, distribution and conservation.
- Undertake further searches in the Northern Wheatbelt for extant arid bronze azure populations using community groups and local media outlets.

---

### **Conservation of the graceful sun-moth**

SPP# 2010-006

#### *Team members*

C Bishop (0.80), A Williams (0.75), T Gamblin (0.50), J Fissioli (0.15), M Williams (0.15).

#### *Context*

This project focuses on a high-profile threatened invertebrate that is listed as an endangered species under the Commonwealth EPBC Act, and as declared rare fauna under the WA Wildlife Conservation Act. The graceful sun-moth (*Synemon gratiosa*) is a day-flying moth restricted to the Swan Coastal Plain that is threatened by urban and other development. This project will obtain information to resolve potential conflicts between conservation of the species and the impacts of land clearing. By involving community organisations and environmental consultants, it extends co-operative partnerships with the community.

#### *Aims*

- Undertake research to determine the distribution and habitat requirements of the graceful sun-moth.
- Develop survey techniques to accurately determine the presence of the species, and to assess its abundance in bushland areas.
- Determine what factors determine the realised niche of the species using habitat suitability modelling.
- Review the conservation and taxonomic status of the graceful sun-moth using molecular genetic methods.
- Identify management strategies to enable effective conservation.

#### *Summary of progress (2009/2010) and main findings*

- 70 sites surveyed using walk transects.

- Interim report prepared on the distribution and patterns of abundance of the graceful sun-moth in south-west Western Australia.
- Ongoing advice provided to managers and regional staff, DEC's Species and Communities Branch and DEC's Environmental Management Branch on impacts of proposed developments.

#### *Management implications*

Information on the distribution, abundance and habitat requirements of the graceful sun-moth are required to assess conservation status and develop management strategies.

#### *Future directions (next 12-18 months)*

- Continue surveys and ecological studies of the graceful sun-moth to enhance information on habitat requirements, distribution and conservation status.
  - Undertake further searches in the northern extent of the range, north of Jurien Bay.
  - Undertake a molecular genetic study of specimens vouchered in March 2010.
-



# FLORA CONSERVATION AND HERBARIUM

## Program Leader: Dr David Coates

Applied flora conservation research seeks to understand the factors and processes that are critical for the conservation of Western Australia's native plant diversity. Major objectives include ensuring the persistence of rare and threatened species, ameliorating key threats such as *Phytophthora* dieback and weeds, and improving understanding of genetic and ecological factors that are vital for the long-term viability of plant species. This research is aligned to the information needs of the Department of Environment and Conservation (DEC). Strong collaborative linkages exist with universities, cooperative research centres, CSIRO and other research institutions and the corporate sector.

The program also includes the WA Herbarium which houses the State collection of scientific specimens of plants, algae and fungi, which underpins their conservation. The herbarium is responsible for:

- documenting and understanding the diversity of Western Australia's plants, algae and fungi
- maintaining a research and archive collection of specimens of all species in these groups from throughout their range in Western Australia
- helping the community, industry and researchers understand and identify plants, algae and fungi
- contributing to, supporting and servicing the research, conservation and decision-making activities of the government
- contributing to taxonomic research by Australia's and the world's scientific community.

---

## Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora

SPP# 1998-003

### Team members

M Byrne (0.3), D Coates (0.15), N Gibson (0.05), B Macdonald (0.5), M Hankinson (0.1), S McArthur (0.1), A Perkins (0.075), K Shepherd (0.1), R Butcher (0.1), J Wege (0.1), K Thiele (0.1), H Nistelberger (0.75).

### Context

The flora of Western Australia is complex due to the antiquity of the landscape and this can lead to obscurity in taxonomic identity, which impacts on conservation status of rare and threatened taxa. Genetic analysis can inform the conservation and biosystematics of these taxa.

### Aims

- Provide genetic information for the conservation and management of Western Australian flora, especially rare flora.
- Determine taxonomic identity of populations in the *Synaphea stenoloba* complex.
- Determine level of differentiation between populations of *Eremophila microtheca* and *E. rostrata* to inform taxonomic status.
- Determine the level of differentiation in *Calothamnus quadrifidus* to assist in the taxonomic revision of the group.
- Determine the level of differentiation in *Banksia mimica* and *Pultenaea pauciflora* to assist in the taxonomic revision of the groups.
- Determine the hybrid status of *Eucalyptus stoataptera*.
- Determine the mating system in populations of *Grevillea curviloba*.
- Clarify the taxonomic status of *Platytheca* sp. *Sabina*, *Hakea* aff. *prostrata*, *Pityrodia* sp. Yilgarn, and

## *Hydrocotyle scutellifera* and associated taxa.

### Summary of progress (2009/2010) and main findings

- Analysis of *E. stoataptera* and its putative parents *E. stoatei* and *E. teptaptera* have confirmed the hybrid status of this species. Analysis also indicates *E. erythrandra* is a hybrid between *E. angulosa* and *E. teptaptera*.
- Sequencing of ten chloroplast and rDNA gene regions has been undertaken for 64 samples of *Platytheca* sp. *Sabina*, *Hakea* aff. *prostrata*, *Pityrodia* sp. *Yilgarn*, and *Hydrocotyle scutellifera* and associated taxa. Journal papers detailing taxonomic relationships among the species have been drafted for *Platytheca*, *Hakea* and *Pityrodia*. A journal paper detailing the use of the tested gene regions in molecular taxonomy has been submitted to Molecular Ecology Resources.
- Utility of ten gene regions for phylogeography has been tested in six species with known phylogeographic structure. A draft paper detailing the most variable genes has been written.
- Sequencing of three chloroplast genes on samples from 40 populations of *C. quadrifidus* showed phylogeographic structure with lineages in the north, central and southern areas of the south-west of WA. Some evidence of expansion of lineages from coastal populations was evident.
- Analysis of genetic structure in *C. quadrifidus* using AFLP markers has commenced.

### Management implications

- Assessment of the genetic structure within collections of *Synaphea* from the Pinjarra Plains will inform taxonomic revision and determine identity of questionable populations of the DRF taxa.
- Assessment of genetic differentiation in *E. microtheca* and *E. rostrata* will assist in determination of sub-specific taxa, and clarification of DRF status.
- Assessment of genetic differentiation in *C. quadrifidus* will enable taxonomic revision of the group and identification of rare taxa.
- Possible taxonomic revision is required for *P. pauciflora* and revised assessment of conservation status.
- Taxonomic revision and revised assessment of conservation status of *B. mimica* taxa is required.
- Clarification of the genetic relationships among populations of *P. pauciflora* has revealed the need for a morphological assessment and taxonomic reassessment of the species.
- Clarification of taxonomic status of *Platytheca* sp. *Sabina*, *Hakea* aff. *prostrata*, *Pityrodia* sp. *Yilgarn*, and *Hydrocotyle scutellifera* and associated taxa will enable evaluation of conservation status and implementation of conservation actions if required.

### Future directions (next 12-18 months)

- Analysis of *E. microtheca* and *E. rostrata* will be completed to determine possible subspecies status within each species.
- Assessment of genetic structure within *C. quadrifidus* and allied taxa will be undertaken to inform taxonomic revision of the group. Phylogeographic structure in the complex will be published.
- Hybrid status of *E. stoataptera* will be published.
- Taxonomic revisions of *Platytheca* sp. *Sabina*, *Hakea* aff. *prostrata*, *Pityrodia* sp. *Yilgarn*, *Hydrocotyle scutellifera* and associated taxa will be published.

---

## Genetic and ecological viability of plant populations in remnant vegetation

SPP# 2002-001

### Team members

D Coates (0.2), M Byrne (0.1), C Yates (0.2), T Llorens (0.6), S McArthur (0.3), N Gibson (0.05).

### Context

A priority for long-term conservation of remnant vegetation is the maintenance of viable plant populations. However, little is currently known about what biological factors actually affect population persistence. This project quantifies genetic and ecological factors that influence the viability of plant

populations in fragmented WA agricultural landscapes and explores how these are affected by remnant vegetation characteristics such as size, isolation, disturbance and landscape position.

#### Aims

- Identify and quantify the genetic and demographic factors that affect the viability of plant populations in vegetation remnants. The focus will be on the effects of genetic erosion, inbreeding and pollinator limitation on seed production and seedling fitness.
- Examine and model the relationships between key genetic and demographic factors affecting viability and remnant vegetation characteristics such as size, disturbance and landscape position.
- Compare results among three target taxa, *Calothamnus quadrifidus*, *Eremea pauciflora* and *Eucalyptus wandoo*, in the Dongolocking area of the wheatbelt, with varied ecologies to assess how life history affects the impact of remnant characteristics on population viability.
- Directly quantify patterns of pollen movement and seed dispersal for *Banksia sphaerocarpa* in a highly fragmented 10 x 20km area south of Harrismith in the south western Wheatbelt
- Assess the importance of gene flow to the reproductive output and population dynamics of patch populations of *Banksia sphaerocarpa* by quantifying the relative frequency of local versus immigrant mating events, and then comparing the fitness of resulting seedlings in growth trials as well as contrasting the overall demographic performance of high and low gene flow sites.
- Develop specific genetic and demographic guidelines for management of remnant populations of the target taxa and general landscape design principles for major plant life history types that will maximise the probability of population persistence.
- Develop an understanding of the population biology, mating systems and gene flow of flora with distributions centred on the seasonally wet Busselton ironstone communities to inform management for long term conservation in relation to population viability (population size and degree of connection) and appropriate fire frequency.

#### Summary of progress (2009/10) and main findings

- A draft journal paper detailing the genetic structure in the *B. sphaerocarpa* study area has been written.
- In *C. sp. Whicher* seed set and germination showed no relationship with population size. Levels of inbreeding were unusually high for a bird-pollinated shrub and are most likely consequence of self-pollination. Seed production in *C. sp. Whicher* is apparently robust to the effects of population fragmentation. Plants in small populations produce substantial numbers of viable seeds despite the decline in the availability of mates.
- Although levels of seed production were similar in *C. sp. Whicher* populations, seedlings and juveniles were only observed in the medium- and large-sized populations, indicating that these populations are currently stable or increasing in size, but small populations, because of a lack of recruitment, will decline and eventually be lost from the landscape.
- Genetic diversity in medium and large populations of *C. sp. Whicher* was higher than in small populations and genetic distances among populations were very high. This indicates that all population fragments of *C. sp. Whicher* contain irreplaceable genetic diversity, and the loss of small populations will result in the significant loss of genetic diversity
- Flowering, fruit and seed production in *H. oldfieldii* showed no relationship with population size, with the exception of the smallest population which produced significantly fewer seeds than other populations. Seasonal variation in seed production may make populations susceptible to local extinction following fire. Investigations of the mating system of *H. oldfieldii* showed that seeds arise predominantly from outbreeding due to a self-incompatibility system preventing effective self-pollination. As a consequence small populations of *H. oldfieldii* will be susceptible to mate limitation and subsequent reductions in seed production.
- The low rates of seedling emergence and predominance of *H. oldfieldii* plants in adult size classes indicate recruitment may be intermittent in this species. Medium and large-sized populations may be relatively stable in the short term but patterns of recruitment suggest that populations will decline in the longer term
- Genetic diversity in *H. oldfieldii* was moderate and similar among populations. Genetic differentiation among populations of *H. oldfieldii* was high. All population fragments contain irreplaceable genetic

diversity and the loss of populations will result in the significant loss of genetic diversity.

- Analysis of genetic diversity in populations of *B. nivea* showed genetic differentiation among the subspecies. Genetic diversity within populations of the rare subsp. *uliginosa* was similar to that in the common subsp. *nivea*. Pollen dispersal in two populations of ssp. *uliginosa* showed high levels of outcrossing. Pollen dispersal distance was greater in a larger nature reserve population than in a smaller road verge population.

#### *Management implications*

- Ability to rapidly and accurately assess the conservation value of a vegetation remnant is a critical step in landscape management aimed at integrating the goals of conservation and agricultural production. Currently much of this assessment is based on best guesses using anecdotal species-specific evidence, on the general principle that bigger is better (but at unknown cost in terms of one large site versus many small sites tradeoffs) and on simple presence and absence data that take little account of long-term remnant trajectories. The improved accuracy of assessment of long-term persistence of broad classes of plant species that this research provides will facilitate better prioritisation of remnants for conservation and therefore better allocation of limited management effort.
- Establishment of realistic empirically based goals for remnant size and landscape configuration that maximise regional persistence of plants species will allow more efficient conservation efforts at the landscape level by facilitating cost-benefit analyses for remnant management and restoration work. That is, it is very useful to know when thresholds for viability have been reached so that limited management and restoration efforts can be redeployed to other areas where gains can be maximised.
- Identification of knowledge gaps in our ability to assess population viability and remnant vegetation value is crucial to improving future remnant management through targeted research efforts.

#### *Future directions (next 12-18 months)*

- Prepare draft papers on seed set/reproductive output studies, genetic structure and gene flow in *B. sphaerocarpa*.
- Write papers on mating system variation and reproductive output in *Eremaea pauciflora*, genetic diversity in *E. wandoo* and genetic diversity in *C. quadrifidus*.
- Write papers on genetic diversity, pollen dispersal and mating systems in *C. sp. Whicher*, *H. oldfieldii* and *B. nivea* ssp. *uliginosa*.
- Write papers on reproductive biology and demography in *C. sp. Whicher*, *H. oldfieldii* and *B. nivea* ssp. *uliginosa*.

---

### **Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance**

SPP# 2001-001

#### *Team members*

D Coates (0.2), M Byrne (0.1), S McArthur (0.1), M. Millar (0.1).

#### *Context*

Understanding the interactions between mating systems, levels of inbreeding and patterns of genetic variation within populations of species is a key element in assessing the viability of plant populations, particularly rare and threatened taxa, and the development of management strategies that will reduce the likelihood of local extinction.

#### *Aims*

- Assess the relationship between effective population size and levels of genetic diversity, and the minimum effective population size for maintaining genetic diversity.
- Assess the effects of population size and habitat degradation on mating system parameters that indicates inbreeding or the potential for inbreeding.

- Assess whether reduction in population size, increased inbreeding and reduced genetic variation are associated with any reduction in fitness.
- Assess whether there are differences in the levels of genetic diversity and mating system between rare and common congeners, which provide a more general understanding of rarity in this flora and how it can be managed.

#### *Summary of progress (2009/2010) and main findings*

- Data analysis undertaken of microsatellite genotypes of 13 extant and five extinct populations of *Banksia brownii*.
- Paper on the disparate levels of clonality, genetic diversity and genetic differentiation subspecies of the *Banksia ionthocarpa* has been submitted for publication.

#### *Management implications*

- Assessment of genetic variation will inform prescriptions for the prevention of inbreeding and maintenance of genetic variation in small fragmented populations of rare and threatened plants and will facilitate strategies for managing inbreeding and loss of genetic diversity during translocation programs.
- Effective population sizes should be updated for *B. ionthocarpa* ssp. *chrysophoenix*. Recommendations for management include establishment of *ex situ* collections of the 16 ssp. *chrysophoenix* genotypes via vegetative propagation and implementation of translocation for ssp. *chrysophoenix* to establish all genets in two new populations in secure and threat free sites. The two monoclonal populations of ssp. *chrysophoenix* are threatened by weed invasion that should be controlled to maximise vegetative reproduction. A reintroduction - translocation program for ssp. *ionthocarpa* should be re-commenced utilising mixed seed material from both subpopulations to: significantly increase plant numbers in the translocation site on the Kalgan Plains Nature Reserve and augment plant numbers in the two populations.
- Translocation programs for *Banksia brownii* should continue to mix seed collections from within the three eco-geographic regions but translocations should not yet be established with seed mixes from different regions.

#### *Future directions (next 12-18 months)*

- Finalise paper on 'Population genetic structure and mating system variation in *Verticordia fimbriilepis* ssp. *fimbriilepis*'.
- Complete temporal mating system data analysis on *Banksia cuneata*.
- Submit for publication two papers on genetic structure and the impact of localised extinction on genetic diversity levels in *Banksia brownii*.

---

### **Assessment of genetic diversity, key population processes and evolutionary relationships in the banded ironstone formation endemic *Acacia woodmaniorum* and its close relatives**

SPP# to be allocated

*Team members*

D Coates (0.1) MA Millar (0.9).

#### *Context*

*Acacia woodmaniorum* is a recently described species endemic to the Blue Hills banded ironstone ranges of the Midwest region. Known from ~ 29 000 plants and restricted to an area of about 40km<sup>2</sup>, the species is gazetted as a Declared Rare Flora. The entire species distribution is currently covered by exploration mining leases hence potential impacts on population and species viability from proposed mining activities must be identified. This study investigates the detailed genetic structure within this species as a basis for estimating loss of genetic diversity due to potential impact from mining. Phylogenetic and phylogeographic relationships between this rare species and its more common close relatives will also be investigated to better understand its origins, whether rarity is associated with habitat specialisation or historical circumstances and the origins of the unique banded ironstone flora.

#### *Aims*

- Determine levels and partitioning of population genetic variation within *A. woodmaniorum*.
- Identify key population processes, such as mating and dispersal that influence future levels and patterns of genetic variation.
- Determine evolutionary relationships and distinctness of *A. woodmaniorum* and its closest relatives.

#### *Summary of progress (2009/2010) and main findings*

- A paper reporting the development and utility of 15 polymorphic microsatellite markers in *A. woodmaniorum* has been published.
- Overall species genetic diversity is high and comparable to widespread species. The majority of genetic variation is contained within populations and is concentrated in the main range across Mungada/Windaning ridge. Genetic differences among populations increase with geographic separation although genetic divergence between populations and regions is low and overall estimates of gene flow are high. Mating within populations appears to be random with little evidence of inbreeding. There is no genetic evidence of recent population bottlenecks suggesting habitat destruction, disturbance or anthropogenic fragmentation has not occurred.
- Initial assessment indicates that the removal of populations through mining activities at Terapod, Blue Hills and the most westerly populations across the main range of Mungada/Windaning ridge would result in a 13% drop in total species genetic diversity and a 45% drop in unique genetic variation that is of particular concern for the Blue Hills population. Because of their geographic position, these populations may play an important role in the maintenance of gene flow and genetic continuity among populations and regions.
- Progeny from the 2009 flowering season have been planted for paternity analysis studies.
- Twelve monthly and eighteen monthly reports have been provided to Gindalbie Metals Ltd.

#### *Management implications*

- Determination of genetic diversity will enable assessment of the impact of the loss of populations through different mining scenarios may have on levels of genetic diversity in the species.
- Populations likely to be impacted by mining operations contain a high degree of genetic diversity and private allele richness. Blue Hills contains a disproportionate level of private allele richness for its size that will require specific management such as targeted collections for rehabilitation activities.
- Structuring of genetic diversity within *A. woodmaniorum* reveals that the connectivity between regions and populations through pollen and seed dispersal is significant and populations likely to be impacted upon by mining activities may play an important role in this regard due to their geographic position near the centre of the species distribution.
- Specific rehabilitation in this area may be required to maintain connectivity among regions.

#### *Future directions (next 12-18 months)*

- Genotype ~800 *A. woodmaniorum* seedlings at six polymorphic microsatellite loci for gene flow estimates and analyse data.
- Identify DNA sequences of sufficient variation to provide phylogenetically informative data in *A. woodmaniorum*, *A. restiacea* and *A. cerastes*. Sequence populations of *A. woodmaniorum*, *A. restiacea* and *A. cerastes* and analyse data.
- Quantify pollinator visitation, pollination rates and seed production in all populations.
- Prepare paper on genetic diversity for publication.

---

### **Seed biology, seedbank dynamics and collection and storage of seed of rare and threatened Western Australian taxa**

SPP# 1999-010

#### *Team members*

A Cochrane (0.8), A Crawford (0.9), A Monaghan (0.5), S Dudley (0.3), L Barrett (0.1), S Schreck (0.1),

D Coates (0.05).

#### *Context*

Seed conservation is a specific and targeted action to conserve biodiversity and entails the banking of genetic material in the form of seed. Seed banking provides an important opportunity for assessing and utilising genetic material for *in situ* recovery actions, and seed research. Understanding the seed biology and ecology of plant species is important for the conservation and management of conservation-significant Western Australian taxa and for developing and implementing recovery plans for rare and threatened flora.

#### *Aims*

- Provide a cost effective and efficient interim solution to loss of plant genetic diversity by collecting and storing seed of rare and threatened Western Australian plant species and thereby provide a focus for flora recovery.
- Increase knowledge of seed biology, ecology and longevity.
- Incorporate all information into a corporate database (WASEED) and provide relevant information on seed availability, seed biology, storage requirements and viability of seed of rare and threatened taxa to assist the development of management prescriptions and preparation of interim recovery plans and translocation plans.

#### *Summary of progress (2009/2010) and main findings*

- Fieldwork undertaken to collect seed from 92 rare, threatened, poorly known and other taxa (133 accessions). All information is accessible in the seed database WASEED.
- Material of 261 collections duplicated for safekeeping with the Millennium Seed Bank Project in the UK to complete agreed project targets.
- Provision of final report to Millennium Seed Bank Project December 2009.
- Seed collections made of 20 Declared Rare Flora species.
- Seed collection and provision of germinated seeds for translocation of 15 critically endangered flora.
- Articles published in *Australasian Plant Conservation* and *Mountain Forum Bulletin*.
- Book chapter and paper in *Australian Journal of Botany* published.

#### *Management implications*

Provision of seed biology and ecology data will increase the success of recovery and improve conservation of threatened and endemic WA flora.

#### *Future directions (next 12-18 months)*

- Ongoing seed collection for conservation, including DRF and priority taxa, and common species associated with threatened ecological communities and biodiversity hotspots.
- Ongoing research into seed biology and seed storage behaviour of threatened plant taxa.
- Germination testing, storage and monitoring of existing collections.
- Commence new transition phase of international collaboration with Millennium Seed Bank (MSB) Project and provide final report to MSB.
- Complete State NRM funded Flora Recovery and Translocation projects (seed collection components) and report.
- Publication on seed longevity and seed germination thresholds in *Banksia*.

---

### **Translocation of Critically Endangered plants**

SPP# 2001-004

#### *Team members*

L Monks (0.55), R Dillon (0.9), D Coates (0.05).

### *Context*

In order for translocations of threatened flora to contribute to the successful recovery of species it is important that best practice techniques are developed and there is clear understanding of how to assess and predict success.

### *Aims*

- Develop appropriate translocation techniques for a range of Critically Endangered flora.
- Develop detailed protocols for assessing and predicting translocation success.
- Establish a translocation database for all threatened plant translocations in Western Australia.

### *Summary of progress (2009/2010) and main findings*

- Translocations of 15 Critically Endangered plants were completed. This involved the establishment of new populations for five new species and eight species that have been previously translocated. Enhancement plantings of two species were carried out at existing translocation sites.
- Three year research project commenced (in collaboration with UWA) on two translocated species investigating watering regimes, microhabitat selection and planting methods.
- Eleven translocations planted in previous years were monitored.
- Ongoing monitoring of translocations is providing information on the success of methodologies used and the probability of long-term success. Close collaboration with district and regional staff on this project then enables this information to be utilised immediately in other flora translocation projects.
- Ongoing development of flora translocation database continuing in collaboration with Species and Communities Branch.
- Drafted book chapter on translocation success of long lived plants.
- Completed draft paper of study on *Lambertia orbifolia* translocation success, commenced writing paper on *Acacia* translocation success.

### *Management implications*

- Translocations are an important management strategy for improving the conservation status of Critically Endangered plant taxa.
- Improved awareness of best practice translocation methodologies for DEC staff and community members undertaking such work will lead to greater translocation success.

### *Future directions (next 12-18 months)*

- Continue the planting of experimental translocations of 15 Critically Endangered plant species where further plantings are deemed necessary.
- Continued the monitoring of the 32 translocations and analyses of population biology data.
- Publish translocation methodology data, *Lambertia orbifolia* translocation data, *Acacia* translocation success study.
- Publish book chapter on translocation success.

---

## **Ecophysiology of rare flora restricted to shallow-soil communities**

SPP# to be allocated

Team member

P Poot (0.3).

### *Context*

The south-west Australian Floristic Region is recognised as one of only 34 global biodiversity hotspots; those regions on earth richest in endemic species under threat. Approximately 2 000 of a total of 8 000 plant species in south-west Australia occur on granite outcrops or other shallow-soil environments. Many of these species are shallow-soil endemics that have a highly scattered and often restricted distribution.



Also worldwide a large number of rare species occur in open, shallow, rocky and drought-prone environments. This suggests that shallow-soil endemics may have special adaptations to their own habitats that prevent them from establishing and being competitive in others.

#### *Aim*

To enhance our knowledge of the key adaptations of species endemic to shallow-soil habitats, and how these adaptations may restrict them in their distribution. This knowledge will help improve our ability to manage and restore shallow-soil ecosystems and the many rare species they contain.

#### *Summary of progress (2009/2010) and main findings*

- Preliminary results on 'granite outcrop/non-granite outcrop' congeneric species pairs showed similar shallow-soil specialisations as found earlier for the coastal plain ironstone endemics; species endemic to granite outcrops either invested more biomass in their roots or showed a faster lateral root spread than their non-granite outcrop congeners.
- An investigation into the plasticity of root allocation to high nutrient and moisture patches in rare ironstone *Hakea* species and their common congeners showed some clear differences amongst species but they were not related to the habitat the species originated from.

#### *Management implications*

- Revegetation/replanting of perennial vegetation in shallow-soil communities can only be expected to be successful when there are cracks 'available' to the plants' roots in the underlying rock. This may only be the case after fire or after the death of mature individuals. Also, relatively bare areas with low native vegetation cover are unlikely to be useful for revegetation purposes (i.e. they are bare for a reason - low water supply).
- Using glasshouse grown seedlings with relatively few and often stunted and air pruned roots may be especially problematic for revegetation purposes on shallow soils. A high investment in roots appears essential for first summer survival and glasshouse grown seedlings often have much higher shoot to root ratios.
- Watering over summer may greatly increase survival of transplanted shallow-soil endemics as individuals that did not reach cracks with sufficient water supply before summer get another chance. However, long term establishment will be dependent on obtaining a more permanent access to a water supply.

#### *Future directions (next 12-18 months)*

- Continue research on shallow-soil endemics.
- Write up and submit the ironstone species work on phenotypic plasticity, and the work on granite outcrop species.

---

### **Effects of pre-treatments, microhabitats and on-site management in the translocation success of threatened plant species: an ecophysiological approach**

SPP# to be allocated

#### *Team members*

P Poot (0.2), M Moody (0.05), R Dillon (0.1), L Monks (0.05), D Coates (0.05).

#### *Context*

In order for translocations of threatened flora to contribute to the successful recovery of species it is important to better understand the effects of pre-treatments, microhabitats and on-site management on the health, growth potential and ultimately survival of the transplants. In this project we will make use of ecophysiological techniques (e.g. infrared thermal imaging, chlorophyll fluorescence, gas exchange) and environmental monitoring (e.g. soil moisture, incident radiation, rainfall) to monitor how health and physiological activity of seedlings is associated with seasonal changes in environmental conditions. Translocations will be setup as scientific experiments with a range of experimental 'treatments' that will depend on the specific target species and their habitat.

#### *Aims*

- Develop a better understanding of the causes of failure and success in rare flora translocations by employing ecophysiological and environmental monitoring techniques to determine the effects of a range of experimental 'treatments'.
- Develop a more efficient rare flora translocation program firmly based on scientific findings.

#### *Summary of progress (2009/2010) and main findings*

Two experimental translocations of *Dryandra ionthocarpa* sp. *ionthocarpa* have been planted in the South Coast Region in Kamballup Nature Reserve near Mt Barker. This experiment involved different pre-treatments (seedlings grown on washed river sand and on standard Kings Park potting mix), different microhabitats (open areas, removed low open heath and removed tall closed heath), different planting times (early May versus early July), and different watering regimes (monthly hand watering over summer and frequent automatic watering).

#### *Management implications*

- Improved understanding of the factors that are most relevant to translocation success will lead to an improved conservation status for endangered plant taxa.
- Improved awareness of best practice translocation methodologies for DEC staff and communities members undertaking such work will lead to greater translocation success.

#### *Future directions (next 12-18 months)*

- Monitoring environmental conditions, health and physiological activity of the 1300+ seedlings of the two species that have been transferred so far, to determine the initial effects of seedling pretreatments, site microhabitat, watering treatment and planting time.
- Start necessary preparations to enable at least two new scientific translocations in 2011.

---

### **Integrated strategies for the control of *Phytophthora cinnamomi* using phosphite**

SPP# 1993-068

#### *Team members*

B Shearer (0.5), C Crane (0.5).

#### *Context*

Understanding long-term effects of control of *Phytophthora cinnamomi* by phosphite application is important for developing and implementing ecologically appropriate control options for the management of *P. cinnamomi*. This study, established in 1979, was designed as a series of long-term experiments.

#### *Aim*

To understand the effectiveness of phosphite against *P. cinnamomi* in native flora for long-term control of the pathogen.

#### *Summary of progress (2009/2010) and main findings*

Published two papers in *Biological Invasions and Australasian Plant Pathology*.

#### *Management implications*

Effective methods of *P. cinnamomi* control using phosphite will provide options for the management of dieback infections.

#### *Future directions (next 12-18 months)*

- Prepare results of injection and spray trials for publication.

- Submit paper on variation in phosphite efficacy between taxa.

---

### **Susceptibility of rare and endangered flora to *Phytophthora***

SPP# 1999-019

*Team members*

B Shearer (0.5), C Crane (0.5).

#### *Context*

Determination of the susceptibility of threatened flora to *Phytophthora cinnamomi* is important for prioritising flora at risk of infection and implementing ecologically appropriate control options for the management of *P. cinnamomi*. This study, established in 1996, was designed as a series of yearly testing of threatened flora as germinants become available from the Threatened Flora Seed Centre.

#### *Aims*

- Determine variation in susceptibility to *P. cinnamomi* between and within families.
- Identify within species variation in susceptibility.
- Rank taxa according to susceptibility to identify those at risk.

#### *Summary of progress (2009/2010) and main findings*

- Tested 100 taxa for susceptibility in 2009.
- Database of 200+ taxa updated.
- Provisional susceptibility list distributed within DEC.
- Prepared for publication paper on Variation in susceptibility to *Phytophthora cinnamomi* within the genus *Lambertia*.

#### *Management implications*

Identification of flora at risk of infection by *P. cinnamomi* will enable quantification of the threat of *P. cinnamomi* to flora conservation.

#### *Future directions (next 12-18 months)*

- Update database and analyse trends within database.
- Submit for publication a paper on Variation in susceptibility to *Phytophthora cinnamomi* within the genus *Lambertia*.
- Prepare poster for the 8<sup>th</sup> National Conference of the Australian Network for Plant Conservation

---

### **An investigation of the epidemiology and use of novel phosphite application techniques in *Phytophthora cinnamomi* infestations in the national parks of the south coast region of Western Australia**

SPP# 2009-007

*Team member*

C Dunne (0.45).

#### *Context*

Determination of the biology and epidemiology of *Phytophthora cinnamomi* in the South Coast Region is important for implementing appropriate management options for the control of *P. cinnamomi*. Further, understanding of the efficacy of high intensity phosphite for the control of *P. cinnamomi* would provide more options for the management of infested areas.

### Aims

- Advance our understanding of disease biology and epidemiology of *P. cinnamomi* in the native plant communities within the national parks of the South Coast Region of Western Australia.
- Demonstrate the use of novel phosphite control techniques to reduce the impact of *P. cinnamomi* within the Threatened Ecological Communities of the Stirling Range National Park and Bell Track infestation in the Fitzgerald River National Park.

### Summary of progress (2009/2010) and main findings

- Complete monitoring of seasonal and spatial variation in the soil population dynamics of *P. cinnamomi* in the national parks of south coast WA.
- On-going monitoring of the efficacy of the High Intensity Phosphite application at three locations in the South Coast Region. Results to date have shown that high intensity phosphite treatment can retard front movement, reduce soil *Phytophthora* inoculum, and decrease mortality rates in target susceptible species. The treatment works best in Proteaceous heathland on deep sands.

### Management implications

- Improved efficacy of phosphite treatment to control *P. cinnamomi* means this technique is now being used at the Bell Track infestation in the Fitzgerald River National Park to contain the pathogen to its current micro-catchment.
- Increased understanding of disease epidemiology will allow for more accurate modelling of disease centre extension.
- Improved management of *P. cinnamomi* through the use of appropriate hygiene practices will prevent further spread of infections.
- Improved field diagnostics for determining the presence and absence of the pathogen in soil and plant tissue samples will enable greater accuracy in identification of infections.

### Future directions (next 12-18 months)

- Monitor the efficacy of high intensity phosphite to prevent disease centre extension and minimise the impact of *P. cinnamomi*.
- Investigate the potential to eradicate spot infestations of *P. cinnamomi* on the South Coast of WA.
- Publish the research findings on the 'Seasonality of *P. cinnamomi* from the South Coast of WA'.
- Publish a technical paper on the 'Last Stand at Bell Track' project.

---

## Selection, screening and field testing of jarrah resistant to *Phytophthora cinnamomi*

SPP# 1993-112

Team member

M Stukely (0.05).

### Context

Genetically-based resistance to *Phytophthora cinnamomi* (Pc) has been demonstrated in jarrah (*Eucalyptus marginata*). A long-term selection and screening program has been carried out by means of inoculation trials and subsequent field validation trials to prove the selections. Individuals showing the highest levels of resistance have been selected from those half-sib jarrah families that showed the best overall Pc-resistance levels. These elite seedlings have been propagated and multiplied by tissue-culture. The resulting clonal lines have been used in validation trials, in field plantings, and to establish seed orchards for the production of Dieback Resistant Jarrah (DRJ) for future operational forest rehabilitation plantings.

### Aims

- Collect and screen a wide range of jarrah provenances (half-sib families) for resistance to

*Phytophthora cinnamomi* (Pc).

- Select outstanding individuals from Pc-resistant families for propagation, undertake field validation testing, and include in seed orchards.
- Test clonal lines of Pc-resistant jarrah in field inoculation trials to validate their selection for inclusion in seed orchards.
- Establish a DEC/FPC seed orchard for production of Pc-resistant jarrah.

#### *Summary of progress (2009/2010) and main findings*

A paper on the use of grafting in the propagation of DRJ was published in *Conservation Science WA*.

#### *Management implications*

Now that seed production has started in the seed orchard, DRJ seedlings can be grown in the nursery and made available to DEC managers, community groups and land holders for use in rehabilitation plantings of degraded forest and cleared sites. The first public release of DRJ seedlings was made in the 2007 planting season. It will be possible to re-establish jarrah on degraded sites where it has been mostly lost to dieback, and on sites likely to become infested, across the range of jarrah.

#### *Future directions (next 12-18 months)*

- The project is being maintained with a low level of activity. The field trials will be re-pegged and retained for long-term monitoring.
- Future research relating to the DRJ Seed Orchard will necessarily include initial quality-control testing (inoculation trials) of its progeny for Pc resistance and culling as required; also possibly more refined testing of existing lines, elimination of inferior lines based upon performance data, and the focused selection and cloning of additional resistant lines to maintain the required level of genetic diversity in the orchard in the long-term.

---

### **Dieback-resistant jarrah establishment in operational forest rehabilitation sites**

SPP# 1994-006

*Team member*

M Stukely (0.05).

#### *Context*

Operational Dieback Forest Rehabilitation (DFR) plantings will desirably include Dieback Resistant Jarrah (DRJ), i.e., lines of jarrah that have been selected for their genetic resistance to *Phytophthora cinnamomi*. Seedling DRJ are now available for operational plantings as the DRJ seed orchard becomes productive. During the 1990s, trial plantings of clonal DRJ were established in operational forest rehabilitation sites in several DEC Districts. While survival was good at some sites, it was often very poor on the harsher sites, such as the Black Gravels. Due to the high cost of producing DRJ clones, and difficulties with re-establishing clonal jarrah in forest sites, it was decided that the clones will now be used to establish managed DRJ seed orchards rather than directly planting them into operational forest rehabilitation sites. A new approach addressing the broader problem of poor survival of eucalypt seedlings in DEC's operational Dieback Forest Rehabilitation sites was started in 2003, with support from Alcoa and in collaboration with DEC Perth Hills District.

#### *Aims*

- Re-establish jarrah, using dieback-resistant plants, in operational Dieback Forest Rehabilitation (DFR/FIRS) sites.
- Test a range of site treatments aimed at maximising the survival of seedlings planted in dieback graveyard sites.

#### *Summary of progress (2009/2010) and main findings*

No progress on this SPP in 2009/2010.

#### *Management implications*

The site preparation and seedling treatments giving the best seedling survival rates will be applied to routine forest rehabilitation (DFR) procedures for the re-establishment of jarrah in degraded sites across the range of jarrah, including forest graveyard sites, clearings, log landings and tracks. The treatments will be applied to the dieback-resistant progeny from the DRJ seed orchard (SPP# 1993/112) when these become available for operational-scale planting. These treatments will also be applicable for the establishment of marri in these sites.

#### *Future directions (next 12-18 months)*

- A journal paper on the results of site treatments tested in the field trials will be submitted for publication.
- The project is being maintained with a low level of activity. The field trials will be retained for long-term monitoring.

---

### **Mundulla Yellows disease in Western Australia**

SPP# to be allocated

*Team member*

M Stukely (0.15).

#### *Context*

Mundulla Yellows (MY) is a lethal disease of eucalypts that appears to be well established in various disturbed sites in WA (and in all other states). Over 50 species of eucalypt are affected. The cause of MY is unknown, but there is evidence that a virus or similar organism(s) is involved. Priority research (now being carried out in SA and Victoria) includes determining the cause(s) of MY and its mechanisms of spread, and the development of a rapid diagnostic test for the disease. If it is caused by an infectious pathogenic agent, MY has the potential to cause enormous environmental damage if it progresses unchecked. Both remnant and planted trees of all ages can be affected.

#### *Aims*

- Monitor Mundulla Yellows (MY) disease occurrence and spread in WA.
- Conduct trials to investigate mechanisms of spread and conditions contributing to development of MY.

#### *Summary of progress (2009/2010) and main findings*

- Monitoring of MY in WA by DEC has continued. Newly observed MY-affected sites have been checked and sampled. Spread of MY symptoms at any given site does not appear to be rapid, and diseased and apparently-healthy trees can grow alongside each other. Affected trees have still not been observed within undisturbed forest or woodland stands.
- Seedlings are being grown on in the glasshouse for testing in transmission trials.
- A paper on investigating the cause of MY was published in the journal *Acta Horticulturae*.

#### *Management implications*

- If it is caused by an infectious pathogenic agent, MY has the potential to cause enormous environmental damage if it progresses unchecked. Both remnant and planted trees of all ages can be affected.
- Once its cause(s), mechanisms of spread and contributing factors are known, the levels of threat posed to vegetation can be estimated, and management strategies can be developed to control the disease and prevent its spread to new areas.

#### *Future directions (next 12-18 months)*

- Continue monitoring of existing and new occurrences of MY in Western Australia.
- Prepare scientific paper on soil and foliar nutrient data from WA sites for publication.
- Harvest foliar material from seedling transmission trials in the glasshouse for testing for molecular markers.

---

## **Vegetation Health Service**

### Core Function

#### *Team members*

M Stukely (0.25), J Webster (0.6), J Ciampini (0.4).

### *Context*

Accurate knowledge of the *Phytophthora* infestation status of particular land units and sites (and adjacent areas), and of its variation over time, is essential and crucial for effective land management and biodiversity conservation. The Vegetation Health Service (VHS) provides a dedicated, specialist scientific service for the detection and identification of *Phytophthora* species from samples associated with the management of the State's forest and conservation estate, logging and mining activities, private industry and research. The VHS is also a service contributor to the Centre for *Phytophthora* Science and Management (CPSM) based at Murdoch University.

### *Aims*

- Provide a dedicated service for the detection and identification of *Phytophthora* species from samples associated with the management of the State's forest and conservation estate, logging and mining activities, private industry and research as well as providing a service which is available to external customers for a charge.
- Provide advice to assist Departmental personnel and the public with *Phytophthora* Dieback and other plant disease problems in parks and reserves, forests and other native ecosystems, plantations and nurseries.

### *Summary of progress (2009/2010) and main findings*

- A total of 1470 samples were processed for *Phytophthora* testing between 1 July 2009 and 31 May 2010, and all isolates of *Phytophthora* spp. (other than *P. cinnamomi*) were subcultured for identification to species.
- DNA sequencing of new *Phytophthora* isolates, as well as historical isolates from the VHS culture collection, has continued through the CPSM. This has shown that at least ten new and undescribed *Phytophthora* taxa (designated *P. spp.* 1-11) are established in WA's natural ecosystems. They are all associated with dying native plants. Additional isolates of several of these new taxa have again been identified. Most of these taxa have not been reported from outside WA to date.
- DNA sequencing of VHS isolates by Dr T Burgess has provided further evidence that several unique, hybrid phytophthoras exist in WA native ecosystems. Investigation of these is continuing.
- A paper on the new *Phytophthora* taxa *P.sp.2*, *P.sp.1* and *P.sp.9*, and a second paper on the occurrence in WA of unique *Phytophthora* hybrids, were presented at the 5<sup>th</sup> IUFRO Conference, Rotorua, New Zealand.
- The formal description of *Phytophthora elongata* (*P.sp.2*) was submitted for publication (with CPSM).
- A research note on the discovery of *P.sp.1* is in preparation for publication and the formal descriptions of two more new *Phytophthora* species, *P.sp.1* and *P.sp.9*, are in preparation for publication.

### *Management implications*

- Accurate testing of samples for *Phytophthora* by the VHS is an essential element of the dieback

interpretation process for assessing the dieback status of a site and mapping areas affected by *Phytophthora* dieback. A wide range of management decisions for given areas are based on this information, and efficient resource use by managers is dependent upon its accuracy.

- The availability of DNA sequencing technology through the Murdoch University Centre for *Phytophthora* Science and Management (CPSM) means that it is now possible to identify sterile *Phytophthora* isolates that cannot be identified using traditional morphological techniques, and also to differentiate between morphologically similar but genetically quite distinct taxa that had previously been grouped and treated as single species. Knowledge of the pathogenicity, distribution and environmental requirements of these new and different *Phytophthoras* is essential to enable estimates to be made of the level of threat they pose to biodiversity, and to develop appropriate strategies for their monitoring, management and control. It may not be appropriate to treat all species in the same way as *P. cinnamomi*. All of the undescribed *Phytophthora* taxa have been associated with dying native plants in WA, which is a clear indication that they have pathogenic capability in natural ecosystems.
- The existence of putative *Phytophthora* hybrids associated with dying plants in WA native ecosystems, in addition to the new taxa, adds a new dimension to *Phytophthora* management.

#### *Future directions (next 12-18 months)*

- Continue to verify field dieback-interpretation by testing of soil and plant samples.
- Culture collection will continue to be available for use by CPSM and to assist student projects.
- Continue to contribute to and assist with projects under the *Phytophthora* Management theme of the Biodiversity Conservation Initiative (BCI), and *Project Dieback*.
- Continue collaborative work with CPSM on the recently isolated *Phytophthora* spp. nov., and on the putative *Phytophthora* hybrids.
- Draft recommendations for managing *Phytophthoras* other than *P. cinnamomi* will be developed further.
- The *Phytophthora* Culture Collection and WA *Phytophthora* database will be maintained and expanded, and available to researchers.

---

## **The population ecology of Critically Endangered flora**

SPP# 2000-015

*Team Member*

C Yates (0.1) .

### *Context*

South-west Western Australia is a global hotspot of plant diversity. Determining the relative importance of multiple threatening processes including the interactions between fragmentation and small population processes, fire regimes, weed invasion and grazing regimes is critical for conservation and management of Declared Rare Flora and Threatened Ecological Communities.

### *Aim*

To determine the critical biological factors and the relative importance of contemporary ecological interactions and processes that limit population viability and persistence of Declared Rare Flora, particularly Critically Endangered Species and other key plant species occurring in Threatened Ecological Communities.

### *Summary of progress (2009/2010) and main findings*

- Continued monitoring the effect of fire interval on plant species richness and abundance in the Critically Endangered Eastern Stirling Range Montane Heath and Thicket community.
- Continued monitoring the demography of DRF and other taxa of conservation significance in the Critically Endangered Eastern Stirling Range Montane Heath and Thicket community.



- Continued monitoring the demography of the Critically Endangered *Verticordia staminosa* subsp. *staminosa* in relation to climate change.
- Published manuscript in *Australian Journal of Botany* and a manuscript has been accepted for publication in *Plant Ecology*.

#### *Management implications*

- The research in the Eastern Stirling Range Montane Heath and Thicket Community is yielding valuable information about the impact of fire interval on floristic diversity, fire response strategies and life histories of DRF and other vascular plant species. This will contribute to the development of ecologically appropriate fire regimes.
- Prescribed fire will be needed for *Verticordia fimbrilepis* subsp. *fimbrilepis* to persist in long unburnt wheatbelt fragments.

#### *Future directions (next 12-18 months)*

Continue to monitor the fire ecology of the Eastern Stirling Range Montane Heath and Thicket Community.

---

### **Causes of rarity in four *Tetradlea* taxa in the goldfields ranges**

SPP# 2000-015

#### *Team members*

C Yates (0.1), N Gibson (0.1).

#### *Context*

The Eastern Goldfields Ranges are local hotspots of plant diversity with many endemic taxa. This project centres on the critically endangered *Tetradlea paynterae* ssp. *paynterae* found at Portman Iron Ore Ltd's Windarling mine, and three other threatened *Tetradlea* taxa on adjacent ironstone ranges with mining prospectives, *T. paynterae* ssp. *cremnobata* found on the Diehardy Range; *T. harperi* found on the Mount Jackson Ranges; and, *T. aphylla* found at the Helena and Aurora Ranges. The project is investigating the environment, reproductive biology and demography of the ironstone *Tetradlea* taxa.

#### *Aims*

- Describe and compare the physical environmental domains of the four banded iron formation (BIF) *Tetradlea* taxa and associated floristic assemblages to assist with identifying sites and techniques for translocation.
- Describe and compare the reproductive biology of the four BIF *Tetradlea* taxa and investigate how reproduction is influenced by climate.
- Describe and compare the population structures and demography of the four BIF *Tetradlea* taxa and estimate annual rates of demographic parameters.
- Construct models of population dynamics for exploratory investigation of the potential impact on population viability of further reducing the number of plants in the *T. paynterae* subsp. *paynterae* population and other disturbances.

#### *Summary of progress (2009/2010) and main findings*

Project completed and final report submitted to Portman Iron Ore Ltd in 2008/2009, draft manuscript in preparation.

#### *Management implications*

- The geographic restriction of the BIF *Tetradlea* to single BIF ranges and the highly specific habitat, restrict options for translocating the taxa if habitat is destroyed by mining.
- The relatively undisturbed, *T. harperi*, and *T. paynterae* subsp. *cremnobata* will provide useful bench-

marks for gauging the performance and viability of the *T. paynterae* subsp. *paynterae* population in the mine and post-mine environments.

- Further reducing the size of the *T. paynterae* subsp. *paynterae* population will reduce the viability of the population.

#### *Future directions (next 12-18 months)*

- Submit manuscript to refereed scientific journal.
- Publish paper on the floristic assemblages of the ranges where the four *Tetratheca* species occur.

---

### **Taxonomic studies on native and naturalised plants of Western Australia arising from biological survey**

SPP# to be allocated

Team member

G Keighery (0.1).

#### *Context*

Many Declared Rare Flora (DRF) have nomenclatural and taxonomic issues that require resolution for their conservation and management. Many new taxa are routinely uncovered during biological survey.

#### *Aims*

- Provide informative, stable taxonomy of potentially conservation dependent taxa to aid their conservation and management, especially rare flora.
- Ensure that new taxa discovered during biological surveys are curated and described where possible. Studies are being undertaken on the following:
  - *Adenanthos pungens*; taxonomic status of two named subspecies.
  - *Calytrix breviseta*; status of hills population and taxonomic status of two named subspecies.
  - *Hypocalymma angustifolium*; taxonomic status of Yerina Springs.
  - *Adenanthos eyeri*/*A. forrestii*/*A. ileticus* species complex; resolution of taxa.
- Taxonomy of *Cynoglossum* in Western Australia.
- *Grevillea curviloba* and *Grevillea evanescens* taxonomy.

#### *Summary of progress (2009/2010) and main findings*

- Two papers produced on native and naturalised species in *Oxalis corniculata* complex.
- DRF *Petrophile latericola* described.
- DRF *Grevillea brachystylis* subsp. *grandis* described.
- Checklist of naturalised Aloe species published and checklist of naturalised *Prunus* species in press.
- Weeds of Pilbara submitted.

#### *Management implications*

- The presumed extinct *Grevillea evanescens* is not a distinct species and can be removed from the Presumed Extinct Declared Rare Flora list.
- *O. corniculata*, currently considered to be a widespread weed, has now been shown to be comprised of mainly native species. The true distribution *O. corniculata* can now be accurately re-assessed and its threat status correctly determined.

#### *Future directions (next 12-18 months)*

- Complete field work on *Adenanthos forrestii* complex.

- Taxonomic notes on *Hypocalymma*, *Adenanthos pungens* to be published.
- Taxonomy notes on *Calytrix breviseta* to be drafted and taxonomic notes on *Cynoglossum* in press.

---

## **Wattles of the Pilbara**

SPP# 2004-022

*Team members*

B Maslin (0.1), S van Leeuwen (PSB component).

### *Context*

*Acacia* is a key genus in the Pilbara dominating many of the ecosystems across the region. Understanding their taxonomy, and having the ability to readily identify taxa in this region, is critical to facilitate their conservation and management.

### *Aims*

To produce a book and accompanying CD that will provide easy identification and access to relevant information for Pilbara acacias in order to facilitate their management and use in nature conservation, rehabilitation and sustainable utilisation.

### *Summary of progress (2009/2010) and main findings*

CD and accompanying booklet completed and pre-publication copies of same are currently with authors for checking.

### *Management implications*

Identification and information dissemination of Pilbara *Acacia* species will facilitate their management and conservation.

### *Future directions (next 12-18 months)*

Publish *Wattles of the Pilbara* CD with accompanying booklet.

---

## **Conservation status and systematics of Western Australian *Acacia***

SPP# 2003-008

*Team members*

B Maslin (0.3), J Reid (0.1).

### *Context*

*Acacia* species are coming under increasing consideration for utilisation as commercial crops for salinity control and re-vegetation programs, and for their importance in the management of remnant vegetation. Understanding their biology and taxonomy is important if their utilisation is to be sustainable and their conservation effective.

### *Aims*

To undertake research to provide taxonomic and other advice to enable the effective utilisation of *Acacia* for nature conservation and applied purposes.

### *Summary of progress (2009/2010) and main findings*

- *Acacia saligna*: field studies undertaken and taxonomic revision of *A. saligna* is being prepared for publication.
- Curation of Herbarium *Acacia* collections ongoing (as basis for re-assessment of conservation status)

of the WA taxa).

- Revision of *A. verniciflua* group published (with D Murphy).
- Revision of *A. microbotrya* completed.

#### *Management implications*

Identification of *Acacia* species with agroforestry potential will provide options for revegetation programs.

#### *Future directions (next 12-18 months)*

- Publish *A. microbotrya* and *A. saligna* revisions.
- Continue reassessment of conservation status of WA *Acacia* flora.

---

### **Wattles in the Shire of Dalwallinu**

SPP# 2000-013

*Team member*

B Maslin (0.1).

#### *Context*

The Dalwallinu Shire has one of the richest *Acacia* floras anywhere in the world. The improved identification of *Acacia* in this area combined with their promotion for conservation and land management is leading to increased local interest not only in *Acacia* conservation but biodiversity conservation in general.

#### *Aims*

- Research and promote *Acacias* of the Dalwallinu Shire.
- Publish a book (field guide) and scientific papers.
- Conduct an *Acacia* Symposium in Dalwallinu.
- Maintain an *Acacia* website (WorldWideWattle) which is co-hosted by the Dalwallinu Shire.

#### *Summary of progress (2009/2010) and main findings*

WorldWideWattle website is being maintained.

#### *Management implications*

Greater understanding of *Acacia* species will enable more effective community engagement in their conservation.

#### *Future directions (next 12-18 months)*

- WorldWideWattle: maintain and further develop the website.
- Progress field guide to *Acacias* of the Dalwallinu Shire.

---

### **Understanding Mulga**

SPP# to be allocated

*Team members*

B Maslin (0.5), J Reid (0.9), J Sampson (0.1). External collaborators: J Miller, Uni. Iowa, R Rutishauser, Uni Zurich.

#### *Context*

Mulga forms a significant component of rangelands vegetation. These species are crucially important to the structure, ecology and functioning of these systems, as well as being of economic importance. Mulga species, especially *A. aneura* itself, are notoriously variable, the taxonomic boundaries are poorly understood and identification of these taxa is extremely difficult. Understanding this variation, determining its causal factors and being able to reliably identify the taxa, are critically important to the effective management, conservation and utilisation of this valuable resource.

#### *Aims*

To elucidate variation patterns within species of the Mulga group to provide a reliable means of identifying the taxa so that they may be effectively managed, conserved and sustainably utilised.

#### *Summary of progress (2009/2010) and main findings*

- Field studies were undertaken in Murchison, Ashburton and Pilbara districts of WA to collect material for taxonomic and genetic study, and seed for ontogenetic study.
- Analyses of cDNA and microsatellite results were undertaken.
- Main patterns of variation within Mulga in WA were elucidated and species were defined and are being described.
- Seed was germinated and seedling growth characters were scored.
- Anatomical examination of selected Mulga pods was undertaken and a paper prepared for publication.
- Mulga gum was submitted to Government Chemical Laboratory for analysis.

#### *Management implications*

Clarification of the taxonomy of Mulga species will facilitate their effective conservation.

#### *Future directions (next 12-18 months)*

- Undertake further field work in Pilbara to clarify outstanding Mulga problems in that area.
- Deliver electronic key on web for identification of WA Mulga.
- Present Mulga Workshops to facilitate identification of the species.
- Publish Mulga pod paper with Rutishauser.
- Prepare taxonomic revision of Mulga in WA.
- Prepare genetic overview publication of Mulga (with Miller).
- Progress ontogenetic and anatomical study.

---

### **Taxonomic review and conservation status of the members of the Myrtaceae tribe Chamelaucieae and miscellaneous other Western Australian plant groups**

SPP# 1993-011

#### *Team members*

B Rye (0.5).

#### *Context*

The main group of plants under study comprises over 400 species of shrubs in the Myrtaceae. They are very poorly known at both the species and generic levels. The lack of an adequate taxonomy continues to impede their conservation, study (in fields other than taxonomy) and commercial utilisation. The other main group under study is two genera of the Proteaceae (*Isopogon* and *Petrophile*). No other plant groups are being actively examined at present.

#### *Aims*

- Publish a series of taxonomic papers describing many new species, most of which have conservation priority, and in some cases also describing new genera.
- Complete a 'Flora of Australia' treatment of many members of tribe Chamelaucieae of the Myrtaceae.
- Produce and continually update an interactive key to members of this tribe.

#### *Summary of progress (2009/2010) and main findings*

- Draft flora treatments have been updated, as have the data included in the interactive key to members of the Myrtaceae tribe Chamelaucieae.
- Three papers have been published, including an interim key to all of the Western Australian genera of the Myrtaceae.
- Two more papers are currently in press. A paper previously submitted on *Petrophile* has now been split into two papers following the referee's recommendations, with a cladistic analysis to be added to one of those papers.

#### *Management implications*

An improved understanding of the numbers and status of the taxa will facilitate their management and conservation. For the large tribe Chamelaucieae, in which generic boundaries are still far from clear, an interactive key provides the best practical means of identification of all its members.

#### *Future directions (next 12-18 months)*

- Complete the interactive key to the point where it can be officially released and then continue to update it.
- Submit a full draft of the 'Flora of Australia' treatment of the Myrtaceae tribe Chamelaucieae.
- Resubmit papers on *Enekbatus* (Myrtaceae) and *Petrophile* (Proteaceae).
- Prepare additional papers on these two families.

---

### **Taxonomic resolution and description of new plant species particularly Priority Flora from those areas subject to mining in Western Australia**

SCP 2009-006

#### *Team members*

R Butcher (0.9), K Shepherd (0.4), J Wege (0.1), C Wilkins (0.6).

#### *Context*

Western Australia has a rich flora that is not completely known. New species continue to be discovered through the taxonomic assessment of herbarium collections, floristic surveys and the botanical assessment of mineral leases. There are over 1500 putatively new and undescribed taxa in Western Australia, a significant proportion of which are poorly known, geographically restricted and/or under threat (i.e. Declared Rare or Priority Flora). The lack of detailed information on these taxa makes accurate identification problematic and inevitably delays the Department's ability to survey and accurately assess their conservation status.

#### *Aim*

To resolve the taxonomy and expedite the description of manuscript or phrase-named plant taxa, particularly Priority and Declared Rare Flora and those taxa vulnerable to future mining activities.

#### *Summary of progress (2009/2010) and main findings*

- Three taxonomic manuscripts (*Hakea*, *Hibbertia*, *Marianthus*) were published in *Nuytsia* and a further eight papers (*Androcalva*, *Commersonia*, *Eragrostis*, *Ptilotus*, *Stylidium*, *Tecticornia*, *Tetratheca*) have been submitted for publication in various Australian journals. Together these publications contain up to date descriptive information for 75 taxa, of which 23 are listed as being of conservation

concern.

- An improved taxonomic understanding of a number of species complexes within *Amaranthus*, *Corchorus*, *Pityrodia*, *Platytheca*, *Ptilotus*, *Rhynchosia*, *Stylidium*, *Synaphea*, *Tecticornia*, *Tephrosia* and *Vigna* was achieved. Eleven phrase-names have been added to Western Australia's plant census and draft descriptions generated for a number of taxa.
- *Hibbertia abyssa* was gazetted as Declared Rare Flora, *Stylidium* sp. Yalgoo was nominated for listing as Declared Rare Flora and a further ten taxa were newly added to the *Declared Rare and Priority Flora List for Western Australia*.
- Field studies resulted in the acquisition of c. 290 herbarium specimens for the State collection, including 13 new populations of various taxa of conservation concern.
- Team members collectively provided expert determinations for c. 1100 specimens housed at the Western Australian Herbarium.

#### *Management implications*

The provision of names, scientific descriptions, illustrations and associated data for a range of new species will enhance the capacity of conservation and industry personnel to identify these taxa, thereby improving conservation assessments and effective management.

#### *Future directions (next 12 months)*

- Assess and formalise the taxonomy of new Western Australian plant taxa, particularly those of conservation significance.
- Conduct field studies on poorly collected and taxonomically difficult species groups.
- Add and remove taxa from the Western Australian Plant Census, as required, and make recommendations regarding the appropriate conservation listing of Western Australian plant taxa.

---

### **Taxonomy of selected families including legumes, grasses and lilies**

SCP# 2007-013 (SPP# to be allocated)

#### *Team members*

T Macfarlane (0.7), R Cranfield (0.4).

#### *Context*

Successful conservation of the flora requires that the conservation units equate to properly defined, described and named taxa. There are numerous known and suspected un-named taxa in the grass, legume and lily families as well as numerous cases where keying problems or anomalous distributions indicate that taxonomic review is required. This is true of various parts of the families but current focus is on *Austrodanthonia*, *Wurmbea*, *Thysanotus* and *Lomandra*.

#### *Aims*

- Identify plant groups where there are taxonomic issues that need to be resolved, including apparently new species to be described and unsatisfactory taxonomy that requires clarification.
- Carry out research using fieldwork, herbarium collections and laboratory work.
- Publish results as journal articles and as contributions to FloraBase.
- Provide botanical support for FORESTCHECK project.

#### *Summary of progress and main findings*

- *Wurmbea* (Colchicaceae): field work was conducted in Midwest and Murchison regions, which provided the first flowering material of one species and the discovery of one new species with further field research on other poorly known species; field work in the Goldfields resulted in finding another new species; drafting of two papers; submission of a case for conservation priority for a species from the Gascoyne region.

- Hydatellaceae: participated in field work in Manjimup area for pollination studies by a visiting United States researcher and subsequent submission of a joint paper on *Trithuria submersa*; field visit to endangered species *T. occidentalis*.
- *Centrolepis* (Centrolepidaceae): paper submitted on a new interpretation of inflorescence structure.
- *Austrodanthonia* (Poaceae): research and description preparation for an undescribed Wheatbelt species.
- Poaceae: further investigation of an undescribed Queensland grass formerly thought to belong to Neurachne; DNA results carried out in California confirm morphological finding that it belongs to the tribe Uniola, not previously recorded from Australia; the aim now is to determine what genus it belongs to, and finalise a paper.
- *Thysanotus*: paper published describing a new species *T. unicusensis* from the southern forests; fieldwork in the Midwest, southern Wheatbelt and South Coast regions helped understanding of some poorly known species, e.g. *T. pyramidalis*, *T. speckii*, *T. lavanduliflorus* and *T. volubilis* and a new species related to *T. manglesianus* was discovered.
- *Baeckea* group (Myrtaceae): contributions were made to the almost complete interactive key to species of the large *Baeckea* group led by B Rye.
- Biological survey, Charles Darwin Reserve: participated in the national pilot study of reserve surveys and submitted the final report. Participated in a second survey of the ABRIS program now named Bushblitz on the DEC-managed former pastoral properties Karara, Lochada and Kadji Kadji and submitted the report. The results included many new records for the areas and several new or potentially new species.
- *Leptospermum spinescens* (Myrtaceae): Further research on some aspects, draft paper amended but not yet completed.
- *Brachyloma* (Epacridaceae): A draft paper of a taxonomic revision of a section the genus is currently undergoing final editing.
- *Logania* (Loganiaceae): researched and submitted a paper describing a new species from the eastern edge of the jarrah forest.
- Preparation of identification aids for cryptogams, especially lichens, for field surveys in the southern forests and jarrah forest; early stages of interactive key development for lichens.

#### *Management implications*

- The conservation status was clarified for several species. Phrase names that were applied to several newly recognised un-described species enables them to be protected if required.
- The Midwest reserve flora surveys have provided improved inventories of the plants and identified those species of special conservation concern on DEC-managed lands.
- The *Trithuria* pollination biology study provides basic biological understanding of this poorly known plant group which is of major scientific interest, and for management it is relevant to know that the plants are wind-pollinated so there are no associated pollinator vectors to add complexity to the conservation process. On the other hand local genetic variation may exist in different populations.

#### *Future directions*

- Complete and submit papers describing known new species and learn more about those species known from only one or a few populations.
- Continue to revise plant groups and investigate via field and herbarium studies various putatively new species in order to improve knowledge of the flora, provide stable plant names and provide means of identifying species.

---

### **Taxonomic studies in selected families, including Asteraceae, Celastraceae Malvaceae, Proteaceae**

SCP# 2008-001 (SPP# to be allocated)

*Team member*

N Lander (0.4).



### Context

Asteraceae classification is undergoing fundamental reassessment at the genus and species level. In Australia this is gaining momentum in preparation for the forthcoming publication of the *Flora of Australia* volumes dealing with this family. This project will resolve the limits of currently accepted species within the largest Australasian genus in this family, *Olearia*, formally describe and publish new taxa species, provide identification tools to distinguish between them. A number of new satellite genera will be described, and a review of the small related genus *Eriodiophyllum* will be presented. Additionally, it will provide an interactive identification key for all WA genera within the family for incorporation in FloraBase.

### Aims

- Revise genus *Olearia* in Australia.
- Resolve species in Asteraceae, Celastraceae, Malvaceae.
- Publish in *Nuytsia* and other suitable journals new taxa in the above groups.
- Publish review of genus *Eriodiophyllum*.
- Publish interactive keys in FloraBase to Asteraceae genera of WA, *Olearia* species of WA, Proteaceae species in WA in genera *Banksia*/*Dryandra*, *Conospermum*, *Grevillea*, *Hakea*.

### Summary of progress (2009/2010) and main findings

- Interactive key to WA Asteraceae genera (183 genera) with binary keys to species and comprehensive glossary of technical terms was compiled and added.
- e-Genera. Major revision of database completed and extended to include new data available in a recently published monograph of the family. Draft version of interactive system and descriptions made available via DEC Intranet to Reference Herbarium users and DEC staff. ~two-thirds complete (109 of 188 genera).

### Management implications

- The Asteraceae have a major centre of diversity in WA, with over 570 species (in 183 genera) of shrubs and herbs occurring in virtually every environment. Over 80 are listed as conservation taxa. With the current flux in classification and taxonomy in a group difficult to identify to species level, an authoritative source of current information is fundamental to correctly managing the conservation taxa and the lands on which they occur. Additionally, the Asteraceae are represented in WA by 125 weedy species, some of critical significance.
- As a group, the Proteaceae are highly susceptible to a number of major threatening processes, including salinity and *Phytophthora* dieback. In south-west Western Australia some members of this family are common indicator species for the presence of dieback, and it is the family with the highest number of listed species affected.

### Future directions (next 12-18 months)

- Prepare further papers on taxonomy of *Olearia* and several new related genera.
- Submit interactive key to WA Asteraceae Genera for incorporation in FloraBase.
- Complete interactive key *Olearia* for incorporation in FloraBase in the light of feedback received from users of draft release.
- Revise treatment of *Olearia* for new edition of *Flora of South Australia*.
- Resolve status of a number of new taxa of WA Asteraceae from the Pilbara (WA), from NSW and South Australia and publish new taxa as necessary.

---

## Herbarium collections management

Core function

Team members

K Knight (1.0), K Thiele (0.2), R Cranfield (0.4), R Rees (0.5), C Parker (0.2), P Spencer (0.5), M Falconer (0.6), BS Mahon (0.2), R Davis (0.8), S Coffey (1.0), A Chapman (0.1), M Hislop (0.9).

### Context

The Western Australian Herbarium's collections provide the core resource for knowledge of the State's flora and fungi. The collection is growing constantly, through addition of new specimens representing new taxa and new records of existing taxa. The collection is maintained to a high standard, and provides DEC and the community with the fundamental resource to allow accurate identification of plant and fungi specimens throughout Western Australia.

### Aims

- Fully document and audit the diversity of Western Australia's plants, algae and fungi.
- Maintain in perpetuity a comprehensive, adequate and representative research and archive collection of specimens of all taxa in these groups occurring in Western Australia.
- Contribute to, support and service the research, conservation and decision-making activities of DEC.
- Contribute to, support and service taxonomic research by the world's scientific community.

### Summary of progress (2009/2010) and main findings

- 15 109 specimens were added to the collection, which now stands at 722 574, a 2.1% increase during the year.
- The major plant groups in the collection are as follows:

Taxonomic Group	Number of specimens (June 2009)	Increase since June 2009	
		Number	%
Myxomycetes	754	102	15.6
Fungi	22 787	2 037	10.0
Lichens	16 190	646	4.1
Algae	22 798	316	1.4
Liverwort & Hornworts	1 959	62	3.3
Mosses	6 633	183	2.8
Ferns and fern allies	3 591	77	2.1
Gymnosperms	1 996	22	1.1
Flowering Plants	645 866	11 663	1.8
Total number	722 574	15 109	2.1

- Significant curatorial work was accomplished in the genera *Eucalyptus*, *Baeckea*, *Acacia*, *Chamelaucium*, *Beyeria* and *Calothamnus*.
- Updating the collection's systematic sequence according to the new linear Angiosperm Phylogeny Group (APGIII) was completed. This large project resulted in many changes made to WACensus (including name changes/additions and edits to reference citations and authorities).
- Significant collections added to the Herbarium holdings came from the Yilgarn Ranges Survey, Mulga Project, Pilbara Regional Herbarium, Threatened Flora Seed Centre vouchers, Kings Park, DEC Regional Offices, Regional Herbaria, West Kimberley Heritage Assessment, Charles Darwin Reserve Survey, Pilbara Biological Survey, Mornington Sanctuary and a range of environmental consultancies.
- Loans and exchange:
  - Loans outward – 3 042 specimens and exchange outward – 3 622 specimens.
  - Loans inward - 872 specimens and exchange inward - 103 specimens
- Volunteer participation was significant, totalling ~ 7 000 hours. This is reduced compared with previous years because of the closure of the volunteer program in preparation for the move.
- Tasks managed by curation staff with the assistance of volunteers were as follows:

- Mounting and labelling 7 927 specimens.
  - General curation of specimens, and incorporation of specimens into the collection.
  - Auditing the collection.
- Specialist volunteer projects:
  - Curating *Austrostipa*, *Eucalyptus*, *Pterostylis*, *Verticordia*, *Calandrinia*, *Proteaceae* and *Goodenia*.
  - Capturing and preparing composite images for FloraBase.
  - Increasing the collection and documentation of Myxomycetes
  - Maintaining and adding specimens to the Reference Collection
- Maintained and increased the number of taxa represented in the Reference Herbarium which currently has over 14 000 specimens representing c. 11 000 taxa. Over 3 000 visitors used this resource to identify plant specimens during the year.

#### *Management implications*

- Maintenance and curation of the Herbarium collections underpins all conservation activities in Western Australia, as it is only through the collection's voucher specimens that an adequate and authoritative inventory of the plant biodiversity of Western Australia can be achieved.
- The collections are drawn upon constantly by DEC staff, consultants and others for validating specimen records from biological surveys.
- Many taxa in Western Australia are yet undiscovered, but many of these are already represented by specimens in the Herbarium, awaiting recognition by taxonomists.

#### *Future directions (next 12-18 months)*

The move to the new Biodiversity Science Centre and new herbarium building will provide a challenge to the Herbarium over the next 12 months. During this time the collection will be prepared for the move, to ensure a smooth transition with a minimum of disruption.

---

### **The Western Australian Plant Census and Australian Plant Census**

Core function

*Team members*

S Carroll (0.4), C Parker (0.1), T Macfarlane (0.1) .

#### *Context*

The Western Australian Plant Census (WACensus) is a complete, authoritative database of all names of plants in Western Australia, including synonyms created by taxonomic change. It is continually updated to reflect changes in our knowledge of the flora. The Census constitutes the fundamental master list for many DEC processes and datasets, including the Declared Rare and Priority Flora databases maintained by the Species and Communities Branch, the Herbarium's specimen database, the MAX database utility and NatureMap.

The Australian Plant Census (APC) is a project of the Council of Heads of Australian Herbaria, designed to provide a consensus view of all Australian plant taxa. Until now plant censuses have been only state-based, which has made it difficult to obtain authoritative information on what species occur in Australia as a whole and to obtain accurate statistics. In addition to working systematically through the vascular plant families the APC process provides for updates as taxonomic changes or new findings are published. The consensus also extends from family and genus level to an overall classification of the plants that occur in Australia. The Western Australian Herbarium is providing substantial input into the APC project through an APC Working Group and membership of the Council of Heads of Australian Herbaria. As the APC project continues, the Western Australian Plant Census is updated to reflect the consensus view.

#### *Aim*

To maintain an accurate and up-to-date listing of all plants and fungi in Western Australia, including both current names and synonyms, and integrate with the national consensus.

*Summary of progress (2009/2010) and main findings*

- A total of 473 new names were added to WACensus, with 199 being new manuscript or phrase names and 274 being published names.
- A total of 305 other edits were made to WACensus.
- WACensus updates are regularly distributed to over 400 registered Max users on a monthly basis.
- 15 names lists processed for the APC

*Management implications*

- All DEC systems utilising WA plant names are based on, or integrated with, the WACensus database.
- Staff maintaining plant databases can use Max and the regular WACensus updates to check name currency.

*Future directions (next 12-18 months)*

The Census currently includes names of all vascular plants, lichens, moss and algae. Work during 2010-2011 will add liverworts, Myxomycetes and some Fungi groups. The APC is extending its coverage to non-vascular plants, which will involve DEC staff checking and contributing to lists for those groups.

---

## **The Western Australian Herbarium's specimen database**

Core function

*Team members*

S Carroll (0.6), M Falconer (0.4), E McGough (0.5).

*Context*

The Western Australian Herbarium's specimen database allows staff at the Herbarium to manage and maintain the Herbarium's collections, and provides core data on the distribution, ecology and morphology of all taxa for DEC and the community, through the FloraBase and NatureMap websites. Data from the specimen database is provided to researchers, consultants and community members on request.

*Aim*

To capture, maintain and validate spatial, phenological, population and habitat data for all the Herbarium's collections, enabling curation of the collection and providing core data for FloraBase and DEC decision support and research.

*Summary of progress (2009/2010) and main findings*

- 15 109 records were added including 1 456 Priority Flora and 254 Declared Rare Flora.
- 60 requests for specimen data (species lists for areas of WA, specimen label data for particular taxa) were processed from DEC offices, researchers and the general public.

*Management implications*

WAHerb represents the most comprehensive database on WA plants available. This provides a source of information that managers can use for updates on biodiversity or conservation status, plant identification, clarification of plants in an area prior to survey, and identification of knowledge gaps.

*Future directions (next 12-18 months)*

Editing will continue on the WAHERB database to maintain its currency with the Herbarium collections including checking the accuracy of existing records.

---

## **FloraBase – the Western Australian flora**

Core function

*Team members*

A Chapman (0.6), B Richardson (0.4).

*Context*

FloraBase, the web information system for the Western Australian flora, has increasingly become DEC's main means of communicating botanical taxonomic information. Based on three constantly maintained corporate datasets, FloraBase is developing to become a model global information resource. FloraBase delivers its data using international data standards, an important issue in an increasingly connected world. Regular updates provide improved access and new features to the site.

*Aim*

To deliver authoritative taxon-level and specimen-level information on all Western Australian plants, algae and fungi to a wide audience, using efficient, effective and rigorous web-based technologies.

*Summary of progress (2009/2010) and main findings*

- Ongoing implementation of a five year rolling plan to move FloraBase to become a complete Flora of Western Australia.
- Progressed development of a model for the technology and content to appear in FloraBase 3.
- Completed development of access to all Census data fields for query and display in FloraBase.
- Completed documentation of the Herbarium's move to a completely new family classification system.
- Completed development of upgraded spatial query and simple taxon distribution map production.
- Completed development of direct links from FloraBase to 13 381 interactive taxon maps in the NatureMap web application.
- Refined the software application for management of 37 885 taxon images available in FloraBase.
- Finalised development underpinning the integration of available PDF's of *Nuytsia* journal papers more tightly into FloraBase.
- Ongoing implementation of a staged roll-out of features and improvements as documented in the Herbarium's issues tracking tool (MANTIS).
- Ongoing maintenance of generic and family descriptions and other features.
- Launched weed management content for the weeds of the Swan Region, in collaboration DEC's Urban Nature Program staff.
- Collaboration with DEC's Eco-Education unit, and the regular provision of Plant of the Month content for their statewide newsletter.

*Management implications*

- FloraBase continues to provide access to authoritative and accurate information on the State's flora. The community and conservation staff are able to retrieve the most recent information on the name, features, status and distribution of the 13 213 currently recognised native and naturalised WA vascular plant taxa. Consequently, conservation efforts across the State are made more effective by building on quality current data in a readily accessible format from authoritative information systems.
- Continued training in best practice use of FloraBase and vouchering at the Western Australian Herbarium will further aid efficiencies in flora management within the State.
- Collaboration with external agencies and community groups wanting to maximise their conservation efforts is beginning to deliver qualitative improvements in the persistent documentation of flora surveys in the conservation estate.

#### *Future directions (next 12-18 months)*

- Implementation of the third major version of FloraBase.
- Upgrade the management of taxon descriptions from a range of sources.
- Add new content, including interactive keys for identification of plant groups at species level.
- Add further standards support to allow FloraBase to participate in national and international bio-infrastructure projects.
- Maintain the quality of information and the adequacy of software and hardware systems.

---

### **Biodiversity Informatics at the Western Australian Herbarium**

Core function

*Team members*

A Chapman (0.1), B Richardson (0.2).

#### *Context*

DEC's Science Division databases contain a large amount of quality biodiversity data. For some of these databases, there is no means of access other than direct to the database itself. DEC can better promote the understanding of Western Australia's natural biodiversity by providing access to this data through web services. The most important method of providing access to biodiversity information is through the use of data standards created by international biodiversity information standards bodies. These standards describe the way in which biodiversity data should be represented and requested by software other than web browsers, and makes it possible to recombine the data in powerful new ways.

#### *Aim*

To deliver DEC's biodiversity data to the Internet using standards-compliant web services and data structures.

#### *Summary of progress (2009/2010) and main findings*

- Completed design and delivery of Image Collection Management software to provide sophisticated management and service options for the WA Herbarium's 60 000 plant images.
- Completed implementation of a web service interface to support provision of DEC biodiversity data to Australia's Virtual Herbarium and the Global Biodiversity Information Facility.
- Progressed implementation of Digital Object Identifiers across DEC bibliographic databases.
- Participation in the final implementation and launch of the Council of Heads of Australasian Herbaria's new Australia's Virtual Herbarium (AVH) web service.

#### *Management implications*

- Conservation efforts across the State are made more effective by building on quality current data in a readily accessible format from authoritative information systems.
- Continued training in best practice use of biodiversity informatics tools will further aid efficiencies in flora management within the State.
- Collaboration with scientists, external agencies and standards organisations at national and international levels that aim to standardise biological data and build flexible management and visualisation software on top of these standards will maximise efforts to deliver qualitative improvements in the persistent documentation of global biodiversity.

#### *Future directions (next 12-18 months)*

- Implement use of Image Collection Management software and conduct training to Herbarium staff and volunteers.

- Commence planning for the complete move of herbarium information systems to ORACLE, the departmental standard database platform.
- Continue the integration of FloraBase and NatureMap to identify and build shared software components.
- Collaborate with national (e.g. Atlas of Living Australia project, Herbarium Information Systems Committee) and international bodies (e.g. TDWG, GBIF) in the definition of standards for biodiversity information.
- Collaborate in projects that simplify the use of biodiversity information in the online context, e.g. co-authorship of software that our clients can download and use.

---

## **Taxonomic review and floristic studies of the benthic marine algae of north-western Western Australian and floristic surveys of Western Australian marine benthic algae**

SPP# 2009-009

*Team members*

J Huisman (0.8), C Parker (0.1) .

### *Context*

This project involves systematic research into a poorly known group of Western Australian plants and is directly relevant to the Department's nature conservation strategy. It includes floristic studies of the marine plants of several existing/proposed marine parks and also areas of commercial interest (Ningaloo, Dampier Archipelago, Barrow Island, Montebello Islands, Rowley Shoals, Scott Reef, Maret Islands etc.). In addition, the general floristic surveys will provide baseline information enabling a more comprehensive assessment of the Western Australian marine biodiversity.

### *Aims*

- Collect, curate and establish a collection of marine plants representative of the Western Australian marine flora, supplementing the existing WA Herbarium collection.
- Assess the biodiversity of the marine flora of Western Australia, concentrating initially on the poorly known flora of the tropics.
- Prepare a Flora for north-western Australia, documenting this biodiversity.

### *Summary of progress (2009/2010) and main findings*

- The primary focus for the period was the continued generation of descriptions and illustrations for the '*Marine Benthic Flora of north-western Australia* (due for completion in 2010). This book will include some 300 species, many of which are new to science, and each will be fully illustrated.
- New collections made from Shark Bay and Walpole have included several new taxa, one of which has been described as the new genus *Spongophloea* in a paper accepted for publication.
- A major paper concerning the typification of an important historical collection of Western Australian algae (by Irish botanist W.H. Harvey) has also been accepted for publication.

### *Management implications*

- Enhanced knowledge of marine biodiversity allows a more accurate assessment of management and development proposals.
- Easier identification of marine plant species leads to a more comprehensive understanding of their conservation status, recognition of regions with high biodiversity and/or rare species, recognition of rare species, and recognition of potentially introduced species and discrimination of closely-related native species.

### *Future directions (next 12-18 months)*

- Publication of papers describing new and existing genera, species and other categories;

contributions to FloraBase.

- Finalise production of an 'Algae of Australia' Flora covering the marine plants of north-western Australia.

---

### **The Western Australian marine benthic algae online and an interactive key to the genera of Australian marine benthic algae**

SPP# 2009-008

*Team members*

J Huisman (0.2), C Parker (0.2).

#### *Context*

This project is a direct successor to the 'WA Marine Plants Online'. It will provide descriptions of the entire WA marine flora as presently known, accessible through FloraBase. In addition, an interactive key to the genera is in preparation that will enable positive identification of specimens and provide a baseline marine Flora for future revisions. This project will provide a user friendly resource that will enable the identification of marine plants by non-experts. It will be of great value in systematic research, teaching, environmental and ecological research, and additionally in environmental monitoring and quarantine procedures.

#### *Aims*

- Prepare an interactive key to the 600 genera of Australian marine macroalgae, using the software LUCID.
- Provide online descriptions of the Western Australian marine flora as presently known (approx 1 000 species).

#### *Summary of progress (2009/2010) and main findings*

- Close to 800 species descriptions have been collated or newly generated. These will be uploaded to FloraBase by the end of 2010.
- Fact Sheets including descriptions and images have been prepared for the 600 genera to be included in the interactive key.

#### *Management implications*

- Easier identification of marine plant species will lead to a more accurate understanding of their conservation status.
- Enhanced knowledge of marine biodiversity will allow a more accurate assessment of management proposals/practices.
- Provision of a readily available web-based information system will facilitate easy access by managers, researchers, community and other marine stakeholders to marine plant species inventories and up-to-date names.

#### *Future directions (next 12-18 months)*

- Complete coding of LUCID key.
- Continue collating existing species descriptions (where available) and write new descriptions for uploading to FloraBase.
- Upload additional marine plant images to FloraBase.

---

### **Perth Urban Bushland Fungi (PUBF) Project**

Core function

*Team member*



N Bougher (0.4), R Hart (0.3), B Glossop (0.1).

#### *Context*

Knowledge of the fungi and other cryptic organisms that help keep the region's plants healthy is essential for effective conservation management of Perth's bushlands. This project has developed protocols to foster community participation and education while simultaneously capturing scientific data about fungi. PUBF is raising the previously low level of awareness and knowledge about fungi and encouraging the inclusion of fungi in bushland management.

This is a collaborative project between the Western Australian Naturalists' Club, the Perth Urban Bushland Council, and in conjunction with the Western Australian Herbarium.

#### *Aims*

- Promote a better understanding of the significance of fungal diversity and function in bushlands.
- Generate and provide access to scientifically accurate information about fungi of the Perth Region.

#### *Summary of progress (2009/2010) and main findings*

- Conducted 115 workshops and forays in 59 urban bushlands.
- Produced foundation fungi inventories for 38 bushlands.
- Recorded 4 749 fungi and processed and vouchered about 1300 fungi specimens for WA Herbarium collection.
- Published fungi reports for five community group bushlands, including online.

#### *Management implications*

- Perth's urban bushlands lie within one of the world's 34 terrestrial biodiversity hotspots for conservation priority, the only such hotspot in Australia.
- The bushlands are an important natural refuge for many fungi. Fungi underpin the long-term health and resilience of the bushlands.
- Knowledge of the fungi and other organisms that help keep the region's plants healthy is essential for effective conservation management of this hotspot region.

#### *Future directions (next 12-18 months)*

- Conduct three public field events (forays and workshops) and a contracted survey during the 2010 season.
- Further the incorporation of PUBF fungal specimen data and species images into WA Herbarium databases.
- Input PUBF data into the updated census of Western Australia's larger fungi.
- Input PUBF data into FloraBase or similar taxa-based online information system.

---

### **Improving the comprehensiveness, accuracy and availability of taxonomic data about WA's fungi in DEC biological datasets and biodiversity collections**

SPP# not yet allocated

#### *Team member*

N Bougher (0.6).

#### *Context*

This project represents a new and timely effort to build the State's biodiversity knowledge base, and create and apply more comprehensive and accurate fungal scientific knowledge for conservation and management of the State's biodiversity.

### *Aims*

- Generate and provide scientifically accurate and comprehensive taxonomic data for fungal taxa in WA that are previously unrecorded, unidentified, mis-identified, or ill-defined – particularly taxa of relevance to specific current DEC conservation initiatives.
- Make available descriptive information about fungi taxa in published form and in online information systems.
- Improve access and uptake of fungi scientific knowledge about fungi and thereby promote better awareness and understanding by scientists and community of the significance of fungal diversity and function in bushlands.
- Achieve greater taxonomic and geographic representation of WA fungi in datasets and as permanent vouchers at the WA Herbarium.

### *Summary of progress (2009/2010) and main findings*

- Ecological journal paper published about fungi enabling successful translocation of Gilbert's potoroo.
- Ecological journal paper published on the interaction between native beetles and fungi.
- Two taxonomic journal papers published concerning fungi genera *Hemimycena* and *Inocybe*.
- Two historical journal/book papers published about fungi in WA.
- Two fungi research surveys for external client completed and reported.
- Promoted access and uptake of fungi scientific knowledge, completed and reported five public biological surveys.
- Census data submitted for 100 species represented in the book *Fungi of the Perth Region and Beyond* which was launched during this period.

### *Management implications*

The availability of scientifically accurate and comprehensive information about more taxa of fungi in WA will encourage and enable a greater uptake and capacity by DEC and community to incorporate fungi in management. This includes regional biological surveys, managing the interdependent linkages between fungi and plants and animals, and a better basis for assessment of the conservation status of fungi taxa.

### *Future directions (next 12-18 months)*

- Generate and provide descriptive and identification data for fungal species involved in current DEC conservation initiatives.
- Continue investigations into interactions between native fauna and fungi.
- Foster community participation, education, and capacity to capture scientific data about fungi.
- Continue updated census of WA macrofungi.
- Continue input of descriptive fungi data into FloraBase or similar taxa-based online information system.
- Re-assess the conservation status of some further fungi taxa in WA.

---

## **Taxonomic studies in Epacridaceae, Rafflesiaceae, Rhamnaceae and Violaceae**

SCP# 2007-015 (SPP# to be allocated)

*Team member*

K Thiele (0.1).

### *Context*

This project involves systematic research, particularly resolution of species boundaries and descriptions of new species, in a number of families of Western Australian plants. Describing new species, particularly conservation taxa, is of fundamental importance for conservation, as it provides an

underpinning to all other biodiversity research. The families studied in this project include taxa of high conservation and biodiversity significance.

#### *Aims*

- Collect and curate specimens for the WA Herbarium collection in the target families.
- Assess species boundaries and describe new species.
- Document the conservation, taxonomic and nomenclatural status of species.

#### *Summary of progress (2009/2010) and main findings*

- A paper describing the two rare and threatened species *Hibbertia abyssa* Wege & Thiele and *H. atrichosepala* Wege & Thiele has been published in *Nuytsia*.
- A paper describing three new, geographically restricted species of *Hibbertia* from the Lesueur Sandplain region (*H. leucocrossa*, *H. fasciculiflora* and *H. propinqua*) has been published in *Nuytsia*.
- A paper describing the rare species *Banksia recurvistylis* has been published in *Nuytsia*.
- A paper revising the *Lysinema ciliatum* species complex (Epacridaceae) has been published in *Nuytsia*, resulting in the reduction of eleven phrase-named taxa to two described taxa.
- A paper describing a new, rare species of *Darwinia*, *D. hortiorum*, has been submitted to *Nuytsia*. *Darwinia hortiorum* is restricted to the Wandering area and is listed as a P1 species.
- A paper describing a new, rare species of *Hibbertia*, discovered during biological surveys of the greenstone belts of the Goldfields, is in preparation for submission to *Nuytsia*.
- A new rare species for Western Australia, *Hibbertia crispula* J.M. Black, has been identified from Herbarium material. Previously thought to be endemic to South Australia, *H. crispula* is represented in Western Australia by a single population in the Great Victoria Desert and is rated P1

#### *Management implications*

Knowledge of species in Western Australia, and the ability to recognise them, is critical for conservation planning and management.

#### *Future directions (next 12-18 months)*

Work on the taxonomy of *Hibbertia* (Dilleniaceae) has made it clear that many undescribed species remain in the genus. Resolving and describing these will be a principal focus for this project.

---

### **Development of interactive identification platforms and content**

SCP# 2007-014 (SPP# to be allocated)

#### *Team members*

K Thiele (0.1); C Hollister (0.4, volunteer).

#### *Context*

Botanical identification keys are important tools that allow a wide variety of people – researchers, DEC staff, consultants, students and members of the general public – to identify plants. Good keys are particularly important in Western Australia in the absence of a complete Flora for the state.

This project is developing, in conjunction with botanists and other members of the Herbarium community, a range of computer-based, interactive identification keys for various groups of Western Australian plants, using the Lucid software tools. Completed keys will be published on FloraBase for community-wide access.

#### *Aim*

To develop user-friendly and accurate identification keys for important groups of Western Australian plants.

#### *Summary of progress (2009/2010) and main findings*

- Keys to species in all genera of Proteaceae in Western Australia are largely complete and have been made available for testing and use by members of the community particularly consultants.
- A key to species of the important family Goodeniaceae has been commenced. Initial coding is complete for most of the larger genera except *Lechenaultia* and *Scaevola*.

#### *Management implications*

The ability to accurately identify plant species in Western Australia is critical for conservation planning and management.

#### *Future directions (next 12-18 months)*

Continue development of the key to Goodeniaceae, and proceed to the stage of testing the key by a range of users

---

### **Surveys, systematics and genetic diversity of granitic vernal pools flora**

SPP# to be allocated

*Team member*

M Moody (0.25).

#### *Context*

The granite outcrop vernal pools (gnammas) are one of the highly unique ecosystem to Western Australia and perhaps one of the most threatened by global climate change. Yet, these systems have received little attention and their biodiversity and ecology is poorly known. Several of the more conspicuous plants of the vernal pools have been recognised as priority or rare, with less conspicuous plants poorly known. A comprehensive plant survey and genetic study of these systems will provide an understanding of their diversity, composition and likely to lead to the discovery of cryptic species. Population level genetic studies of rare species in the system will provide information on genetic diversity in populations and gene flow among populations to assess the immediate threat these species may face due to loss of habitat.

#### *Aims*

- Determine the plant diversity in the granitic vernal pools of southern Western Australia. Apply molecular tools to identify cryptic species or subspecies (unique lineages) among the often inconspicuous and difficult to identify aquatic plants. Develop a DNA barcode for the rare and priority species of the gnammas.
- Examine the genetic diversity of rare and/or priority plants in this system and compare with more common plants.
- Survey ecological factors that are important to these systems.

#### *Summary of progress (2009/2010) and main findings*

- Completed collections of southwest granites for *Myriophyllum petraeum* and *M. lapidicola*. Along with these taxa collected of *Isoetes*, *Glossostigma* and *Crassula* species across the southwest granites. This includes all but some of the most remote locations of *M. petraeum* and *M. lapidicola*. In collaboration with M Barrett and R Barrett have a complete collection from all known locations of *M. callitrichoides* ssp. *striatum*.
- Examination of the taxon *M. callitrichoides* from the sandstones of the Kimberley has uncovered species level divergence likely leading to the description of a new species and in the context of the Haloragaceae phylogeny potentially will reinstate the genus *Vinkia*.
- DNA extractions from *Glossostigma* spp. and *Isoetes* spp. have been performed and sequence data has been collected. Preliminary analyses suggest taxonomic revision will be necessary regarding

*Glossostigma*. A much wider distribution than currently known for *Glossostigma trichodes* means recommendation for alternative conservation designation is likely. Comparative phylogeography based on these data set and those of the distribution patterns of *M. petraeum* are being conducted.

- Complete data sets of cpDNA and ITS for *M. petraeum* have been constructed and analysed with strong regional divergence discovered. Species level divergence was uncovered and morphological characteristics being examined for possible split into a southern and northern species. This suggests a recommendation for higher conservation ranking of elements of this species is likely.

#### *Management implications*

Identification of unique lineages and rare species will lead to better, more targeted conservation plans. For example if regional patterns of diversity for *M. petraeum* are confirmed specific geographic groups of populations should be targeted for conservation rather than treating all populations equally. The vernal pools are under particular threat due to global climate change and weeds, especially those reaching through the wheatbelt and into more arid zones of the south-west.

#### *Future directions (next 12-18 months)*

- Complete analyses of *M. petraeum* data and collect data from an additional cpDNA region.
- Complete collection of molecular data from species of *Glossostigma*, *Isoetes* and *Crassula*.
- Test microsatellite markers developed for other *Myriophyllum* spp. for transferability to those rare and priority in the vernal pools, particularly the DRF *M. lapidicola*.

---

### **New tools to uncover a *Eucalyptus* phylogeny and evaluate conservation priority species**

SPP# to be allocated

*Team member*

M Moody (0.20).

#### *Context*

*Eucalyptus* is species rich genus with many taxa of conservation concern (including 35 species/subspecies in the south-west Western Australian groups *Hadrotes* and *Glandulosae* alone). Within *Eucalyptus* species boundaries can sometimes be vague and subspecific designation is often employed. Most species are described using morphology alone, but more frequently molecular methods are being employed to evaluate species limits across all organisms, especially among traditionally difficult taxonomic lineages. Given that conservation management uses 'species' as the primary measure of biodiversity, rigorous methods for species hypothesis testing are crucial. Newly developing methods to evaluate species hypotheses in systematics include phylogenetic or haplotype-network analyses using DNA sequence data, which requires data with high variability from both chloroplast and nuclear DNA sources, not currently available for *Eucalyptus*. This research will develop and test nuclear DNA intron sequence markers for variability at the species level among Western Australian taxa. These molecular markers can also be used to help in identification of seedling (de facto DNA barcode) or recognition of recent hybridisation, both important for conservation research.

#### *Aims*

- Develop nuclear DNA intron sequence markers that are phylogenetically informative at the species level and transferable across *Eucalyptus* using the Expressed Sequence Tag (EST) library for *Eucalyptus grandis*.
- Evaluate the utility of these markers through a phylogenetic analysis of the south-west Western Australia endemic *Eucalyptus* subsection *Hadrotes* and a selective sampling of *Glandulosae* and a sampling across all subgenera and several sections.
- Evaluate the utility of two chloroplast DNA intron markers for which high variability has recently been described across taxa evaluated using the nuclear markers.

#### *Summary of progress (2009/2010) and main findings*

- Completed evaluation of 20 nuclear DNA regions with 35 primer pairs. A subset of ten markers were isolated as most consistent for amplification across a wide range of *Eucalyptus* lineages with a further subset of six that were the most promising for species level phylogeny.
- Sequence data for most species of *Eucalyptus* subsection *Hadrotes* has been collected and currently being aligned and analysed across several accessions.
- Chloroplast DNA sequences have been collected for most species examined for nuclear DNA and comparisons of variability and phylogenetic topology will be compared.

#### *Management implications*

Development of these markers and their apparent utility at the species level is promising for use across *Eucalyptus* lineages for systematic studies evaluating species/subspecies hypotheses. These markers can potentially be used for species and hybrid identification and determining phylogeographic patterns.

#### *Future directions (next 12-18 months)*

- Complete collection of sequence data for the nuclear markers and test amplification across a wider set of *Eucalyptus* species.
- Complete analyses of variability of genes across all taxa, complete phylogenetic analyses of the *Hadrotes* group and evaluation of current species and subspecies limits of subsection *Hadrotes*.

---

### **Systematics of the triggerplant genus *Stylidium***

SPP # 2010-001

*Team Member*

J Wege (0.9).

#### *Context*

With almost 300 known taxa, the triggerplant genus *Stylidium* (Stylidiaceae) is one of the most abundant and diversified genera in Australia. Whilst substantial progress has been made over the past 20 years in documenting Australia's *Stylidium* diversity, our knowledge of the genus remains insufficient for scientific and conservation needs. There are many new taxa awaiting formal description, numerous species complexes that remain poorly understood, nomenclature and typification problems that require resolution, and there is no phylogenetic framework. Perhaps the most significant issue at this point in time is the lack of readily accessible diagnostic information and identification tools for the known species in Western Australia, which hinders accurate identification by conservation personnel, botanical consultants and other stakeholders. This is especially concerning in the south-west region where more than 60 taxa are listed as Declared Rare or Priority Flora, the majority of which require further survey to understand the full extent of their distribution.

#### *Aims*

- Improve the underlying taxonomic knowledge necessary for effective biodiversity management of *Stylidium* and to make this information readily accessible to stakeholders. This will be achieved through the resolution of the taxonomy, nomenclature and conservation status of each taxon, and the creation of an electronic key and species fact sheets. The current project focus is taxa occurring in southern Australia.
- Investigate phylogenetic relationships within *Stylidium* with a view to providing new insights into the evolutionary history of the genus and an evolutionary context for conservation management.

#### *Summary of progress (2009/2010) and main findings*

- An intensive program of field work in the south-west was planned and implemented in Spring, enabling data to be obtained for several species complexes currently undergoing taxonomic review. Samples were obtained for a molecular phylogeny project along with photographs of a range of species for inclusion in the interactive key. New populations for several conservation-listed taxa were

discovered. Some interesting and novel observations on pollinator activity were also recorded.

- A detailed taxonomic assessment of the microgeophyte *Stylidium* sp. Yalgoo confirmed that it is a distinct new species endemic to the Yalgoo region and potentially threatened by mining and mineral exploration. A paper describing this species and revising allied species has been drafted.
- Taxonomic research on *Stylidium despectum* and allies has been advanced. This has included a review of type specimens and the subsequent application of correct names to herbarium specimens at the Western Australian Herbarium, and institutions in Adelaide, Sydney, Melbourne and Hobart.
- 470 *Stylidium* specimens at the Western Australian Herbarium have had their identity corrected or confirmed. Additional specimens were annotated on visits to the National Herbarium of New South Wales, the State Herbarium of South Australia, and the National Herbarium of Victoria, at which time data was captured for inclusion in the interactive key.
- A paper discussing the naming of *Stylidium* and the type specimens of *S. graminifolium* and *S. lineare* was published in *Telopea*.
- A paper describing five taxa from south-west Western Australia and reviewing the typification of 24 taxa has been accepted for publication in *Nuytsia*.

#### *Management implications*

- Field survey, opportunistic collections, and the correction of misidentified herbarium specimens have together improved our understanding of the distribution, habitat requirements and conservation status of a range of south-west triggerplants. A nomination to list *Stylidium* sp. Yalgoo as Declared Rare Flora under the *Western Australian Wildlife Conservation Act 1950* will update the conservation status of this species.
- Nomenclatural stability for a range of species has been achieved through a review of type material. The publication of names, scientific descriptions, illustrations and associated data for several new taxa will enable stakeholders to recognise them.

#### *Future directions (next 12 months)*

- Conduct field studies and complete taxonomic papers on focus groups.
- Advance interactive key and fact sheets.
- Progress research on phylogenetic relationships within the genus and aspects of pollination ecology (in collaboration with the Royal Botanic Gardens, Kew and Prof. Scott Armbruster).

---

### **Comparison of plant canker disease impact and climatic variables in Proteaceae on the south coast of Western Australia and evaluation of selected fungicides as a management tool for canker control in the Declared Rare Flora *Banksia verticillata* and *Lambertia orbifolia***

SPP# 2010-004

#### *Team members*

C Crane (0.8), S Barrett (0.2), B Shearer (0.05), C Dunne (0.05).

#### *Context*

The contribution of canker fungi to stem and branch death in South Western Australia has largely been ignored. Canker pathogens both primary and facultative constantly take advantage of changes in the environment and host susceptibility and will provide direct measures of the mechanisms of climate change fluctuation on species distribution.

#### *Aims*

- Advance understanding of canker disease biology and epidemiology in the native plant communities within the national parks of the South Coast Region of Western Australia.
- Monitor shifts in canker expression in relation to current and predicted climate change.
- Develop direct therapy methods of mitigating impact of canker pathogens in high value natural and

translocated DRF populations including TEC's.

#### *Summary of progress (2009/2010) and main findings*

- Fifty four permanent transects have been established in *Banksia baxteri*, *B. coccinea*, *B. verticillata* and *Lambertia orbifolia* with 1 620 individuals scored for canker severity and impact assessed across 32 sites.
- 540 individual cankers have been cultured and the four most common known canker fungi have been selected, isolated and identified morphologically.
- Six hundred seedlings have been established in pots to be used in the stem inoculation/fungicide trial in October.
- Preliminary analysis indicates that the most frequently isolated pathogenic canker fungi in the *Banksia* species considered are those in the *Botryosphaeria* complex, a putative *Microthia*, *Cryptodiaporthe* and *Cytospora* spp. respectively. All of these fungi except *Cytospora* spp. are also being isolated at a low level from healthy asymptomatic tissue. This suggests they have some degree of benign endophytic role and indicates that the environment is moderating the host pathogen relationship. Co-occurrence of several of these pathogens in a single canker lesion demonstrates a possible synergism in canker disease expression.

#### *Management implications*

- Information will enable predictive capacity of temperature increases on canker in Proteaceae.
- Increased management options will be available through development of prescriptions for fungicidal treatments to reduce cankers in affected DRF species (including translocated populations), TEC's and native plant communities of significant biodiversity value in south Western Australia.

#### *Future directions (next 12-18 months)*

- Conduct and analyse efficacy study of three fungicides *in vitro* on mycelial inhibition of three canker fungi.
- Testing efficacy and phytotoxicity of top two fungicides selected from the *in vitro* trial in the glasshouse *in vivo* for four Proteaceous species.
- Testing efficacy and phytotoxicity of fungicides on *B. baxteri* and *B. verticillata* in the field and write up as research paper for submission to *Australasian Plant Pathology*.
- In collaboration with Dr T Burgess the anamorph of the putative *Microthia* and molecular description will be published.

---

### **Taxonomy of *Ptilotus* and *Gomphrena* (Amaranthaceae) and *Swainsona* (Fabaceae)**

SPP# to be allocated

Team member

R Davis (0.2).

#### *Context*

*Ptilotus*, *Gomphrena* and *Swainsona* are important genera particularly in arid and semiarid areas of Western Australia such as the Pilbara and Midwest regions, where they are often dominant components of the vegetation. This project includes basic taxonomic studies in these three genera, including the description of new species and taxonomic assessments of existing taxa, and preparation of a *Flora of Australia* treatment of the family Amaranthaceae. It also includes the development of interactive key to all Western Australian species in the three genera. Once complete, these will allow easier and more accurate identifications of all species than is the case using available keys.

#### *Aims*

- Publish new taxa in the genus *Ptilotus*.
- Review infraspecific taxa within *Ptilotus*.



- Create interactive keys to all Western Australian species of *Ptilotus*, *Gomphrena* and *Swainsona*.

#### *Summary of progress (2009/2010) and main findings*

- Two papers pending for *Nuytsia* dealing with infraspecific taxa in *Ptilotus stirlingii* and *Ptilotus polystachyus*.
- One paper published in *Nuytsia* dealing with the infraspecific taxa in *Ptilotus astrolasius*.
- 3 phrase-named taxa were added to the *Census of Western Australian Plants* as a result of ongoing taxonomic studies.
- Draft interactive keys to *Ptilotus*, *Gomphrena* and *Swainsona* completed.

#### *Management implications*

- *Ptilotus*, *Gomphrena* and *Swainsona* are ecologically important genera in the rangelands and arid lands of Western Australia. Many are annuals, and *Swainsona* is a nitrogen-fixing legume. Some species are useful indicators of ecological condition. Hence their taxonomy and identification is important for rangeland and arid land management.
- A number of species in all three genera are Priority listed or Declared Rare Flora, and further undescribed taxa are expected to be rare or narrowly endemic.

#### *Future directions (next 12-18 months)*

- Completion of descriptions of *Ptilotus* for the Flora of Australia treatment.
- Preparation of further papers describing new taxa in *Ptilotus* and other genera.
- Further field studies to assist in the resolution of problematic groups, particularly the widespread *Ptilotus obovatus* species complex.
- Progress Lucid keys to *Ptilotus*, *Gomphrena* and *Swainsona*.

---

### **Taxonomy of undescribed conservation taxa in the Ericaceae subfamily Styphelioideae**

SPP# to be allocated

*Team members*

M Hislop (0.2), A Chapman (0.1)

#### *Context*

Epacrid classification is undergoing fundamental reassessment at the generic level as new information on relationships is revealed. *Leucopogon*, in particular, is species-rich in Western Australia but is relatively poorly understood and includes many undescribed taxa, including ones of conservation significance. It is also clear that the genus cannot be maintained in its current circumscription, although generic boundaries are still uncertain. This project will continue to describe new taxa in *Leucopogon* and other genera in the subfamily Styphelioideae and, in collaboration with partners in eastern Australia, work towards a generic reclassification of the subfamily.

#### *Aims*

- Publish new taxa from the tribes *Styphelieae* and *Oligarrheneae*, prioritising, where practical, those of high conservation significance.
- Revise generic concepts in line with recent systematic studies.
- Continue a taxonomic assessment of species boundaries across the tribe *Styphelieae* (mainly in *Leucopogon*) with a view to identifying previously unrecognised taxa, especially those which may be geographically restricted.

#### *Summary of progress (2009/2010) and main findings*

- Two papers published in *Nuytsia* - seven new taxa of *Leucopogon* were described. A paper

describing a new, apparently rare species of *Acrotriche* was submitted.

- 12 phrase-named taxa were added to the Census of Western Australian Plants as a result of ongoing taxonomic study.
- Six taxa were added to the Declared Rare and Priority Flora List for Western Australia and one was removed.
- Collection and re-determination of *Leucopogon* and *Monotoca* specimens in the WA Herbarium, improving the standard of identification in the collection, and veracity of FloraBase output.

#### *Management implications*

The epacrids, of which *Leucopogon* comprises by far the largest genus, have a major centre of diversity in south-west Western Australia. An authoritative source of current information is fundamental to correctly managing the conservation taxa and the lands on which they occur for this taxonomically difficult group that is also very susceptible to a number of major threatening processes, including salinity and *Phytophthora* dieback.

#### *Future directions (next 12-18 months)*

- Preparation of further papers describing new taxa in *Leucopogon* and other genera.
  - Further field studies to assist in the resolution of problematic groups.
-

# LANDSCAPE CONSERVATION

**Program Leader: Dr Lachlan McCaw**

Applied research undertaken by the Landscape Conservation Program seeks to understand the factors and processes that determine the overall health and productivity of lands managed by the Western Australian Department of Environment and Conservation (DEC), which include State forests, national parks and other conservation reserves. This research is aligned to the information needs of DEC and the Forests Products Commission. Strong collaborative linkages exist with universities, cooperative research centres, CSIRO and other research institutions and the corporate sector.

---

## **FORESTCHECK – Integrated site-based monitoring of the effects of timber harvesting and silviculture in the jarrah forest**

SPP# 2006-003

### *Team members*

R Robinson (0.25), L McCaw (0.2), J Farr (0.25), K Whitford (0.3), R Cranfield (0.2), G Liddelow (0.2), V Tunsell (0.8), B Ward (0.2), A Wills (0.2), P Van Heurck (0.1).

### *Context*

FORESTCHECK is a long-term monitoring program and results will be used by forest managers to report against Montreal Process criteria and indicators for Ecologically Sustainable Forest Management. Initiated as a Ministerial Condition on the *Forest Management Plan 1994-2003*, FORESTCHECK has been incorporated in the *Forest Management Plan 2004- 2013* as a strategy for increasing knowledge on the maintenance of biodiversity and management effectiveness in WA's forests.

### *Aim*

To quantify the effects of current timber harvesting and silvicultural practices in the jarrah forest (gap creation, shelterwood, post-harvest burning) on soils, macrofungi, cryptogams (lichens, liverworts and mosses), vascular plants, invertebrates, terrestrial vertebrates and birds.

### *Summary of progress (2009/2010) and main findings*

- Eight grids in the Perth Hills district were re-measured during 2009/2010, with data collected for cryptogams (lichens, liverworts and mosses), macrofungi, vascular plants, invertebrates, terrestrial vertebrates, birds, litter and stand structure (basal area and stocking of overstorey species). Supplementary data were gathered on size and condition of coarse woody debris at each site.
- The 2009-10 annual report for the Wellington grids was completed. Findings were presented to Wellington district staff in October 2009.
- Eight draft papers have been finalised, and a further two are near completion, dealing with results of analysis from the first five years of monitoring.
- Briefings on the project were provided to staff of Sustainable Forest Management Division and the Forest Products Commission, the Conservation Commission and the Environmental Protection Authority.
- A proposal to establish additional monitoring grids as part of a biological survey of forests was presented to the Conservation Commission.

### *Management implications*

FORESTCHECK provides a systematic framework for evaluating the effects of current silvicultural practices across a range of forest types and provides a sound basis for adaptive management.

*Future directions (next 12-18 months)*

- Major analysis of data for the first five years of monitoring will be finalised.
- Draft papers to be submitted for publication.
- Establish additional monitoring grids in examples of forest harvested under SFM Guideline No.1, 2004, *Silvicultural Practice in the Jarrah Forest*.

---

**Monitoring long-term effects of various fire regimes on species richness and composition of southern jarrah forest understorey**

SPP# 1993-099

*Team members*

N Burrows (0.05), B Ward (0.20), R Cranfield (0.05), G Liddelow (0.1).

*Context*

Understanding long-term effects of fire on the floristics and structure of jarrah forests is important for developing and implementing ecologically appropriate fire regimes and for managing fire to protect life and property. This study, established in 1972 in Lindsay forest west of Manjimup, and in 1986 in Perup forest east of Manjimup and McCorkhill forest west of Nannup, was designed as a long-term experiment.

*Aims*

- Understand and quantify the long-term effects of different fire regimes on species richness, composition and structure of southern jarrah forest understorey.
- Determine the effects of different fire regimes on tree health and growth rate.

*Summary of progress (2009/2010) and main findings*

- A paper comparing tree diameter growth rates and crown condition over 20 years at the Perup forest site and under different fire treatments has been published.
- Spring and autumn burn treatments were applied at the Perup and McCorkhill sites.

*Management implications*

Based on 20 years of monitoring, there is no indication that regular prescribed burning at 6-10 year intervals, or long periods of fire exclusion, is having any significant effect on tree mortality and growth rate in low rainfall (~700 mm per annum) jarrah forest. Water stress will lead to reduced growth rates so stand density and leaf area index may need to be managed to maintain healthy forests in a drying climate.

*Future directions (next 12-18 months)*

- Maintain fire treatments at both study sites.
- Assess species richness and composition at both sites.
- Analyse all data on the effects of various fire regimes on understorey vegetation and prepare a paper for publication.

---

**Project Rangelands Restoration: Developing sustainable management systems for the conservation of biodiversity at the landscape scale in rangelands of the Murchison and Gascoyne bioregions**

(see also Rangelands Restoration – reintroduction of native animals to Lorna Glen page 79)

SPP# 2003-004

*Team members*

N Burrows (0.05), D Algar (0.2), G Liddelow (0.2), B Ward (0.2), J Angas (0.2), N Hamilton (0.2), M Onus (0.2). Goldfields Regional staff (0.2), Prof T Bragg (University of Nebraska, Omaha).

### *Context*

Despite the relatively pristine nature of most of the arid interior (desert bioregions) and rangelands (beyond the pastoral zone), there has been an alarming and recent loss of mammal fauna with about 90% of medium-size mammals and 33% of all mammals either becoming extinct or suffering massive range contractions. There is also evidence of degradation of some floristic communities due to altered fires regimes. The extent and nature of change in other components of the biodiversity, including extant mammals, birds, reptiles and invertebrates is unknown. The most likely causes of the decline and degradation in biodiversity are introduced predators, especially the fox (*Vulpes vulpes*) and the feral cat (*Felis catus*), and altered fire regimes since the departure from traditional Aboriginal burning practices over much of the region. Taking an adaptive experimental management approach in partnership with DEC's Goldfields Region, this project aims to reconstruct some assemblages of the original native mammal fauna on Lorna Glen, a pastoral lease recently acquired by DEC. This will be achieved by an integrated approach to controlling introduced predators and herbivores, ecologically appropriate fire management and fauna translocations.

### *Aims*

- Develop efficient, effective and safe introduced predator (fox and feral cat) control technologies for the interior rangelands and the arid region.
- Reconstruct the original suite of native mammal fauna through translocation once sustainable feral cat control can be demonstrated.
- Implement a patch-burn strategy to create a fine-grained, fire-induced habitat mosaic to protect biodiversity and other values.
- Describe and predict pyric (post-fire) plant succession and describe the life histories of key plant species.
- Monitor the long-term trends in species assemblages and abundance of small mammals and reptiles in an area where introduced predators are not controlled compared with an area where they are controlled.
- Model the relationship between seasons (rainfall) and the frequency and size of wildfires.

### *Summary of progress (2009/2010) and main findings*

- A successful feral cat, fox and wild dog baiting operation was carried out again in 2009 as part of the Western Shield program.
- Fire ecology (plants) and biodiversity monitoring sites were re-assessed. There are indications that predator control is increasing the diversity and abundance of extant ground dwelling vertebrate fauna, but this needs further analysis and may become more apparent with time.
- Strategic buffer and research burning was successfully carried out according to the fire management plan.
- An 1100ha predator-proof acclimatisation compound was constructed.
- Fire and biodiversity monitoring sites were installed.

### *Management implications*

- Information will inform guidelines for the proactive management of fire in the arid zone rangelands to reduce the severity (scale and intensity) of wildfires and to provide habitat choice through mosaic burning.
- Guidelines for controlling introduced predators in the arid zone rangelands will reduce this threat to native fauna.
- Reintroduction and protection of arid zone rangelands mammals, other extant fauna, vegetation and other elements of the biota will provide reconstruction of animal and plant assemblages in an arid zone ecosystem.

- A framework and protocol for assessing and reporting trends in ecosystem condition in arid zone rangelands will provide a basis for ecosystem condition monitoring.

#### *Future directions (next 12-18 months)*

- Implement and assess the effectiveness of a seventh annual feral cat and fox baiting program in August 2010.
- Increase the population of bilbies by further reintroductions.
- Reintroduce another two native mammal species.
- Continue to monitor extant fauna and vegetation (biodiversity monitoring sites).
- Complete analysis and write-up of first stage of fire ecology study.
- Implement revised fire management plan.
- Write-up and publish results of baiting trials at Lorna Glen.
- Continue assessment of vascular plants and invertebrates.
- Collate a progress report and promote and publicise all facets of the Rangelands Restoration project.

---

### **Burning for biodiversity: Walpole fine grain mosaic burning trial**

SPP# 2004-004

#### *Team members*

N Burrows (0.05), J Farr (0.1), R Robinson (0.1), G Liddelow (0.1), B Ward (0.25), R Cranfield (0.05), V Tunsell (0.1), P Van Heurck (0.1), A Wills (0.1). Frankland District are partners in the project and provide operational support for burning and ecological assessments.

#### *Context*

Fire management based on sound science is fundamental to the conservation of biodiversity and the protection of life and property in fire-maintained ecosystems of south-west Western Australia. There is a substantial body of scientific evidence that, within ecologically circumscribed parameters, fire diversity can benefit biodiversity at the landscape scale. We hypothesise that a fine-grained mosaic of patches of vegetation representing a range of biologically-derived fire frequencies, seasons and intensities will provide diverse habitat opportunities and can also contribute to reducing the occurrence of large, damaging and homogenising wildfires.

#### *Aims*

- Determine whether a fine-scale mosaic of vegetation at different seral (post-fire) stages benefits biodiversity at the landscape scale. Specifically the project will investigate:
  - the abundance of fire regime specific plant taxa, DRF and reserve listed taxa (e.g. *Synaphaea* sp., *Lambertia rariflora* subsp. *lutea*, *Banksia quercifolia*, *B. occidentalis*, *Banksia formosa*, *Hakea oliefolia*) under this fire regime;
  - abundance of fire regime specific fauna and condition of associated habitats including honey possum (*Tarsipes rostratus*), quokka (*Setonix brachyurus*), mardo (*Antechinus flavipes*), sunset frog (*Spicospina flammocaerulea*), reptile assemblages, bird assemblages, invertebrate assemblages, vascular plant assemblages and fungi and cryptogams.
- Develop the operational techniques to be able to use frequent and planned introduction of fire into the landscape (patch-burning) to create a fine-scale mosaic of patches of vegetation at different stages of post-fire development.

#### *Summary of progress (2009/2010) and main findings*

Additional biodiversity monitoring sites were established.

#### *Management implications*

The study demonstrates that fine grain patch-burning is operationally feasible in forest areas. The benefits to biodiversity are yet to be fully assessed – this will take time to emerge.

*Future directions (next 12-18 months)*

- Further/ongoing analysis of satellite imagery to determine patch-burn mosaic and distribution of seral stages, and schedule for next patch-burning in 2010/2011.
- Ongoing mapping of seral stages.
- Re-assess monitoring grids in spring/autumn 2010/2011 and establish and assess further grids in long unburnt vegetation as the mosaic shifts.

---

## **Genetic analysis for the development of vegetation services and sustainable environmental management**

SPP# 1998-007

*Team members*

M Byrne (0.2), B Macdonald (0.5), M Millar (0.1).

*Context*

Understanding the genetic structure and function of plants is important for their effective utilisation for revegetation and provision of ecosystem services, such as hydrological balance, pollination and habitat connectivity.

*Aims*

To provide genetic information for the conservation and utilisation of revegetation species. Current work aims to identify the mating system and population relationships of *Acacia saligna*; investigate the mating system and diversity in sandalwood, and determine genetic relationships between trees in a salinity/waterlogging trial in *Eucalyptus occidentalis*.

*Summary of progress (2009/10) and main findings*

- *Acacia saligna* –The structure of genetic differentiation among populations has assisted with identification of intra-specific taxa. Draft journal paper is in preparation.
- *Santalum album* – Genetic diversity paper has been published in *Silvae Genetica*.
- *Santalum spicatum* – Collections made from 15 natural populations and DNA extractions completed.
- *Eucalyptus occidentalis* – Journal paper on effect of genetic distance on progeny performance accepted for publication in *Silvae Genetica*.

*Management implications*

- *Acacia* - Several genetic and evolutionary lineages have been identified in both *A. microbotrya* and *A. saligna*. The level of differentiation between the lineages will support and inform taxonomic revisions of these two complexes. Clarification of the taxa within these complexes will enable development for revegetation plantings to be carried out in a reliable manner without risk of genetic contamination and hybridisation in natural populations.
- *E. occidentalis* – Improved survival of progeny from wide crosses under saline conditions and low genetic structure among families implies breeding with salt and/ waterlogging tolerant individuals would result in substantial increases in salt and/ waterlogging tolerance, but no decline in genetic diversity.

*Future directions (next 12-18 months)*

- Journal paper detailing genetic structure among intra-specific taxa of *A. saligna* will be finalised.
- Journal paper describing genetic diversity in *A. microbotrya* will be written.

---

## Identification of seed collection zones for rehabilitation

SPP# 2006-008

*Team members*

M Byrne (0.1), D Coates (0.1), S McArthur (0.5).

### *Context*

The Sustainable Forest Management Division of DEC provides guidelines to the Forest Products Commission on seed collection zones for forest rehabilitation. Rehabilitation of sites through revegetation requires knowledge of the genetic adaptation of species to sites in order to manage on an ecologically sustainable basis. This requires an understanding of the genetic structure and local adaptation of the species.

### *Aim*

To identify appropriate seed collection zones (provenances) for species being used for rehabilitation. Initial work is focused on species in the jarrah and karri forest where seed is used for rehabilitation after logging.

### *Summary of progress (2009/2010) and main findings*

- *Kennedia coccinea* – leaf material has been collected from 20 individuals in 25 populations and DNA extractions have been completed. Genotyping of samples has commenced.
- Trial DNA extractions of *Allocasuarina humilis* and *A. fraseriana* have been undertaken.

### *Management implications*

Knowledge of genetic structure and local adaptation will enable identification of appropriate seed collection zones for rehabilitation of forest areas in order to maintain the genetic integrity of the forest on a sustainable basis.

### *Future directions (next 12-18 months)*

- Further data analysis undertaken for *Bossiaea ornata*.
- Genetic analysis of *Kennedia coccinea* will be completed.
- Foliage samples of *Allocasuarina humilis* will be collected.

---

## Management of environmental risk in perennial land use systems

SPP# 2004-003

*Team members*

M Byrne (0.2), L Stone (0.2), H Clarke (0.15), C Munday (0.6), J Sampson (0.6).

### *Context*

The development of perennial-based land use systems for management of dryland salinity promises significant environmental and economic benefits, but there are also risks to existing natural biodiversity. These risks include the establishment of new plant species as environmental weeds, hybridisation with native species and gene flow from cultivated populations into natural populations.

### *Aims*

- Develop and implement procedures for management of environmental risk in the form of assessment and management protocols to be applied to all germplasm under development within the Future Farm Industries (FFI) CRC.
- Determine the mechanisms, extent, implications and management of genetic risk for selected taxa in commercial development.



#### *Summary of progress (2009/2010) and main findings*

- Weed risk assessments completed for 12 exotic and seven native forage and woody species; published on line at FFI CRC website.
- Revised environmental risk management policy presented to Management Committee.
- Genetic risk assessment protocol developed and journal paper written and submitted to *Evolutionary Applications*.
- Continued involvement in national discussions on improvements to border and post-border weed risk assessment.
- Journal paper on comparative assessment of weed risk protocols accepted for publication in *Plant Protection Quarterly*.
- Commenced data analysis for research study investigating flower: fruit production in variants of *Acacia saligna* under common environmental conditions, which may lead to the ability to select for less weedy cultivars.
- Commenced data analysis of the impact of the exotic species *Plantago lanceolata* on regeneration of native flora following a fire.
- Journal paper on the genetic structure in *Atriplex nummularia* and genetic differentiation between subspecies written.
- Conference paper entitled 'The 'duty of care' in introducing new plants for agriculture' presented at the Biosecurity in the new Bioeconomy: Threats and Opportunities symposium, Canberra and journal paper submitted to *Current Opinions in Environmental Sustainability*.
- Format for species management guide for land holders finalised, and guide drafted for three species.
- Guidelines for management of experimental trial sites drafted and circulated to FFI CRC members for comment.

#### *Management implications*

- Introduction of weed risk management and culture into the FFI CRC will reduce the risk of large-scale plantings of new perennial species becoming environmental weeds.
- Knowledge of gene flow will enable the risk of genetic contamination and hybridisation to be assessed and lead to development of risk management guidelines.

#### *Future directions (next 12-18 months)*

- Finalise genetic risk assessment protocol for implementation within the FFI CRC.
- Produce individual management guides for key species with some weed potential but significant agricultural benefit for publication by the FFI CRC.
- Finalise field trial guidelines for researchers in FFI CRC in consultation with agencies and stakeholders across Australia.
- Continue technical advice to FFI CRC researchers on weed issues, including new weed risk assessments.
- Publish research into flower and fruit production in *A. saligna*.
- Publish research on impact of *P. lanceolata* on native flora regeneration after fire.
- Continue involvement in national discussions on approaches to post-border weed risk assessment.
- Write paper on genetic identification of weedy populations of *A. saligna*.

---

### **State Salinity Strategy wetland monitoring**

SPP# 1998-018

#### *Team members*

A Pinder (0.1), D Cale (0.4), A Leung (0.1), M Lyons (0.25), C McCormick (0.75), J Lane (0.4), A Clarke (0.8), Y Winchcombe (0.4), B Muir (0.05).

### *Context*

Substantial biodiversity has been lost across the Wheatbelt Region of Western Australia over the past 100 years. The most pronounced physical changes to wetlands have been associated with native vegetation clearing and salinisation. Broadscale clearing has more or less ceased but salinisation and fragmentation processes will continue to be expressed for many decades. While it is known that salinisation is a major threat to wetland biodiversity, the relationships between its physical expression and loss of biodiversity are poorly documented and poorly understood. Physico-chemical monitoring aspects of this program began in 1977. Intensive monitoring of fauna, flora, water chemistry and groundwater began in 1997. This is a long term monitoring project.

### *Aim*

To monitor changes in biodiversity, surface water quantity and quality, and groundwater levels at selected wheatbelt wetlands in relation to increasing dryland salinity and land-use changes to provide information that will lead to better decision-making.

### *Summary of progress (2009/2010) and main findings*

- Fauna monitoring – field component of 2009 monitoring completed, invertebrate dataset being incorporated into comprehensive reports on data collected between 1997 and 2009. A new sub-project monitoring fauna in the Lake Warden and Lake Gore wetland systems was commenced. This is a continuation of work undertaken by consultants since 2006. Further field assessment of multi-decadal changes in waterbird use and habitat condition of selected south-west Wetlands Monitoring Program (SWWMP) wetlands was undertaken.
- Surface water monitoring – 2009 depth and water quality monitoring was undertaken at 103 wetlands, and data added to the SWWMP database and supplied to managers and external researchers. Continuous water level recorders and rain gauges installed on several high conservation value wetlands under threat. High resolution oblique aerial photography was obtained for a number of wetlands in the Wheatbelt and Midwest regions. Direction and support provided for student study of impact of small increases in salinity on biota of freshwater wetland (Lake Davies).
- Wetland bathymetry – No bathymetric surveys were undertaken in 2009/2010, however several water edge contours were mapped at a small number of wetlands.
- Vegetation monitoring for 2009 completed.
- Reporting – Ten year review of all project components produced for review of wider State Salinity Strategy. Report on 1998 to 2007 monitoring at Lake Eganu completed. Report on 1997 to 2009 monitoring at Lake Wheatfield in preparation. Paper on the fauna monitoring component presented at the 2009 Australian Society for Limnology Conference in Alice Springs as part of a workshop on state based wetland monitoring programs. Annual report presenting 1977-2008 depth, salinity and pH data for 101 currently-monitored wetlands completed. Report on multi-decadal changes in waterbird use and habitat condition at selected wetlands completed.

### *Management implications*

- Monitoring of depths, salinities and pH of 101 SWWMP wetlands reveals a number of wetlands are undergoing changes that warrant further investigation and corrective management.
- Loss of vegetation is continuing even at long-salinised wetlands where the physical expression of salinity in water is more or less stable. Such wetlands also show declines in faunal use. However, even highly salinised wetlands have high value for some fauna elements if they freshen during fill events (e.g. Lake Eganu).
- The long term nature of the project has provided an understanding of the range of variation in biotic communities under different climates, providing a context against which to assess and predict future changes.
- Surface water management is as important in some Wheatbelt wetlands (eg. Coomalbidgup Swamp) as groundwater management in maintaining wetland health and greater focus on surface water is required.
- Some wetlands not threatened by saline groundwater rise are nonetheless increasing in salinity due to declining rainfall and evapo-concentration of surface water salts. Changes in waterbird habitats

and waterbird use are also occurring due to declining water levels alone. Rising groundwater and declining rainfall are effectively squeezing the south-west wetland resource at both ends. This has implications for prioritisation of conservation efforts.

*Future directions (next 12-18 months)*

- Continue monitoring according to current protocols but monitor some of the 25 intensively monitored wetlands less frequently where continued biennial monitoring is considered redundant.
- Produce 1977-2008 and 1977-2009 annual SWWMP reports during 2010/2011 financial year.
- Continue to produce reports on all data collected between 1997 and 2006 during 2010/2011 financial year, with priority given to wetlands in recovery catchments.
- Complete program of obtaining high resolution, oblique aerial photography of all SWWMP wetlands to assist in vegetation mapping, condition monitoring and fauna surveys, and for interpretive purposes.
- Undertake bathymetric surveys of SWWMP monitored wetlands on an opportunistic basis.
- Continue continuous water level and rainfall monitoring at selected high value SWWMP wetlands under threat as a precursor to hydrological modelling.

---

**Monitoring stream biodiversity (KPI 20 of the Forest Management Plan)**

SPP# 2006-002

*Team members*

A Pinder (0.15), A Leung (0.4), M Pennifold (0.70).

*Context*

Key Performance Indicator 20 of the *Forest Management Plan 2004-2013* requires that aquatic macroinvertebrates be monitored in a selection of streams to provide information on trends in aquatic biodiversity across the forest, particularly in relation to logging and associated forest management activities. It is intended that there be no widespread or sustained decline in aquatic biodiversity as a result of land management practices.

*Aim*

To monitor richness of aquatic macroinvertebrate families (and species richness within selected orders) at 50 sites in jarrah and karri forest each spring.

*Summary of progress (2009/2010) and main findings*

- The fifth round of sampling was completed in 2009.
- Annual logging and fire histories of all 50 catchments summarised in a GIS environment for the period from 2000 to 2010.
- A report summarising findings of the first four years of monitoring was completed.

*Management implications*

There is very little evidence that current logging and fire management practices in forest catchments have a significant effect on downstream aquatic invertebrate communities.

*Future directions (next 12-18 months)*

- Identify invertebrates from the 2009 sampling.
- Undertake stream sampling in spring 2010.

---

## **Bushfire CRC Project 1.4: Improved methods for the assessment and prediction of grassland curing**

SPP# 2007-007

*Team member*

L McCaw (0.05).

### *Context*

Grassland curing has a significant effect on bushfire behaviour, particularly the development and subsequent rate of spread of a fire. Australian and New Zealand fire behaviour models and fire danger rating systems require grassland curing as an input to predictions of fire danger and fire spread. Outputs from fire danger rating systems are used by fire management agencies to determine fire danger and to aid in fire management activities such as determining fire season status, resource allocation and imposition of restrictions on activities. These decisions can have significant economic and social impacts on local communities. Similarly, predictions of rate of spread and headfire intensity based on grassland fire behaviour models assist in fire suppression decision-making, and in decision making about prescribed burning. The degree of curing is currently assessed visually or by satellite remote sensing using an index based on the reflective properties of grasses at different wavelengths. Improved techniques for estimation of grassland curing are particularly important for implementing fire management programs in remote areas of northern and interior Western Australia.

### *Aims*

- Extend current grassland curing field data across Western Australia so that improved methods for the assessment and prediction of grassland curing are robustly applicable over a wide range of grassland types.
- Develop and validate improved methods for assessment and prediction of grassland curing by establishing sampling sites representative of the major grasslands of Western Australia, and collecting and analysing grassland curing data from major grasslands.

### *Summary of progress (2009/2010) and main findings*

- Four curing map products based on different algorithms were made available to DEC fire practitioners on a fortnightly basis during the southern Australian dry season to facilitate field evaluation in Midwest, Wheatbelt, Swan, South West, Warren and South Coast Regions.
- Feedback was collated and provided to scientists at CSIRO to assist in validating the remote sensing products.

### *Management implications*

Development of methods for assessing and predicting current and future levels of curing in grasslands, focusing on two main areas, remote sensing applications and pasture (grass) growth modelling, will allow improved predictions of fire behaviour.

### *Future directions (next 12-18 months)*

- Feedback from the field validation will be analysed and used to select the most reliable curing algorithm.
- Findings of the project will be prepared for publication.

---

## **Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the jarrah forest**

SPP# 2000-003

*Team member*

J Kinal (1.0).

### *Context*

This is a long-term experiment established in 1999 to address part of Ministerial Condition 12-3 attached to *Forest Management Plan 1994-2003*. Ministerial Condition 12-3 states that DEC shall monitor and report on the status and effectiveness of silvicultural measures in the intermediate rainfall zone (900 – 1100 mm/yr) of the jarrah forest to protect water quality.

### *Aim*

To investigate the hydrologic impacts of timber harvesting and associated silvicultural treatments in the intermediate rainfall zone of the jarrah forest.

### *Summary of progress (2009/2010) and main findings*

- Monitoring of groundwater levels, stream flow, stream salinity and stream turbidity in the two treatment catchments and in the control catchment continued during 2009/2010.
- Nine years after treatment peak groundwater response, relative to the control catchment, was about 1.8 m in the intensive-treatment catchment and about 1.2 m in the standard-treatment catchment. There has been no measurable streamflow or stream salinity response to treatment, relative to the control, because deep saline groundwater has disconnected from surface water and continued to decline following the treatments and hence does not contribute to streamflow.
- A DEC Science Information Sheet summarising the key findings of the study was produced.
- A paper describing the comparative hydrological response to two different intensities of timber harvesting and silvicultural treatment was submitted to the *Journal of Hydrology*.

### *Management implications*

- The strong relationship between the magnitude of vegetation reduction and the extent of groundwater rise can guide harvesting and silvicultural practices.
- The risk of increased stream salinity from current harvest and silvicultural practices is lower than with past practices because the prevailing drying climate and retention of more vegetation following harvest result in more subdued groundwater rise than observed in the past.
- This study has confirmed the need to adequately control runoff from roads located within stream buffers to prevent sedimentation of streams.

### *Future directions (next 12-18 months)*

- Monitoring of groundwater levels, streamflow, stream salinity and turbidity and rainfall should continue because the data provide a unique long-term record of the hydrological response of the jarrah forest to climate change.
- Prepare a paper describing the effect of declining groundwater levels on streamflow generation and stream salinity in the jarrah forest.
- Prepare a joint paper with Geoff Stoneman on the effects of climate change on the hydrology of forests in the south-west of Australia and implications for future forest management to be presented at the 2010 IUFRO World Congress in Korea.
- Collaborate with other agencies to apply a hydrological model to the results of this study.

---

## **Management of the Vasse-Wonnerup wetlands**

SPP# 1999-017

### *Team members*

J Lane (0.20), A Clarke (0.1), Y Winchcombe (0.1).

### *Context*

There is a long history of mass fish deaths in the lowest reaches of the Ramsar-listed Vasse-Wonnerup

wetland system. The incidence and severity of deaths can be reduced by timely openings of the entrance sandbar and two sets of floodgates. Careful management of flows and water levels is needed to prevent adverse impacts on fringing vegetation, waterbirds and adjoining properties. Following a mass fish kill in 1997, DEC led the establishment of an inter-agency technical working group to co-ordinate relevant agency activities. This lead role is being maintained.

#### *Aims*

- Perform a lead role in the management of water levels, flows and salinities in the Vasse-Wonnerup wetland system.
- Undertake monitoring programs that will enable impacts of Vasse-Wonnerup water level, flow and salinity regimes to be assessed. The principal issues of interest in this project are impacts on waterbird populations, fringing plant communities and adjoining properties and the occurrence of mass fish deaths.

#### *Summary of progress (2009/2010) and main findings*

- Monitoring of fish activity and water levels at the floodgates was undertaken by team members during 2009/2010. The Vasse estuary floodgates fish gate was opened for periods in summer-autumn to maintain the target water level, allow fish to pass and kill some potentially toxic algal blooms. The Wonnerup estuary floodgates fish gate was opened periodically to maintain a minimum level sufficient to allow fish to be released if necessary.
- A mass fish kill event occurred in the Vasse estuary exit channel on 7 February 2010 following malfunction of an electronically-controlled fish gate installed by the Water Corporation. The probable cause and contributing factors were identified, relevant authorities were alerted and a cleanup was undertaken.
- Bathymetric maps of the Vasse-Wonnerup estuary and adjoining floodplain were completed.
- A study of historical (pre- and post-1830s) use and management of Vasse-Wonnerup and its floodplain was initiated.

#### *Management implications*

Water levels and flows are managed throughout the summer-autumn period to minimise adverse impacts on waterbird populations and fringing plant communities that could result from excessive water levels and salinity. The potential for, and risks associated with, malfunction of the electronic fish gate control system during critical periods was identified and addressed.

#### *Future directions (next 12-18 months)*

- The Vasse Estuary Technical Working Group will be convened as necessary to decide on management, monitoring and other responsibilities.
- Monitor water levels and fish activity during summer-autumn to guide the use of gates for managing water levels and fish populations.
- Employ measures that will eliminate (preferably) or reduce risks associated with electronic fish gate malfunction during critical periods.
- Prepare a concise report documenting water levels, floodgate openings, fish releases and mass fish death incidents in the Vasse-Wonnerup system since the December 1997 report of Lane, Hardcastle, Tregonning and Holtfreter.

---

### **Monitoring post-fire effects from the 2001 Nuyts wildfire**

SPP# 2006-001

#### *Team members*

G Liddelow (0.05), B Ward (0.05), R Cranfield (0.05), P Van Heurck (0.01), L McCaw (0.05). Frankland District staff as required.

### *Context*

Understanding the effects of different fire regimes is important for developing and implementing ecologically appropriate fire regimes and for managing fire for the protection of life and property. This study was established to take advantage of the opportunity presented by an unplanned fire that was ignited by lightning in March 2001 following an extended period of below average rainfall.

### *Aim*

To monitor impact of severe bushfire in karri/tingle forest on plants, invertebrates, vertebrate fauna and stand structure.

### *Summary of progress (2009/2010) and main findings*

- Eucalypt survival and growth were re-assessed in December 2009.
- Data on tree mortality, eucalypt regeneration, shrub regeneration and bird population responses are being analysed and prepared for publication.

### *Management implications*

This study contributes to the development of ecologically appropriate fire regimes for tall forests in southern Western Australia. Results to date indicate that long-term fire exclusion can result in very severe fire impacts on many components of the forest ecosystem and that large scale high intensity bushfires can have undesirable ecological outcomes including simplification of plant population structure and depletion of seed banks.

### *Future directions (next 12-18 months)*

- Data will be prepared for scientific publication.
- Further measurements may be made in 2011 to provide information on responses ten yrs after fire.

---

## **Long-term monitoring of impact of timber harvesting on bird populations in south-west forests**

SPP# 1994-008

### *Team Members*

I Abbott (0.01), G Liddelow (0.01), C Vellios (0.01), V Tunsell (0.01), M Williams (0.01).

### *Context*

Understanding the long-term effects of timber harvesting on bird populations in karri and jarrah forests is important for predicting how bird species and numbers of individuals respond in terms of time since regeneration.

### *Aim*

To quantify the effects of timber harvesting and silvicultural practices in karri and jarrah forests on birds.

### *Summary of progress (2009/2010) and main findings*

A paper presenting results from long term monitoring of bird populations after logging in forests in south-west Western Australia was published in *Conservation Science Western Australia*.

### *Management Implications*

- This study evaluates the effect of past silvicultural practices in the karri and current silvicultural practices in the jarrah forests.
- Avifaunal composition of logged and unlogged karri forest was the most similar so far, 21 years after logging took place, but species richness and total abundance remained higher in unlogged karri

forest. In jarrah forest, species composition in four treatments (two logged, two unlogged) had not closely converged after ten years.

- The data accrued so far provide an important baseline for assessing future impacts from changing climate, and any associated changes in fire regimes and infection by animal disease and *Phytophthora cinnamomi*, as well as for evaluating the ecologically sustainable basis of forest management.

#### *Future directions (next 12-18 months)*

- Counts are scheduled for the Kingston plots in 2011 (15 years after regeneration).
- Counts at the Gray plots should be repeated less frequently (every 15 years), with the next due in 2021 (36 years after regeneration).
- These plots are now historically significant and have been converted into a long-term monitoring study; they should not be disturbed by logging, and fire management needs to be timed so that scheduled bird counts are not compromised by the introduction of confounding factors.
- Resources permitting, eight plots in karri forest established and studied in 1981-1982 by Alan and Sue Tingay will be relocated, permanently marked, and censused for birds. The regenerated forest on the four logged plots is now 26-77 years old, and this range of ages will help complement the information already obtained from Gray forest block (21 year old regeneration, 120-250 year old mature karri forest).

---

### **Project Vesta – prediction of high intensity fire behaviour in dry eucalypt forest**

SPP# 1997-003

*Team member*

L McCaw (0.3).

#### *Context*

Successful fire management depends on the ability to reliably predict the behaviour of fires burning under a wide range of fuel and weather conditions. Fire management policy and practice must be underpinned by a sound understanding of fire behaviour so that the most effective and appropriate practices are employed for particular circumstances. This project has addressed recognised limitations in previous fire behaviour prediction models for dry eucalypt forests.

#### *Aims*

- Develop a national fire behaviour prediction system for dry eucalypt forests.
- Quantify changes in fire behaviour as fuels develop with age.
- Develop new algorithms describing the relationship between fire spread, wind speed, and fuel characteristics.
- Characterise wind speed profiles in forests with different overstorey and understorey structures.

#### *Summary of progress (2009/2010) and main findings*

- A paper describing the fuel moisture prediction module of the fire behaviour guide has been accepted for publication in the *International Journal of Wildland Fire*.
- Fire practitioners from Donnelly, Frankland, Blackwood and Wellington Districts were briefed on the practical application of the *Field Guide for Fire Behaviour Prediction in Dry Eucalypt Forests* and potential fire behaviour for representative fuel types was calculated daily throughout the 2009/2010 fire season.
- Findings from the project were used in preparing expert evidence to the Victorian Bushfires Royal Commission on the effectiveness of fuel reduction burning in mitigating the behaviour of intense summer bushfires. A presentation on this topic was also made to the Stakeholder Roundtable group on prescribed burning convened by the Victorian Department of Sustainability and Environment.
- A manuscript detailing flame characteristics during summer bushfires was prepared.



- Key findings from Project Vesta have been incorporated in a chapter on fire behaviour for an updated edition of the *Flammable Australia textbook*.

#### *Management implications*

Fire managers will be provided with the best available tools to predict fire behaviour to achieve prescribed burning objectives and safe wildfire suppression.

#### *Future directions (next 12-18 months)*

Complete publication of scientific papers on fuel description, fire behaviour experiments, flame dimensions and spotting.

---

### **Increasing productivity of karri regrowth stands by thinning and fertilising**

SPP# 1993-106

*Team member*

L McCaw (0.05).

#### *Context*

Thinning to concentrate growth on selected trees is an important component of the silviculture of regenerated karri forest and contributes to achievement of forest structure and productivity goals. Thinning also benefits forest protection by reducing the likely impacts of drought, and facilitating the re-introduction of prescribed fire into regrowth stands. This study quantifies the growth response of a variety of stands on different site types and contributes important information on long-term growth and stand development.

#### *Aim*

To provide information about tree and stand growth response to a range of silvicultural treatments that may be applied to even-aged stands of karri regrowth including thinning from below, fertilising with macronutrients and trace elements and coppice control.

#### *Summary of progress (2009/2010) and main findings*

- The thinning experiment in mixed karri marri regrowth forest at Sutton block was re-measured.
- Data from thinning experiments at Treen Brook, Warren and Sutton forest blocks were validated in preparation for analysis.

#### *Management implications*

Growth response from thinning is factored into scheduled timber yields from the karri forest, and it is important that the magnitude of the response be validated by periodic measurements. Potential losses from *Armillaria* root disease also need to be quantified.

#### *Future directions (next 12-18 months)*

- Re-measurement of the Warren experiment is scheduled for 2010/2011 and may incorporate a further thinning treatment in some plots.
- Analyse growth response data from thinning experiments to make information available for a review of silviculture during 2011/2012.

---

### **Espacement effects on the development and form of regrowth karri stands**

SPP# 1993-107

*Team member*

L McCaw (0.05).

### *Context*

Karri forest is regenerated following clearfell timber harvesting by planting with nursery-raised seedlings. Initial planting density has important long term effects on the productivity and growth form of regenerated stands. Planting densities were increased during the 1990s in recognition of the fact that some stands planted at 1250 stems per ha had poor form with persistent large branches and short boles. This trial was established in 1991 and is periodically re-measured to assess tree and stand growth, survival and tree form. The trial was last measured in 2009.

### *Aim*

To quantify the effects of initial stocking and espacement on stand growth, tree growth and form of karri planted following clearfell harvesting operations. This trial employs a scotch plaid design with four replicate blocks each providing examples of nine spacings ranging from 800 to 5 000 trees per ha.

### *Summary of progress (2009/2010) and main findings*

Data from measurements done in 2009 were validated and prepared for analysis. The relative dominance of individual trees has become clearly established and many suppressed trees have died as a result of competition.

### *Management implications*

Current guidelines for planting density in regenerated karri stands appear soundly based, and initial planting densities above 3 000 stems per ha do not appear to confer any significant improvement in the form of dominant or codominant trees.

### *Future directions (next 12-18 months)*

- Complete measurement of tree height and branching habit.
- Prepare a manuscript comparing survival, growth and form of planted karri for the period 1991-2009.

---

## **Fire induced mosaics in semi-arid shrublands and woodlands**

SPP# 1993-086

*Team member*

L McCaw (0.10).

### *Context*

Shrublands and woodlands are widespread in semi-arid areas of southern Western Australia. Large areas occur on unallocated crown land and in conservation reserves that are sparsely populated and have not been extensively disturbed by pastoralism, mining or clearing. Summer lightning storms regularly ignite wildfires that may burn for months with minimal or no intervention. The spread of fires is determined by the distribution of vegetation types, low fuel areas such as salt lakes and rock outcrops, and the pattern of past fires. Intense fires can cause long-term changes to the structure of eucalypt woodland communities and in some cases it is difficult to reconcile the long-term persistence of woodlands with the pattern of burning observed over the past few decades. Remote semi-arid lands provide a valuable opportunity to examine natural disturbance regimes which can be compared with more populated and intensively managed landscapes in the south-west.

### *Aims*

- Examine the frequency, intensity and cause of fires in semi-arid landscapes dominated by woodland and shrubland.
- Document the age-class (time since fire) distribution for woodlands and shrublands at a landscape scale.
- Document and interpret the response of vegetation structure to different fire regimes.

#### *Summary of progress (2009/2010) and main findings*

- A paper describing the potential of *Callitris preissii* for dendrochronology has published in *Dendrochronologia*. This paper confirms that tree rings can be used to accurately date the year of past fire events. Tree rings of *Callitris* showed strong inter-series correlation across a broad geographic area suggesting consistent growth response to regional environmental factors.
- A paper examining spatial controls on bushfire frequency has been accepted for publication in the *Journal of Biogeography*.
- Information gained from this project has been presented at two workshops on fire management in the Great Western Woodlands.

#### *Management implications*

Fire managers will be better informed about current fire regimes and the need for active intervention through planned burning or fire suppression, and potential effects of changing patterns of rainfall and temperature in southern Western Australia.

#### *Future directions (next 12-18 months)*

- Publish a paper on the influence of climatic factors on fire occurrence in semi-arid ecosystems.
- Contribute to data analysis and preparation of papers on stand structure and recruitment of *Callitris* in semi-arid ecosystems.

---

### **Fire regimes and biodiversity decline in the Kimberley**

SPP# 2007-008

#### *Team members*

I Radford (1.0), R Fairman (1.0).

#### *Context*

Recent studies in the Northern Territory have shown declines in critical weight range (CWR) mammals (35g-5kg) and some species of birds and shrubs. Biodiversity declines in otherwise intact landscapes have been attributed to increased intensity and frequency of fires. Studies in central Australian arid environments have also highlighted the strong influence of fire, combined with introduced predators, on mammal species abundance. This evidence from both the tropical savannas and arid environments has obvious implications for northern regions in WA including the Kimberley, as these regions have also apparently undergone major shifts in fire regimes. A direct link between abundance of threatened animals and fire regimes in this region has yet to be established. This study will establish whether fire has a strong influence on abundance of threatened taxa in the north Kimberley (Mitchell River region), the last mainland stronghold for many threatened critical weight range mammal species. Studies will also address the question of how fire influences CWR mammals by analysing vegetation structure and resource dynamics.

#### *Aims*

- Spatially quantify the fire history in the Mitchell River and Purnululu regions.
- Establish whether fire history influences abundance of threatened groups, particularly mammals, and to quantify re-colonisation rates for threatened species after fire.
- Link fire history and mammal abundance with vegetation and resource community (consumers including invertebrates and small vertebrates) attributes, which might explain the effect of fire.

#### *Summary of progress (2009/2010) and main findings*

- Eight sandstone sites (of the original 18 sites) were sampled in more detail from March 2008 to April 2010. In addition to mammal trapping, vegetation structure and reptiles/frogs were sampled five times, ground dwelling invertebrates four times, grass layer invertebrates three times and ground

active and subterranean ants once each.

- Non-fire related influences had the greatest effects on mammals, with sandstone habitats having much greater mammal abundance than woodlands on laterite or basalt. Time-since-fire and associated vegetation structural features (e.g. grass cover and biomass) had only weak and sporadic influence on mammal abundance. Site specific features had the greater influence on mammal abundance and fire frequency did not influence animal abundance.
- Food resource features showed no relationship with mammal abundance. Although grass seed availability showed a positive relationship with time-since-fire, rodents which eat grass seeds were not strongly influenced by this resource.
- Mosaic scale context had an important influence on localised mammal presence at study sites. Common mammals were present in most samples within fine-grain mosaic sites throughout the study period. In contrast, some mammals such as northern quolls and rock rats were often absent from coarse-grain mosaic sites.
- Findings from the project were presented at a workshop attended by personnel from the Australian Wildlife Conservancy and DEC at Mornington Sanctuary in November 2009.

#### *Management implications*

Persistence of CWR mammals will be favoured by fire mosaics with small burn patch size (<1 km<sup>2</sup>) and that retain patches of long unburnt vegetation. While this may be difficult to achieve at a regional scale throughout tropical savannas due to resource constraints, target management areas could be established for application of fine-grain mosaics locally to test their conservation benefits. Evaluating biodiversity outcomes of DEC fire management operations is crucial within an adaptive management context if we are to avoid mammal communities collapses which have already occurred elsewhere in northern Australia (e.g. Kakadu).

#### *Future directions (next 12-18 months)*

- Establish a regional monitoring program in the north Kimberley regional to evaluate the effectiveness of fire management in maintaining mammal populations.
- Prepare a manuscript on influence of fire regime on northern quoll populations.
- Prepare a manuscript on the influence of fire mosaics on northern quoll home range and population dynamics.

---

### ***Armillaria spread in karri***

SPP# 1998-006

*Team member*

R Robinson (0.2).

#### *Context*

*Armillaria* root disease impacts significantly on the silviculture and management of regrowth karri forests. Levels of infection in young stands increase significantly following thinning on high quality sites. Infection impacts significantly on the mean total volume of a stand in the form of wood defect and mortality in residual crop trees. This study is designed to look at the options for control of *Armillaria* root disease at the stage of first thinning in karri regrowth forests on high quality sites.

#### *Aims*

- Investigate control methods of *Armillaria* root disease in karri regrowth forest.
- Investigate the effects of management on *Armillaria* root disease in karri regrowth forest.
- Investigate how *Armillaria* root disease affects karri tree growth.

#### *Summary of progress (2009/2010) and main findings*

- Findings from Warren thinning experiment were presented and discussed at a meeting on

management of *Armillaria* root disease convened by Sustainable Forest Management Division in February 2010.

- A presentation on management of *Armillaria* root disease was given to the International Association of Arboriculturalists (Australian Chapter).

#### *Management implications*

The control of *Armillaria* root disease has been integrated into first thinning operations in high quality karri regrowth forest.

#### *Future directions (next 12-18 months)*

- Review plan for second thinning of plots in the Warren thinning experiment.
- Procedures for *Armillaria* root disease assessment and impact will be revised.

---

### **The effect of wildfire on forest fungi**

SPP# 1998-015

#### *Team member*

R Robinson (0.1).

#### *Context*

Fungi are amongst the most important of forest organisms in terms of their biodiversity and ecosystem functions. Fungi play key roles in decomposition and nutrient cycling, enhance soil structure and nutrient uptake by plants, and provide food for native mammals. Fire impacts significantly on the physical environment in which fungi persist. By monitoring the presence of fungal fruit bodies on burnt sites over time, changes in species composition and abundance can be determined. The results can be included in the forest management when making decisions on appropriate fire regimes for the maintenance of biodiversity.

#### *Aims*

- Investigate the effects of wildfire on fungi in karri forest.
- Monitor the succession of fungi on burnt sites in karri forest.
- Collect vouchers and catalogue macrofungi in karri forest.

#### *Summary of progress (2009/2010) and main findings*

- Co-authored a report on the impacts of wildfires on fungal in eucalypt forests for the Victorian National Parks Association.
- Co-authored a review paper on the impacts of bushfire on Australian fungal communities which was accepted for publication in the *Australian Journal of Botany*.

#### *Management implications*

Results contribute to information on the management of fire for the conservation of biodiversity in eucalypt forest. Results show that many species of fungi respond directly to fire or are associated with the post-fire conditions in karri forest. Fungal community structure differs significantly for each year following fire for at least five years. Fire mosaics have the potential to enhance fungal diversity across a landscape.

#### *Future directions (next 12-18 months)*

- Analysis of 10-year post-fire survey data continued.
- Laboratory work continues to catalogue and identify voucher specimens collected.
- Analyse biodiversity data against rainfall and Soil Dryness Index measurements as a measure of

fungal diversity in karri forest.

---

## Forest health and vitality surveillance and monitoring

SPP# to be allocated

*Team members*

R Robinson (0.15), J Farr (0.15).

### *Context*

Key Performance Indicator 17 of the Forest Management Plan requires that DEC report on the severity status of weeds and pests and investigate the cause of any increase in severity status as a result of management actions. This forms part of the adaptive management process. DEC requires a structured approach to monitoring to identify significant weeds, diseases and pests and track their status over time.

### *Aim*

To devise, establish and implement a Forest Health Surveillance (FHS) system for Western Australian forests.

### *Summary of progress (2009/2010) and main findings*

- A pest, disease and quarantine status report for WA forests was prepared and incorporated into the 2009-2010 Research Working Group 7 (Forest Health) report for Australia and New Zealand.
- An outbreak of gum leaf skeletoniser (*Uraba lugens*) was detected north of Manjimup in February 2010, with distinct centres of activity in Yanmah/Wheatley and in Dingup/Kinkin and Quillben forest blocks. A road survey of 45 monitoring sites established following a previous outbreak in the 1980s was conducted to establish the geographic distribution and severity of outbreak. Findings from the road survey were summarised in a brief report.

### *Management implications*

Pest and disease incursions can have major implications for economic and biological values of native forests and plantations and monitoring has a key role to play in timely and effective response to incursions.

### *Future directions (next 12-18 months)*

- Prepare 2010-2011 pest, disease and quarantine status report for WA forests.
- Re-activate the program of canopy sampling for gum leaf skeletoniser at sites previously monitored for insect population activity during the 1980s.

---

## Aspects of dieback behaviour relevant to the formulation of jarrah silviculture guidelines

SPP# 2007-009

*Team member*

M Stukely (0.5).

### *Context*

Jarrah stands are managed in accordance with SFM Guideline No.1 *Silvicultural Practice in the Jarrah Forest* to promote the growth of crop trees for timber production and to conserve other forest values. The presence of the pathogen *Phytophthora cinnamomi* requires implementation of appropriate measures to minimise the impact of *Phytophthora* dieback disease on the forest and the consequent reduction in its productivity and ecological integrity. On sites where disease impact is predicted to be moderate to high the silvicultural operation termed 'Selective cut in dieback' is in general use. A number of key assumptions underpin this guideline.

### *Aims*

- Understand the effect of current silvicultural treatments on dieback expression.
- Understand the effect of alternative approaches to silvicultural treatments on dieback expression.
- Investigate the effect of retained over-storey in relation to dieback impact escalation.
- Investigate the occurrence and persistence of jarrah regeneration [and key tolerant species] in the presence of *Phytophthora cinnamomi* on different sites.

### *Summary of progress (2009/2010) and main findings*

- Initial tree and mid-storey plant measurements were completed on the newly established permanent trials at Sites 1-4 in Cobiack Block (Wungong Catchment) which represent different thinning regimes, dieback status and topographic positions. A fifth trial has been pegged here.
- Dieback disease fronts adjacent to the above sites have been permanently marked to allow long-term monitoring and measurement of disease spread upslope, downslope and across slope under different conditions.

### *Management implications*

- The project will provide scientific data and conclusions to evaluate key assumptions that underpin SFM Guideline No.1. The findings will be relevant primarily to jarrah forest areas that are managed in the presence of *Phytophthora* dieback for timber production, and some key elements will also apply to management for nature conservation values.
- Knowledge gained will be used in supporting, or modifying and updating, the guideline. The project will contribute to the provision of a clearer scientific basis for the adaptive management of jarrah forest in the presence of *Phytophthora* dieback.

### *Future directions (next 12-18 months)*

- Complete initial crown and tree regeneration assessments and tree measurements on the first five trials, and analyse data.
- Permanently mark additional dieback fronts for long-term monitoring and measurement of disease spread under different conditions.
- Continue site selection and establishment of trials on different Havel Site Types, and under different thinning regimes, and carry out initial assessments and measurements on the new trials.
- Commence second measurements as appropriate on the first five trials.

---

## **The impact of wildfire in old growth forest of the Walpole-Nornalup National Park on short-range endemic invertebrates and their forest floor communities**

SPP# 2003-003

### *Team members*

P Van Heurck (0.10). Frankland District staff.

### *Context*

Tall tingle and karri forests contain a high proportion of short range relict invertebrate species. In March 2001 a wildfire in the Nuyts Wilderness near Walpole provided an opportunity to assess the impact of high intensity fire on the species composition of invertebrate communities. Species composition was also compared with relict invertebrate communities in prescribed burnt and long unburnt tall forests. Understanding effects of a single intense fire on invertebrate biodiversity is important for developing and implementing ecologically appropriate fire regimes and for managing fire for community protection. This study was established in December 2001 and has involved local volunteers in the establishment of a long-term invertebrate collection.

### *Aim*

To describe differences in species composition of arthropod litter communities containing short range endemics at forest sites with a variety of fire histories.

### *Summary of progress (2009/2010) and main findings*

- During 2009/2010 the Nuyts beetle collection was compared with beetle assemblages collected in the Bushfire CRC and Walpole fine grain mosaic burning projects. Results to date indicate a high level of local endemism in the beetle fauna of southern forests. Although less than 30km apart beetle assemblages collected for these three studies have only a small proportion of species in common.
- Protocols developed for identifying, curating, databasing and placing large specimen reference collections on the website have also been applied to related projects. This includes use of high resolution imagery software and equipment.

### *Management implications*

- The Nuyts Invertebrate Collection contains a large proportion of invertebrate species previously undescribed from old growth forests of the Warren bioregion. The occurrence of species within a wide range of fire ages surveyed provides fire managers with important conservation information on a large segment of the local biodiversity, including short range endemic taxa.
- Training volunteers from the Walpole-Nornalup National Parks Association and Walpole community in biosurvey techniques has made possible the sorting of large numbers of specimens collected over the period of the study. Volunteers have gained a greater understanding of the use of prescribed fire in the conservation of biodiversity and are becoming increasingly interested and skilled in invertebrate biosurvey. Making high resolution images available on a website for the use of international taxonomists has facilitated rapid identification of reference collection morphospecies. This project has achieved a successful partnership between fire managers, scientists and the local community.

### *Future directions (next 12-18 months)*

- Finish manuscript write-up and submit for publication the completed analyses beetle assemblages with specific requirements for postfire age.
- Establish the Nuyts study area as a long-term high rainfall comparison to future fire studies in more arid south-west ecosystems.

---

## **Effects of timber harvesting on terrestrial vertebrates in medium rainfall jarrah forest**

SPP# 1993-115

### *Team members*

A Wayne (0.1), C Ward (0.2), C Vellios (0.2), M Maxwell (0.2).

### *Context*

Understanding the impacts of timber harvesting on the terrestrial vertebrates of the jarrah forest is necessary for biodiversity conservation and the development of ecologically sustainable forest management practices.

### *Aims*

- Investigate the impacts of current silvicultural practices on jarrah forest ecosystems.
- Determine what factors contribute to observed impacts.
- Develop or modify silvicultural prescriptions to ensure the ecologically sustainable management of timber harvesting in the jarrah forest.

### *Summary of progress (2009/2010) and main findings*

- Spotlight monitoring on three standardised transects was maintained at six repeat surveys per



transect per year. Western ringtail possum populations remain at very low levels, only one individual has been detected on transects that previously averaged around 10-12 individuals (up to 33) per transect per night prior to the decline in 1999/2001.

- Quarterly trapping on 22 grids was completed during the 2009 calendar year. Analysis and preparation for publication are underway.
- Data collation and validation for trapping and spotlighting is complete and up-to-date.
- Findings relevant to the response of vertebrates to timber harvesting were presented at a Sustainable Forest Management Forest Fauna workshop in September 2009.

#### *Management implications*

- Improved ecologically sustainable forest management practices and the conservation of biodiversity.
- Improved efficiency of methods used for fauna monitoring (e.g. Western Shield) and research based on the findings submitted for publication on the factors affecting the detection of possums by spotlighting.

#### *Future directions (next 12-18 months)*

- Publish findings of immediate and short-term responses of medium-sized mammals to jarrah forest timber harvesting, based on trapping data.
- Analyse and publish the findings of the abundance of possums over time based on spotlight monitoring data.

---

### **Characteristics of hollow-bearing jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) trees and coarse woody debris (CWD), their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them**

SPP# 1993-095

#### *Team members*

K Whitford (0.3), D Feeniks (0.2).

#### *Context*

Hollow bearing trees and logs are elements of forest structure that are essential for the conservation of hollow dependent birds and mammals. Developing detailed knowledge of hollows and the attributes of trees and logs that bear these hollows improves DEC's capacity for ecological sustainable forest management. Studies of standing trees are now complete and current work focuses on hollows in logs on the ground.

#### *Aims*

- Describe the size of hollows used by jarrah forest fauna species and the distributions of the sizes, shapes and orientations of these hollows.
- Determine the relationship between tree size and tree age for jarrah and marri and the minimum age and size of trees bearing hollows potentially suited to hollow dependent fauna species.
- Identify the types of trees and tree crowns that bear hollows and develop predictive relationships for hollow occurrence and abundance.
- Identify fauna species most likely to be threatened by any future shortage of suitable hollows and examine the occurrence of hollows suited to the species most at risk.
- Examine the relationship between the numbers and types of logs and hollows present on the forest floor and site type, forest management and burning history.
- Understand process affecting recruitment and decay of logs on the forest floor.
- Assemble information on hollow log requirements of various hollow dependent fauna in the jarrah forest.

#### *Summary of progress (2009/2010) and main findings*

- This year an additional 200m long sampling transect was added to each of the 48 FORESTCHECK plots already surveyed. These additional transects reduce variability in the assessments of log volume and size class distribution. We now have a complete set of three 200 m transects on 48 plots. Data will be used to examine the available volumes, diameter distribution, condition and decay of CWD. Increased transect length and tagging of individual logs will facilitate accurate re-survey after fire or other disturbance.
- We commenced resurvey of FORESTCHECK plots after they have been burnt to determine the impact of fire on CWD volume and decay.

#### *Management implications*

This research contributes to knowledge of hollows and hollow use in the jarrah forest and the results provided the basis for much of Appendix 5 of SFM Guideline No.1, 2004, *Silvicultural Practice in the Jarrah Forest*. Ongoing information will be used to update the guideline.

#### *Future directions (next 12-18 months)*

Analysis of data will commence in the coming year, and will include identification of gaps in knowledge required to fulfil the aims of this study. The potential for using this data to model the accumulation and decay of CWD will be investigated.

---

### **Evaluation of key soil indicators of sustainability in Australian mediterranean forests (Indicators 4.1d, 4.1e)**

SPP# 1999-021

*Team member*

K Whitford (0.2).

#### *Context*

Timber harvesting and forest management activities impact on soil physical and chemical properties. This study evaluated indicators of soil physical and chemical status, and contributed to the development of standards for soil management during timber harvesting activities in the jarrah and karri forests.

#### *Aims*

- Investigate the use of soil organic matter as an indicator of ecologically sustainable forest management and examine the impact of fire on organic C and N in the jarrah and karri forest.
- Provide a scientific basis for the soil disturbance monitoring and management system applied in jarrah and karri forests by establishing base data on the intensity and extent of soil disturbance in harvesting coupes, and developing, refining and implementing survey techniques for estimating soil disturbance.
- Develop appropriate techniques for measuring bulk density in gravelly forest soils, and examine the relationship between soil disturbance class, bulk density and soil shear strength.
- Investigate the impact of extraction track compaction on tree and stand growth in the karri forest.

#### *Summary of progress (2009/2010) and main findings*

- Further analysis of data from this study has identified significant interaction between pre-harvest soil bulk density and soil gravel content in determining soil compaction. A manuscript has been submitted for publication.

#### *Management implications*

- Engineering solutions, such as covering the ground with harvest waste prior to harvesting, can provide small reductions in soil compaction and disturbance; however on most forest soils, operating machinery in dry conditions and thoughtful planning and management of machine movement across

the harvested area offer the simplest solutions for minimising the impact of timber harvesting on soils.

- This work contributed to development and implementation of Appendix 6 of FMP 2004-2013, the *Interim Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests* and the draft *Soil and Water Conservation Guideline*.

*Future directions (next 12-18 months)*

- Finalise publication of manuscript on the adaptive trials of cording.
- Revise and submit for publication a manuscript on the effects of fire on soil carbon.

---

**Effect of stand density and fertilising on seed-fall. Exp B. Establishment of jarrah (*Eucalyptus marginata*) in shelterwood areas and on dieback 'graveyard' sites**

SPP# 1993-094

*Team member*

K Whitford (0.2).

*Context*

The availability of a seed crop of appropriate density is a fundamental requirement for the success of shelterwood regeneration following timber harvesting. This study enables more accurate specification and prediction of seed available in stands that are to be harvested to shelterwood specifications.

*Aims*

- Determine the effect of stand density and fertiliser on the quantity of seed produced in jarrah forests stands.
- Examine seasonal variations in seed-fall.
- Examine the production and loss of buds, flowers and capsules to increase understanding of the seed production cycle.
- Develop a method of estimating the future seed crop of trees from field assessments of these trees.

*Summary of progress (2009/2010) and main findings*

- A relationship for predicting the seed crop based on the attributes of individual trees has been developed.
- A desktop study of the factors influencing bark thickness in jarrah was completed and the results used to calculate the overbark stand basal area of plots from the Inglehope thinning trial east of Dwellingup. Trees in this study had their bark scraped, and consequently overbark diameters from this study were inconsistent with overbark diameters of trees in the wider forest. This exercise enables conclusions from this study to be applied more broadly across the jarrah forest.
- The relationship between stand basal area and seed production was investigated.
- A manuscript reporting findings from the study of seed fall in a jarrah thinning trial at Inglehope has been revised for submission to a journal for publication.
- A Science Division information sheet based on seed forecasting in jarrah forest has been prepared.

*Management implications*

Results from this research have been used to revise the section on seed crop assessment, and in the formulation of Appendix 4 of SFM Guideline No.1, 2004 *Silvicultural Practice in the Jarrah Forest*.

*Future directions (next 12-18 months)*

- Submit manuscript on jarrah seed fall for publication in a scientific journal.
- Assess, fell and strip additional trees to add to the data set used in developing a tree based seed crop assessment procedure.

- Prepare manuscript on the development of the tree based seed crop assessment procedure and promote the application of this assessment procedure in shelterwood silviculture.

---

### **Control of jarrah leafminer: selective retention of JLM resistant trees and ground coppice in a demonstration forest plot**

SPP# 1993-097

*Team member*

A Wills (0.01).

#### *Context*

Jarrah leafminer (JLM) is an important pest species of jarrah, with significant effects on biomass production. Few management options are available to control JLM. This trial represents, on a small scale, a possible remediation of the impact of leafminer through selective retention of resistant trees by appropriate silviculture during tree harvesting operations.

#### *Aim*

To provide a visual demonstration of improvement in stand health and productivity by management practices.

#### *Summary of progress (2009/2010) and main findings*

Sites were inspected, with maintenance dependent on severity of JLM activity for expression of resistance.

#### *Management implications*

Outbreaks of JLM have abated since the demonstration coupe was established. When JLM next outbreaks in the area, this plot should provide striking visual evidence of the value of selective removal of susceptible stems in reducing population size of the insect.

#### *Future directions (next 12-18 months)*

Inspect site annually and carry out coppice removal on treated areas as required.

---

### **Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity**

SPP# 2001-005

*Team members*

A Wills (0.3), J Farr (0.01).

#### *Context*

Understanding the factors controlling the distribution of invertebrates in the jarrah forest landscape is important. Specialised or fire sensitive faunas that are restricted to particular geomorphic units are important for developing and implementing ecologically appropriate fire regimes and for managing fire for the community protection.

#### *Aims*

- Document the effects of topography on the distribution and abundance of invertebrates in jarrah forest.
- Determine whether landscapes provide natural fire and climatic refuges in the northern jarrah forest.

#### *Summary of progress (2009/2010) and main findings*

- Incised valleys of the Darling Range provide niche diversity through microclimatic and habitat diversity for invertebrate species.
- High beta diversity over short distances provides for high gamma diversity of invertebrates within and across valley systems.
- Low frequency of occurrence of most species make it difficult to draw conclusions about refugial nature of southern aspects, though for some species aspect is apparently important determinant of local distribution. Greater trapping effort over a longer duration would be required to confirm this hypothesis.

#### *Management implications*

- In finding high beta diversity at small geographical scale (tens to a few hundred metres) within valley geomorphic units, the study expands on the findings of other studies of jarrah forest which show broad similarity of assemblages (low to medium beta diversity) at medium geographical scales (up to a few tens of kilometres), and higher beta diversity at large geographical scales. Disturbance at any geographical scale within the valleys is likely to have a greater effect on invertebrate species composition than disturbance at such scale in upland jarrah forest.

#### *Future directions (next 12-18 months)*

- Update database and analyse the combined dataset.
- Write up and publish in a refereed journal.

---

### **Monitoring the northern extent of jarrah leafminer outbreak**

SPP# to be allocated

*Team members*

A Wills (0.04), J Farr (0.01).

#### *Context*

Jarrah leafminer (JLM) is an important pest species of jarrah, with significant effects on jarrah biomass production and forest ecosystem health. Monitoring the incursion of JLM infestation into highly productive areas of jarrah informs management of those areas as a long-term demonstration of the absence of impact of standard management practices on the spread of infestation.

#### *Aims*

- Monitor and document the northern extent of jarrah leafminer outbreak in jarrah forest.
- Provide warning of change in forest health and productivity caused by incursion of jarrah leafminer into as yet unaffected forest.

#### *Summary of progress (2009/2010) and main findings*

A survey of the northern extent of jarrah leafminer was conducted in October 2009. The survey confirmed no pervasive trend in northwards or eastwards expansion of JLM. Some parts of the infestation from expanded while other parts recessed.

#### *Management implications*

Biomass productivity of jarrah and forest ecosystem health in the northern jarrah forest is unaffected by jarrah leafminer.

#### *Future directions (next 12-18 months)*

- Draft five year report on extent of JLM in northern Jarrah.

- October 2010 census JLM infestation on 27 FORESTCHECK sites north of Collie.

---

## **Bushfire CRC Project B1.1: Managing fires in forested landscapes in south-west Western Australia**

SPP# 2007-003

### *Team members*

R Wittkuhn (1.0), L McCaw (0.2), R Robinson (0.2), J Farr (0.2), B Ward (0.1), G Liddelow (0.2), V Tunsell (0.09), P Van Heurck (0.1), A Wills (0.2).

### *Context*

Understanding long-term effects of fire on the floristics and structure of forested landscapes is important for developing and implementing ecologically appropriate fire regimes and for managing fire for the protection of life and property. This study incorporates the known fire history in the Frankland District (in the form of maps that date back to 1953) to establish survey plots that investigate the impact of fire history on diversity and abundance of flora, fauna, invertebrates and fungi.

### *Aims*

To improve understanding of the ecological effects of fire at landscape scale by comparing the flora and fauna in forest areas that have experienced different fire regimes over the past five decades.

### *Summary of progress (2009/2010) and main findings*

- A manuscript describing the assembly of the fire history data for the Warren Region has been published in *Conservation Science Western Australia*.
- A manuscript describing the GIS mapping of fire interval and fire season sequences has been accepted for publication in the on-line journal *Fire Ecology*.
- A manuscript describing the influence of variation in fire interval sequences on plants, vertebrates, fungi and invertebrates has been submitted to an international journal. The main findings of this manuscript are that the patterns of fire interval sequences have had little influence on the species composition of any of the taxonomic groups.
- A manuscript is in preparation that examines the contribution of spatial, environmental and fire variables to variation in assemblage data. The main finding is that environmental variables account for most variation explained by the model, while fire and spatial variables contribute little.
- A final report for this project was submitted to the Bushfire CRC.

### *Management implications*

- Provision of scientifically-based guidelines for the appropriate fire frequency in the southern jarrah forest will achieve a range of land management objectives.
- Development of protocols for the collection, digital capturing and attribution of fire information at the landscape and plot scale will improve management of fire history data.

### *Future directions (next 12-18 months)*

- The project is now focussed on publication of results.
- Develop a fire management guideline that informs fire planners and practitioners of the implications of this research.

---

## **Fire, fragmentation, weeds and the conservation of plant diversity in Wheatbelt Nature Reserves**

SPP# 2009-005

### *Team members*

C Yates (0.1), C Gosper (1.0). (External - S Prober CSIRO).

### *Context*

Application of an ecological approach to fire management in DEC-managed conservation reserves, encompassing some 612 nature reserves confronting multiple threatening processes, is a significant operational and scientific challenge. Progress is being made in this area, but it is acknowledged that the lack of scientific information on fuel accumulation rates and fire behaviour for major plant communities, and the relationships between fire and the biota in the region, is a limiting factor. Moreover, because many reserves are small (median size 116 ha) and isolated there are real concerns that prescribed fire regimes will act synergistically with other threatening processes and have undesirable consequences for the native biota in the longer term. For example, some fire regimes may reduce the resistance of native plant communities to invasion by non-native annuals that are abundant in the surrounding landscape. Yet there is a danger that biodiversity will be lost regardless, because of a lack of any fire management.

This is a collaborative project funded between DEC and CSIRO Sustainable Ecosystems (CSE).

### *Aims*

- Characterise current fire regimes experienced by remnants of native vegetation in the wheatbelt, and how these relate to landscape context, such as remnant size.
- Identify the upper and lower limits of the fire interval needed to maintain diversity in plant communities in vegetation remnants.
- Investigate how current fire management methods, such as chaining and burning, affect native plant communities.
- Determine whether fire and other disturbances interact to reduce resistance of eastern wheatbelt plant communities to weed invasion.

### *Summary of progress (2009/2010) and main findings*

- Comparative analysis of historical fire regimes in the fragmented landscape of the wheatbelt and continuously vegetated areas in the Great Western Woodlands were completed, and a manuscript of this work is under review.
- Sampling of vegetation community composition and structure across a time-since-fire gradient in tallerack mallee-heath and mallee communities completed. The two plant communities show different patterns of change with increasing time since fire, with mallee-heath showing declining species richness and senescence in structure, whilst mallee does not. One manuscript arising from this work is under review with another in preparation, and an information sheet was produced.
- Measurement of vital attributes (mortality and fecundity) for select species with contrasting fire life-histories was completed. Many serotinous species take 20-30 years post-fire to accumulate a substantial seed bank, but some obligate seeding species have high mortality in long-unburnt (> 50 years) vegetation.
- Measurement of impacts of chaining and burning on mallee-heath was completed. A manuscript was published in the *International Journal of Wildland Fire*, a second is in press in *Rangelands Ecology and Management*, and an information sheet has been produced demonstrating that chaining and burning affects recruitment in serotinous obligate seeders and the resprouting capacity of mallees.
- An experiment investigating whether fire and other disturbances interact to reduce resistance of eastern wheatbelt plant communities to weed invasion was completed. Weed invasion was greater at nutrient enriched edges of reserves, irrespective of whether these were burnt or not. Invasion in reserve interiors was minimal. A manuscript is currently in review and an information sheet has been published.
- Three presentations on the results and management implications of the study were made at international conferences: Conference of the Society for Ecological Restoration International and the International Fire Ecology and Management Congress.

### *Management implications*

The research will inform ecological fire management of nature reserves and other remnant vegetation in the Wheatbelt and South Coast regions.

*Future directions (next 12-18 months)*

- Complete publication of scientific manuscripts arising from this work.
  - Prepare general interest article and fire management guideline outlining the management implications of the study.
-



# MARINE SCIENCE

**Program Leader: Chris Simpson**

The broad goal of the of the Department of Environment and Conservation's (DEC's) Marine Science Program is to ensure DEC's marine biodiversity conservation and management programs are based on good science. Specifically, the Marine Science Program promotes and undertakes marine research and monitoring to improve the scientific basis for the conservation and management of Western Australia's statewide system of marine protected areas (MPA), threatened marine fauna and marine biodiversity generally. The Marine Science Program also coordinates and manages external marine research programs such as the current investigations into the ecology of the Ningaloo Marine Park (NMP) which is undertaken as part of the Western Australian Marine Science Institution.

The research and monitoring programs undertaken by the Marine Science Program are based around the research and monitoring strategies identified in MPA management plans and threatened species recovery/management plans ensuring that all activities are clearly linked to departmental priorities and programs.

---

## **WAMSI Node 3: Science administration, coordination and integration**

Core project.

*Team members*

K Waples (0.6), C Simpson (0.1).

### *Context*

In 2005 the State Government allocated \$5million to undertake research at Ningaloo Marine Park that would underpin its management. A research plan was developed in consultation with DEC marine resource managers and scientists to address key strategies in the *Ningaloo Marine Park Management Plan*. In 2007 a joint research body, the Western Australian Marine Science Institution (WAMSI) was formed. Research within WAMSI was divided into several themes, each with a lead agency. DEC is the leader of Node 3 of WAMSI which addresses research in marine biodiversity and conservation. Key ecological and biodiversity elements of the research plan were accepted as the science plan for Node 3 of WAMSI.

At the same time as the development of WAMSI, CSIRO Wealth from Oceans National Research Flagship program established the Ningaloo Collaboration Cluster (the Cluster) to address the integration of knowledge of reef use, biodiversity and socio-economics into a Management Strategy Evaluation (MSE) model for Ningaloo Marine Park and the Gascoyne region in general.

The research program of the Cluster complements that undertaken through WAMSI and collectively these two programs, along with core research undertaken by AIMS at Ningaloo, have become known as the Ningaloo Research Program (NRP). DEC is working together with representatives from the Cluster and AIMS to ensure the research program will meet management needs and be properly integrated and communicated to those who will use it.

The science plan for Node 3 of WAMSI consists of six main projects which include up to 20 subprojects. Each project area is led by a different institution/University. Thus the coordination and administration role entails ensuring that all project plans are in place and are running smoothly according to the agreed outputs and timeframes. A key focus of this project is to ensure the transfer and uptake of knowledge generated through the research into DEC management policies, practices and actions. The latter element will become an increasing focus of this project as the research program progresses to completion in 2010 and the final synthesis report is developed for the wrap up of WAMSI in December 2011. As such, both communication and data management are critical elements in knowledge transfer and uptake and are being addressed through this program.

Integration of research within the NRP is managed through the formation of the Ningaloo Research Coordinating Committee (NRCC) and through the following activities which serve to provide forums for sharing information, increasing collaboration between scientist groups and engaging managers and stakeholders:

- annual Ningaloo Research Symposium
- WAMSI Operations Group
- WAMSI cross-nodal symposia and meetings
- directed workshops for specific projects (e.g. Management Strategy Evaluation).

#### *Aims*

- Ensure the coordination and administration of the research program conducted under Node 3 of WAMSI.
- Ensure the integration of this research program with other research within WAMSI and with external programs relevant to the Ningaloo Marine Park.
- Ensure the outputs of research undertaken through the NRP reach target audiences.
- Ensure that knowledge transfer and uptake occurs between scientists, resource managers and decision-makers.
- Ensure the long term storage and custodianship of data from research undertaken through Node 3 of WAMSI.

#### *Summary of progress (2009/2010) and main findings*

- Milestone reports received from the projects underway demonstrate that research is on track and is producing relevant findings on sanctuary zone effectiveness, biodiversity distribution, patterns and processes, geomorphological, geological and oceanographic processes, benthic habitat distribution and reef use patterns.
- A WAMSI science review of all Node 3 research projects was undertaken in March 2010. All projects were deemed to be producing quality science and to generally be progressing well.
- A synthesis workshop was held to bring together the scientists engaged in the NRP. The main aim of the forum was to identify the key research findings that are beginning to emerge and to collectively develop a strategy to enhance and ensure the transfer of this information to those agencies responsible for the management of this region. The workshop was well attended and led to constructive and informative discussions between scientists and managers.
- A Ningaloo Student Research Day was held on 30 March in Perth. This event was well attended, with ten presentations made on a range of topics. Several interviews with the media were undertaken on the day.
- Data management was enhanced at DEC through the adoption of the MEST (Metadata Entry and Search Tool) and development of an internal metadata database.
- A draft technical report was developed on the rationale and process for a knowledge transfer and uptake framework that will be used for all research project/programs undertaken in the Marine Science Program.
- A draft paper was prepared outlining the details of the knowledge transfer and uptake process that will be carried out over the next 18 months.
- A number of presentations were made to other Sections, Branches and Divisions within DEC regarding the knowledge transfer and uptake process and its application through the Ningaloo Research Program.

#### *Management implications*

- A key role of this project is to ensure that outcomes of the research both within the NRP and from external research programs are reviewed and used in refining and updating management of the Ningaloo Marine Park through changes to policy, management activities and planning exercises where relevant. Specific implications for management will come from each of the individual projects in the research program and will be implemented as appropriate over time.
- The development of a knowledge transfer and uptake framework will be instrumental in ensuring a similar process is followed for other research projects and programs conducted by DEC.

*Future directions (next 12-18 months)*

- Continue to monitor progress of the various research projects and provide advice to project leaders to inform project reports.
- Prepare a WAMSI Node 3 synthesis report by 30 June 2011 that will bring together the key findings and implications for management of the Ningaloo Research Program.
- Continue to interact with the NRCC and develop and implement joint communication activities to further integrate the research programs.
- Develop the knowledge transfer and uptake framework further and submit a paper for publication in a peer reviewed journal on the framework and process.

---

**Conservation of marine turtles in Western Australia**

SPP# 1993-040

*Team member*

B Prince (0.75).

*Context*

All marine turtles found in Western Australian waters are listed as threatened species by the Commonwealth of Australia and the State of Western Australia. This long-standing statewide research project aims to provide the critical scientific information for the conservation of marine turtles in Western Australia and the management of human pressures on these animals. Currently turtle research and monitoring in Western Australia is undertaken by DEC Science Division and regional staff, academics and industry consultants with limited standardisation of methods or integration of data. There has also been a significant increase in turtle research in Western Australia by external (to DEC) scientists over the past decade as a result of the potential impacts on these species from industrial development. A comprehensive review of all (internal and external) historical and current turtle research and monitoring is needed to underpin the development of an integrated statewide approach to turtle research and monitoring in Western Australia, as outlined in the recently completed Western Australian turtle recovery plan.

*Aims*

- Gain an adequate understanding of the distribution and abundance of marine turtle populations utilising WA rookeries and marine habitats, the nature of inter-relationships within species at the regional level between groups using different rookeries, and the linkages between nesting and living areas important for the maintenance of these adult turtle populations.
- Develop an understanding of the processes affecting maintenance and abundance of these marine turtle populations as an aid to addressing management needs.
- Develop appropriate management measures and interpretation packages.

*Summary of progress (2009/2010) and main findings*

- Completed and submitted paper on olive ridley turtles in WA.
- Draft data report prepared on historical time-series data from Exmouth Gulf.

*Management implications*

The provision of knowledge will allow appropriate conservation and management programs of marine turtle stocks in Western Australia to be developed to minimise the impacts of human activities on these animals.

*Future directions (next 12-18 months)*

Project to be reviewed in 2010/2011 as part of a broader review of turtle research and monitoring in DEC.

---

## **Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015**

Core Project

*Team members*

S Wilson (0.1), A Kendrick (0.1), C Simpson (0.1).

### *Context*

Historically much of the research needed to inform DEC's marine conservation and management programs has been delivered through externally-funded programs such as the Northwest Shelf Joint Environmental Management Study, the Strategic Research Fund for the Marine Environment and the Western Australian Marine Science Institution. Although a small research capacity has recently been established within DEC Marine Science Program, external delivery of research will remain a key mechanism to meet DEC's marine research needs for the foreseeable future.

A strategic marine research plan is being developed to ensure that DEC marine research needs are identified, prioritised and delivered in a timely manner so that appropriate scientific information is available to support DEC's marine protected areas, marine fauna management and marine environmental protection programs.

The document will outline a systematic framework to identify and prioritise DEC's marine research needs, the opportunities and constraints to meeting these needs and the strategies needed to take advantage of the opportunities and overcome the constraints.

### *Aim*

To develop and progressively implement a strategic marine research plan to support WA's marine protected areas, marine fauna management and marine environmental protection programs.

### *Summary of progress (2009/2010) and main findings*

- A revised draft of the strategic plan was completed for internal review.
- Greater alignment of the research programs of the Australian Institute of Marine Science, CSIRO and the newly-formed WA Oceans Institute and DEC's research needs is being progressed.
- Recent (last ten years) temperate marine research in Western Australia is being collated to identify the management implications of this research for DEC.
- Research planning meetings were held with regional marine park staff, and feedback from these meetings contributed to the development of the draft strategic plan.
- A number of high priority research projects have been identified and initiated in the Walpole Nornalup Inlets Marine Park, the metropolitan marine parks and the Ningaloo Marine Park.
- Existing data from a 12 month DEC survey of water quality of the Jurien Bay Marine Park has been analysed and a manuscript has been prepared for submission to a peer-reviewed journal.

### *Management implications*

Development and implementation of the strategic marine research plan will enhance DEC's capacity to identify, prioritise and deliver DEC's marine research needs for departmental marine conservation and management programs.

### *Future directions (next 12-18 months)*

- Completion and distribution of the strategic marine research plan.
- Progressive implementation of the strategic marine research plan.

---

## **Strategic plan for the development and implementation of the Western Australian Marine Monitoring Program (WAMMP)**

SPP # to be allocated

#### *Team members*

K Friedman (0.1), C Simpson (0.05).

#### *Context*

The successful establishment of a long-term, broadscale, institutional marine monitoring, evaluation and reporting (MER) program requires a strategic approach to be taken. The strategic plan for the Western Australian Marine Monitoring Program (WAMMP) will outline the rationale, major tasks, timelines and delivery models that are required in the development and implementation of an integrated long-term, statewide marine protected area and threatened marine fauna monitoring program in Western Australia's coastal waters.

#### *Aim*

To develop a strategic plan to guide the development and implementation of an integrated long-term, statewide marine protected area and threatened marine fauna MER program in Western Australia.

#### *Summary of progress (2009/2010) and main findings*

- A draft strategic plan to guide WAMMP has been completed. The plan identified six major sub-projects of WAMMP. These are:
  - WAMMP Sub-project 1: Asset knowledge reviews.
  - WAMMP Sub-project 2: Historical time-series development.
  - WAMMP Sub-project 3: 'Fit to Park' (i.e. monitoring program implementation).
  - WAMMP Sub-project 4: MPRA/DEC audit support.
  - WAMMP Sub-project 5: Community participation.
  - WAMMP Sub-project 6: Data management and presentation.

#### *Management implications*

The development and implementation of the strategic plan for marine MER within DEC's marine conservation programs in an adaptive management context will guide the development and deployment of DEC's marine monitoring capacity over the next ten years. Ultimately the WAMMP will provide the data to continuously improve the efficiency and effectiveness of DEC's marine operational management programs.

#### *Future directions (next 12-18 months)*

Finalise and publish the strategic plan.

---

### **WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation**

SPP # to be allocated

#### *Team members*

K Friedman (0.2), C Simpson (0.1), A Kendrick (0.1), S Wilson (0.1), K Bancroft (0.1), K Onton (0.1), T Holmes (0.1), M Rule (0.1), K Waples (0.05).

#### *Context*

Monitoring the status of environmental assets assists DEC to fulfill its statutory responsibilities for the conservation of the State's biodiversity, as it is recognised that the 'health' of the environment is a powerful surrogate for biodiversity conservation. Long-term systematic integrated marine monitoring, together with evaluation and reporting of change, is a key management strategy for measuring success of Marine Protected Area (MPA) and marine fauna management plans, as early detection of detrimental impacts facilitates responsive active adaptive management for the conservation of marine biodiversity.

In the past, DEC marine monitoring work has largely proceeded opportunistically or in response to

particular concerns, whereas the purpose of the Western Australian Marine Monitoring Program (WAMMP) is to develop and implement a more strategic integrated program, initially focusing on WA's MPAs and on threatened marine fauna. The condition (structure and function) or 'health' of assets identified in MPA management plans and threatened marine fauna recovery plans is affected by pressures; natural pressures, anthropogenic pressures/uses and climate change pressures. Pressures can be both biotic (e.g. recruitment, predation etc) and abiotic (e.g. sea temperature, cyclonic storms). The primary purpose of monitoring programs is to identify undesirable changes in asset condition as a result of human pressures (as expressed relative to a management target) and to instigate management response/s to mitigate these effects.

Monitoring programs must, therefore, be designed to detect changes when they occur, and identify whether these changes are caused primarily by natural factors, human use or climate change, so that appropriate management responses can be formulated and implemented. Use of a Condition-Pressure-Response (CPR) monitoring framework, assists managers in assessing management efficiency and effectiveness, which is a critical element of an adaptive management framework. Each Asset Knowledge Review will need to have sufficient breadth and detail to guide the development of this aspect of WAMMP. Implementation of the reviews will permit trials of the methods, an output of which will be the documentation of appropriate standard operating protocols (SOPs).

#### *Aim*

Develop Asset Knowledge Reviews that identify what to measure (i.e. indicators); how to measure these indicators (i.e. methods) with due consideration of scientific 'power', cost, relevant historical data and practicality; and why these indicator/s and methods were chosen (i.e. rationale).

#### *Summary of progress (2009/2010) and main findings*

- Guidelines on the process of developing Asset Knowledge Reviews were developed and distributed to Asset Knowledge Review authors.
- Draft reviews were completed for internal review for the following assets: coral, seagrass and mangrove communities and Little Penguins.
- Draft reviews were completed for the following assets: finfish, intertidal communities, coastal birds, cetaceans, pinnipeds and water quality.
- A data management and reporting review for WAMMP was completed.

#### *Management implications*

Monitoring, evaluation and reporting programs are a key element in the adaptive management cycle and are aimed at continuously improving the efficiency and effectiveness DEC's conservation and management programs.

#### *Future directions (next 12-18 months)*

- Complete all reviews outlined above, including an external peer-review process, and publish as appropriate (e.g. DEC technical reports or as papers in *Conservation Science*).
- Initiate three new reviews from the following asset list: dugong, stromatolites, sharks and rays (including manta rays and whale sharks) and turtles.
- Develop guidelines on the development of SOPs within WAMMP.
- Develop draft SOPs as field procedures are trialed and protocols are standardised.

---

### **WAMMP Sub-project 2: Historical time-series development**

SPP # to be allocated

*Team members*

K Friedman (0.1), K Bancroft (0.3), C Simpson (0.05).

#### *Context*

Extensive monitoring of the marine environment of Western Australia has been undertaken over the last three decades or more by State and Commonwealth Government agencies, universities, industry and community groups. Although many of these monitoring programs were often issue specific and constrained in time and space, these data have significant potential to help understand historical trends in the condition of biodiversity assets, the pressures on these assets and, in some cases, the management responses to these pressures. This project will examine historical datasets from marine research and monitoring programs in Western Australia that are relevant to the objectives of the Western Australian Marine Monitoring Program (WAMMP). While the main aim is to reconstruct historical trends in asset condition and pressures to extend our understanding 'backwards in time', this project will also inform the process of selecting indicators and methods and temporal and spatial scales of WAMMP monitoring programs into the future. This will further help to ensure relevant past and future datasets are comparable and will also assist in designing the temporal and spatial scales of WAMMP monitoring programs. Historical timelines are, potentially, also a key aid in improving our understanding of climate change impacts on marine biodiversity over the past several decades.

#### *Aims*

- Develop a framework outlining the decision rules to guide the construction of historical time-series on asset condition, pressure and management response and on accessing data for high priority biodiversity assets identified in MPA management plans and threatened species recovery plans.
- Incorporate datasets into MPA annual report cards which are part of the Marine Parks and Reserves Authority audit process (see WAMMP sub-project 4).

#### *Summary of progress (2009/2010) and main findings*

- Draft Historical Time-series Development guideline was completed.
- A historical time-series for coral community data from Ningaloo Marine Park was used to trial the guidelines.
- Preliminary assessment of historical data of water quality, fish and seagrass was completed for the September 2009 MPRA Audit review.

#### *Management implications*

The construction of historical data will capture past DEC investment in marine monitoring programs and assist the design of future WAMMP monitoring programs. Knowledge of historical trends in marine biodiversity asset condition, pressure and management response will also facilitate an improved understanding of future trends, thereby improving the efficiency and effectiveness of DEC marine conservation and management programs.

#### *Future directions (next 12-18 months)*

- Submit a manuscript on the Historical Time-series Development guidelines.
- Develop a database of past monitoring programs relevant to WAMMP objectives for priority marine biodiversity assets.
- Collate historical information on all previous DEC marine monitoring programs to assist in the temporal and spatial design of future WAMMP monitoring programs.
- Continue the identification, retrieval and assessment of historical time-series (including data from sources external to DEC) of asset CPR data with marine park coordinators and other DEC staff for progressive inclusion into the Marine Parks and Reserves Authority audit process (see WAMMP sub-project 4).

---

### **WAMMP Sub-project 3: 'Fit to Park'**

SPP # to be allocated

#### *Team members*

K Friedman (0.3), A Kendrick (0.1), S Wilson (0.1), K Bancroft (0.4), T Holmes, (0.4), K Onton (0.4), M Rule (0.4).

### *Context*

The Western Australian Marine Monitoring Program (WAMMP) sub-project 3: 'Fit to Park' is focussed on implementation of monitoring programs in the field using the the indicators and methods identified in WAMMP Sub-project 1 with due acknowledgement of historical data identified in Western Australian Marine Monitoring Program (WAMMP) sub-project 2. The initial focus of this project will be to determine the appropriate temporal and spatial scales of WAMMP monitoring programs prior to their implementation. This will ensure that monitoring locations and monitoring frequency allow biodiversity asset monitoring data to be comparable within and between major geographical areas of interest (e.g. MPAs). The project will also identify the practical constraints (including costs) in regard to field implementation and assess the capacity and role of regional and other DEC staff and community involvement in WAMMP.

### *Aims*

- Develop guidelines for determining the spatial (WHERE) and temporal (WHEN) scales of asset CPR monitoring programs.
- Identify the practical constraints to the implementation of WAMMP monitoring programs within geographical areas of interest.
- Progressively implement asset CPR monitoring programs for assets priorities outlined in MPA management plans.
- Progressively implement CPR monitoring programs for threatened marine fauna according to established DEC priorities.

### *Summary of progress (2009/2010) and main findings*

- Draft guidelines for determining the locations and spatial scale of WAMMP monitoring sites were developed.
- Coral communities were surveyed at previously established and newly established monitoring sites in the Ningaloo Marine Park, Shark Bay Marine Park and the Montebello/Barrow islands MPAs.
- Fish community monitoring sites were established and surveys undertaken in the Shoalwater Islands Marine Park, Shark Bay Marine Park and the Montebello/Barrow islands MPAs.
- Seagrass monitoring sites were re-surveyed at Jurien Marine Park under historical sampling regime.
- Coastal sea-bird and shore-bird populations were monitored in the Shark Bay Marine Park.
- New sites and methods were established for DEC regional staff and community monitoring of coral communities, litter and coral predator abundance in 'high use' areas of Ningaloo Marine Park.
- Re-survey of Historical seagrass monitoring sites were re-surveyed in the Shark Bay Marine Park.
- The 'beach camera system' to monitor Little Penguin beach-landing numbers was re-established to help determine the most effective use of beach camera records for monitoring Little Penguins.
- A 'stand-alone' remote camera system for monitoring loggerhead turtle nesting activity at Dirk Hartog Island, Shark Bay Marine Park was established. Operational for 2009/2010 nesting season.
- Methods were trialled for the monitoring of 'coastal biological communities' along the coastal strip in Ningaloo Marine Park, including the establishment of monitoring sites.
- New video and still imagery methodology were trialled to increase the efficiency of in-water data collection.
- Software applications for post-processing of imagery were developed.
- A newly developed integrated drop-camera method was tested for the remote collection of seagrass community data in Jurien Bay Marine Park and in Marmion Marine Park.

### *Management implications*

In due course, the CPR data being collected on the assets (outlined above) will be available for marine park coordinators and senior regional staff to help them assess the efficiency and effectiveness of management actions. The data will also be incorporated into the MPRA audit process of Western



Australia's MPA system.

*Future directions (next 12-18 months)*

- Finalise the guidelines for determining the spatial and temporal scales of asset CPR monitoring programs.
- Continue to identify and address the practical constraints to the implementation of WAMMP monitoring programs.
- Progressively implement CPR monitoring programs using asset priorities outlined in MPA management plans.
- Progressively implement CPR monitoring programs for threatened marine fauna according to established DEC priorities.
- Continuing focus on integration of monitoring across assets, improving the efficiency of field data collection and data post-processing.

---

**WAMMP Sub-project 4: MPRA/DEC audit support**

Core project

*Team members*

K Friedman (0.1), C Simpson (0.05).

*Context*

Marine protected areas (MPA) in Western Australia are established under the *Conservation and Land Management Act 1984* (CALM Act) and are vested in the Marine Parks and Reserves Authority (MPRA). One of the statutory roles of the MPRA is to monitor (i.e. audit) the implementation of MPA management plans.

The audit function of the MPRA is expressed in three levels of review:

- an annual review (including an asset CPR report card) of the progressive implementation of the strategies in the MPA management plans
- audit of management performance for each MPA on a periodic basis, partly based on the preceding three annual reviews
- a ten-year audit of the implementation of the management plan.

A comprehensive MPA performance assessment report, including a CPR report card, is presented to the MPRA annually. The Western Australian Marine Monitoring Program (WAMMP) assists DEC regional MPA staff, in this regard, by providing asset CPR monitoring data to 'populate' the MPRA's MPA performance assessment framework.

*Aim*

The aim of this project is to assist DEC MPA managers in meeting DEC MPRA audit requirements by advising on and, where appropriate, providing CPR data to 'populate' the MPA performance assessment framework the MPRA use to service their audit function.

*Summary of progress (2009/2010) and main findings*

- The roles, responsibilities, capacity and processes needed to meet MPRA audit reporting priorities and needs were identified through meetings between MSP and most regional MPA managers (usually marine park coordinators).
- Asset CPR data from WAMMP was provided, as it became available, to all MPA managers.
- A presentation was made to the MPRA Audit Committee and regional MPA managers on the progress of the WAMMP.
- Additional CPR data (including historical datasets) was provided to MPA managers where data was sourced from external providers.

### *Management implications*

The MPRA audit process provides an annual understanding of asset CPR for all Western Australian MPAs and is a statutory requirement of DEC under the CALM Act. The same data are used as part of an emerging adaptive management culture by regional MPA managers to improve the efficiency and effectiveness of their management programs.

### *Future directions (next 12-18 months)*

- Development of a clearer understanding of MPRA audit requirements.
- Finalisation of the process (including roles, responsibilities and capacity between the MSP and regional MPA managers) to meet MPRA audit reporting requirements.
- Continues provision of asset CPR data from WAMMP and sources external to DEC, as it becomes available, to all MPA managers.

---

## **WAMMP Sub-project 5: Community participation**

Core project

*Team members*

K Friedman (0.08), K Waples (0.05).

### *Context*

Community engagement and participation is recognised as a key strategy to develop better links between managers, scientists and the community at large. Community partnerships within the context of the Western Australian Marine Monitoring Program (WAMMP) offer the opportunity of extending the scope of an early warning system for detecting change in the marine environment and opportunities to inform and improve understanding of marine conservation issues and priorities in the general population.

### *Aims*

- Successfully engage with the general community on issues of marine conservation, with special regard to WAMMP activity.
- Provide opportunities for direct involvement in monitoring, related activities and presentations of information to ensure the community is involved in managing the health of our marine and coastal environment.
- Ensure the data collected by the community will complement the monitoring data collected by Government agencies and scientists so that, together these data will be used by management agencies and local communities to help manage human impacts on their local marine environment.

### *Summary of progress (2009/2010) and main findings*

- Eight presentations were made on WAMMP, including how the public can participate, were delivered to community groups.
- A community coral monitoring program was established by an Exmouth School group in Ningaloo Marine Park.
- Six community volunteers were supported and trained in the post-processing of ecological asset imagery following Little Penguin surveys at Shoalwater Islands Marine Park and coral and fish community surveys in Ningaloo and Montebello Marine Parks.

### *Management implications*

The management of MPA's and threatened marine fauna will benefit from increased community understanding resulting from extensive communication of and direct community participation in WAMMP.

### *Future directions (next 12-18 months)*

- Continue community presentations on the objectives of WAMMP.
- Seek external funding/sponsorship to fund a Community Monitoring Coordinator for three years.
- Continue to foster public participation in WAMMP programs where possible.

---

## **WAMMP Sub-project 6: Marine Science Program data management and presentation**

Core project

*Team member*

K Friedman (0.05)

### *Context*

The research and monitoring capacity within the Marine Science Program (MSP) focuses effort on the ecological and social science needed to inform the adaptive management of Western Australia's marine protected area network, the conservation of threatened marine fauna and the conservation of the State's marine biodiversity generally. These programs will generate enormous volumes of data that must be analysed, presented and stored for future uses. To complete these tasks a framework is needed to support research and monitoring data management requirements. Data management in this context is the development and execution of architectures, policies, practices and procedures that properly manage the full data lifecycle needs of the MSP, particular emphasis on the long-term datasets required for the Western Australian Marine Monitoring Program (WAMMP).

### *Aim*

To establish and implement a best practice data management system for the Marine Science Program, with particular emphasis on the long term datasets required for WAMMP.

### *Summary of progress (2009/2010) and main findings*

- A preliminary review of the data management requirements of WAMMP has been completed.
- Development of a data management system has been commenced.

### *Management implications*

As the primary purpose of the monitoring and research is to acquire, evaluate and make available natural resource information to contribute to adaptive management (including pressure and management response), a well structured data handling and archive system is a critical component for management. Ordered, accessible and secure data derived from long term monitoring studies and research projects offer managers an insight into work that has been completed. Having the raw data from past studies, limits the duplication of work and offers the opportunity for reassessment if new questions arise.

### *Future directions (next 12-18 months)*

Complete development of a data management system.

---

## **Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park**

SPP# 2009-013

*Team members*

A Kendrick (0.2), M Rule (0.2). Contract (0.15).

### *Context*

The Walpole and Nornalup Inlets Marine Park (WNIMP) was created in 2009 to include the entrance channel, both basins and the tidal extent of the Frankland, Deep and Walpole rivers. Invertebrates are

recognised as a significant ecological value of the marine park and a Key Performance Indicator of management effectiveness. The benthic invertebrate community of the inlets has been described by Hodgkin & Clark (1999) from surveys conducted in 1984 and 1987. The fauna was found to be relatively diverse compared to most estuaries in the south-west of WA because of the predominantly marine conditions that are sustained in the inlets. Few subsequent studies have examined this fauna, and the current knowledge of benthic invertebrates in the system is considered to be inadequate for marine reserve management. Little is known, for example, of how the fauna varies in response to the seasonal hydrological cycle.

#### *Aims*

- Determine spatial patterns in the WNIMP benthic invertebrate community.
- Determine temporal variation in the WNIMP benthic invertebrate community, particularly in relation to seasonal changes in the hydrological cycle of the inlet system.
- Assist DEC's Marine Monitoring Unit develop methods for long-term monitoring of benthic invertebrate communities in the WNIMP and more broadly across temperate estuarine marine protected areas.

#### *Summary of progress (2009/2010) and main findings*

- Invertebrate sampling was completed with Frankland District staff in 'summer' and 'autumn' 2010. Approximately 60 benthic core and grab samples were collected in each season and the invertebrates were sorted and removed from the samples. A collection of voucher specimens is now being identified.
- Sediment cores were collected at each site during the 'summer' sampling period and the analysis for grain size, composition and organic is underway.

#### *Management implications*

This study will provide knowledge of how benthic invertebrate in the WNIMP are structured in space and time. Such 'inventory' and/or 'baseline' information is required to determine the composition of these ecological assets in relation to natural processes, and to benchmark their condition with regard to the impact of current and future anthropogenic impacts.

#### *Future directions (next 12-18 months)*

- Seasonal invertebrate sampling will continue for three years. Four sampling trips are planned for 2010/2011.
- Data from the first four 'seasons' will be analysed in 2010/2011.

---

### **Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater Islands and Marmion marine parks**

SPP# 2009-002

#### *Team members*

A Kendrick (0.2), M Rule (0.2). Contract (0.15).

#### *Context*

The Marmion Marine Park (MMP) and Shoalwater Islands Marine Park (SIMP) are located on the north and south Perth metropolitan coast, respectively. Both marine parks support a diverse range of marine conservation values ranging from various marine habitats to threatened marine fauna and are dominated by sub-tidal and emergent limestone reefs and shallow sandy embayments. These marine parks are subject to high levels of recreational and commercial human activity due to their proximity to the Perth metropolitan area. Significant areas of intertidal reef platform occur in both mainland and island shores and as isolated offshore patch reefs. While a number of local studies of intertidal communities provide a significant regional knowledge base, the broad spatial patterns of intertidal biodiversity across both the MMP and SIMP are not adequately understood. Particular gaps exist in

knowledge of the intertidal communities of the SIMP and offshore platform reefs.

This study will determine relationships between the composition of these communities and the physical structure and location of the reefs.

#### *Aims*

- Determine the spatial and temporal patterns in the composition of intertidal reef communities in the MMP, SIMP and the proposed northern extension to the SIMP (comprising Garden Island and Carnac Islands).
- Determine if the intertidal reef communities in management zones protected from extractive activities differ from the intertidal reef communities of otherwise comparable reefs.
- Assist DEC's Marine Monitoring Unit in the development of methods for long-term monitoring of temperate west coast intertidal communities.

#### *Summary of progress (2009/2010) and main findings*

- Seven mainland intertidal reef sites were sampled in the MMP and SIMP by MSP and Swan Coastal District staff in the 2009/2010 'summer' sampling period. Large swell waves severely restricted sampling opportunities during this period resulting in less progress than planned.
- A collection of voucher specimens is being progressively developed as a taxonomic aid.

#### *Management implications*

- This study will provide a basis for the design and implementation of comparative intertidal research in marine parks and reserves across WA.
- Inventory and baseline information will be used to determine the composition of ecological values in relation to natural processes, and to benchmark their condition with regard to the impact of current and future anthropogenic impacts.

#### *Future directions (next 12-18 months)*

Twenty sites in MMP and SIMP are planned to be sampled during the 'summer' season in 2010/2011. Sites at Garden Island and Carnac Island will also be sampled if conditions permit.

---

### **Interactive effects of fishing and climate change on coral reef fish populations**

SPP# 2009-003

#### *Team members*

S Wilson (0.325), T Holmes (0.35), K Onton (0.1).

#### *Context*

Climate change and over-fishing are widely regarded as the major threats facing coral reef communities worldwide. Typically fishing has a 'top-down' affect on communities, through the removal of large predators, whilst climate change causes degradation of habitat which effects fish that recruit, feed and shelter within corals. The independent impact of these threats are well studied, however the interactive effects between fishing and climate change are yet to be examined. This interaction may be particularly important on reefs off the mid-western WA coastline where per-capita boat ownership and recreational fishing pressure is extremely high.

Two critical processes that determine community structure of coral reef fish are recruitment and early post-settlement predation. It is hypothesised that degradation of coral associated habitat due to climate change will cause a decline in recruit numbers. Conversely fishing will reduce abundance of large predators and increase numbers of smaller habitat-associated predators, thereby increasing post-settlement predation. Examining how changes in habitat and predators interact and influence post-settlement survival of fish will be critical to understanding impacts to biodiversity of fish communities and fish populations.

### *Aims*

- Determine how habitat degradation instigated by climate change and changes in predation instigated by fishing pressures effect the composition of the predator community on WA coral reefs.
- Assess diet of predatory species targeted by fishers.
- Identify microhabitats preferentially used by juvenile fish.
- Assess how variation in fishing pressure and habitat complexity/composition influence predation rates on juveniles.

### *Summary of progress (2009/2010) and main findings*

- Field work in November and December quantified abundance of small bodied cryptic predators and predation upon juveniles in the northern section of Ningaloo Marine Park. This work is being analysed and prepared for submission to a marine journal. Field work in February collected data on habitat associations of juvenile fish.
- A paper prioritising research required to progress our knowledge of climate change impacts on coral reef fish has been published in the *Journal of Experimental Biology*. This paper is based on the opinions of 33 scientists from 23 institutes and ten countries. The results were presented at the JEB conference in Japan in August 2009.
- A manuscript assessing diet of finfish targeted by fishers in north west Australia has been submitted to *Environmental Biology of Fishes*. The study highlights spatial and temporal variation in some species diets and identifies species where more dietary information is required.
- A manuscript identifying habitat associations of juvenile fish has been submitted to *Marine Ecology Progress Series*. The study demonstrates corals of high structural complexity are important habitat for ~ half the species investigated. The study also shows algal meadows are important juvenile habitat for some species, including species targeted by fishers.
- A database of juvenile fish photos has been created as a basis of an identification field guide.

### *Management implications*

- Knowledge on the combined effects of fishing and on fish recruitment project will inform effective management of recreational fishing that may alleviate pressures placed on coral reef biodiversity.
- The project will identify appropriate indicators for ongoing monitoring programs, particularly those undertaken by MSP and identify finfish species that require protection from recreational or commercial fishing.

### *Future directions (next 12-18 months)*

- Complete analysis of data collected in November and December 2009 and prepare a manuscript for submission to international journal.
- Assess diet of fish species that may be affected by fishing.
- Continue to develop photographic library of juvenile fish.
- Establish and monitor survey areas of differing coral complexity and fishing intensity.

---

## **Preliminary assessment of diseases affecting Western Australian corals**

SPP# 2009-011

### *Team members*

K Onton (0.3), S Wilson (0.025).

### *Context*

Coral diseases have contributed significantly to coral reef degradation in locations around the world over the last three decades. However there is little information on the prevalence and type of disease on Western Australian coral reefs. Ningaloo Reef is the largest fringing coral reef in Australia, home to

highly diverse marine life and is regarded as an icon of Western Australian marine conservation. Research into coral disease at NMP will create a baseline data set that can be used to measure how climate and anthropogenic drivers threaten coral reef sustainability over time, and across regions with varying levels of anthropogenic influence.

#### *Aim*

- Review the current knowledge of coral diseases on Western Australian reefs.
- Document the prevalence of diseases affecting corals and the coral taxa/morphologies susceptible to various diseases within NMP.
- Characterise coral disease legions morphologically and histologically.
- Contribute to the development of coral disease standard monitoring protocols.

#### *Summary of progress (2009/2010) and main findings*

- Field work documenting disease occurrence and prevalence along NMP has been completed. Work focused on the northern sector, with some more intense surveying at Bills Bay, in central NMP. A data report detailing what information was collected and where it is stored has been completed.
- Samples from diseased corals have been prepared and examined for histological abnormalities.
- A draft manuscript is almost complete.
- Data has been submitted for presentation on the Ningaloo Atlas website.

#### *Management implications*

The results of this study will provide an indication of the spatial and temporal distribution of various diseases providing information on the prevalence and identity of diseases affecting Western Australian corals. This will assist in identifying the current threat posed by disease and provide a baseline for assessing any changes in impact. This will enable assessment of current management strategies designed to mitigate the impact of threats on coral communities.

#### *Future directions (next 12-18 months)*

- Analyse data and publish a manuscript in a marine journal.
- Present findings at conference and public lectures.
- Submit an article to *Environment and Conservation News* or *LANDSCOPE*.

---

### **The biogeography of Shark Bay Marine Park mangrove communities**

SPP # to be allocated

*Team members.*

A Kendrick (0.15), M Rule (0.15).

#### *Context*

The Shark Bay Marine Park (SBMP) and the adjacent Hamelin Pool Marine Nature Reserve are World Heritage-listed and support a diverse range of iconic marine conservation values. The ecological diversity of SBMP is high because this area is the southern distributional limit of many typically tropical species and the northern limit of many temperate species. The mangrove communities of Shark Bay are the most southern, extensive mangroves on the Western Australian mainland and are recognised as a significant marine park conservation asset, and eastern Shark Bay is listed under the Directory of Important Wetlands in Australia. While SBMP mangroves have sustained localised degradation due to impacts from activities associated with land-based recreational fishing and unmanaged visitor access, no significant mangrove areas are currently included in sanctuary zones of the marine park. Despite their recognised conservation value, the biota associated with SBMP mangrove communities are poorly understood.

### *Aims*

- Determine relationships between the biological communities associated with mangrove stands and the physical structure and location of the stands within the SBMP.
- Determine a classification of mangroves within the SBMP based on canopy structure and environmental parameters.
- Assess the relationship between the mangrove-associated biota and the physical structure and location of the different stands.
- Assess the human impacts on mangrove-associated biota.
- Identify indicator species for on-going monitoring of mangrove community condition.

### *Summary of progress (2009/2010) and main findings*

- A pilot study to assess proposed methodologies and potential study sites, has been completed and significant logistical constraints were identified.
- A *LANDSCOPE* article on the SBMP mangroves was published in the Spring 2009 edition.

### *Management implications*

This study will identify the relative biodiversity significance of mangroves in the SBMP and will provide the basis for a revised zoning of the SBMP. Part of the study will also identify appropriate monitoring indicators and methods for assessing mangrove community health.

### *Future directions (next 12-18 months)*

The project scope will be reconsidered due to logistical constraints.

---



# SCIENCE APPLICATIONS

## Unit Manager: Paul Gioia

The Science Applications Unit focuses on managing the corporate biodiversity assets of the Division making available online databases of species occurrence, maps of where species have been recorded, and lists of species that have been recorded for any sized area within Western Australia.

---

### Development of biodiversity indices

SPP# to be allocated

*Team members*

P Gioia (0.05), N Burrows (0.05). (External S Hopper).

#### *Context*

The current DEC reserve acquisition and NRM process uses a range of inputs to help identify high priority areas with significant biodiversity values. Biodiversity indices such as species endemism and richness provide a valuable tool in this process. DEC currently uses IBRA bioregion boundaries in a range of administrative and analytical contexts. However, IBRA boundaries have been identified as having a number of shortcomings when used to represent floristic diversity in Western Australia. A more ecologically appropriate set of boundaries is desirable.

#### *Aim*

To develop a range of biodiversity indices using corporate databases and involving ongoing collaborative research into species distribution, richness and endemism.

#### *Summary of progress (2009/2010) and main findings*

- A methodological paper was submitted to *Journal of Biogeography* for calculating plant richness and endemism and compensating for collector effort bias. Reviewers provided a number of suggestions for improving methodologies to be more accurate and consistent with current approaches.
- A mammal species richness map was generated from expert-derived polygon distributions.

#### *Management implications*

Species richness and endemism maps are regularly used in DEC planning to improve biodiversity management.

#### *Future directions (next 12-18 months)*

- Identify recently published methods for generating species distributions and compensating for collector effort bias and recalculate species richness and endemism indices using 2003 data and compare with results using most recent data from the Herbarium.
- Finesse the faunal richness maps for use within a regional planning context.

---

### Provision of authoritative names of WA taxa

Core function.

*Team member*

P Gioia (0.05).

#### *Context*

DEC, academia and the community rely on authoritative species names to manage species databases. Without authoritative names, the ability to provide and integrate information is substantially minimised.

The WA Herbarium is the recognised custodian of the names of Western Australian plants. WACensus, a database system, is the primary mechanism for managing those names. It captures both current names and synonymies and information is disseminated widely throughout Western Australia. DEC assumes a leadership role in providing authoritative names to assist in bio-inventory, and the delivery of high quality information to a range of clients.

#### *Aim*

To provide accurate and timely information on the names of WA taxa to assist in management of species databases within DEC and the wider community.

#### *Summary of progress (2009/2010) and main findings*

- The WACensus application was migrated to a new environment supporting current-generation database architecture.
- Integration with WA Museum has proceeded slowly because of differences in how species names are processed and managed between the two organisations.

#### *Management implications*

The development of any database in DEC that involves species names needs to be linked directly to WACensus data so that nomenclatural changes can be taken into account.

#### *Future directions (next 12-18 months)*

- Further embedding of WACensus information into DEC's information systems.
- The feasibility of WACensus to manage and disseminate fauna names within DEC will be assessed. If successful, this will facilitate the usage of correct fauna names internally, while new initiatives will be developed to manage names changes originating from WAM.

---

### **Online GIS biodiversity mapping (NatureMap)**

Core function

*Team member*

P Gioia (0.45).

#### *Context*

Western Australia, home to one of thirty-four global biodiversity hotspot, represents about a third of the Australian landmass. A major challenge in managing the conservation estate in such a large region, with its enormous biodiversity, is providing access to current and reliable information on species and their populations. Countless surveys and research projects have been undertaken within WA over a long period of time, resulting in many datasets and reports containing valuable and essential information for the ongoing management of its unique biota. Tools are required to enable conservation workers, industry and the public to more easily discover, assemble, analyse and report on biodiversity information that has been collected.

#### *Aim*

Digital delivery of authoritative scientific information on the distribution and identity of major elements of the Western Australian biota from a single, online portal.

#### *Summary of progress (2009/2010) and main findings*

- A major release of NatureMap was made available in March, 2010 that included many enhancements requested at demonstrations and from user feedback. Examples include – integration capability with FloraBase, new species data sources and spatial layers, improved querying and display capabilities.

- NatureMap won the 2009 WA Spatial Excellence Award (WASEA) in the Environment and Sustainability category.

#### *Management implications*

NatureMap will significantly reduce the time spent searching for point-based biodiversity data as well as ease the process of generating species lists for any area of the State.

#### *Future directions (next 12-18 months)*

- Provision of enhancements to NatureMap based on feedback from government and industry groups.
- Provision of extra biodiversity layers, such as predictive species distribution and Landsat imagery.
- Investigate options for using NatureMap platform in citizen science context.

---

### **Species database management software (Max)**

Core function.

*Team member*

P Gioia (0.05).

#### *Context*

There is a need to provide a standard mechanism for collection and management of plant species information. The mechanism should integrate with the WA Herbarium's information systems. Max is a species database management system that substantially improves data accuracy through facilitating the correct use of names, and promotes a standard database design integrated with WAHerb, the Herbarium's specimen database.

#### *Aim*

Max is a software utility that assists in the management of species databases. It uses the latest WACensus names information from the WA Herbarium to update species databases as well as providing facilities for entering specimen label information.

#### *Summary of progress (2009/2010) and main findings*

- No progress was made in the last 12 months.

#### *Management implications*

Max provides a standard mechanism for entering specimen data, as well as the capacity to check species names against the most authoritative source, thus enabling better integration of information.

#### *Future directions (next 12-18 months)*

- Complete development of fauna collecting books.
- Update Max data model to be more consistent with WACensus V2 and provide better support for higher order names.
- To implement better support for site/species organised databases through customised forms.

---

### **Baselining the Wheatbelt NRM Region (Terrestrial)**

*Team members*

B Bayliss (0.5), P Gioia (0.05), J Harvey (0.5), A Rick (Consultant).

#### *Context*

This project is part of the National Reserve System and Biodiversity Conservation Program - Wheatbelt NRM (previously the Natural Diversity Program within the *Avon Investment Plan, 2005* - Avon Catchment Council).

#### *Aims*

- Collate, analyse and disseminate Wheatbelt NRM biodiversity relevant data.
- Assist in developing a strategic conservation plan to direct the Wheatbelt NRM's natural diversity funding,
- Examine and report on gaps in knowledge and/or current natural diversity programs that restrict the Wheatbelt NRM from achieving its natural diversity goals.
- Develop benchmark descriptions of Wheatbelt vegetation, primarily the woodlands, and develop metrics to assess vegetation condition.

#### *Summary of progress (2009/10) and main findings*

- Version 1.2 of The Avon Vegetation Map (AVM) Application was made available on DVD. The extent of spatial data represents 23% of remnant vegetation in the Avon Catchment's agricultural zone, representing over 560 reserves and native vegetation remnants derived from 80 source references and survey documents. Work is continuing on NVIS attribution of spatial data.
- Process for displaying vegetation maps and key vegetation attributes from the AVM database in NatureMap is being developed.
- A community and sub-community classification of Wheatbelt woodlands has been completed based on floristic and environmental data from over 1 200 sites and polygons, photographs and expert knowledge. Thirty two species of *eucalyptus* are considered in the description of nearly 100 communities of sub communities.
- Profiles for five common Wheatbelt eucalypts; salmon gum, york gum, wandoo, gimlet and red morrell have been prepared and include descriptions of sub communities and attributes that will contribute to the definition of a community benchmark.
- Developed and field tested metrics for assessing vegetation condition.
- Collated and updated data on existing Gypsum Dune communities and carried out additional surveys in the south east salt lake system. Reclassification of communities, report and recommendations are in final stages of preparation.

#### *Management implications*

- The AVM database is being used in the development of vegetation (woodlands) description and condition assessment. The database provides an information resource for vegetation mappers, managers and Wheatbelt NRM stakeholders requiring information on the location and composition of native vegetation communities in the Avon Catchment.
- The Wheatbelt woodlands community classification will be a useful aid to vegetation mappers and those assessing clearing proposals, and undertaking restoration activities.
- The vegetation description and condition indices will facilitate consistent collection of data for community classification and condition monitoring.
- The vegetation condition metrics and formulation of benchmarks will be useful to land managers, scientists and community organisations for setting restoration objectives and assessing outcomes.

#### *Future directions (next 12-18 months)*

- Corporatising of AVM dataset and inclusion as a NatureMap layer.
- Review of AVM database methods and NVIS framework as a basis for interpreting and integrating historical vegetation map data.
- Continuation of the preparation of benchmark descriptions for Wheatbelt woodland communities.
- Undertake additional surveys including some in the uncleared part of the NRM region, to aid the identification and description of potential Threatened Ecological Communities.

- Investigation of the application of classification and condition assessment methodology to other vegetation types.

---

## **Baselining the Wheatbelt NRM Region (Wetlands)**

### *Team Members*

S Jones (0.25), A Pinder (0.1), A Leung (0.25), C Francis (0.25), P Gioia (0.05).

### *Context*

This project is part of the National Reserve System and Biodiversity Conservation Program - Wheatbelt NRM (previously the Natural Diversity Program within the *Avon Investment Plan, 2005* - Avon Catchment Council). It is part of the Department's contribution towards the NRM process.

### *Aims*

- Map, classify and evaluate the conservation significance at a regional scale of all basin and granite outcrop wetlands greater than one hectare, within the Wheatbelt NRM region.
- Develop an on-ground methodology for evaluating the conservation significance of inundated basin wetlands in the Wheatbelt NRM region.
- Conduct a literature review of the potential impacts of agricultural drainage on wetland biota and identify priority areas for future research.
- Enhance knowledge of the region's wetlands by producing relevant information products.

### *Summary of progress (2009/2010) and main findings*

- Publication of a book on aquatic invertebrates and waterbirds of the Avon catchment. Published by DEC and the AVON NRM.
- Drafting of a scientific paper on aquatic invertebrate communities of south-western Australian salt lakes.

### *Management implications*

- Recognition of the high conservation value of the aquatic invertebrates and waterbirds of the Avon Catchment will assist in garnering community support for conservation management.
- Recognition of the very high diversity and endemism of salt lake invertebrate communities will assist in development of conservation programs.

### *Future directions (next 12-18 months)*

- Project completed.
-

# PERTH OBSERVATORY

**A/Program Leader: Ralph Martin**

Perth Observatory, established in 1896, is Australia's oldest continuously operating observatory. Perth Observatory is the only significant professional observatory between South Africa and the eastern states of Australia and is sought for collaborations with other astronomy institutions because of its capabilities and its particularly isolated location on the globe.

---

## Astronomical Outreach and Education

Core Function

*Team members*

R Martin (0.1), A Verveer (0.3), V Smith (0.1), A Williams (0.25), C Mesiku (0.6), G Lowe (0.6), A Taylor (0.8).

*Context*

This core function involves providing services of direct use to the general public and education sector. Its authority is underpinned by active involvement in astronomical research. Some of the research projects are long-term worldwide collaborations. There is a significant demand for astronomy education services from many different groups and individuals within the community.

*Aims*

- Provide relevant and timely education services.
- Demonstrate science in action.
- Facilitate the development of the tourism potential of astronomy.

*Summary of progress (2009/2020) and main findings*

- The Observatory continued its involvement in the 'International Year of Astronomy' during the second half of 2009. It participated in a highly successful Astronomical Festival held at Curtin University and ran a workshop at Kings Park to teach members of the public how to effectively use a small telescope.
- The Observatory supported charitable institutions by running an Astronomical Field Night for the Organ Donation and Tissue Foundation and collaborating in a fund raising event for the Army Museum of Western Australia.
- The number of visitors attending star viewing nights and day time guided tours totaled 4 339 for the year.
- 21 lectures and presentations were made to university undergraduates, primary school students and community groups.
- Customer satisfaction showed 97% satisfied with their visit or service provided by the Observatory, and 99% were satisfied with the educational quality of the services in which they participated.

## Activity Measures

Activity	09/10	08/09	07/08	06/07	05/06	04/05
Star viewing sessions	77	102	93	143	183	151
Night visitors	3604	4334	4371	4 234	5 420	5 170
Sunday guided tours	46	37	28	30	37	48
Daytime guided tours	689	1131	954	1 036	1 179	1 716
Astronomy field nights	7	10	2	16	24	29
Field night attendance	1488	1846	150	2045	1 244	3 293

Lectures and talks	21	44	64	97	47	71
Talk attendance	825	1294	1 214	2 191	1 748	3 067
Student consultations	2	25	36	56	19	15
Customer satisfaction (star viewing and guided tours, %)	97	98	96	98	98	98
Astronomy awareness raised (%)	100	100	96	98	97	97
Educational quality (%)	99	98	96	97	96	98

#### *Management implications*

The substantial visitor numbers, together with sound customer satisfaction evaluations, indicates that there is continuing strong demand for these services from the Observatory.

#### *Future directions (next 12-18 months)*

- Trial star viewing nights that are wholly run by the Perth Observatory Volunteer Group.
- Adequately house the 76-cm aperture telescope - the largest telescope available for public star viewing in the Southern Hemisphere.

---

### **Astronomical Information Services**

Core function

#### *Team members*

R Martin (0.8), A Verveer (0.60), V Smith (0.1), A Williams (0.9), C Mesiku (0.4), G Lowe (0.4).

#### *Context*

This core function involves providing information of direct use to various groups within the community. Its authority is underpinned by active involvement in astronomical research. Some of the projects are long-term worldwide collaborations. There is a significant demand for astronomical information from many different groups and individuals within the community.

#### *Aim*

To provide relevant and timely astronomical information.

#### *Summary of progress (2009/2020) and main findings*

- There were eight peer reviewed papers published in scientific journals.
- Continued participation in the establishment of the Murchison Widefield Array, a path finder telescope for the Square kilometer Array (radio telescope).
- The 2010 edition of the *Western Australian Astronomical Almanac* and CD was produced.
- A photographic exhibition, developed for the International Year of Astronomy went on permanent display at the Observatory following a tour to regional museums in 2009.
- The Observatory's display room has been updated with captions for major items of interest.
- There were over 244 696 'page view hits' on the Observatory's website.

### **Activity measures**

Activity	09/10	08/09	07/08	06/07	05/06	04/05	03/04
Telephone enquiries	8 916	4 817**	9 858	13 348	14 655	11 516	19 095
Information line	1 832	1 031	2 179	3 413	2 935	1 996	3 416

Email enquiries	494	769	615	777	447	543	519
Consultations	9	38	47	56	36	20	20
Newspaper, radio & TV	109	129	175	201	161	105	147
www page views (000s)*	244*	323*	404*	1 519	880	709	2 200
Positive responses to 'quality' questions in surveys (%)	99	98	99	98	98	98	98
Satisfaction of information requests as they occur (%)	99	98	97	95	95	98	92

\*From 07/08, 'page views' rather than raw 'hits' have been recorded as a performance indicator because this better reflects the actual use of a website.

\*\* Affected by a long duration equipment malfunction.

#### *Management implications*

The sustained level of information service provision, together with sound customer satisfaction evaluations, indicates that there is continuing strong demand for these services from the Observatory.

#### *Future directions (next 12-18 months)*

- Continue talks with the senior researchers at the International Centre for Radio Astronomy Research and also academics at local Universities, to identify areas of synergy.
- Continue in our support role of software development and data collection for local astronomy institutions.
- Make further progress towards a self-guided tour by writing fact sheets about the telescopes at the Perth Observatory.

---

### **Variable star observations**

SPP# 1998-009

#### *Team members*

D Frew (0.0), R Martin (0.01), A Verveer (0.05), A Williams (0.11), G Lowe (0.03).

#### *Context*

This SPP represents a long-term worldwide collaboration to study variable stars.

#### *Aim*

To monitor the brightness of variable stars. This will lead to an increased knowledge of the structure and processes within stars. One paper was published in a peer reviewed journal.

#### *Summary of progress (2009/2010) and main findings*

- Monitoring observations of the central stars of planetary nebulae continued on the PLAT. The observation of 30 central planetary nebula stars has found six stars that are variable.
- A peer reviewed paper describing variability of two hot subdwarfs (sdB) stars has been published. Variations in the brightness of the first star, LB 1516, are typical for an sdB star. A likely explanation for the variability of the second star, He 0218-3437, is that it is a member of a binary star system. An asymmetric light curve is thought to be the result of ellipsoidal distortions induced in the primary star by a companion star.

#### *Management implications*

The scenarios that lead to some B type stars prematurely losing their outer layer of hydrogen and



becoming hot subdwarf stars are not well understood. The kind of variability observed in He 0218-3437 hasn't previously been observed in an sdB star. These observations may provide support for the argument that mass loss in sdB stars can result from gravitational interaction between a B type star and a companion star.

*Future directions (next 12-18 months)*

- Participation in variable star monitoring programs will continue for successful observation.
- Reduction of data and publication of results.

---

## **Imaging and spectrophotometry of comets**

SPP# 1998-010

*Team members*

R Martin (0.01), A Verveer (0.05), A Williams (0.01), G Lowe (0.03).

*Context*

This project involves a long-term collaboration with astronomers from United States of America in the study of comets.

*Aims*

- Monitor cometary brightness changes in specific wavelength bands.
- Observe comets over a wide range of heliocentric distances both pre-perihelion and post-perihelion.
- Image the coma and tail(s) for specific structural features.

*Summary of progress (2009/2010) and main findings*

This project was dormant in 2009/2010 owing to the lack of suitable targets.

*Management implications*

Observations of comets will facilitate a comparison between the various cometary families and build a database of cometary properties.

*Future directions (next 12-18 months)*

Partners at Lowell Observatory will undertake high priority observations as opportunities concerning suitable comets arise.

---

## **Imaging and CCD photometry of transient and variable sources**

SPP# 1998-011

*Team members*

R Martin (0.01), A Verveer (0.05), A Williams (0.20), G Lowe (0.03).

*Context*

Conduct 'Target of Opportunity' observing of suitable targets, taking images and processing as appropriate. The Murchison Widefield Array (MWA) is a low frequency (80-300MHz) radio telescope being built at the proposed 'Square Kilometre Array' site in WA. When operating, the MWA will generate a complete, high-resolution image of the entire sky, horizon-horizon, every eight seconds, in the selected radio frequencies.

*Aims*

- Image newly discovered celestial objects and/or poorly known variable sources, so as to increase knowledge of Solar System objects, discover new Solar System objects.

- Increase knowledge of the structure and processes within stars.

#### *Summary of progress (2009/2010) and main findings*

- The 32-tile prototype to the MWA telescope was successfully demonstrated, and the build-out to the full 512 tile system was approved by relevant funding agencies.
- A peer reviewed paper describing the MWA was published.

#### *Management implications*

The eight second all-sky images will detect transients (either new sources or variability in existing sources), and alert the international astronomical community of their presence. The automated optical telescopes at Perth Observatory will follow up these detections to see if there are optical counterparts.

#### *Future directions (next 12-18 months)*

- Suitable targets will be observed as time and resources permit.

---

### **Astrometry of minor planets, comets and targets of opportunity**

SPP# 1998-012

#### *Team members*

R Martin (0.01), A Verveer (0.05), A Williams (0.01), G Lowe (0.04).

#### *Context*

This project involves a long-term worldwide collaboration to track and discover asteroids and comets. Targets of opportunity are also observed as appropriate. The origin of these bodies is of fundamental interest in itself in order to determine the origin, history and fate of each object. Also, knowledge of an object's position facilitates other specialised types of observation (and these not need be restricted to the visible part of the electromagnetic spectrum).

#### *Aims*

- Measure the position of minor bodies, so as to determine their orbits.
- Measure the position of targets of opportunity such as supernovae in order to confirm their existence as well as facilitate follow-up observations with other instruments.

#### *Summary of progress (2009/2010) and main findings*

The positions derived from observations of one asteroids and 16 newly discovered comets were forwarded to the Minor Planet Center at Harvard University.

#### *Management implications*

Astrometric positions are supplied to the Minor Planet Center to refine the orbits of selected asteroids and comets.

#### *Future directions (next 12-18 months)*

Monitoring of NEOs and comets will continue with the milestone an increased number of published positions.

---

### **Monitoring gravitational microlenses**

SPP# 1998-013

#### *Team members*

R Martin (0.3), A Verveer (0.05), A Williams (0.30), G Lowe (0.03).

### *Context*

Members of the PLANET group are distributed worldwide, as is the telescope network, with all planning of the observing strategy for the events being followed carried out via an online 'homebase' control system based on real-time data reduction and automatic modelling. As the night finishes at one telescope site, the next telescope to the west continues observing so that targets can be observed for 24 hours a day, seven days a week. Members anywhere in the world are able to adjust target selection and sample rates to optimise coverage of ongoing anomalies. The project uses the gravitational microlensing effect to gain information about our galaxy, its stars and their planetary companions. Access to telescopes in Perth, Siding Springs, Tasmania, South Africa, the Canary Islands, Chile, Brazil, and Hawaii (ranging from 0.6m to 2m) allows 24-hour monitoring during the 'galactic bulge season' (May - August).

### *Aims*

- Use precise light curve measurements in order to characterise the statistics and kinematics of Galactic microlensing events.
- Detect extra-solar planets.
- Gather information on the stellar population in and around the Galactic Bulge.

### *Summary of progress (2009/2010) and main findings*

- Five peer reviewed papers were published this year:
- An extrasolar planet of approximately Neptune's mass was discovered, bringing the total number of planets in this mass range discovered by microlensing to ten, twice the number of Jupiter-mass gas giants discovered this way. This implies that the abundance of low-mass extrasolar planets is approximately three times that of gas giant planets, confirming theoretical predictions.
- Two papers described high-magnification microlensing events where a planet was *not* discovered, but where there was enough high-quality data coverage to determine the physical properties of the lens stars, and to rule out the existence of any planets around those stars, over a wide range of masses and orbital distance.
- Two papers published this year focused on techniques – one focused on the modeling of extremely high magnification events, the other described the application of a new image processing and parameter fitting algorithm.

### *Management implications*

- While there are several techniques for finding extrasolar planets, microlensing searches an entirely different region of parameter-space, with different selection biases, and forms a perfect complement the radial velocity technique to help determine planet formation mechanisms and the statistics of planetary systems.
- Detailed examination of null-results like the two papers described above are essential to allow the calculation of a precise 'detection efficiency' for planets, necessary to estimate the actual abundance of extrasolar planets given the available data.

### *Future directions (next 12-18 months)*

- One more paper is in press, and several more are in preparation.
- The May-September 2010 'bulge season' observing is underway.

---

## **Supernova search**

SPP# 1998-014

### *Team members*

R Martin (0.3), A Verveer (0.05), A Williams (0.1), G Lowe (0.03).

### *Context*

A long-term study of supernovae are involved in this project - an endpoint in stellar evolution. The Perth Automated Supernova Search is a search for extra-galactic supernovae in low redshift spiral galaxies and uses the Perth Lowell Automated Telescope (PLAT) at Perth Observatory.

#### *Aims*

- Contribute to the broader study of supernovae by employing methodical search techniques to detect supernovae at early stages of their evolution.
- Make an independent determination of the supernovae rates within late spiral galaxies.
- Undertake additional research on the supernovae found. For example, collect photometric light curves of supernovae discovered by Perth Automated Supernova Search.

#### *Summary of progress (2009/2010) and main findings*

- A peer reviewed paper on SN1999ga establishes that it is an example of a rarely discovered and poorly understood supernova. Using photometry and spectroscopy SN1999ga is classified as a sub-luminous type II supernova. Examination of low resolution images of the host galaxy and spectroscopy suggest a progenitor star that is eight to ten times the mass of the Sun, with a moderate to small hydrogen envelope.
- Two supernovae were discovered: SN2009jy and SN2010e.
- Computer code to automatically focus the PLAT was completed and successfully integrated into the telescope's software.

#### *Management implications*

- SN1999ga is the first relatively under luminous,  $^{56}\text{Ni}$  poor core-collapse supernova that can be classified as a type IIL supernova.
- The development of an automated focus algorithm for the PLAT has improved the quality and consistency of the data collected by this telescope.

#### *Future directions (next 12-18 months)*

To increase the number of supernovae that are photometrically monitored.

---

### **Astronomical evaluation of sites in WA**

SPP# 2000-006

#### *Team members*

R Martin (0.06), A Verveer (0.05), A Williams (0.01), G Lowe (0.01).

#### *Context*

The evaluation of various sites regarding their suitability for astronomical observations are the key aspects of this project.

#### *Aim*

Testing appropriate Western Australian sites regarding their suitability for astronomical observations.

#### *Summary of progress (2009/2010) and main findings*

This project was dormant in 2009/2010.

#### *Management implications*

Determining the suitability of sites for astronomical observations will provide information necessary for the planning of future facilities.

*Future directions (next 12-18 months)*

- This site evaluation project will result in a paper detailing the preliminary results of conditions for optical astronomy observing in WA.
  - Observations at other sites will be conducted as appropriate.
-

# STUDENT PROJECTS

## PROGRESS REPORT

The following reports were supplied.

---

**Scientist:** I Abbott

*Student:* P Van Heurck

*Project title*

**The compositional, structural, and functional succession of beetle communities in habitat mosaics created by three different fire regimes in the southern forests of Western Australia**

*Progress report*

In March 2003 an intense wildfire in heavy fuels burnt approximately 20 000ha of proposed National Park north-east of Mt Frankland. The rapid southward spread of this wildfire was eventually controlled along the northern boundary of London forest block, which had been prescribed burnt in the previous spring of 2002. The contrasting intensities at which these adjoining two forest blocks were burnt has provided an opportunity to compare the fire impact on the biodiversity of their invertebrate communities. Beetle species represent roughly 20% of these communities, occur in all trophic guilds, and hence should be responsive bio-indicators of the differing fire seasons and intensities. An additional aim is to compare the impact on beetle biodiversity of a future patchy 'small grained mosaic' fire regime, with that of a 'normal prescribed' fire regime and a 'no-planned burn' regime, all in the adjoining forest blocks.

Fieldwork at 18 sites will be completed in spring 2010 and analyses and writeup are to be completed for thesis submission in December 2011.

---

**Scientist:** D Algar

*Student:* S Hilmer

*Project title*

**Ecophysiology of the feral cat (*Felis catus*) in Western Australia**

*Progress report*

Cats are common in a variety of habitats, even in harshest environments without access to free water, and appear to be highly adaptive to a wide range of conditions. Despite their abundance and threat to biodiversity, little data is available regarding the cat's ecophysiology.

This study provided physiological background and understanding of the ecology of the feral cat by investigating potential differences in basal metabolic rate and body temperature regulation of cat populations in relation to different climates (arid, temperate and tropical zone) and seasonal conditions. It also compared physiological differences of free ranging versus captive cats to identify any 'captivity effects' that proved to affect the physiology of cats. It also investigated the flexibility in behavioural traits of feral cats by studying home range size, overlap and activity patterns of feral cats from a semi-arid island off Western Australia's coast.

This work concluded that a combination of behaviour (e.g. nocturnal behaviour, opportunistic hunting) and physiological traits (e.g. tolerance of high  $T_b$ , direct physiological change to varying conditions) allowed the feral cat to colonize Australia's versatile climate zones.

The thesis was handed in in January 2010, assessed as 'very good' in May 2010. It is available in the Wildlife Library, Woodvale.

---

**Scientist:** D Algar

*Student:* K Koch

*Project title*

**Genetic diversity and phylogeography of Australian cats**

*Progress report*

Cats are well studied in terms of behaviour, domestication, genetics and genomics across most continents, but we lack information on the Australian feral cat populations. In particular, hardly any genetic data are available to determine the origin and secondary invasion, population structure and sizes of Australian feral cats. In order to fill this gap and to provide the necessary information for effective monitoring and control of cats, this project will assess the genetic variation of several mainland and island populations. Current analysis will identify the origin of cats from Cocos Keeling Island, Christmas Island, Dirk Hartog Island and various mainland locations. Additional sampling throughout Shark Bay will be conducted in the beginning of 2011. Reinvasion rates, population growth rate and geneflow from Shark Bay will be determined.

---

**Scientist:** AH Burbidge

*Student:* R Scott

*Project title*

**Can vocal recognition be used to discern population spatial structure and dispersal in Carnaby's black cockatoo?**

*Progress report*

Carnaby's black cockatoo is an endangered species that breeds in agricultural areas of south-western Australia. Some populations migrate into the metropolitan area during the non-breeding season, but the origin of these birds, and their migration routes, is unknown. This project, which has just commenced, aims to document variation in cockatoo calls to enable the tracking of breeding flocks through time and space. These findings will be used to inform landscape scale management of the birds and their habitat.

---

**Scientist:** M Byrne

*Student:* R Thavornkanlapachai

*Project title*

**Pollen dispersal in *Banksia nivea* ssp. *uliginosa***

*Progress report*

This project investigated the extent and pattern of pollen dispersal among populations of *Banksia nivea*, a rare species restricted to a specialised environment, the ironstone habitat around Busselton. The project determined the pattern of pollen dispersal by paternity assignment for a sample of seed produced in selected populations. The source of the paternal contribution to the seed either from within the population or from another population was determined through genotyping all adult plants in the populations and assaying the genotypes of a sample of seed. The genotypes of the plants and the seedlings were analysed to determine the source of paternity in the seedlings. The level of outcrossing and pollen immigration was correlated with other variables such as population size and population isolation. Reproductive biology parameters were also investigated and seed production over the last three years and seed germination was determined for eight populations.

*Banksia nivea* ssp. *uliginosa* exhibits a predominantly outcrossing mating system ( $t_m = 0.95$ ) with a small amount of selfing which indicated self-compatibility. The size and the density of the patches impacted on the pattern of pollen dispersal in the populations. Plants in the smaller road verge population had fewer potential fathers in seed crops and greater pollen pool differentiation, leading to increased mating between relatives and self pollination. Pollen dispersal distance was also less with most pollination events within 10m of a mother plant compared with 50m in the larger and more dispersed nature reserve population. Pollen immigration was similar in both populations and may buffer the smaller population from inbreeding. There was no significant relationship between seed set and population size, which also suggested gene flow among populations. There was a weak negative correlation between distance to the nearest population and seed set. High levels of predation limited the production of viable seeds and destroyed as much as 54% of seed set in an infructescence. Germination success was generally high (93.4%) in all populations regardless of the seed age but older seeds took longer to germinate.

---

**Scientist:** M Byrne

*Student:* A Shah

*Project title*

**Genetic diversity and differentiation among subspecies of *Banksia nivea***

*Progress report*

*Banksia nivea*, commonly known as swamp honeypot, consists of both a rare and common subspecies. The rare subspecies, *B. nivea* subsp. *uliginosa* is currently listed as critically endangered and occurs in a number of populations in the Busselton region that are separated from a few populations on the Scott River Plain by the Whicher Range. The common subspecies *B. nivea* subsp. *nivea* has a widespread distribution that ranges from Geraldton to Esperance. A third proposed subspecies *B. nivea* subsp. *morangup* is restricted to a single population near Toodyay. This project will investigate the genetic diversity within populations of the subspecies and the genetic differentiation among the subspecies.

Genetic diversity was high among populations of all subspecies of *B. nivea*. There was moderate differentiation between subsp. *nivea* and subsp. *uliginosa* but subsp. *Morangup* was not differentiated from subsp. *nivea*. Within the rare subsp. *uliginosa* there was significant differentiation between the populations on the Busselton Ironstones and those on the Scott River Plain.

---

**Scientist:** P de Tores

*Student:* J Clarke

*Project title*

**Translocation outcomes for the western ringtail possum (*Pseudocheirus occidentalis*) in the presence of the common brushtail possum (*Trichosurus vulpecula*): Health, survivorship and habitat use**

*Progress report:*

The project investigated the health, survival and habitat use of *Pseudocheirus occidentalis* translocated from the Busselton region into 1080-baited and unbaited sites at Leschenault Peninsula and Yalgorup National Park during 2006-08. *Trichosurus vulpecula* resident at the sites were similarly studied.

Predation was the ultimate factor limiting translocation success of *P. occidentalis* in this study. Predator species included foxes, cats, pythons and raptors. Survival also appeared to be adversely affected by *T. vulpecula* population sizes and aspects of habitat quality, particularly nutrition. Although both possum species were clinically healthy and disease-free, there was a relationship between pre-translocation white blood cell counts and post-translocation survival for *P. occidentalis*, which suggests that low-level inflammatory processes or stress responses were proximate factors influencing susceptibility to predation. Longer term survival was a function of temperature and rainfall, with drought conditions appearing particularly deleterious for *P. occidentalis*. Establishment and maintenance of viable translocated populations of *P. occidentalis* requires more effective control of exotic predators. However, even then, the carrying capacity of the field sites may be too low for long term population stability, especially in the face of climate change. Preservation of existing habitat in and around Busselton is paramount.

Thesis was submitted in February 2010 and is currently with examiners.

---

**Scientist:** P de Tores

*Student:* J Cruz

*Project title*

**Ecology of the common brushtail possum in the northern jarrah forest in relation to predation and resource availability**

*Progress report*

The western subspecies of the common brushtail possum (*Trichosurus vulpecula hypoleucus*) or koomal, has declined in abundance and spread and is currently listed as 'near threatened'. This PhD project examined the general ecology and behavior of koomal in the northern jarrah forest, with particular focus in understanding the effects of resource availability and predation on koomal demographics and behaviour.



Fieldwork was completed in autumn 2009 and data analysis is currently underway with the aim to complete the PhD thesis by the end of 2010.

Four out of the ten sites trapped had koomal populations of ranging densities, although densities were low compared to densities commonly found in the southern jarrah forest. Early results from the dietary analysis suggest that koomal often supplement their leaf diet with energy-rich foods including invertebrates, seeds and flowers. This study assessed koomal's reproductive output at three sites (the fourth site only had male koomal) to determine which reproductive strategy koomal employed when subjected to limiting resources. Biasing the offspring towards males lowers the long term, mother-offspring competition pressure, since males are the dispersing sex, and female offspring usually settle within their mothers' home ranges.

The effects of population density and gender on koomal's home range size were assessed at three sites using a combination of radio-tracking, trapping and spool-and-line tracking. Results suggest that koomal's home ranges vary with gender, with males having larger home ranges than females. Furthermore, home range sizes don't appear to be density dependent.

Finally, the project evaluated the behavioural responses of koomal to predation risk from foxes, cats and chuditch using spool and line tracking. Results suggest that koomal remained closer to trees in response to an increased predation risk from foxes and cats. Increased risk of predation by foxes also resulted in koomal using more open habitats, presumably so that they could detect approaching foxes with time to escape. An increased predation risk from chuditch resulted in koomal selecting areas of greater vegetation cover, where they were likely to be better concealed from chuditch. These results suggest that koomal are able to detect the predation risk from the two introduced predators examined and adjust their behaviour in order to minimise the risk.

---

**Scientist:** P de Tores

*Student:* H Grim

*Project title*

### **Possum ecology and health on the Geographe Coastal Plain**

*Progress*

The project investigated naturally occurring populations of ngwayir (western ringtail possum, *Pseudocheirus occidentalis*) and koomal (Common brushtail possum, *Trichosurus vulpecula*) at two discrete sites on the southern Swan coastal plain between Bunbury and Busselton.

Population density at the two sites was obtained for ngwayir using distance sampling analysis (program 'Distance') of spotlighting data, and for koomal using spatially-explicit mark/recapture software (program 'Density') to analyse trapping data. The population density of both species was higher in the tuart/peppermint woodland compared with the banksia woodland, but the density of ngwayir at both sites was lower than that in the pure peppermint woodland typical of the Busselton coastal strip.

Home ranges were produced by kernel density estimation after calculation of the smoothing parameter using likelihood cross-validation (software 'Animal Space Use'). The repeated use of diurnal rest sites by possums strongly influenced the home ranges produced, with simplified internal range structure and expanded range size, particularly in apparently unused areas. The home range and habitat use results indicated substantial overlap in the use of habitat resources on a spatial basis, within and between species. The results of ngwayir habitat use also indicated a strong inclination for the use of tree hollows when they are available.

---

**Scientist:** P de Tores

*Student:* K Yokochi

*Project title*

The efficacy of rope bridges in mitigating negative effects of roads on populations of possums in southwest Western Australia

*Progress report*

Roads represent a threat to wildlife populations through processes such as road mortality, habitat destruction and population fragmentation. Mitigating such negative impacts on wildlife is becoming increasingly important as the rates of wildlife extinction and urban development increase.

Rope bridges built over roads connecting vegetation on either side of roads, have been constructed in several locations as a mitigation measure for arboreal species. However, no study has demonstrated their use by multiple individuals, or gene flow as a result of the crossing structures and it is therefore not known if they successfully re-connect the fragmented animal populations.

This project aims to assess the effectiveness of rope bridges in mitigating the negative ecological and genetic impacts of roads on the threatened western ringtail possum (*Pseudocheirus occidentalis*) and the common brushtail possum (*Trichosurus vulpecula*) in the Bunbury-Busselton region.

Three sites for installation of rope bridges have been identified at locations with reported high road mortality for ringtail possums and their installation will be undertaken in cooperation with Main Roads WA, Satterley Property Group, Western Power and the Shires of Capel and Busselton. Data and DNA samples have so far been collected from 16 western ringtail possums from Locke Nature Reserve 11 of which have been fitted with radio-collars.

---

**Scientist:** P de Tores

*Student:* L Zimmermann

*Project title*

**Population density estimate of western ringtail possums (*Pseudocheirus occidentalis*) at Karakamia Wildlife Sanctuary**

*Progress report*

This project is applying distance sampling techniques to derive estimates of density and abundance for the western ringtail possum (*Pseudocheirus occidentalis*) at Karakamia Wildlife Sanctuary. The Sanctuary is privately owned by the Australasian Wildlife Conservancy and protected by introduced-predator-proof fencing. Western ringtail possums were translocated into Karakamia from 1995 to 2001, however the density of the population is yet to be determined. The project will assist in determining the long-term outcome of these translocations and will provide a reference for translocations of western ringtail possums to DEC managed estate where foxes are controlled through the use of 1080 baiting. Fieldwork is currently underway and is due to be completely by mid July 2010.

---

**Scientist:** J Farr

*Student:* K Ironside

*Project title*

**Trophic dynamics of predatory invertebrates in jarrah forests of differing fire history**

*Progress report*

This project proposes to use stable isotopes to investigate how historical fire regimes have influenced the trophic relationships of invertebrate communities in southern jarrah forest ecosystems. It tests the hypothesis that frequent fire increases the incidence of intraguild predation in litter dwelling predatory invertebrate groups. To achieve this, the effect of contrasting fire interval patterns and fire frequency on the litter dwelling invertebrate community has been investigated using the sites established for the Bushfire CRC project. An inventory of invertebrate fauna to determine if species richness and abundance differ within or between fire treatments has been completed. Specimens have been categorised into their respective trophic groups to determine if fire has changed the trophic structure of the communities.

Field work has been completed and specimens have been identified to morphospecies taxonomic level. To date no differences for fire historical regime have been found for biodiversity and abundance. Early results for stable isotope analysis suggest differences between fire treatments such that the C/N ratio for plant material is low, indicating nitrogen depletion on long unburnt sites. Data analysis is in progress and the project write up has commenced. Completion is anticipated for April 2011.

---

**Scientist:** JA Friend

*Student:* J Pridham

*Project title*

**Finding a dietary surrogate for the Critically Endangered Gilbert's potoroo (*Potorous gilbertii*)**

### *Progress report*

One of the primary strategies to promote the conservation of the potoroo is to establish translocated colonies. A requirement for the potoroo's habitat is significant hypogeal fungi which comprises 90% of its diet. Mycophagy is a trait shared with three more common mammals also found in the potoroo's habitat; bush rat *Rattus fuscipes*, quokka *Setonix brachyurus* and quenda *Isodon obesulus*. Scats from live captured animals at three sites will be microscopically examined to ascertain which has the most similar fungal diet to the potoroo and to determine if one (or more) of the more common species can be used as an indicator of food resource abundance for Gilbert's potoroo to assess future translocation sites. Survey trapping is undertaken three times per year; March, July and November.

Samples have been obtained from a number of sites. Examination of scats so far obtained from the target species to determine the fungal component of their diets is in the process of being analysed.

---

**Scientist:** J Lane

**Student:** S Davies

### *Project title*

## **An Investigation of the cause and effects of increased salinity in a freshwater coastal wetland: Lake Davies, Western Australia**

### *Progress report*

In Australia, salinisation of wetlands is a growing problem. Knowledge of both causes and consequences of salinity is necessary for wetland management. This study investigated possible causes of incremental salinisation of Lake Davies, a coastal freshwater wetland in south-west Western Australia, and the effects of salinity on biota. Between 1991 and 2009, salinity increased from 1360mgL<sup>-1</sup> to 2853mgL<sup>-1</sup>. This small increase could potentially have a large impact on the freshwater system. Previously, little work has investigated effects of small salinity increases in freshwater systems. In such cases, effects to biota may take time to become evident and long term data sets are essential for their detection. This study involved the interpretation of monitoring data collected in 1991 and 2009, as well as climate and groundwater data from external sources.

A negative correlation existed between rainfall and salinity at Lake Davies, suggesting climate change, particularly decreased rainfall, may be taking effect. Spatial data provided suggestive evidence for saline intrusion, a mechanism potentially exacerbated by increased groundwater extraction lowering groundwater levels.

Effects of salinity on biota were most obvious in the fringing vegetation with four new salt-tolerant species recorded in 2009. Sublethal salinity stress possibly affected *Baumea arthropphylla* with smaller specimens present at the west end. The loss of one chironomid subfamily (Orthocladinae) from the macroinvertebrate community is likely. Salinity alone could not explain other changes. Further monitoring is required for conclusive waterbird results although the loss of two species is possible. Frogs appear unaffected by salinity, although potential for sublethal effects to tadpoles is high. Fish species (*Pseudogobius olorum*; *Leptatherina wallacei*) were not affected by salinity due to their marine ancestry.

This research provides valuable insight into the effects of small increases in salinity in freshwater wetlands at the ecosystem level. It can aid management of coastal water resources where surface, ground and sea waters may interact.

---

**Scientist:** L McCaw

**Student:** J Cargill

### *Project title*

## **Fate of *Eucalyptus marginata* seed from canopy store to emergence in the northern jarrah forests of Western Australia**

### *Progress report*

This project seeks to improve understanding of the factors that determine the success of jarrah seedling establishment following shelterwood harvest in jarrah forest. In contrast to jarrah, marri generally establishes an abundant crop of seedlings following harvesting and burning. Factors being investigated through experimental research include seed availability, seed viability, seedbed receptivity and losses

from post-seedfall predation.

Seedfall, seedling emergence and establishments have been monitored following shelterwood burns conducted at Dale and Palmer blocks. Survival from December 2008 until June 2009 was good (>70 %) despite dry conditions persisting into late autumn.

Data analysis is currently underway and it is anticipated that the thesis will be submitted in the second half of 2010. This will include guidelines for an improved seed forecasting system for jarrah. Results and management implications of this research were presented to the Healthy Forests forum hosted by at the Institute of Foresters of Australia in March 2010 and to an audience of DEC and Forest Products Commission silvicultural practitioners at Bunbury in May 2010.

---

**Scientist:** L McCaw

*Student:* A O'Donnell

*Project title*

**Fire patterns and vegetation structure in semi-arid woodlands and shrublands in southern Western Australia**

*Progress report*

This study draws on fire history information (including air photo, satellite imagery and vegetation mapping) to investigate fire patterns at the landscape level in the Lake Johnson area in southern Western Australia, where very large fires have occurred at different intervals over previous decades. Research questions include:

- How much of the landscape has been burnt at various frequencies over the last ~50 years for which air photo and satellite imagery records exist?
- How patchy are large fires? Does patchiness reflect effects of weather factors or underlying landscape and vegetation attributes?
- Has fire history induced changes in vegetation structure and can these changes be deduced from comparison of present day vegetation and Beard's mapping (1970s)?
- Can fire-induced boundaries be detected in the field from differences in vegetation structure or species composition (e.g. absence of fire-sensitive obligate seeder species such as *Callitris*).
- Are eucalypt woodlands in decline or is regeneration adequate to provide for long-term persistence and development?

The project will provide information to test hypotheses that: a) fire history has led to structurally degraded vegetation, and b) the proportion of the landscape in different post-fire age classes follows a negative exponential model.

Fire activity has been studied in relation to climatic data, demonstrating that large fire events are associated with drought years during the fire year, preceded by significantly wet and cool conditions during the preceding year. This work is now also being prepared for journal publication.

---

**Scientist:** L McCaw

*Student:* J Hollis

*Project title*

**Coarse woody fuel availability and consumption in Australian forest fires**

*Progress report*

The ability to predict the amount and type of fuel consumed during wildfires is important to land and fire managers throughout Australia. Consumption of coarse woody fuels is important for wildlife habitat management and plant regeneration, prediction of radiant heat load on firefighting personnel and equipment, and for carbon accounting. Factors governing the consumption of fine fuels <6 mm diameter are well understood but less is known about the consumption of coarse woody fuel that may smolder for some time following the passage of a flaming fire front.

Experimental fires have been completed at three sites in south-west Western Australia (Wilga, Quillben, Hester) and two fires at Tallarook in central Victoria. An extensive fuel consumption data set gathered in conjunction with Project Aquarius fire experiments in Western Australia during 1983 has been validated and incorporated into an evaluation of existing fuel consumption predictive models. A paper describing

this work has been accepted for publication in *Forest Ecology and Management*.

Relationships between woody fuel consumption and fire intensity have also been investigated using data from the experimental fires, and data gathered following intense wildfires including the 2005 Perth Hills fire and the 2009 Black Saturday wildfires in Victoria. Findings from this work were presented in a paper to the 2009 conference of the Institute of Foresters of Australia, and will be submitted for publication in *Australian Forestry*.

---

**Scientist:** K Morris

*Student:* J Dunlop

*Project title:*

**Factors affecting fauna translocation success**

*Progress report*

Fauna translocations, particularly to mainland sites, have a low rate of success (<20%). Loss of founders to introduced predators has usually been the main reason for this. This project aims to assess the role other factors such as disease and parasite loads, founder genetic variability, founder size and founder source may have on translocation success. Data collection commenced with the arrival at Lorna Glen of translocated boodies from Dryandra in January 2010 and boodies and golden bandicoots from Barrow Island in February 2010. Each animal was assessed for reproductive condition and body condition. DNA samples were taken from a large proportion of the founder population to quantify genetic diversity and ensure that following generations do not suffer significant bottlenecks. Blood samples were taken where possible, for basic health parameters such as white and red blood cell counts, and detection of haemoparasites. Ectoparasites were collected when present. Half of the population receives anti-ectoparasite treatment whenever captured in order to manipulate the presence of haemoparasites in these animals and determine whether there is a follow-on effect of improved condition and/or reproductive success.

Results so far have indicated that the animals are healthy and have greatly reduced their ectoparasite load since being moved from Barrow Island (both treated and untreated groups). The animals from Barrow Island have gained weight and are highly reproductive. The boodies have lost approx 25% of their initial weights and stabilised, presumably reflecting a return to a 'healthy' body weight after being overweight in the captive colony. Monitoring has shown 13 animals (11 boodies and two bandicoots) have died, detected via radiotelemetry, and 20 new animals (four boodies and 16 bandicoots) have been recorded in the population and microchipped so far.

Another aspect of this project is to examine the historic role disease may have had in the decline of mammals. We are currently working toward developing successful methodology for detecting haemoparasites (trypanosomes and toxoplasma) from old museum skin specimens. Parasite DNA extraction methodology will be tested on some non-vital museum woylie skins, since woylies are a species that has shown high prevalence for trypanosomes in previous studies and are likely to give a positive result. When these are successful, we will be in a good position to approach other museums and ask to take samples of older and more valuable specimens.

---

**Scientist:** I Radford

*Student:* A Cook

*Project title*

**Can mosaic burning protect northern quolls from severe wildfires in the north Kimberley?**

*Progress report*

This project forms part of the major research and monitoring program being conducted in the north Kimberley region, which is a detailed investigation of density, fecundity and survivorship of critical weight range mammals in relation to current fire regimes. The study is being conducted at the Mitchell Plateau in the north Kimberley where large areas frequently experience broad-scale intense wildfires, with some small areas being managed or protected where a small-scale fire mosaic results. This project investigated habitat use and home range movements of northern quolls (*Dasyurus hallucatus*). The northern quoll remains abundant in several areas of the north Kimberley and is a suitable species for detailed investigation of landscape/habitat and resource use in the context of fire mosaics as it is a

major native predator ranging over relatively large territories.

Differences in home range area appear to be related to seasonal effects rather than fire. Quolls were not displaced by the fire event and the home ranges of two individuals radio-tracked prior to and after the fire were entirely within the burnt area. This study was conducted in a landscape where fire is a regular occurrence and investigated the effect of a relatively low intensity fire in the mid dry season (June) when environmental conditions are considered less stressful than later in the year. Results indicate that northern quolls are able to tolerate fires under these conditions but the response may have been quite different if the fire occurred later in the season. Of 15 males investigated it was confirmed that nine had survived beyond the breeding season. Four of these were confirmed to survive to their second breeding season.

---

**Scientist:** M Stukely

*Student:* A Rea

*Project title*

**Classical and molecular taxonomy and pathogenicity testing of *Phytophthora* species**

*Progress report*

The aim of this project is to characterise, from a molecular taxonomic perspective, undescribed *Phytophthora* taxa occurring in natural ecosystems in Western Australia, and to formally describe three of these new species. The pathogenicity of these three species will also be assessed.

Progress has been made on the description of the three novel taxa of *Phytophthora*, the microsatellite analysis of *P. citricola*, and the coalescent analysis focussing on *P. multivora*.

A paper describing one new species has been accepted for publication in *Australasian Plant Pathology*. A manuscript describing two new species is still in the draft stage, but all results are finalised.

Four potential microsatellite markers for *Phytophthora* clade 2a have been found, and 'genome walking' to design primers for use in the coalescent study will now start.

Nineteen isolates have been analysed to date in the coalescent analysis, of which 15 are *P. multivora*. These isolates are from WA, NSW and South Africa. Six genes have been sequenced, all of which show intra-specific variation and will provide good data for the analysis. Sequencing of the same genes will now proceed for 21 isolates of *P. plurivora* and 3 isolates of *P. pini*, which are closely related species from Europe and the USA, respectively. A number of *P. multivora* isolates from Europe have been delayed in quarantine by AQIS. It is hoped that this study will provide insight into the origin of *P. multivora*, which is hypothesised to be WA.

---

**Scientist:** S van Leeuwen

*Student:* G Page

*Project title*

**Mulga ecology and applications to site restoration at West Angelas, Pilbara**

*Progress report*

This project aims to investigate the structural and ecophysiological diversity of *Acacia aneura* (mulga) and its close relatives across the range of landscapes and soil types present at West Angelas, an iron ore mine in the Pilbara.

A presentation titled 'Rapid dilution of foliar  $\delta^{13}\text{C}$  following a simulated cyclonic rainfall event in a semi-arid Australian woodland' made at the 10<sup>th</sup> Australasian Environmental Isotope Conference at Curtin University was awarded a student prize. A collaboration was also commenced with Dr Jie Liu and Prof Klaus Regenauer-Lieb from CSIRO to analyse 3-dimensional xylem structure in mulga branches using X-ray micro-tomography. There is an ongoing collaboration with the *Understanding Mulga* project to determine the genetic similarity of the mulga 'types' identified during the study in the West Angelas area.

---

**Scientist:** A Wayne

*Student:* K Bain

*Project title*

## **Ecological study of the quokka (*Setonix brachyurus*) in the southern forests of south-west Western Australia**

### *Progress report*

This project aims to determine if a reliable estimate of quokka abundance can be obtained from indicators of activity including scats, tracks and runnels; identify the preferred habitat of quokkas in southern forests in relation to factors such as vegetation structure and floristics, position in the landscape, landform systems and geomorphology; identify the current distribution and abundance of quokkas in the southern forests (Warren Region) and the influence of fire and the presence of feral pigs; determine the mobility and activity patterns of quokkas in the broader landscape and whether the sub-populations constitute a functional meta-population

A comparative assessment of a range of survey methods, applied at 16 sites, included trapping webs, scat collections, runnel counts and track counts. Analysis indicates that faecal pellet counts relate strongly (runnels less so) to population abundance. There is no relationship between population abundance and tracks or incidental sightings.

Observed high levels of temporal variation in habitat occupancy is not consistent with the current hypothesis that animals move to the ridgelines in winter and occupy the same creek lines each summer. Ongoing surveys and monitoring across the region also indicates quokka populations are typically smaller than previously observed and fragmented. Individuals are also apparently in relatively poor condition. Surveys of quokka abundance and habitat from 12 sites selected based on fire history and prescribed burn plans were completed in Spring 2009. Post-burn surveys have also been conducted at the three sites that were burned as planned in Spring/Summer 2009/2010.

Trials of the GPS collars found no evidence of adverse effects to quokka welfare or behaviour in captivity beyond the initial signs of discomfort by some individuals. Investigations into habitat use and seasonal movement using GPS collars is continuing. Incorporation of measures of health and stress are also being considered given the recent findings from regional monitoring. Aspects of this project have been presented at the Australian Mammal Society Annual Conference, Walpole and Denmark communities and William Bay National Parks Association.

---

**Scientist:**     **A Wayne**

*Student:*       *H Hunt*

*Project title*

## **Ancient DNA provides insights into population decline and genetic diversity loss in the Critically Endangered woylie (*Bettongia penicillata ogilbyi*)**

### *Progress Report*

The primary aim of this research was to investigate historical genetic diversity in woylie populations using ancient and historical museum skin and sub-fossil specimens. A temporal comparison between contemporary and historical levels of genetic diversity will potentially provide insight into the genetic effects of population contractions. Sixty five samples were obtained, representing woylies across a wide geographical area in Western Australia, dating from 12 000 years ago to the 1970's. Ancient DNA techniques were applied to determine mitochondrial haplotype diversity and also nuclear microsatellite diversity. Assessment of the historical samples revealed 15 unique mitochondrial control region haplotypes from the 23 historical individuals analyzed; representing a loss of 50% diversity when compared to the contemporary results (15 haplotypes from 230 individuals). This represents a considerable loss of genetic diversity, which has accompanied the population declines. Phylogenetic analysis also revealed gene flow occurring between the extant populations, consistent with historical distribution patterns. Additionally, microsatellite analysis revealed ten unique alleles, identified from the 21 individuals genotyped. Furthermore, a significantly higher average allelic richness, (rarefaction was used to correct for sampling bias) was identified in the historical populations, indicating some loss of genetic diversity. Taken together this data shows higher historical levels of genetic diversity compared to that observed in modern populations today. The extent of genetic diversity lost may be more substantial given that such a small sample size limits the representation of historical populations. The findings of this study have implications on the conservation and management of the species, with evidence of historical gene flow between populations and a severe loss of genetic diversity suggesting strategies to maintain and increase genetic diversity are critical to the long term persistence of the species.

---

**Scientist:** A Wayne

**Student:** G Kaewmongkol

**Project title**

**Characterisation of two novel *Bartonella* species isolated in ticks and fleas from woylies of brush-tailed bettong (*Bettongia penicillata*)**

**Progress report**

*Bartonella* species are recognised increasingly as pathogens of humans and dogs. As more *Bartonella* species are being identified from many different countries and animals, their pathogenic potential is also being re-evaluated. The aim of this project is to investigate the presence of *Bartonella* species in ticks and fleas collected from woylies and other mammals in the south-west of Western Australia. Nested-PCRs of the citrate synthase gene (*gltA*) and the ITS region were used for the detection method. The genetic characterisation of *Bartonella* species was established by the multilocus sequences analysis. A novel *Bartonella* species was detected from fleas (*Pygipsylla hilli*) and ticks (*Ixodes Australianis*) collected from woylies. Multilocus sequence analysis of the 16S rRNA, *gltA*, *ftsZ* and *rpoB* genes and the intergenic spacer region (ITS) revealed that this isolate is a distinct *Bartonella* species and related to *Bartonella australis* previously isolated from kangaroos from the eastern states. Another *Bartonella* species was detected from ticks (*Ixodes australiensis*) collected from woylies. Phylogenetic analysis of the citrate synthase gene demonstrated that this isolate is also a potentially novel *Bartonella* species. Further study is required to extend the investigation of these two novel *Bartonella* species in more ectoparasites collected from woylies and if possible in their blood or tissue samples. It is not known whether these organisms have the potential to cause disease in woylies however the proposed research may enable some questions to be answered.

---

**Scientist:** A Wayne

**Student:** C Pacioni

**Project title**

**A conservation conundrum: the population and epidemiological dynamics associated with recent decline of woylies (*Bettongia penicillata*) in Australia.**

**Progress report**

This research project aimed to contribute to the knowledge on the general health and ecological attributes of woylie populations that were considered directly relevant for the conservation and recovery of the species. A haematological investigation was carried out and reference ranges were established. Based on the results of a disease risk assessment, selected viruses were ranked as high priority and the serological response to Macropod Herpesvirus, Encephalomyocarditis virus and Orbivirus (Wallal and Warrego serogroups) was investigated. There was no serological evidence of any of the tested viruses affecting woylie populations.

Genetic profiles of indigenous and translocated woylie populations were examined and genetics does not appear to be a contributing factor to the present decline. Nevertheless, particular concern was raised that indigenous and translocated populations, have a substantially reduced genetic diversity. Important insights were gained into woylie population structure and dynamics through analysis of molecular data and the mtDNA analysis, including evidence of historical connections between indigenous populations, which not longer exist as result of the habitat fragmentation caused by agriculture and farming land use.

Lastly, a population viability analysis (PVA) was developed and available for the evaluation of different management strategies. Additionally, the PVA model demonstrated that the main threatening process is the result of the interaction of various variables (particularly predation and inbreeding) that acquired a considerable strength together, whilst not being greatly significant by themselves. It also quantified the minimum mortality rates that are necessary for the decline to occur.

---

**Scientist:** A Wayne

**Student:** S Pan

**Project title**

***Toxoplasma gondii* infection and atypical genotypes in Western Australian wildlife species**



### *Progress report*

The project work has been focusing on genotyping of *Toxoplasma gondii* in Western Australian wildlife species. Significant effort has been made to collect a wide range of samples, including frozen carcasses and fresh samples. In total, 417 samples (335 marsupials and 82 introduced animals) and 177 individuals (137 marsupials and 40 introduced animals) were screened for *T. gondii*, including 26 woylies, ten ravens, eight quokkas, 23 ringtail possums, five brushtail possums, eight bandicoots, 16 kangaroos (three species), 22 chuditch, 11 brushtail phascogales, eight cats, five barn owls, four numbats, three rabbits, two bilbies, two foxes, two feral pigs, two water rats, and one each of echidna, western pygmy possum, tawny frogmouth, bush rat, tammar wallaby, mardo, dunnart, and penguin. Nested-PCR markers specific for gene locus B1, SAG1, SAG2, SAG3, SAG4 and GRA6 have been carried out for all samples. Extensive optimisations were carried out to select the right gene markers suitable for WA wild animal samples. Reproducible results were obtained from the optimisation procedures. This study has accumulated over 330 DNA sequences across multiple animal species and gene markers.

In total, 60% (249 out of 417) tissue samples and 75% (133 out of 177) individual animals were infected with *T. gondii* based on the analysis of two loci (B1 gene and SAG3). The marsupial samples were detected with typical infection rate of 75% (103/137). Out of the total 30 Western Australian native mammals species studied, 24 were infected with *T. gondii* (80%). High variation and unique *T. gondii* genotypes in multiple loci have been revealed in a range of animal species, such as Kangaroos, Chuditch and Woylie. Part of the research outcomes was presented at the World Association for the Advancement of Veterinary Parasitology 22<sup>nd</sup> International Conference.

---

**Scientist:** A Wayne

*Student:* G Yeatman

*Project title*

### **Population demographics of a fenced population of woylie (*Bettongia penicillata*)**

#### *Progress report*

This project aims to investigate changes in demographic parameters of the woylie population (*Bettongia penicillata*) at Karakamia sanctuary between 1995 and 2010 in response to increased density. Information will be collated from regular trapping regimes conducted at Karakamia between these years. Specific aims include identifying whether increases in density reduce individual body condition; investigating if there has been a switch to seasonal breeding over time; investigating if there has been a change in sex ratio and whether increased density affects home range behaviour.

Radio tracking was conducted between January and May. Nest and foraging ranges have been calculated for six woylies and preliminary analyses suggest a threefold increase in these parameters compared to other published estimates of woylie home range. Trapping data between 1995 and 2010 has been collated and initial results do not reveal changes in sex ratio with increased density. Analysis of remaining parameters is yet to be completed.

---

**Scientists:** A Wayne and N McKenzie

*Student:* P Webala

*Project title*

### **Bat community structure and habitat use across disturbance regimes in jarrah forests, south-west Western Australia**

#### *Progress report*

The project is now complete and consisted of two major components. First, investigating bat community responses to jarrah forest logging in south-west Western Australia. This involved assessing habitat use of foraging and commuting bats (measured as bat activity) in different logging histories (recently logged, young regrowth and old regrowth sites) using of Anabat bat detectors. The second major component involved the study of the roosting and foraging ecology of two bat species, namely; the southern forest bat *Vespadelus regulus* and Gould's long-eared bat *Nyctophilus gouldi*. The entire project was undertaken by means of radio-telemetry, roost site characterisation, vegetation assessments and measures of insect abundance.

The activity of different bat species related in different ways to structural parameters of vegetation,

generally reflecting bat echolocation ability and manoeuvrability. Bats tended to use tracks more than off-track locations, thereby avoiding clutter. At the same time, tracks recorded similar activity across logging histories. However, off-track activity in old regrowth was significantly greater than either young regrowth or recently logged forest. Two species, *Vespadelus regulus* and *Nyctophilus* sp. were more active in old regrowth than other logging histories. Similarly, *V. regulus*, *Nyctophilus* sp., *Chalinolobus gouldii*, *C. morio* and *Falsistrellus mackenziei* activity was significantly greater on-track than off-track, but this activity was similar on-track across forest types, suggesting bats' use of forest tracks was unaffected by logging. As an indication of the association of low bat activity off-track with clutter, negative relationships of under-storey clutter were the most consistent predictors of bat habitat use. Conversely, reduced clutter and abundant roost resources seemed the most likely explanations for greater activity at old regrowth sites.

There were inter-specific similarities and differences in the selection and location of roosts between *V. regulus* and *N. gouldi*. Both species were highly selective, preferring old large at intermediate or advanced stages of decay, crown senescence and deterioration with a lower percent bark cover as roost sites compared to random trees. Both species also selected hollows for roosting, with *V. regulus* roosting exclusively in hollows but a few *N. gouldi* bats also used roosts under decorticated bark, cracks and under the skirt of balga (*Xanthorrhoea preissii*) grass trees. *Vespadelus regulus* preferred tall trees in the canopy with roost entrances higher above the ground with little surrounding vegetation while *N. gouldi* preferred roosting closer to the ground and in dense clutter. In general, little evidence was found of bats roosting in eucalypt regrowth, in neither shelterwood creation nor gap release silvicultural treatments, although a few *N. gouldi* bats roosted in retained habitat, or remnant, trees in these forest types.

---

**Scientist:**     **A Wayne**

*Student:*       *K Zosky*

*Project title*

**Food resources and woylie declines in south-west Western Australia**

*Progress report*

The aim of the project is to examine the dietary ecology of the woylie and investigate its role in current population declines. Specific aims are to examine temporal and spatial variation in the diet of the Woylie, examine changes in woylie diet in relation to population decline, and investigate food resource availability.

The study involves two components, an assessment of diet using faecal material collected during woylie population monitoring and seasonal fungi surveys to assess food resource availability. Fifty-six species of hypogaeal fungi have been identified (three new). Preliminary results indicate fungi constitute the dominant dietary component throughout southwestern Australian populations but also include plant invertebrates and seed. There is limited spatial variation in diet at regional and subregional scales but strong seasonal changes with fungi being greatest in winter. A poster was presented at the Australian Mammal Society Conference in Perth, July 2009. A paper is in press with *Australian Mammalogy* entitled, 'Do preservation methods affect the identification of dietary components from faecal samples? A case study using a mycophagous marsupial.' Other papers are being drafted.

---

