ANNUAL RESEARCH ACTIVITY REPORT

July 2005 – June 2006

Science Division

Discovering the nature of WA
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Government of Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

FOREWORD

This report provides a concise summary of the research activities of the Science Division of the Department of Conservation and Land Management (CALM) for the fiscal year 2005/2006. Following a restructuring of CALM's Marine Conservation Branch, the Marine Science Program under the leadership of Dr Chris Simpson was created in the Science Division at the end of this reporting period. This Program's activities will be reported in future Annual Research Activity Reports.

Over this period staff produced 210 publications, were active on 130 science project plans and a range of core functions, assisted or supervised 62 mostly PhD students and developed some 96 significant partnerships with external agencies. In addition, they provided advice, gave presentations and assisted with numerous enquiries from other departmental staff, colleagues and the broader community.

Progress achieved in the performance of core functions is also documented. Our research activities included all 9 administrative regions of the State as recognized by the Department. In terms of the 26 IBRA bioregions included in Western Australia, staff were involved actively in research projects in each one. The distribution of effort was as follows:

CALM Region	No. Projects	IBRA Bioregion	No. Projects
South West	37	Jarrah forest	61-70
Warren	35	Warren	41-50
Swan	33	Avon Wheatbelt, Swan Coastal Plain	31-40
South Coast	25	Esperance Plains, Geraldton Sandplains, Mallee	21-30
Wheatbelt	28	Pilbara, Murchison, Gascoyne, Coolgardie	11-20
Midwest	23		
Pilbara	8		
Goldfields	14		
Kimberley	10		

25 projects were relevant to all CALM regions.

If more information is required on any of the topics listed, I encourage you to contact the relevant project team leader or refer to the Division's Business Plan and Operations Plan accessible at http://www.naturebase.net/science/science.html

It is instructive to summarize the breadth and variety of the Division's research projects. Staff are:

- Applying techniques from the molecular (DNA) level to the astronomical (photometry).
- Working at spatial scales from small islands and remnant vegetation formed by agricultural land use to the regional level (Pilbara Biological Survey).

- Studying biota across most Kingdoms, including fungi and invertebrates (terrestrial and aquatic).
- Working with organisms from the microscopic (some fungi and invertebrates) to the macroscopic (trees, birds and mammals).
- Investigating issues along a major part of the temporal spectrums, from the 1870s (biodiversity decline) to the end of this century (climate change).
- Investigating many ecological processes including predation by foxes and cats, disturbance regimes (fire), hydrological regimes (salt), disease, competition, herbivory, fragmentation and germination.
- Involved and expert in many research disciplines including genetics, ecology, biogeography and taxonomy.
- Contributing to policy development, monitoring programs, conservation planning, corporatization of data, information management and adherence to statistically sound project design and analysis.

I'd like to acknowledge the high profile enjoyed by some publications, as endorsed by the high number of copies downloaded from journals published by CSIRO.

CALM scientific papers have been among the most read of the CSIRO-published journals able to be downloaded from the net since 2000.

Papers about feral cats, salinity, eucalypt woodlands, burning, bats, logging and burning impacts on bird species richness, acacia, truffles, and dieback, written by CALM scientists took out the most read sections in five journals.

Number one spot in the Australian Journal of Botany journal was a paper by CALM scientist Colin Yates and academic research partner Richard Hobbs about eucalypt woodlands and a review of their status. Further down the list, at number 13, was a paper about salinisation and the prospects for biodiversity in rivers and wetlands in south-west WA by CALM scientists Stuart Halse and Adrian Pinder.

In the Wildlife Research journal, CALM scientist Ian Abbott's paper about the origin and spread of the feral cat held number one spot, with another of his papers, written with partners Amanda Mellican, Michael Craig, Matthew Williams, Graeme Liddelow and Ian Wheeler, on the short-term logging and burning impacts on species richness of birds in jarrah forest, at number 16.

At number 12 in the Australasian Plant Pathology journal was a paper by CALM scientist Bryan Shearer, CALM threatened flora officer Sarah Barrett and academic research partner Giles Hardy about the use of phosphite as a fungicide to control dieback, while number 16 was a paper by the same authors on the success of using phosphite to inoculate banksia trees against dieback.

In the Australian Journal of Zoology journal, CALM scientist Norm McKenzie and research partner D. Bullen's paper about bat flight was at number 14.

In the Australian Systematic Botany journal a paper by CALM scientist Bruce Maslin and research partners J.T. Miller and D.S. Seigler about the generic status of acacia was at number four, followed at number nine by a paper by CALM (then CSIRO) scientist Neale Bougher and research partner Teresa Level on truffle-like fungi of Australia and New Zealand.

It is also very pleasing to see that two of our astonomers were co-authors of a paper, published in Nature, that announced the discovery of a new, distant planet (see item no 18, p.11).

For an overview of the contribution of Science Division to the Department of Conservation and Land Management (CALM) since its formation in 1984, please see the foreword to the previous Annual

Research Activity Report (July 2005-June 2006).

This edition of the Annual Research Activity Report is the last under the Department of CALM, as this agency ceased to exist on 30 June 2006. It was replaced by the Department of Environment and Conservation (DEC), formed from a merger of CALM and the Department o Environment, on 1 July 2006.

Users of this document should contact me at Neil.Burrows@dec.wa.gov.au if they have any suggestions for improving the presentation of subsequent reports.

Dr Neil Burrows
Director, Science Division

August 2006

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VISION

We envisage a society where scientific enquiry is highly respected and forms an objective basis for environmental decision making and policy development. We strive to provide excellence in science and technology based on internationally recognized best practice. We operate research centers that foster, promote and reward creativity and innovation.

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.

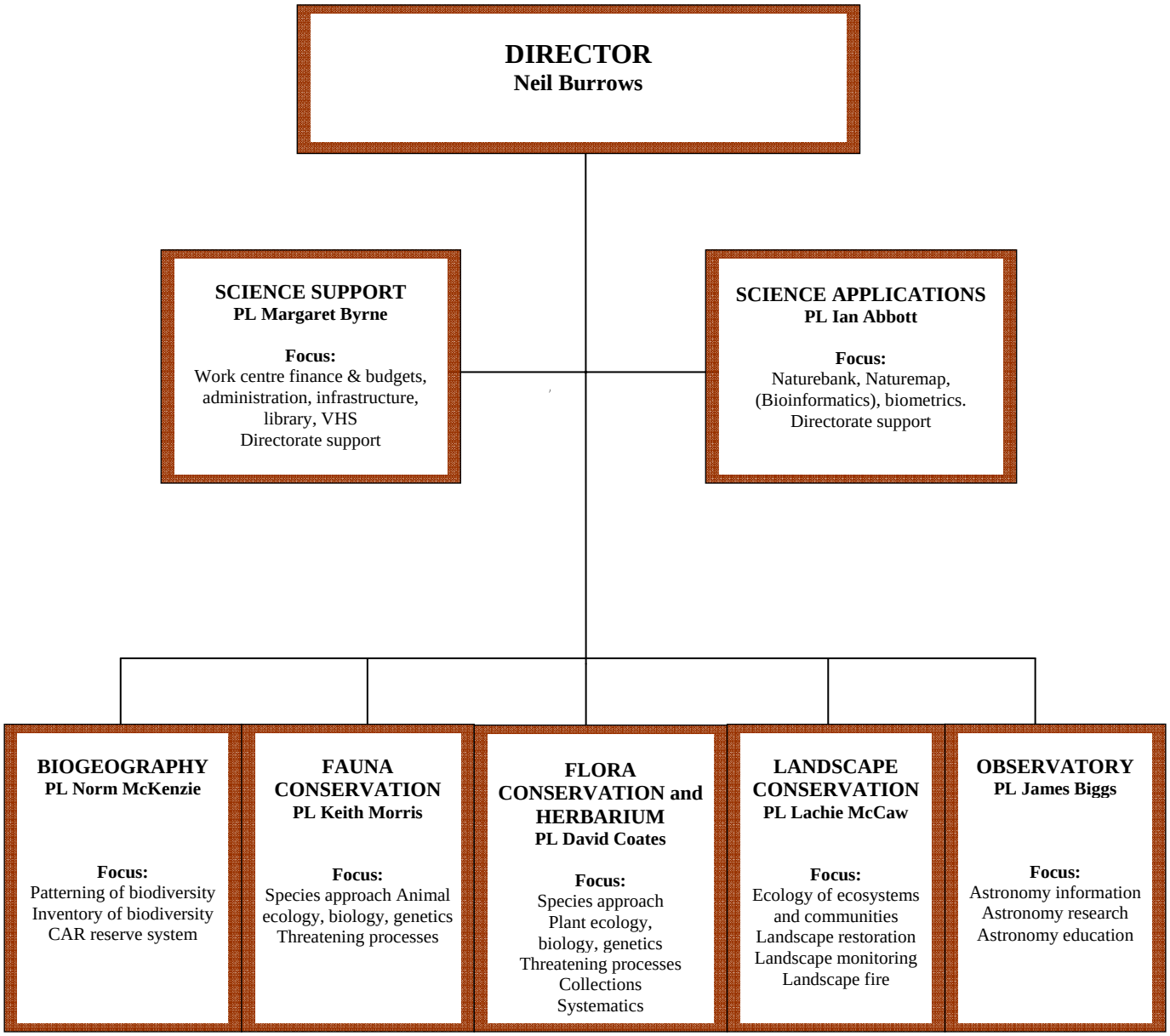
ROLE

To achieve its Mission, Science Division has the following broad objectives:

- 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 Conservation and Land Management (CALM), and carrying out CALM's other legislative responsibilities.
- To ensure that Science Division is responsive to the needs of policy makers and output purchasers in CALM and the Forest Products Commission (FPC) 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 CALM managers, research institutions and the broader community to increase knowledge underpinning conservation and land management in WA.
- To advise CALM and FPC on sustainable resource development opportunities and to promote the conservation of biological resources through their sustainable utilization.
- To communicate and transfer to managers in CALM and FPC 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 the premier national and international scientific journals and through electronic means.
- To contribute, as an integrated part of CALM, to meeting the need for knowledge on conservation and land management matters by the public of Western Australia.

SERVICE DELIVERY STRUCTURE

Science Division



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CURRENT COLLABORATION WITH ACADEMIA
(Student Projects)

Biological component

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Abbott, Ian	T Simmons	Establishing bird community indices in the Jarrah forest of southwest Western Australia	PhD	2001-2004 Deferred 2005	Prof J Fox and Adj Prof S Davies	Curtin University
Abbott, Ian	M Williams	Conservation and ecology of Western Australian butterflies	PhD	1999-2008 (0.4 FTE)	Prof B Lamont	Curtin University
Abbott, Ian	P Van Heurck	The compositional, structural, and functional succession of beetle communities in habitat mosaics created by 3 different fire regimes in the southern forests of Western Australia.	PhD	2005-2011 (0.5 FTE)	Prof J Majer	Curtin University
Algar, David	S Hilmer	Energetics and thermoregulation of feral cats	Honours	2004-2005	Dr Elke Schleucher	Goethe-University Frankfurt, Germany
Angus, John	M Lilith	Benefits arising from the exclusion of domestic cats through local government by-laws	PhD	2003-07 Project completed	Dr M Calver and Dr M Garkaklis	Murdoch University
Angus, John	S Hilmer	Ecophysiology of the feral cat in Australia	PhD	2006-08	Dr E Schleucher	Johann Wolfgang Goethe University
Angus, John	M Lilith	Benefits arising from the exclusion of domestic cats through local government by-laws	PhD	2003-2007	Dr M Calver and Dr M Garkaklis	Murdoch University
Bougher, Neale	A Francis	Sequestrate Cortinarioid fungi	PhD	2003-2007	Dr P O'Brien	Murdoch University
Burbidge, Allan	L Fox	Individual call recognition in birds	PhD	2004-2007	Dr D Roberts and Dr M. Bennamoun	University of Western Australia
Burrows, Neil	J Fissioli	Predicting the distribution of tingle associations in s-w Australia	PhD	2005-2008	Dr Grant Wardell-Johnson	Univeristy of Queensland
Burrows, Neil	C Bishop	Impacts of fire regimes and Phytophthora on vegetation communities of the southern forests.	PhD	2005-2008	Dr Grant Wardell-Johnson	University of Queensland
Burrows, Neil	P Langlands	Interactions between fire and spiders in arid zone rangelands	PhD	2005-2008	Dr Karl Brennan	University of Western Australia
Byrne, Margaret	N George	Development of *Acacia saligna* for revegetation	PhD	2002-2005	Dr G Yan	University of Western Australia
Byrne, Margaret	D Nicolle	Taxonomic revision of *Eucalyptus* series *Subulatae*	PhD	1998-2005	Dr M Whalen	Flinders University
Byrne, Margaret	R Butcher	Systematics of the south-western Australian endemic genus *Synaphea* R.Br. (Proteaceae: Conospermineae)	PhD	1997-2005	Dr J Chappill	University of Western Australia

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Byrne, Margaret	C Tauss	Phylogeny, phylogeography and conservation of *Reedia spathacea* in south-western Australia	MSc	2002-2006	Dr J Chappill	University of Western Australia
Byrne, Margaret	M Millar	An assessment of genetic risk to natural biodiversity from agroforestry revegetation	PhD	2004-2007	Dr I Nuberg	University of Adelaide
Byrne, Margaret	R Hendrati	Development of *Eucalyptus occidentalis* for revegetation	PhD	2004-2008	Dr J Plummer	University of Western Australia
Byrne, Margaret	E Dalmaris	Physiology of Wandoo decline (ARC project)	PhD	2003-2006	Prof H Lambers, Dr E Veneklaas	University of Western Australia
Byrne, Margaret	C Jones	Oil biochemistry and genetic diversity of Indian Sandalwood	PhD	2004-2007	Dr J Plummer, Dr E Ghiz	University of Western Australia
Byrne, Margaret	H Nistelberger	Genetic identity of *Grevillea curviloba* ssp. *Curviloba* and ssp. *incurva*	Hons	2005-2006	Prof J McComb	Murdoch University
Byrne, Margaret	S Stankowski	Gene flow among populations of the restricted *Calothamnus* ssp. Wicher	Hons	2006	Dr I Bennett	Edith Cowan University
Byrne, Margaret	L Kroiss	Gene flow and hybridization among *Cullen* ssp.	PhD	2006-2008	Dr M Ryan	University of Western Australia
Chapman, Alex	A Spooner	Systematics and Conservation of *Lambertia* Sm. (Proteaceae)	MSc	2004-2006	Dr K Lemson	Edith Cowan University
Coates, Dave	C Waters	Developing seed provenance zones for Australian native grasses	PhD	2002-2005	Dr J Virgona	Charles Sturt University, NSW
Cochrane, Anne	B Vincent	Research into the 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	J Clarke	Translocation outcomes for the western ringtail possum (*Pseudocheirus occidentalis*): An assessment of survivorship, habitat use, population demographics and health of western ringtail possums following translocation, and determination of the extent of competition between western ringtail possums and common brushtail possums (*Trichosurus vulpecula*)	PhD	2006-2008	Dr K Warren, Assoc Prof I Robertson	Murdoch University
de Tores, Paul	H McCutcheon	Ecology and disease of the western ringtail possum (*Pseudocheirus occidentalis*) and common brushtail possum (*Trichosurus vulpecula*)	PhD	2006-2008	Dr K Warren, Assoc Prof I Robertson	Murdoch University
de Tores, Paul	G Bryant	The ecology of the south-west carpet python *Morelia spilota imbricata* in the northern jarrah forest of south-west Western Australia. Its role as a mesopredator – is it limiting success of translocated mammal populations?	PhD	2006-2008	Dr K Warren, Dr T Fleming	Murdoch University
Farr, Janet	K Ironside	The effect of fire on the trophic dynamics of predatory invertebrates	MSc	2006-2007	Dr J Prince	University of Western Australia
Friend, Tony	J Austen	Trypanosomes of some Western Australian mammals:	PhD	2006-2009	Dr S Reid	Murdoch University

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
		phylogenetics and ecology				
Friend, Tony	S Smith	Adding DNA to the Toolbox: using conservation genetic techniques to assist with the recovery of 5 threatened marsupial species from Western Australia	PhD	2003-2006	Dr J Hughes	Griffith University
Friend, Tony	A Stewart	Competitive interactions between island populations of dibblers (*Parantechinus apicalis*), Boullanger Island dunnarts (*Sminthopsis griseoventer boullangerensis*) and House mice (*Mus domesticus*)	PhD	2002-2005	Dr R Bencini	University of Western Australia
Gibson, Neil	K Freeman	Studies on vernal pools	MSc	2006-2008	Prof SD Hopper	University of Western Australia
Halse, Stuart	E Lowe	Macroinvertebrates and diatoms as indicators of acidity in wetlands of Western Australia	PhD	2000-2005	A/Prof J John	Curtin University
Halse, Stuart	C Gouramanis	Ostracods as indicators of lake conditions and fine–scale climate change in southern Australia	PhD	2003-2006	Prof P De Deckker	Australian National University
Lyons, Michael	K Voltchanskii	Adaption of *Melaleuca* spp. to waterlogging and salinity: morphological and physiological aspects	PhD	2003-2006	Prof Z Rangel	University of Western Australia
McCaw, Lachie	R Archibald	The role of fire in the decline of Tuart (*Eucalyptus gomphocephala*) woodlands	PhD	2003-2006	Dr G Hardy and Dr B Bowen	Murdoch University
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 and Dr M Boer	University of Western Australia
Morris, Keith	D Cancilla	Ecology of the heath mouse *Pseudomys shortridgei*	PhD	2003-2006	Dr G Hardy	Murdoch University
Morris, Keith	H Owen	Looking at the transmission of rickettsia disease by native animals	PhD	2003-2006	Dr S Fenwick	Murdoch University
Morris, Keith	F Donaldson	Social structure of burrowing bettongs	PhD	2003-2006	Dr R Bencini	University of Western Australia
Morris, Keith	M Cardoso	Genetic consequences of translocation in chuditch	PhD	2005-2007	Dr K Firestone	University of NSW
Morris, Keith	M York	Risk of Probaits to chuditch	Hons	2005	Dr A Needham	Edith Cowan University
Pearson, David	L Delfs	Lizards of the *Tiliqua* genus in the urban environment	PhD	2003-2006	Dr M Pennachio, Dr D Groth and Dr J Wetherall	Murdoch University
Pearson, Grant	T Compton	The phenotypic response of the local Tellinidae to their environment	PhD	2003-2007	Prof T Piersma	Royal Netherlands Institute for Sea Research
Pearson, Grant	D Rogers	Conservation and ecology of migratory shorebirds in Roebuck Bay	PhD	2002-2004	Prof T Piersma	Charles Sturt University
Shearer, Bryan	S Collins	Survival of *Phytophthora cinnamomi* in rehabilitated bauxite mining areas	PhD	Completed 2006	Dr G Hardy	Murdoch University
Shearer, Bryan	T Papp	Epidemiology of Marri canker	PhD	2002-2004	Dr G Hardy	Murdoch University
Shearer, Bryan	K Smith	The role of chlamydospores in the survival of *Phytophthora cinnamomi*	PhD	Completed 2006	Dr G Hardy	Murdoch University

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Shearer, Bryan	P Scott	Tuart decline	PhD	2004-2007	Dr G Hardy	Murdoch University
Shearer, Bryan	R Hooper	Wandoo decline	PhD	2004-2007	Prof K Sivasithamparam	University of Western Australia
Shearer, Bryan	J Ellery	*Ramularia* leaf infection	Hons	Completed 2006	Dr G Hardy	Murdoch University
Start, Tony	T Partridge	Study of fire, small mammals and cats in Purnululu National Park	PhD	2003-2005		Macquarie University
Start, Tony	C Palmer	Study of 4 CWR mammals, their habitat requirements and the effect of fire on those requirements	PhD	2003-2005	Dr J Woinarski	Northern Territory University
Stukely, Mike	M Bexley	Biology and pathology of *Phytophthora citricola*-like organism	Hons	2006-2007	Dr G Hardy	Murdoch University
Van Leeuwen, Stephen	G Page	Ecology and physiology of Mulga types at West Angelas, Pilbara, Western Australia	PhD	2005	Dr P Grierson	University of Western Australia
Yates, Colin	A Franks	Landscape fragmentation and rare plant species: Can we develop a general framework of population responses?	PhD	2002-2007	Prof R Hobbs	Murdoch University
Yates, Colin	K Maher	Fire, fragmentation and mammals, synergistic impacts on ecosystem dynamics	PhD	2004-2007	Prof R Hobbs	Murdoch University

Astronomical component

Biggs, James	T Greig	Asteroid Occultations	3rd Yr research project	2006	Prof M Zadnik	Curtin University
Biggs, James	O Giersch	Investigation of Coronal Mass Ejections Using the Mileura Wide Field Array	PhD	2006-2009	Prof M Lynch	Curtin University

EXTERNAL PARTNERSHIPS

Biological component

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
ABRS	Taxonomy of Stylidium: 1 Scientist (J Wege)	$10k in 2005-2006	Curatorial (0.05)
ABRS	Taxonomy of Baeckea: 1 Scientist (M Trudgeon)	$150k for 5 yrs, $22k in 2005-2006	B Rye (0.5), Curatorial (0.05)
Alcoa	Diversity in Dieback Resistant Jarrah (DRJ) clones	$13k	M Byrne (0.1)
Alcoa	Dieback Forest Rehabilitation - Jarrah (DRJ) re-establishment trials	Alcoa contribution (3 yrs from 2003) $18k in 2003; $10k in 2004	M Stukely (0.3)
ANU	Pilbara biological survey groundwater mapping, ostracod identification and shell chemistry as habitat indicator, Prof P De Deckker, Dr J Reeves	CALM contribution $80K over 4 years	S Halse (0.05)
ANZEC / CRC for Australian Weed Management	Technical Group for weeds of conservation significance	Nil	G Keighery (0.05)
ARC Linkage University of Queensland, University of WA	Broadening the spatio-temporal scope of ecological studies to anticipate change in Australian forested ecosystems	External: 120k for 3 yrs CALM $20k for 3 yrs	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) vacant (0.1) R Robinson (0.1) B Smith (0.1) K Bain (0.0-5) D Green (0.05) T Middleton (0.05) L Shu (0.05)
ARC Linkage Murdoch University, University of WA, Water Corp., Department of Health, ALCOA	Risks to human health and to ecosystems from feral pigs in the Perth Metropolitan Water Catchments.	CALM $5,000 per annum for 3 years	N Burrows (0.05) D Algar (0.05)
Assessment of the emission of dioxins from bushfire activity in Australia	Work is being conducted as part of Environment Australia's National Dioxins Program, co-ordinated through CSIRO Division of Atmospheric Research.	$10k funding made available from Environment Australia to cover costs of sampling emissions from bushfires in south-west WA	L McCaw, 2 vacant posns; Total 0.3 FTE pa. Other collaborators - National Research Centre for Environmental Toxicology and University of Melbourne.
Avon Natural Diversity Alliance (ANDA)	ND001 Baselining natural diversity data in Avon Catchment	$760k first year, $600k 2nd year, $450k 3rd year	P Gioia (0.1), S Halse (0.05)
BHP Billiton Iron Ore Ltd	Pilbara biological bibliographical database	$7.5k – CALM in 2004	S van Leeuwen (0.0)
Bushfires CRC	Improved methods for the assessment and prediction of grassland curing evaluation of fire suppression techniques and guidelines managing fires in forest landscapes SW Australia	2006-08 $150k	L McCaw (0.4), R Robinson (0.2), J Farr (0.2), B Ward (0.2), G Liddelow (0.2), vacant (0.2), vacant (0.2), F Metcalfe (0.2), Li Shu (0.2), R Smith (0.1) (2.1 FTE pa)
Chevron-Texaco	Monitoring mammals on Barrow Island	$6k pa for 5 yrs	K Morris (0.05), A Burbidge (0.05)
CMAE / AGWA/ Gascoyne Murchison Project	Gascoyne Murchison Strategy	2002-2003 - $180k 2003-2004 - $150k	K Tinley (1.0), J Richardson (0.6), G Burke (0.5), J Richardson (1.0) for 25 days

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
CRC for Plant Based Management of Dryland Salinity	Biodiversity Program Project - Management of weed and genetic risk in perennial landuse systems	$756 200 over 4 yrs (2004-2008)	M Byrne, M Lyons, S Halse, N Gibson
CSIRO	Pilbara Biological Survey: 2 scientists	$30K for 4 yrs	Curatorial, taxonomic and authorships - T Weir and other staff as relevant
Dampier Salt Pty Ltd	Pilbara biological survey	$4k for airfares in 2004 – similar amount expected in 2005	S van Leeuwen
Dept of Agriculture WA	GIS vegetation mapping	2002-03 - $20k 2003-04 - $10k	G Serendenco (0.3)
Dept of Environment	Swan Bioplan	$15k for 3 yrs, 2005-2007	G Keighery (0.2)
Dept of Environment (Cwth)	AVH: Australia's Virtual Herbarium: 2.1 - database, curation, identification	2004-2005: $480k , $42k for 2005-2006	A Chapman (0.1), C Parker (0.1), S Carroll (0.1)
Dept of Industry and Resources – Pilbara Iron Environment Committee	Pilbara biological bibliographical database	$6k for 2004 ($4k committed for 2005)	S van Leeuwen (0.01)
Department of Planning & Infrastructure/ CoastWest	Surveying WA's Land Edge (SWALE) Phase 2	2004-2006 - $40K, $4k for 2005-2006	N Lander (0.05), Rob Davis (0.05)
Dept of Planning & Infrastructure	MPP: Marine Plants Project: 1 curator	2004-2006: $107k, $53k for 2005-2006	C Parker (0.2), Database (1.0)
Dept of Premier and Cabinet	Bushplan	$100k for 2003-2004	A Hopkins (1.0)
Desert Knowledge CRC	2 Scientists	Nil	M Cowan (0.25), A Hopkins (0.5), K Tinley (1.0) + 1 more to be advised
International Science Linkages	Resolving determinants of plant diversity and vegetation structure at different spatial scales for the conservation of high rainfall mediterranean-climate ecosystems	$5,000 one off	Access to databases
Invasive Animals CRC	Demonstration site – mesopredator release	$1 155k over 3 yrs	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)
Land and Water Australia / CSIRO	Genetic & ecological viability of plant populations in remnant vegetation. (PhD scholarship)	$92k total ($67k LWA, $25k SAP) $7k CALM contribution	D Coates (0.4), M Byrne (0.1), C Yates (0.2), C Elliott (1.0), B MacDonald (0.1)
Lotteries West	Insect databasing - CALM's insect collection: 1 databaser	$7,431 final funding	Database (0.05)
Millennium Seedbank Project	Seed collection, storage and biology	$210k yr to 2009	A Cochrane (0.8), D Coates (0.1)
Murdoch University	Western barred bandicoot disease studies – ARC Linkage Grant	$15k pa for 3 yrs	T Friend (0.05)
Murdoch University	ARC Linkage Project – Landscape fragmentation and rare plant species. PhD student A Franks	$27 615 for 2002 $28 615 for 2003 $28 218 for 2004	C Yates (0.2), and $7 500 yr for 2002-4. CALM contribution
Murdoch University	Survival of *Phytophthora cinnamomi* in rehabilitated bauxite mining areas S Collins (PhD student)	Nil	B Shearer (0.04)
Murdoch University	Phosphonate distribution in *Eucalyptus marginata* Donn ex Sm. forest and colonization by *Phytophthora cinnamomi* Rands R Pilbeam (PhD student)	Nil	B Shearer (0.04)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
Murdoch University	PhD student Kellie Maher LWA Stipend - Fire, fragmentation and mammals, synergistic impacts on ecosystem dynamics	$30k pa for 3 yrs	C Yates (0.2)
Murdoch University	Epidemiology of Marri canker	Nil	B Shearer (0.4)
Murdoch University	Honours student Melissa Bexley Biology and pathology of *Phytophthora citricola*-like organism	$5,000 from CALM (VHS)	M Stukely (0.05)
Murdoch University	The extraction of DNA from reptile scales and sloughed skins	Nil	D Pearson (0.05)
Murdoch University, Edith Cowan University, Alcoa, City of Mandurah	Tuart woodland decline (ARC project) including support for a PhD student	$280k over 3 yrs ARC $195k over 3 yrs from Industry $20k per yr DEC	D Haswell (0.05), L McCaw (0.05)
Murdoch University/ Ravensthorpe Nickel	PhD student – D Cancilla Management guidelines for the threatened heath mouse and other rodent species in mining lease areas of southern WA	ARC Linkage Grant - $5 k yr for 2003-5 from Stipend funds (CALM contribution)	B Johnson (0.4), K Morris (0.05)
Murdoch University	Management guidelines for the threatened heath mouse and other rodent species in mining lease areas of southern WA – D Cancilla PhD student	ARC Linkage Grant - 3 stipend top ups from CALM of $5k each	P de Tores (0.15)
Netherlands Institute for Sea Research (NIOZ)	Benthic studies – Roebuck Bay, NHT + Wettenhall – Roebuck Bay book	$27k	G Pearson (0.15)
Netherlands Institute for Sea Research (NIOZ)	PhD – T Compton	$5k from Stipend funds (DEC)	G Pearson (0.05)
Newmont Australia and Gindalbie Gold NL	Genetic structure in the Priority One Species Genus sp. Yalgoo (JM Ward s.n. 11/7/1999)	$26k	D Coates (0.05), M Byrne (0.05), B Macdonald (0.05)
NHT	Western bristlebird research plan	$99 387	AH Burbidge (0.1)
NHT	Western ground parrot recovery	$150k	AH Burbidge (0.1), B Barrett (1.0)
NHT	Pilbara biological survey, especially stygofauna	$500k	S Halse (0.7), N McKenzie (0.5), A Burbidge (0.8), S van Leeuwen (0.7)
NHT	Regional assessment of the conservation status of vegetation units throughout WA (Beard)	$31 525	A Hopkins (0.1)
NHT	Review and update of Ramsar Information Sheets for WA	$6900	S Elscot (0.2), J Lane (0.05)
NHT	Nomination and improved documentation of nationally important wetlands in under-represented IBRA regions in WA	$70k for 2003-2005	S Elscot (0.25), G Pearson (0.1), A Clarke (0.2), J Lane (0.15)
NHT Regional Competitive Component	Securing a future for the dibbler – cross-regional recovery program	$108k pa – 3 yrs	T Friend (0.1
NHT 2	Pilbara Biological Survey	$500k in 2004-2005, a separate application has to be made each year	Funding – N McKenzie (0.6), S Halse (0.5) , AH Burbidge (0.9), S van Leeuwen (0.8), N Gibson (0.3), G Keighery (0.2), L Gibson (1.0), M Lyons (0.5), D Pearson (0.2), B Maslin (0.1), K Morris (0.1)
NHT2	Preparation of a recovery plan for rock-wallabies	$35k	D Pearson
SCRIPT	Dibbler distribution and ecology in Fitzgerald River NP	$60k pa – 3 yrs	T Friend (0.1)
SCRIPT	Gilbert's potoroo recovery program	$187k pa – 3 yrs	T Friend (0.75)
SCRIPT	Numbat recovery program, South Coast	$34k pa – 3 yrs	T Friend (0.05)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
NHT2	Seed conservation program	$85k pa to 2008 (SCRIPT)	A Cochrane (0.5)
Nickol Bay Naturalists' Club (funded by Woodside)	Botanical survey of selected Dampier Archipelago islands	$5k	S van Leeuwen (0.01)
Nickol Bay Naturalists' Club (WWF/NHT funded)	Botanical Survey of Dampier Archipelago	$5k in 2005 from Environment Minister's Community Grant Program	S van Leeuwen (0.01)
Pilbara Iron Pty Ltd	Pilbara biological bibliographical database	$7.5k – CALM in 2004	S van Leeuwen (0.0)
Pilbara Iron Pty Ltd & University of Western Australia	Pilbara water use study	$42k	N Gibson (0.05), S van Leeuwen (0.05)
Portman Iron Ore and Botanical Gardens and Parks Authority	An integrated research program focused on practical outcomes for the *in-situ* and *ex-situ* conservation, restoration and translocation of the DRF *Tetratheca paynterae* (Tremandaceae)	$101k pa for 2004, 2005 and 2006	C Yates (0.4), D Coates (0.05)
Robe River Iron Associates (West Angelas Coondewanna West Envion Offsets)	Botanical survey of Tussock Grassland communities in the Pilbara biogeographical region	$20k for 2003	Now incorporated into Pilbara Biological Survey - S van Leeuwen (0.2), B Bromilow (0.2)
Robe River Iron Associates (West Angelas Coondewanna West Environmental Offsets)	Fire-Mulga study: post burn monitoring	$20k pa 2002-2005 $103k 2006-2011	S van Leeuwen (0.1), T Start (0.05), B Bromilow (0.1)
Robe River Iron Associates (West Angelas Coondewanna West Environmental Offsets)	Wattles of the Pilbara	$135k received between 2003-2005	Now incorporated into Pilbara Biological Survey - B Maslin (0.1), S van Leeuwen (0.05), B Bromilow (0.05)
Robe River Iron Associates (West Angelas Coondewanna West environmental Offsets)	A program to research and develop an integrated herbicide control regime of Ruby Dock (*Acetosa vesicaria*) in the Pilbara	$95k received between 2003-2004 $63k received in 2005	S van Leeuwen (0.05, collaboratively with Botanic Gardens and Parks Authority (B Dixon and J Anthony)
Tropical Savannas CRC	Kimberley mammals	$55k for 2002-2003 $55k for 2002-2004 CALM contributes $10k pa into CRC - Sally Black's contract was paid for by DEC	T Start (0.8), N McKenzie (0.1), J Rolfe (0.1), S Black (0.25), A Burbidge (0.1)
University of Adelaide	Pilbara biological survey/Wetland monitoring program – rotifer and cladoceran identifications, Dr R Shiel	CALM contribution $20k	S Halse (0.05), A Pinder (0.05)
University of Adelaide	ARC Linkage Grant – A comparative study of the distribution and spread of potential molecular markers for Mundulla Yellows disease	$5k per yr from CALM for 2004-2006 as an industry partner	M Stukely (0.1) equipment, vehicle
University of Melbourne	Pilbara biological survey planktonic algae identifications, Dr J Payne	Nil	S Halse (0.05), M Lyons (0.05)
University of Northern Arizona	Pilbara biological survey diatom identifications, Prof D Blinn	CALM contribution $15k	S Halse (0.05), A Pinder (0.05)
University of Western Australia	Physiology of Wandoo decline (ARC project) including support for a post doctorate position	$87 800 pa - ARC funds $25k pa - CALM contribution	L McCaw (0.1), M Byrne (0.05)
University of Western Australia	PhD – F Donaldson Social structure of burrowing bettongs	$5k pa for 2003-2005 from Stipend funds (CALM)	K Morris (0.05) and equipment

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
University of Western Australia	Mode of action of phosphonate in native hosts to *Phytophthora cinnamomi* - PhD student – B Komorek	Nil	B Shearer (0.04)
University of Western Australia	Processes in lateritic soil in Western Australia - PhD student - A Koning	Nil	B Shearer (0.04)
University of Western Australia	Pilbara biological survey – amphiod genetics and taxonomy, Dr T Finston	Nil	S Halse (0.05), S Eberhard (0.05)
University of Western Australia	Tree rings and isotopes – reconstructing climate in south-west Australia – Post Doctoral Fellow L Cullen, Dr P Grierson	Nil	L McCaw (0.05)
Urban Bushland Council, WA Naturalists Club, Lotteries West	PUBF: Perth Urban Bushland Fungi project: Education Officer	2003-6: $335k, $47k in 2005-2006	N Bougher (0.05), R Hart (0.5), S de Bueger (0.5)
Urban Bushland Council, WA Naturalists Club, Lotteries West	PUBF: Perth Urban Bushland Fungi project: 1 Scientist, 1 Education Officer	$95k plus $226k 2004-2005	N Marchant (0.05), B Crane (0.05)
Vict Dept of Sustainability and the Environment & Federal Dept of Environment and Heritage	PAPP toxicosis in cats	To be advised	D Algar (0.02), K Morris (0.02)
WA Museum	Pilbara Biological Survey: 3 scientists	$500K for 4 yrs	Field sampling, curatorial, taxonomic and authorships - P Doughty, R Johnston and other staff as relevant
Western Australia Museum	NatureMap	Nil	P Gioia (0.6)
Walpole - Nornalup National Parks Association and Walpole Wilderness Eco-Cruises	The impact of wildfire on invertebrate communities in old growth forests	$45k for 2004-2005	P Van Heurck (0.4), I Abbott (0.1), T Middleton (0.1), WNNPA volunteers (10 x 0.2 =2.0)
Western Australia Museum	Biogeography of insular populations in the Abrolhos	$ 5k (Midwest Region)	D Pearson (0.05)
Western Australian Local Government Association	Perth Biodiversity Project	$15k for 2 yrs, 2004-2006	G Keighery (0.05)
Wind over Water Foundation	Feral cat research	$951k – 5 yrs – ending 2005	D Algar (1.0), N Hamilton (1.0), M Onus (1.0), J Angus (1.0)
World Wildlife Fund - Australia	Woodland Watch	2001-2006: $79k, $9k for 2005-2006	N Lander (0.05)

Astronomical component

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
University of California, Berkeley & Lawrence Hall of Science	Hands on Universe - Internet telescope	$5k	0.03 FTE Scientist, 0.1 FTE TO
Clarion U. & Oil Region Astronomical Society	Internet telescope	$5k	0.02 FTE Scientist, 0.1 FTE TO
Curtin University and University of Western Australia	Lecturing - Perth Observatory education core function	Nil	0.2 FTE scientist
Curtin University	Student project supervision (at tertiary level) - Perth Observatory education core function	Nil	0.05 FTE scientist
Bureau of Meteorology	Weather monitoring - Perth Observatory information core	Nil	0.01 FTE TO

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	Project	Cash funding and source ($)	CALM Involvement (in kind)
	function		
Fire Protection Services, CALM	Fire monitoring - Perth Observatory information core function	Nil	Nil
Lowell Observatory, USA University of Maryland, USA	SPP# 98/0010 - Imaging and spectrophotometry of comets	$2k	0.13 FTE scientist, 0.1 FTE TO
Space Telescope Science Institute, USA; Sth African Astronomical Observatory; Institut d' Astrophysique, France; U Potsdam, Germany; University of St Andrews, Scotland & University of Tasmania	PLANET - SPP # 98/0013 Monitoring gravitational microlenses	$10k	0.45 FTE scientist, 0.12 FTE TO
Scitech Planetarium, UWA, STAWA	Astronomy education	$5k (from grant)	0.05 FTE scientist
GCN (Gamma Ray Burst Communication Network), USA	Supernova search- SPP #98/0014	Nil	0.05 FTE scientist
IAU Minor Planet Center, Harvard University	Asteroid tracking - SPP # 98/0012 Astrometry of minor planets, comets and targets of opportunity	$5k	0.23 FTE scientist, 0.52 FTE TO

Note: 1k = $1 000

SUMMARY OF RESEARCH PROJECTS by CALM and NRM REGIONS

CALM Region	NRM Region	Project Title	**Page**
Swan, South Coast	Agricultural, Rangelands, South Coast, South West, Swan	publish the results and formally describe unpublished DRF taxa	
Pilbara	Rangelands	Wattles of the Pilbara	104
All	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	*Acacia* biology, conservation and utilization	105
Wheatbelt	Northern Agricultural	Wattles in the Shire of Dalwallinu	106
All	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	WATTLE: a computer-based information system for the genus *Acacia*	106
Midwest, South Coast, South West, Wheatbelt	Avon, Northern Agricultural, South Coast, South West, Swan	Experimental translocation of Critically Endangered plants	107
Midwest, Wheatbelt, Swan, South West, Warren, South Coast, Goldfields, Pilbara	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Confirmation of the conservation status of rare and poorly known flora thought to be endangered or critically endangered	109
Goldfields	Rangelands	Declared rare and poorly known flora in the Goldfields region, wildlife management program	109
South West, South Coast	Avon, South Coast, South West, Swan	Integrated strategies for the control of *Phytophthora cinnamomi* using phosphite	110
Midwest, Swan, Wheatbelt, South West, Warren, South Coast	Avon, South Coast, South West, Swan	Susceptibility of rare and endangered flora to *Phytophthora*	111
Warren, South West, Swan, Wheatbelt	Avon, South Coast, South West, Swan	Selection, screening and field testing of Jarrah resistant to *Phytophthora cinnamomi*	112
South West, Swan	Avon, South Coast, South West, Swan	Dieback-resistant Jarrah establishment in operational forest rehabilitation sites	114
Swan, South West, Midwest, Wheatbelt, South Coast, Warren	Northern Agricultural, Swan, Avon, South West, South Coast, Rangelands	Mundulla Yellows disease in Western Australia	115
Midwest, Swan, South West, Warren, South Coast, Wheatbelt	Northern Agricultural, Swan, Avon, South West, South Coast	Vegetation Health Service	116
Goldfields, Midwest, South west, South Coast, Swan, Wheatbelt	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	The population ecology of Critically Endangered flora	118
Goldfields	Rangelands	Causes of rarity in 4 *Tetratheca* taxa in the goldfields ranges	120
All	All	Collections management	121
Kimberley, Pilbara, South Coast, South West, Swan, Warren	Rangelands, Northern Agricultural, Swan, South West, South Coast	WA Marine Plants Online Project	123
Swan	Swan	Perth Urban Bushland Fungi Project	124
All	All	Australia's Virtual Herbarium (AVH)	125
All	All	Biosystematics of the WA flora	126
All	All	FloraBase	130
All	All	WACensus	132
All	All	WAHerb	132
Landscape Conservation Program: Lachie McCaw			
Warren, South West, Swan	South West, Swan	FORESTCHECK – Integrated site-based monitoring of the effects of timber harvesting and silviculture in the Jarrah forest	134
South West, Warren	South West	Long-term effects of various fire regimes on species richness and composition of southern Jarrah forest understorey	135
Kimberley	Rangelands	Demography of Australian Boab (*Adansonia gregorii*) stands in relation to fire and grazing	136
Goldfields	Rangelands	Project Desert Dreaming: Developing sustainable management systems for the conservation of biodiversity at the landscape scale in the Gibson Desert and Gascoyne bioregions	136

SUMMARY OF SIGNIFICANT ACHIEVEMENTS ANTICIPATED for 2006/07

ALIGNED WITH CALM's KEY RESULT AREA

Key Result Area	Anticipated achievements
KRA 1. Establishment of a comprehensive, adequate and representative (CAR) terrestrial and marine conservation reserve system	**Biological survey**: Complete the field program of the biological survey of the Pilbara Bioregion and commence data analysis and write-up. Promotion of the SW Agricultural Zone biological survey findings and communication of results to key stakeholders. Commence planning and implementation of Kimberley islands biological survey. Complete analysis and write-up of some 12 sub-regional biological surveys. Continue floristic surveys of banded ironstone ranges in the goldfields. National Reserve System Working Group: Development of Commonwealth and state policy on standards and directions for NRS, implementation of NRS Directions and Statements. **Information management**: Progress the development of biodiversity information management systems that provide extensive support for systematic biological inventory and decision-making including NatureBase and CALM's Perth Herbarium information systems.
KRA 2. Maintenance of a terrestrial / marine protected area network (IUCN management categories I to VI)	**Introduced animals**: Investigate meso-predator release and reasons for non-sustained fauna recovery in parts of the south-west covered by Western Shield. Expansion of introduced predator control programs, especially feral cat, into the semi-arid and arid zones. In collaboration with Goldfields Regional, continue broadscale feral predator control at Lorna Glen leading to fauna reintroductions, commence investigations into introduced predator control techniques in lower Murchison and Wheatbelt regions. Participate in cane toad monitoring, establishment of predation and diet trials. Continue program of feral camel survey/population benchmarking, commence feral camel DNA project with Murdoch University. Quantify environmental impacts of feral pigs in northern jarrah forest. With community and mining company support, implement introduced predator control (baiting) at Mt Manning Nature Reserve and monitor the response of mallee fowl populations (and other extant fauna). **Fire**: In collaboration with CSIRO, implement fire ecology research program for Kimberley ecosystems and commence investigations into fire-weed interactions in fragmented landscapes. Make final assessment of Tutanning long term fire ecology sites – commence data analysis and write-up. Complete fire management plan, hummock grasslands - Lorna Glen case study. Complete fire management guidelines – rock outcrops and wetlands. Continue field program of Bushfire CRC-funded fire and biodiversity project to investigate fire effects in south-west ecosystems over 50 years. Implement mosaic burn treatments, Walpole Fire Mosaic project. Analyse data on long-term effects of fire regimes on Jarrah forest tree health and growth. Draft revised fire behaviour model, dry sclerophyll forests, Project Vesta. Maintain long term fire ecology research programs in SW forest ecosystems and hummock grasslands (both species specific and ecosystem levels). Develop and implement fire monitoring protocol in SW forests. Develop fire management strategies for hummock grasslands, savannas and SW forests for biodiversity enhancement/protection. Contribute to the development of Bioregional Fire Management Strategies and Regional Management Plans. **Weeds**: Continue to provide advice on weed identification and control strategies. Pending the success of the Invasive Plant CRC application, employ a weed scientists to work with operational weed programs under the Biodiversity Conservation Initiative in an active adaptive management framework. Investigate weed-fire interactions in fragmented landscapes. **Disease**: Ongoing investigations into the effective use of phosphite to control the impacts of Phytophthora cinnamomi. Determination of the susceptibility of a range of threatened flora to Phytophthora cinnamomi. Maintain monitoring of wandoo decline. Assist Tuart Response Group. Maintain watching brief Mundulla Yellows. Continue to investigate animal

Key Result Area	Anticipated achievements
	diseases – e.g., western barred bandicoot wart disease, potential role of disease in woylie decline. Employ another pathologist. **Salinity**: Provide support/advice/data to maintain and recover biodiversity with emphasis on recovery catchments under the State Salinity Strategy. Participate in NRM planning at State and Regional levels and to provide technical support/advice. Model impacts of climate change on south-west biodiversity. **Monitoring**: Continue to monitor wetlands as part of the State Salinity Strategy. Other wetlands being monitored include Peel-Harvey Estuary (waterbirds), Vasse-Wonnerup. Reports produced, findings communicated to land managers and decision makers. Prepare revised edition of the WA chapter of National Directory of Important Wetlands, update the national database of Directory to include new sites and enhanced site descriptors. Participate in development of Rangelands monitoring protocol and establish base-line vegetation condition monitoring in the rangelands. Establish baseline ecosystem health monitoring with respect to climate change in vulnerable/wet SW ecosystems. Ongoing monitoring and reporting on forest vertebrates Perup), benthic invertebrate communities, mammals on Barrow Island, Bernier and Dorre Islands, wheatbelt wetlands, Vasse-Wonnerup wetlands, Peel-Harvey estuary waterbirds, rare arid zone dasyurids, wildfire impacts, previous translocations (bristlebirds, ground parrots, numbats, chuditch, western ringtails, dibbler, western barred bandicoot, Shark Bay mouse. Develop protocol for monitoring rock-wallabies, sea turtles. Monitoring translocations of threatened flora. **Information management**: Continue to develop a framework for managing (warehouse, disseminate, value add) critical biophysical information to support biodiversity conservation and decision making (NatureBank). Develop and maintain a meta-database.
KRA 3. Conservation of landscape /seascape scale ecological systems and processes (integrating reserve and off-reserve conservation)	**Technical support/advice**: Implement audit via planning workshops in each CALM region, represent WA in NLWRA's Biodiversity Audit Mk 2, complete paper reporting on mammal audit, compile recent sub-fossil lists. Science Division staff will provide support/advice to Natural Diversity Recovery Program - additional catchments, planning process for existing Natural Diversity Recovery Program and recovery catchments under the State Salinity Strategy. Science Division staff will continue to participate in NRM planning at State and Regional levels and to provide technical support/advice.
KRA 4. Recovery of threatened species and ecological communities and conservation and sustainable use of other significant species	**Threatened species**: Ongoing investigations to improve knowledge of the distribution, ecology, biology, monitoring and conservation status of threatened species, especially Gilbert's potoroo, dibbler, red-tailed phascogale, brush-tailed phascogale, numbat, western swamp tortoise, western barred bandicoot, chuditch, western ringtail possum, heath mouse, marine turtles, pythons, Lancelin Isl. Skink, rock-wallabies, quokka, noisy scrub bird, western bristle bird, and critically endangered flora – leading to better conservation management decisions. Investigate the cause of recent decline in woylie populations. Increase taxonomic effort to clear backlog of undescribed flora, including threatened and priority flora. Implement threatened flora translocation plans. Provide advice on the impacts of proposed mining operations on conservation values of flora and vegetation of the Goldfields and Swan Coastal Plain. Develop appropriate translocation techniques for a range of critically endangered flora and develop detailed protocols for assessing and predicting translocation success. Accurately assess the conservation status of Western Australian flora listed as poorly known but considered to be rare (CALM Priority Flora) and recommend additions to the list of Declared Rare Flora as necessary. Provide a source of current information on all Rare and Priority taxa in the Goldfields Region, with management and research actions listed for each taxon. Ensure that voucher specimens for new populations of Declared Rare Flora are correct, so that requirements of the Wildlife Conservation Act can be applied correctly, and to ensure that vouchers of Priority Taxa are correctly named. Rank the ecological constraints to population growth in DRF (threatened) and provide management guidelines for use in recovery plans. Ongoing assessment of the conservation status of rare and poorly known flora thought to be critically endangered (130 taxa). Gain an understanding of the reproductive biology & demography of rare Tetratheca impacted by mining. Commence reassessment of conservation status of WA Acacias. Commence major project to elucidate variation in mulga, a keystone rangelands taxon. **Translocations proposed**: Gilbert's potoroo, western bristlebird, dibbler, boodie. Possible translocations of arid zone mammals to Lorna Glen pending success of introduced predator trials. Develop appropriate translocation techniques for a range of critically endangered flora and

Key Result Area	Anticipated achievements
	develop detailed protocols for assessing and predicting translocation success. Continue experimental translocations of 21 critically endangered flora. **Recovery and management plans**: Revise numbat RP, revise chuditch RP, review status rock wallabies and prepare recovery plan, complete red-tailed phascogale RP, prepare draft Marine Turtle Management Plan, assist with fire management plan Two People's Bay and Mt Manypeaks, assist with post-wildfire monitoring Mt Manypeaks, assist with hummock grasslands fire management plan, assist with Kimberley fire management plan, contribute to area-specific and regional management plans. Continue captive breeding including Return to Dryandra, Gilbert's potoroo, cross-fostering trial Gilbert's potoroo. Analyse and write up results of Kimberley mammal survey, sub-fossil survey. **Genetics**: Provide genetic and phylogenetic information for the conservation, circumscription and management of Western Australian flora, particularly Declared Rare Flora and Priority Flora. Determine the phylogenetic relationships between geographically diverse populations and patterns of genetic diversity in Declared Rare Flora, Priority Flora and other species of conservation significance. Identify and quantify the genetic and demographic factors that affect the viability of plant populations in vegetation remnants. Provide a cost effective and efficient interim solution to loss of native plant genetic diversity and a focus for flora recovery in Western Australia by collection and storage of seed from rare and threatened Western Australian plant species. **Weeds**: Assist with the documentation of the occurrence, impact and control of environmental weeds of Western Australia and to assist in prioritizing management of weeds at a local, State and federal level. Identification of weed and native species in threatened ecological communities. Ongoing advice on weeds. **Sustainable Forest Management**: Assist with reviews, provide technical advice as and when required. Maintain FORESTCHECK, an integrated monitoring system that has been developed to provide information to forest managers in the southwest of Western Australia about changes and trends in key elements of forest biodiversity associated with a variety of forest management activities. Complete write-up of 5th year major review of FORESTCHECK. Complete investigation the effects of logging and the associated burning operations on the terrestrial invertebrate fauna inhabiting medium rainfall jarrah forest (particularly spiders, beetles and flies). Complete investigate the ecological impacts of logging and associated burning operations on populations of medium-sized mammals inhabiting medium rainfall jarrah forest. Continue to monitor the effects of timber harvesting on bird species/community composition in the karri forest. Document the effects of topography on distribution and abundance of invertebrates in jarrah forest. Identify appropriate seed collection zones for vascular plants used in rehabilitation of sites disturbed during forest operations. To understand the fundamental processes of seed cycle, regeneration, competition and stand dynamics of jarrah forest on a range of sites as a basis for developing silvicultural practices to achieve a range of ESFM outcomes. Complete paper on forest health monitoring. Continue monitoring run-off and groundwater in response to logging in IRZ – prepare report. Continue to implement monitoring of forest stream biodiversity and water quality.
KRA 5. Providing for sustainable nature-based recreation and tourism and increased enjoyment and appreciation of protected areas	Provide technical and scientific input to management plans, provide plant names to support information booklets (e.g. Bush books), nature trail signage and information brochures. Achievement highlights are publication of forest region flora handbooks, Forest Wheel Project; Ravensthorpe nature Trail etc. There are significant achievements in herbarium training of Operations, P and VS and NC Division staff on how to access plant information through FloraBase.
KRA 6. Providing community involvement and encouraging understanding, and support of biodiversity conservation and other Departmental programs and activities	Ongoing program of workshops, seminars and public meetings. Development of publicly accessible biodiversity information management systems (NatureBank). Landscope expeditions throughout WA. Landscope and other popular articles. Estimated 200 scientific publications from the Science Division. Numerous public meetings, scientific workshops, seminars, field days, etc. Numerous volunteers participate in the range of research projects outlined here. Regional Herbaria and Weed Information Network projects; CALM staff and community plant collecting and plant information programs; 5 training sessions held in period; Science Teachers Associations presentation; The Herbarium successfully manages 60 internal and over 300 external volunteers.

DIVISIONAL PRIORITIES and ANTICIPATED KEY OUTCOMES or ACHIEVEMENTS

over the next 2 - 3 years

Key Result Area	Anticipated outcomes or achievements
KRA 1. Establishment of a comprehensive, adequate and representative (CAR) terrestrial and marine conservation reserve system	**Biological survey**: Complete publication of Pilbara biological survey. Complete data analysis and write-up of 5 sub-regional surveys. Commence field program – Kimberley islands survey. Commence write-up and publications, banded ironstone survey. Commence planning for Yalgoo survey (and possibly Great Victoria Desert bioregion). Commence biological survey of priority forest areas (consistent with Forest Management Plan). Recommendations for strategic acquisition of land for a CAR reserve system.
KRA 2. Maintenance of a terrestrial /marine protected area network (IUCN management categories I to VI)	**Adaptive Experimental Management**: Science staff involvement in at least one active adaptive ecosystem management program in each Region, focussing on managing threatening processes (fire, ferals, weeds, disease) for biodiversity outcomes, and translocations. **Fire**: With Region, implement fire management plan for hummock grasslands – Lorna Glen case study. Commenced adaptive experimental management programs to better understand impacts of frequent and extensive late season fires on biodiversity in the Kimberley. Ongoing field work, data analysis and write up associated with a range of short and long-term fire ecology projects in s-w forest, woodland and desert ecosystems. Finalise a model for predicting the behaviour of high intensity Jarrah forest fires. Completion of field work – fire and biodiversity program – Bushfires CRC. Ongoing application of mosaic burning trials, Walpole Wilderness Area. Commence the establishment of a network of Scientific Reference Areas (SRA's) in S-W forests. Commence establishment of a network of long-term SRAs in other Regions. Assist with the development of fire management strategies to mitigate large and intense wildfires – tropical savannas, hummock grasslands, heathland, mallee, woodlands. **Feral animals**: Successful operational baiting to control feral cats, foxes and wild dogs in the arid zone rangelands. Registration of new fox and cat baits. Understanding of meso-predator replacement and sustainable fauna recovery programs in the south-west. Benchmark data on population, distribution and genetic structure of feral camel herds. Benchmark data on some impacts of feral Pigs in south-west ecosystems. Targeted monitoring sites established and scored prior to the arrival of cane toad. **Disease**: Strategies for the effective use of phosphite and the development of novel phosphite applications to control the impacts of Phytophthora cinnamomi in some ecosystems. Ongoing trials to determine the susceptibility of a range of threatened flora to Phytophthora cinnamomi. **Salinity**: Ranking of the ecological importance of disturbances, including salinization, fire, flooding and grazing, for maintenance of biodiversity. Commencement of landscape scale rehabilitation/restoration ecology research including focal areas of the wheatbelt. Ongoing provision of support/advice/data to maintain and recover biodiversity with emphasis on recovery catchments under the State Salinity Strategy. Participate in NRM planning at State and Regional levels and to provide technical support/advice. **Weeds**: Continue to provide advice to operations staff, update weed lists and threat status, participate in Invasive Plants (IP) CRC (if successful) to investigate effective control measures. Implementation of a study to Investigate interactions between fire, weeds and fragmentation, seek opportunities for Adaptive Experimental Management programs for weed control and ecosystem rehabilitation through the Biodiversity Conservation Initiative (BCI) and IP CRC initiatives. **Herbarium**: New herbarium building completed. Continue developing Corporate information systems and in particular the Regional Herbaria, and continue to assist in community based natural resource management

Key Result Area	Anticipated outcomes or achievements
	planning processes, especially by providing technical data and advice. Several hundred undescribed plant species, described. Significant advances in collections and taxonomy of fungi. **Landscape ecology and restoration**: Guidelines for the appropriate management of viable vegetation remnants in degraded and fragmented landscapes. Commence program to assess the effectiveness of stream buffers – south-west forests (Forest Management Plan). Assist with the design and establishment of rangelands monitoring sites. Finalise and publish 5 year review of FORESTCHECK. Ongoing establishment and assessment of FORESTCHECK and Firewatch monitoring sites. Modelling the hydrological impacts of timber harvesting in the intermediate rainfall zone. Publish investigation into the effects of logging and the associated burning operations on the terrestrial vertebrate and invertebrate fauna inhabiting medium rainfall Jarrah forest (Kingston Project). Continue to monitor the effects of timber harvesting on bird species/community composition in the Karri forest. Understand the fundamental processes of seed cycle, regeneration, competition and stand dynamics of Jarrah forest on a range of sites as a basis for developing silvicultural practices to achieve a range of ESFM outcomes. Understand how the level of soil disturbance and damage during timber harvesting is affected by soil type, environmental conditions, and operational factors and to evaluate techniques for minimizing soil damage during timber harvesting operations. Determine the efficacy of stream buffers in protecting stream biodiversity and water quality during timber harvesting operations. Provide a scientific basis for development of guidelines for soil and water conservation in State forest. Develop an improved understanding of the impacts of timber harvesting on run-off and ground water quality in the intermediate rainfall zone of the Jarrah forest. Develop techniques for assessing and ameliorating the effects of Armillaria root disease in the Karri forest, with particular emphasis on regenerated stands that will be subject to commercial thinning. Develop practical techniques for integrated monitoring of forest health to meet commitments specified in the Forest Management Plan 2004-2013. **Information Management Systems**: Progress the development of NatureBank – an integrated biophysical information management system. Science Division meta-database established and current.
KRA 3. Conservation of landscape /seascape scale ecological systems and processes (integrating reserve and off-reserve conservation)	Continue representation in NLWRA's Biodiversity Audit process. Participate and contribute to the National Reserves System program and IBRA. Science Division staff to participate with Regional staff in adaptive ecosystem management projects. Aim to have at least one AEM project in each region by 2008. Continue to participate in development of management plans. The Herbarium will continue to provide plant identification and species information support for development of effective management of pastoral lands, State forests and timber reserves. Complete analysis and write-up of sub-regional biological surveys – see above. Ongoing monitoring and reporting; forest vertebrates, benthic invertebrate communities, mammals on Barrow Island, wheatbelt wetlands, Vasse-Wonnerup wetlands, Peel-Harvey estuary waterbirds, rare arid zone dasyurids, FORESTCHECK.
KRA 4. Recovery of threatened species and ecological communities and conservation and sustainable use of other significant species.	**Threatened species recovery**: Translocations of threatened mammals including Gilbert's potoroo, boodie, bilby, dibbler and others. Ongoing monitoring of existing and new mammal translocations associated with Western Shield including translocations into the rangelands arid zone (Western Shield extension). Ongoing implementation of recovery plans and ongoing field assessment, analysis and write-up of research into threatened fauna species including Gilbert's potoroo, brush-tailed phascogale, red-tailed phascogale, sea turtles, chuditch, quokka, western bristlebird, ground parrot, western ringtail possum, numbat, carpet, woma and Pilbara olive pythons, Lancelin Island skink, banded stilt, western barred bandicoot, western desert rock wallaby, dibbler, heath mouse. Report on conservation status of WA Acacias. Taxonomic revision of the 'mulga' group. Ongoing provision of genetic information for determining the taxonomic status of flora, especially threatened flora. Ongoing collection, testing and storage of seed of threatened flora. Ongoing assessment of the conservation status of rare and poorly known flora thought to be critically endangered taxa. Ongoing experimental translocations of critically endangered flora. Ongoing investigations into the genetic and ecological viability of plant populations in remnant vegetation. Corporate information systems provide extensive data for nature-based recreation and tourism. FloraBase is increasingly used by CALM staff to access user-friendly plant information.

Key Result Area	Anticipated outcomes or achievements
KRA 5. Providing for sustainable nature-based recreation and tourism and increased enjoyment and appreciation of protected areas	
KRA 6. Providing community involvement and encouraging understanding, and support of biodiversity conservation and other Departmental programs and activities	Ongoing development of biodiversity information management systems (NatureMap/NatureBank). Landscope expeditions throughout WA. Landscope articles. Estimated 200 scientific publications from the Science Division/year. Expectation of a minimum of 2 scientific papers per scientist/annum. Numerous public meetings, scientific workshops, seminars, field days, etc. Numerous volunteers participate in the range of research projects outlined here. External funds have been received to enhance the Regional Herbaria network in the Northern Agricultural region. This will have an accent on weeds and documentation of threatened ecosystems as well as strong support to the Marchagee-Buntine biological survey.
Community and local political pressures:	Ongoing expectations to provide scientific information to underpin reserve selection, fire management, species conservation (rare/threatened), biological survey, weed control, dieback control, feral and introduced animal control. Resource developers, consultants, CALM staff and community groups demand greater access to plant identification services that cannot be provided because of low staffing levels/expertise in this area.
Summary of any major staffing issues:	Key issue for the Science Division is ageing workforce. A Workforce Planning Strategy has been developed and revised to address this. Implementation of this strategy will be a priority for the Division. Greater emphasis on networking and building partnerships and collaborations. Division will focus more attention on 'regionalizing research' through greater emphasis on consultation, advice, technology transfer and participation in adaptive experimental management programs in collaboration with Regions.
Significant funding or other issues (i.e. summary of any issues you wish to raise relating to your cost centre budget and the delivery of Corporate and Output priorities):	Ongoing problem of fixed costs: operating budget ratio. Ongoing reliance on short-term funding sources, which reduce ability to be strategic. Increasing pressure on salary and overheads budget with creeping costs,

RESEARCH ACTIVITY

BIOGEOGRAPHY

Program Leader: Norm McKenzie

Pilbara regional survey

SPP# 2002/04; 2004/002

Team members

N McKenzie (0.60), S Halse (0.8), AH Burbidge (0.8), S van Leeuwen (0.7), N Gibson (0.3), G Keighery (0.25), L Gibson (1.0), M Lyons (0.5), D Pearson (0.3), K Morris (0.1), A Pinder (1.0), S Eberhard (1.0), N Guthrie (1.0), B Durrant (1.0), S Patrick (0.3), P Kendrick (0.2), (External); Total 9.85.

Context

The Pilbara is an economically important region of WA, with major and expanding mineral extraction industries, pastoral industries, etc. Effective biodiversity conservation is needed to minimize the adverse impacts of these activities. The survey addresses problems of incomplete knowledge of biodiversity (composition, patterns, status, trend) for nature conservation planning, including reserve system gaps and weed invasions. Sampling includes reptiles, frogs, small ground mammals, bats, birds, arachnids and aquatic invertebrates including stygofauna, wetland, terrestrial flora and soils to overcome low cross-taxon congruence in biodiversity models. Sampling covers a range of life-history strategies, motilities, ecological roles, longevities, parts of phylogenetic tree, etc. Geomorphic and geographical coverage using c. 800 quadrats; 2 seasons from fully overlapped sampling in 2 different 12 month periods.

It aligns with 2005/06 Corporate Priorities 2, 3, 6 and KRA; NC 1C, 3E, 3I.

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 and main findings

- 151 botanical sites scored twice and the other 151 sites scored once.
- All 500 stygofauna sites have been sampled twice and specimen identifications completed, although taxonomic work is still being undertaken.
- Bat sampling completed at all 24 campsites.
- All vertebrate sampling, including birds, completed at 294 of 302 sites.
- All 90 aquatic invertebrate sites sampled, and sampling of invertebrates was completed at the first 150 terrestrial sites.
- Floristic sampling of 60 wetland flora sites completed.
- Numerous local, state and national presentations and advice on progress of survey.

Management implications

- Basis for systematic regional nature conservation planning for 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)

- Workshop on survey progress in October 2006.
- Sampling of terrestrial invertebrates completed at second 150 sites.
- Second 150 terrestrial botanical sites sampled for a second time.
- Identification/taxonomy of terrestrial plant, vertebrate and invertebrate collections and write-up of survey results.
- Stygofaunal taxonomy and write-up of survey results.
- Identification of all wetland samples and write-up of results.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Biological survey of the agricultural zone (SAP Survey)

SPP# 98/0020

Team members
G Keighery (0.20); Total CALM (0.20).

Context
The south-west Western Australian agricultural zone is a degrading hotspot needing optimised conservation strategies. An ALTERM survey (mixed-taxon species lists from quadrats) was necessary to provide the first quantitative biodiversity model for whole region for focusing and optimising management strategies. Sampling included reptiles, frogs, small ground mammals, arachnids, aquatic invertebrates, wetland birds, wetland flora, terrestrial flora and soils to overcome low cross-taxon congruence in biodiversity. Sampling also covered a range of life-history strategies, motilities, ecological roles, longevities, different parts of phylogenetic tree, etc. Geomorphic and geographical coverage using ca. 932 quadrats; sampled in at least 2 seasons.

It aligns with 2005/06 Corporate Priorities 2, 3, 6 and KRA; NC 1C, 3E, 3I.

Aims

- To identify and prioritize recovery catchments, with respect to nature conservation values.
- To provide a regional perspective on nature conservation priorities to help determine and prioritize management actions particularly in relation to salinity.
- To provide baseline data for monitoring.
- To assist in provision of lists of plant species useful for revegetation and liaise with groups undertaking revegetation of the area.

Summary of progress and main findings

- Despite degradation, the SW Wheatbelt region retains high biodiversity values that require protection from threatening processes including salinity and water logging.
- Results provided to CALM managers and the broader community.
- Numerous presentations, including Wheatbelt Futures.
- Numerous scientific papers published in various journals.
- SAP survey volume has been published.

- A CD that communicates survey results now available.
- Buntine/Marchagee monitoring completed.

Management implications

- Basis for systematic regional nature conservation planning for salinity, reserve system development, and distribution and conservation status of species (indigenous and weeds) and ecological communities, especially in relation to salinity futuring.
- A basis for long-term ecological monitoring of region's biodiversity.

Future directions (next 12-18 months)

- Companion booklet to the SAP survey volume to be published.
- Prepare revisions of wheatbelt Triglochin, and descriptions of new plant taxa.

CALM Regions

Wheatbelt, South Coast, Midwest, Northern Forest, Southern Forest.

IBRA Regions

Geraldton Sandplains, Avon Wheatbelt, Jarrah Forest, Mallee, Esperance Plains.

NRM Regions

Avon, South West, Northern Agricultural, Rangelands.

Biodiversity audit

Core Function - Policy

Team members

N McKenzie (0.20), AA Burbidge (0.10); Total CALM 0.30.

Context

A review to underpin nature conservation planning in WA as part of an Australia-wide process. Used in WA for assessing priorities among alternative nature conservation activities in different IBRA subregions, and as a one-stop reference source for regional NRM groups.

It aligns with 2005/06 Corporate Priority 1; KRA NC 3C.

Aim

To audit WA biodiversity and conservation activities as part of NLWRA program, producing IBRA sub-regional synopses, IBRA bioregional summaries, case studies for 2 sub-regions, and analysis of mammal, Acacia, eucalypt and bird status by bioregion.

Summary of progress and main findings

- WA sub-regional synopses published as a book.
- WA regional summaries published.
- NK1 and AW2 case studies published.
- Member of Nature Conservation Output Working Group.
- Implement audit in Kimberley Region via planning workshop.
- Recent sub-fossil lists upgraded for Yalgoo, Great Victoria Desert and Napier-Oscar ranges.
- Manuscript reporting findings of mammal audit completed.
- Present Audit mammal analysis results at Australian Mammalogy Society meeting.
- 14 mammal species accounts drafted for 'Mammals of Australia'.
- Final sub-fossil mammal identifications for Napier-Oscar Ranges from M McDowell and A

Baynes.

Management implications

- A basis for systematic regional nature conservation planning and delivery.

Future directions (next 12-18 months)

- Mammal audit paper published.
- 15 species accounts published in the revised edition of 'Mammals of Australia'.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

National reserve system working group

Core Function - Policy

Team members
N McKenzie (0.05); Total CALM 0.05.

Context
The Reserve system is Australia's primary nature conservation strategy. The establishment of the National Reserve System (NRS) program under the Natural Heritage Trust meets the requirement under the National Strategy for the Conservation of Australia's Biological Diversity to establish a comprehensive, adequate and representative system of terrestrial protected areas. There is a separate program to establish marine protected areas.

It aligns with 2005/06 Corporate Priority 2, 5; KRA NC 1A, 1C.

Aims

- To establish and manage new ecologically significant protected areas for addition to Australia's terrestrial National Reserve System.
- To provide incentives for Indigenous people to participate in the National Reserve System through voluntary declaration of protected areas on their lands and support for greater involvement of indigenous people in the management of existing statutory protected areas.
- To provide incentives for landholders (both private landholders and leaseholders) to strategically enhance the National Reserve System.
- To develop and implement best practice standards for the management of Australia's National Reserve System Systematic development of a secure CAR reserve system for Australia that meets national and international standards.

Summary of progress and main findings

- Represented WA in developing Commonwealth and State policy on standards and directions for developing a NRS.
- Provided WA IBRA version 6 boundary updates and revised definitions.
- NRS Directions Statement approved by Ministerial Council, released by Commonwealth Government, and implementation of its directions commenced in WA by CALM.
- IBRA version 6 released.

Management implications

- Reserve system development, management and standards.

Future directions (next 12-18 months)

- NRS Technical Working Group address the issue of adequacy.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Ecomorphological clues to community structure, bat echolocation studies
SPP# 93/0028

Team members
N McKenzie (0.10), honorary engineer (R Bullen); Total CALM 0.10.

Context
This currently underpins a component of the Pilbara Survey sampling program (see above).

It aligns with 2005/06 Corporate Priority 2, 12; KRA NC 1C.

Aims

- To extend the strategies and sampling methods that are used in wildlife surveys. If ecological surveys include a wider range of taxa, their results represent more of the ecological network. Guild studies such as these extend our knowledge of the assemblage structuring processes (including disturbances) that affect the composition and richness of Western Australian communities.
- To compile a dictionary of sonar signatures for automatically recording the composition of bat assemblages on quadrats.
- To develop ecomorphological measures of potential niche. Relate them to community structuring mechanisms and species' realized foraging niches.
- To inter-relate disturbance and structural determinism in bat communities.
- To investigate environmental factors controlling the occurrence of bats.

Summary of progress and main findings

- Paper on wing-beat dynamics of WA bats published in Journal of Experimental Biology.
- Paper on echolocation of Little Sandy Desert bats published in Australian Mammalogy Society.
- Bat muscle mass paper published in Australian Journal of Zoology.
- Tadarida australis migration paper published.
- Flight performance data compiled for 10 Pilbara species.

Management implications

- More biodiverse surveys, better understanding of guild and fauna structure in WA ecological communities. Understanding their distributions and status for nature conservation.

Future directions (next 12-18 months)

- Flight performance data collected and compiled for remaining Pilbara bats.
- Identify echolocation calls from 24 Pilbara Survey areas, and compiled matrix from echolocation data.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Provision of biogeographical information for CALM management plans, NRM advice scientific liaison and membership of scientific advisory committees
Core Function - Policy

Team members
G Keighery (0.05); Total CALM (0.05).

Context
Provision of vascular flora data for NRM activities, CALM nature conservation planning and operations in WA.

It aligns with 2005/06 Corporate Priorities 2, 3, 5, 6 KRA NC 1C, 3E, 6.

Aim
To liaise with and advise managers, planners, NRM groups on the identification and protection of flora biodiversity assets.

Summary of progress and main findings

- Monitoring data for 1973 Dorre Island fire sorted and archived.
- Woodland restoration program for Rottnest reviewed.
- Ironstone Threatened Ecological Community workshop, review presented.
- Discussion paper on status of Greenough Flats Threatened Ecological Community prepared.
- Paper on floras of 34 island nature reserves of Shark Bay submitted.

Management implications

- Scientific basis of effective nature conservation.

Future directions (next 12-18 months)

- Submit papers on Leeuwin Nats and Margaret Plateau parks.

CALM Regions
All.

IBRA Regions
All.

NRM Regions

All.

Kimberley Nature Conservation output liaison, including submissions to acquire funding support for Kimberley island biodiversity survey

Core Function - Policy

Team members

A Start (0.05), N McKenzie (0.05); Total CALM 0.10, plus AA Burbidge (Post Retirement Research Fellow).

Context

The North Kimberley bioregion is rich in biodiversity, but poorly known compared with some other bioregions. Access to and understanding of Kimberley biota, and threatening processes including altered fire regimes, weeds, grazing by feral animals and impacts of other invasive pest animals, is required for developing sound conservation management strategies and actions.

It aligns with 2005/06 Corporate Priorities 2, 3, and KRA 1C, 3E, 6.

Aim

To liaise with and advise the Kimberley Regional Manager on nature conservation output, support nature conservation staff over technical issues and liaise with Kimberley Land Council (KLC) on access and collaboration.

Summary of progress and main findings

- Draft Cabinet submission for Kimberley islands biological survey.
- Ongoing liaison on nature conservation output (Regional Manager), technical support (regional staff).
- Assisted with and participated in Kimberley fire management workshop.
- Access and collaboration with KLC.
- Collaborate with regional ecologist in defining Mitchell Plateau reserve options.

Management implications

- Prepare cabinet submission for funds to survey biodiversity of Kimberley islands, particularly mammals, and advise on reservation, management. SPP will need to be prepared for biodiversity survey once funding is identified.

Future directions (next 12-18 months)

- Ongoing liaison and advice as requested.

CALM Region

Kimberley.

IBRA Regions

North Kimberley, Central Kimberley, Victoria Bonaparte, Ord Victoria Plains, Dampierland.

NRM Region

Rangelands.

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

SPP# 93/0038

Team members

N Gibson (0.05), G Keighery (0.25); Total CALM 0.30.

Context

The Swan Coastal Plain is highly fragmented and impacted by settlement, urbanisation and industry. Data at various levels is required to make decisions about the conservation and protection of biodiversity. This project to delivers data from Swan Coastal Plain Floristic and Reserve Survey to Swan Region NRM and Local Government.

It aligns with 2005/06 Corporate Priorities 2, 3, 6 and KRA NC 1C, 3E, 3I, 6.

Aim

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

Summary of progress and main findings

- Tuart Workshop Proceedings published. Tuart Conservation Status management group concluded 6 papers published on taxonomic outcomes of surveys.
- Numerous presentations.
- Conservation Commission advice on significant forest flora, Wicher Range National Park prepared.
- CALM data were one of the major layers used in Department of Environment 'Bush Forever' review.
- Participate in Perth Biodiversity Project (NRM) and Regional Parks Management Plan group.
- Advice to WA Threatened Species and Communities Unit (CALM).
- Published taxonomic paper.
- Published reassessment of conservation significance of clay based wetlands.
- Swan Coastal Plain flora checklist published.
- Floristic Reference sites established in PMA.
- Archiving of SCP etc data sheets completed.
- Reserve flora checklist papers for Ridge Hill Shelf prepared.

Management implications

- The basis for land use planning for biodiversity conservation on the swan coastal plain.

Future directions (next 12-18 months)

- Complete the floristic survey of the Wicher Scarp and Dandaragan Plateau, then analyse data.
- Make floristic references available on WA Local Government web page.
- Taxonomic papers publisher.

CALM Region

Swan.

IBRA Region

Swan Coastal Plain.

NRM Regions

Swan, South West.

Floristic survey of the banded ironstone and greenstone ranges of the Yilgarn
SPP# 93/0166

Team members
N Gibson (0.25), A Markey (1.0), R Meissner (1.0), S Dillon (1.0), Y Caruso (1.0); Total CALM 4.25.

Context
To assess the conservation significance of the flora and vegetation of the goldfields ranges, which are little studied and under increasing pressure from the rapidly expanding iron ore mining interests south of the Pilbara. This increase in interest is driven by the rapidly expanding Chinese market for iron ore.

It aligns with 2005/06 Corporate Priorities 2, 3, 6 and KRA NC 1C, 3I, 6.

Aim
To undertake a detailed floristic survey of the banded ironstone and greenstone woodlands of the Goldfields to identify gaps in the present reserve network and to determine areas of high biological significance. This land system is poorly reserved and poorly documented while being highly prospective for mineral exploration.

Summary of progress and main findings
- Survey Parts 4, 5, 6 and 7 published.
- First year of Yilgarn survey completed, 6 ranges surveyed.
- Plant identifications & databasing complete.
- A number of new taxa and restricted plant communities identified.
- 5 papers currently being prepared.
- Advice to managers.
- Advice to WA Threatened Species and Communities Unit (CALM).
- Advice to CALM's Environmental Protection Branch & Department of the Environment on impacts of proposed developments.

Management implications
- Provide regional context for the assessment of the impacts of proposed developments on conservation values on flora and vegetation of these ranges.

Future directions (next 12-18 months)
- Undertake 2nd year of survey.
- Produce 2nd year reports.
- Lodge herbarium specimens from 1st year of survey.

CALM Regions
Goldfields, Midwest.

IBRA Regions
Coolgardie, Yalgoo.

NRM Region
Rangelands.

Conservation of Western Australia's vegetation assemblages
SPP# 94//0003

Interim framework for developing a CAR reserve system for WA
SPP# 2000//0011
Land-use and vegetation mapping
SPP# 2000/0010

Team members
A Hopkins (0.40).

Context
Assemble a GIS database which can be used for making assessments of values of land for nature conservation and for setting priorities for acquisition and management, (b) provide an up-to-date assessment of the conservation status of the vegetation units described and mapped by JS Beard (and FG Smith) within Western Australia at a scale of 1:250,000 (including identification of possible rare and threatened communities and ecosystems), (c) identify areas of land supporting vegetation units not adequately represented in the conservation reserve system, and (d) examine theories related to reserve adequacy and design using a local data set.

It aligns with 2005/06 Corporate Priorities 2, 6 and KRA NC 1C, 3C, 3E, 6.

Aims
- To produce a framework for in-situ nature conservation in Western Australia. This will be achieved via a State-wide database which brings together information about ecosystems and ecological communities within the State, threats to the nature conservation values of each, and land use data, for the purposes of bioregional planning. The database and associated GIS can then be used to develop priorities for land acquisition and off-reserve management agreements and indigenous protected areas.
- To produce a series of map products and associated databases covering the State to pre-agreed specifications for the themes land-use, pre-European vegetation type and extent, present type and extent and vegetation condition. In addition, we will develop a database of metadata of vegetation survey datasets.

Summary of progress and main findings
- Regular reports to Pastoral Land Purchase program team on vegetation of leases being considered for purchase by CALM.

Management implications
- Broadscale planning of nature conservation output needs e.g. reserve system design and acquisition.

Future directions (next 12-18 months)
- Continue to produce the pastoral land purchase reports as required.
- Continue to update vegetation GIS.
- Write up back-log studies.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

FAUNA CONSERVATION

Program Leader: Keith Morris

Development of effective broad-scale aerial baiting strategies for the control of feral cats

SPP # 2003/0005

Team members

D Algar (0.5), J Angus (0.5), M Onus (0.5), Total (1.5).

Context

Control of feral cats is recognized as one of the most important fauna conservation issues in Australia today. The impact of feral cats on native fauna is acknowledged by Commonwealth legislation, as outlined in Schedule 3 of the Environment Protection and Biodiversity Conservation Act 1999. The national 'Threat Abatement Plan for Predation by Feral Cats' (TAP) lists 38 species on Schedule 1 of the above Act for which there is a known or inferred threat from feral cat populations. Development of an effective broadscale baiting technique, and the incorporation of a suitable toxin for feral cats, was cited as a high priority in the TAP as it was most likely to yield an operational and cost-effective method to control feral cat numbers in strategic areas. The objective of this research program is to develop an effective and cost-efficient broad-scale baiting strategy for feral cat control.

It aligns with Corporate Priority 3, KRA 2, sub-output NC 2A, KRA 4, sub-output NC 4A and 4B. The research is also relevant to and consistent with recommendations 1, 2, 8-11 made by the 'Independent Review of Western Shield' panel report (February 2003).

Aims

CALM researchers have designed and developed a bait medium that is readily consumed by feral cats. The program in progress, is aimed at developing optimal broad-scale control programs for feral cats. A number of key factors are being researched to provide an effective broad-scale aerial baiting strategy for feral cats:

- To 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 maximize efficiency (completed).
- To examine baiting intensity (number of baits laid/km2) in relation to baiting efficiency to optimise control (ongoing).
- To examine baiting frequency required to provide long-term sustained effective control (in progress).
- In addition to optimising the various parameters of baiting programs, research is also being conducted:
- To assess the potential impact of baiting programs on non-target species populations and devise methods to reduce the potential risk where possible. This risk assessment is in part required to gain Australian Pesticides and Veterinary Medicines Authority (APVMA) registration of the new bait as well as assuring the protection of native fauna.
- To provide a technique for the reliable estimation of relative cat abundance.

Summary of progress and main findings

Optimising Baiting Programs

- Current research to optimise baiting programs is primarily being conducted at Lorna Glen, north east of Wiluna. The first experimental feral cat baiting program, conducted at this site, in 2003 was very successful. This baiting program follows similarly successful campaigns at other arid zone sites e.g. Gibson Desert Nature Reserve and Wanjarri Nature Reserve. As part of this adaptive management program, on-going feral cat baiting campaigns are being conducted to develop and prove baiting strategies to provide long-term sustained and effective feral cat control. The programs are designed to provide replication of the previous studies listed, to enable

determination of the confidence limits to which baiting outcomes in the arid zone can be predicted and to assess the rate and extent of reinvasion by cats over time. A second baiting program was conducted in 2004 and resulted in a comparable baiting efficiency with the previous trials above. This baiting efficiency occurred despite an irruption in small mammals numbers following good earlier rains in May and rainfall during and following the baiting program. As with the previous baiting programs, the campaign conducted in 2005 was very successful and has resulted in the lowest levels of cat abundance being recorded on the site.

- Assessment of optimum baiting frequency of baiting programs has recently commenced. Efficacy of feral cat control from continued baiting programs and a comprehensive monitoring and investigation of the timing and extent of cat reinvasion into the baited site will demonstrate whether sustained long-term control can be achieved. Detailed measurement of the extent, rate and timing of dispersal into a baited area is continuing.

Assessing the Potential Impact of Baiting Programs on Non-target Species

- A number of non-target species are potentially at risk from feral cat baiting programs because they are capable of consuming the relatively small, moist bait. A desktop evaluation to assess the likely impact to non-target species and has broadly defined a range of species potentially at risk. Assessment of bait consumption by these species is being undertaken in both field and complementary laboratory trials.
- Encapsulation of the toxin may increase target specificity of the toxin by reducing exposure to the majority of potential bait consuming, non-target mammal species because these species are significantly smaller than feral cats and have different dentition. The inclusion of toxic tablets in baits could be a practical vehicle for toxins that would be ingested by feral cats yet rejected by smaller mammals. Colleagues at DPI (Vic.) have determined that a capsule (4.7 mm diam.) is the maximum particle size reliably accepted by cats, within the feral cat bait medium. They have recently tested the ability of several eastern states non-target species to ingest capsules manually implanted in a bait and found that the pellet in baits was rejected. CALM researchers have focused attention on developing the technology to enable automatic insertion of spherical capsules into the baits during bait manufacture. This was accomplished in 2003-04 and provides a significant breakthrough to the bait-toxin delivery system. Assessment of capsule acceptance/rejection by the range of local species potentially at risk from feral cat baiting programs commenced in 2004 and has shown that encapsulation of the toxin would dramatically reduce the risk of exposure of the toxin to non-target species. This research is ongoing.

Development of a technique to survey feral cat populations

- The primary objective of this program is to develop a statistically sound and efficient sampling design for detecting change in the abundance of feral cat populations. A technique that provides the capacity to efficiently and reliably estimate feral cat relative abundance is an essential prerequisite for the planning and implementation of clearly defined prescriptions for feral cat control. Department researchers have previously employed a track density index to monitor feral cat relative abundance in projects on Peron Peninsula and the Gibson Desert. Trials have commenced to assess the ability of this technique and other options to measure relative feral cat abundance.

Management implications

- Research into the development of baiting strategies to provide sustained and effective feral cat control over time will extend operational introduced predator control and wildlife reintroductions to the arid and semi-arid interior.

Future directions (next 12-18 months)

- Conduct further research to optimise the various parameters of baiting strategies.
- A comprehensive risk assessment of the potential impact of feral cat baiting programs on populations of non-target species is continuing, and where necessary, methods devised to reduce this risk. This risk assessment is required to gain registration of the bait as well as assuring the protection of native fauna.
- Further development of techniques to efficiently and reliably survey feral cat populations.

CALM Regions

Research into optimising baiting strategies is being conducted principally in the Midwest and Goldfields. Assessment of the potential bait risk to non-target species is of necessity being undertaken opportunistically across CALM Regions.

IBRA Regions

Research into optimising baiting strategies is being conducted principally in the Murchison, Carnarvon and Gascoyne regions. Assessment of the potential bait risk to non-target species is of necessity being undertaken opportunistically across IBRA Regions.

NRM Region

Rangelands.

Sustained introduced predator control in the rangelands

SPP submitted

Team members

D Algar (0.5), J Angus (0.5), M Onus (0.5), N Hamilton (1.0); External Collaborators: Australian Wildlife Conservancy, Invasive Animals CRC.

Background and literature review

The objective of this project is to develop operational-scale introduced predator control techniques for the semi-arid bioregions in the lower rangelands.

The program will build 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 the Department of Conservation and Land Management (CALM) and Australian Wildlife Conservancy (AWC). The research will be undertaken at AWC's Mt Gibson Station and at the nearby CALM acquired pastoral leases of Karara and Lochada.

The project is designed to be long-term, of landscape-scale, and with a science-based active adaptive management framework, to provide an integrated, effective and cost-efficient introduced predator control strategy in the semi-arid zone/rangelands ecosystems. The feral cat bait and baiting methodologies (i.e. timing of baiting, baiting intensity and frequency) will be employed to assess an integrated introduced predator (feral cat and fox) control strategy. The work will adopt state-of-the-art technologies and methodologies to refine techniques for monitoring feral cat and fox abundance. The project will also enable the collaborating partners to trial new technologies as they are developed by the IA CRC and CALM, specifically baits and lures for canid control.

The project will provide for the successful reconstruction and conservation of biodiversity as part of the future expansion of 'Western Shield' into this region. When long-term, sustained control of introduced predators has been demonstrated, CALM will be in a position to carry out fauna translocations in the semi-arid zone and rangelands.

Aim

To develop effective and cost-efficient introduced predator control technologies for the interior rangelands and to demonstrate long-term sustained predator control. The hypothesis under test is that cost-effective, sustained introduced predator control is achievable.

Summary of progress and main findings

- The project commenced in January this year and to-date the sites have been established and the various trapping and monitoring grids have been put in place.

- The research is at the planning stage and is currently seeking funds.

Management implications

- Research into the development of baiting strategies to provide sustained and effective introduced predator control over time will extend operational introduced predator control and wildlife reintroductions to the arid and semi-arid interior.

Future directions (next 12-18 months)

Research effort is being focused in three areas:

- Examination of baiting efficiency.
- Monitor predator abundance over time.
- Monitor prey abundance.
- Examination of baiting efficiency

Feral cats do not readily consume baits used in canid baiting programs, whereas feral cat baits provide an efficient mechanism for controlling canids. Baits to be used in this project and earlier baiting campaigns in the arid zone have been developed and produced by CALM, specifically for the control of feral cats. It is proposed initially to employ a feral cat baiting strategy and assess its impact on the abundance of feral cats and foxes. This strategy will involve an annual baiting program to be conducted in July/August with baits to be distributed at a density of 50 baits km-2 . Monitoring the rate of reinvasion and distribution will dictate the necessity for and type of additional control programs for individual species through the year.

The efficacy of baiting programs will be assessed by comparing the various population indices and estimates, described below, immediately prior to and ten days following individual baiting programs. In addition to changes in indices, baiting efficacy will also be assessed from deaths post-baiting of cats and foxes trapped and radio-collared.

- Monitor predator abundance
    - Indices of relative abundance

      Passive plot activity index;
      Active plot activity index.

    - Estimates of abundance: -

      DNA analysis (hair capture at individual active plot stations)
      Camera-trapping

Eight permanent track survey transects (i.e. spatial replicates) have been established across both sites. These transects are located along existing tracks and each is 10 km in length. This transect length is sufficiently long enough to provide reasonably independent observations on adjacent segments and short enough to prevent unreasonable reduction of sample size. To ensure independence of transects, they are separated by at least one average feral cat home range estimated to be approximately 5 km in all directions. The tracks chosen provide a broad coverage of the entire area. Permanently marked sand plots, positioned at the edge of the tracks and located at 0.5 km intervals along the transects, will be used to survey introduced predator abundance. Active stations will be employed at the 1 km interval sand plots, that is, a specific lure will be used to entice animals to the plots and thereby maximize the number of plot incursions for each survey period. Passive stations (i.e. no lure) will be used at the 0.5 km interval sand plots. Sand plot counts will be conducted along each transect for four, where possible consecutive, days during each survey period.

Species recorded at individual plots include cat, fox, dog/dingo and rabbit. Each plot is observed on consecutive days, not for the presence or absence of tracks, but for the number of track intrusions by the species into the plot. Sand plot stations have an index of usage expressed as the mean number of tracks crossing the plot per night, the mean number of positive plots per night or the proportion of positive plots per line. The index is formed by calculating an overall mean from the daily means.

Monitoring population abundance may be performed at various levels of resolution. Two main approaches are available: one method involves the calculation of indices that relate in some way to abundance (e.g. sand plot index) that can be compared over time or between areas. The other method involves the estimate of true abundance using methods to actually count animals (e.g. capture-mark-recapture) and then estimate density of animals in the population. Reliable estimates of abundance are difficult to obtain, as most carnivore species are cryptic and secretive, occur at relatively low densities have large home ranges and movement patterns. There are also major difficulties associated with capture and observation or recapture and re-observation. Therefore there is a reliance on indices of relative abundance, especially indices based on indirect observation (field sign) and detection rate to provide information necessary to make management decisions or to evaluate the impact of a control program. These methods assume that the intensity or frequency of field signs is related in some way to the number of animals present (i.e. it provides an index of abundance). Indices themselves are not estimates of numerical abundance. Indices are most widely used to provide relative estimates of abundance, where the intention is not to estimate population size but to compare abundance between areas in space or to monitor trends in one location over time (e.g. baiting effect). However, index values can be used to estimate population size when it is possible to calibrate them with estimates derived from a formal estimation method carried out in parallel.

Recent developments in molecular techniques have led to the development of a completely non-invasive method of remotely identifying individual mammals at monitoring stations. Genetic analysis of tissue samples, such as hair, has been used in this way to identify individuals in a number of species. Similarly, recently advances in the design and development of camera-trapping techniques have enabled individual animals to be identified. These types of sampling methodologies enable collection of critical data without capturing, handling, or even observing the animals. The sampling protocols for DNA collection and camera-trapping allow the data to be analysed using methods for conventional capture-recapture models to provide estimates of population size, rather than indices of abundance. Thus the program will enable three measures of population abundance to be determined and provides the opportunity to examine the relationship between the indices and population estimates and their utility in ‘Western Shield' monitoring programs.

Introduced predator activity along the transects will be measured at approximately three monthly intervals (October, December, April and the baiting period of July/August) to provide information on the rate and extent of reinvasion into the baited site.

Potential mesopredator release of native predators will be examined by monitoring the number and distribution of large raptor species and by developing an index of varanid numbers along the predator monitoring transects. Native predator activity will be measured as above at three monthly intervals.

- Monitor prey abundance

The final component of the research project is to determine the diet of feral cats and foxes in the study area in relation to prey abundance. Trapping of small-medium vertebrate and invertebrate species, replicated bird surveys recording species presence and abundance at each trapping grid and assessment of rabbit abundance along the predator transects will, provide the basis for assessing the prey resource for the introduced predators. These trapping programs will be conducted at Mt Gibson and Lochada Stations. The stomach contents of feral cats and foxes will be collected concurrently from a trapping program for these species outside the non-baited control site, at Karara Pastoral Lease. Trapping programs are to occur in annually in June, prior to broadscale baiting on Mt Gibson Station, when prey availability is at its lowest, and in September-October at a time of high prey abundance. Trapping will identify and assess availability of dietary items and to assist in determining whether cats and foxes are selective in their prey choice. Dietary analysis will include measures of the number of items, frequency of occurrence and biomass of prey species, and determination of the calorific content of prey items. This will enable examination of niche separation in diet between feral cats and foxes, and evidence of prey selectivity in relation to the availability of prey.

CALM Region

Midwest.

IBRA Region
Yalgoo.

NRM Regions
Northern Agricultural, Rangelands.

Conservation of south coast threatened birds

SPP # CP to be prepared (amalgamates 2000/0002 and 1993/0065)

Team members
AH Burbidge (0.15), B Barrett (1.0), with input from South Coast Region staff; Total (1.15).

Context
Identifying the conservation requirements of threatened south coast birds such as the critically endangered western ground parrot, and vulnerable western bristlebird and western subspecies of the western whipbird will aid *in situ* management of these taxa. Understanding of 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.

It aligns with Corporate Priority KRA 6 and KRA 4 sub-output NC 4C.

Aims
- To develop an understanding of the biological and ecological factors that limit the distribution and numbers of ground parrots and western bristlebirds, including habitat requirements, response to fire and predation pressure.
- To create management prescriptions that will increase the survival chances of the ground parrot, western bristlebird and western whipbird and increase their total population size.

Summary of progress and main findings
- Contemporary records of ground parrots used to develop a spatial model of habitat use in the Fitzgerald River National Park, which will be of value for planning of specific management actions.
- Ground parrot monitoring data from Fitzgerald River National Park analysed, monitoring protocols defined, and paper submitted for publication.
- Monitored translocated population of bristlebirds in Walpole–Nornalup NP and re-assessed options for further translocations.
- Systematic surveys for ground parrots continued in Fitzgerald River National Park and Cape Arid National Park. Results made accessible to relevant park managers and are being used for planning of fire protection and targeted predator control.
- Monitoring surveys for ground parrots continued at Waychinicup; results suggest that the population in this area may have been lost, but reasons are unknown.
- Nuytsland Nature Reserve surveys conducted by Friends of the western ground parrot (Birds Australia WA) with planning, logistic and technical support from CALM.
- Numerous media releases and presentations to community groups, general public and schools.
- High involvement of community in a dedicated volunteer program.

Management implications
- Improved basis for decision-making concerning management, especially in relation to fire, in major conservation reserves on the South Coast.

Future directions (next 12-18 months)

- Analyse existing data on ground parrot response to fire, and submit for publication.
- Investigate specific components of western ground parrot and western bristlebird biology that are essential to their conservation; including response to different fire regimes, habitat preferences, timing and location of breeding, juvenile dispersal, vocalization and population demographics.
- Monitor ground parrot numbers in relation to implementation of feral cat control in key ground parrot habitat in Fitzgerald River National Park.
- Implement Recovery Plans where funds permit (including monitoring and translocation).

Management implications

- Improved basis for decision-making concerning management, especially in relation to fire, in major conservation reserves on the South Coast.

Future directions (next 12-18 months)

- Analyse data from monitoring program and develop monitoring protocols.
- Analyse and publish existing data on response to fire.
- Investigate specific components of western ground parrot and western bristlebird biology that are essential to their conservation; including response to different fire regimes, habitat preferences, timing and location of breeding, juvenile dispersal, vocalization and population demographics.
- Implement feral cat control (with monitoring) in key ground parrot habitat.
- Implement Recovery Plans where funds permit (including monitoring and a trial translocation).

CALM Regions
South Coast, Warren.

IBRA Regions
Esperance Plains, Jarrah Forest, Warren.

NRM Regions
South Coast, South West.

Conservation management of the quokka, *Setonix brachyurus*

SPP # 1993/0054

Team members
P de Tores (0.025).

Context
Research on quokka populations in the northern jarrah forest was completed in 2004/2005 and concluded:

- The continued low abundance of quokkas in the northern Jarrah forest is likely to be a combination of continuing predation pressure and the absence of sufficient suitable swamp habitat supporting the preferred structural mosaic.
- The existing level of predator control is inadequate to enable quokka populations to increase.
- The preferred mosaic is one of specific age classes of Taxandria swamp. The structure of this preferred mosaic has been quantified. The model to describe the variables determining quokka presence indicated the preferred mosaic includes long unburnt areas. However, the upper limit of these long unburnt areas (i.e. the upper limit of fuel age) is not known.
- The preferred mosaic has now been quantified (albeit without determining the upper limit to the long unburnt component of the mosaic). We hypothesize it is possible to manipulate existing sites through the use of fire to create areas supporting this mosaic, however, this is yet to be demonstrated.

Most of this work has now been published and the PhD student (M Hayward) largely responsible for this work has completed his PhD and is now working in a post doctoral position in South Africa.

The Commonwealth has recently provided funding for the preparation of a management plan for the quokka.

Aim

The primary aim of the new work is to produce a management plan to guide management of quokkas over the species entire range. Preparation of the plan has commenced and will seek involvement from relevant experts, interested parties, regional NRM bodies and other stakeholders, including those who will be responsible for implementing proposed actions.

Summary of progress and main findings

- The major findings have been previously reported and are also reported in 11 publications.
- One report for an external agency.
- Two papers in press.
- Two papers in review.
- Two papers in preparation.

Management implications

- The proposed intervention management (i.e. use of fire to manipulate habitat and create the preferred structural mosaic) and maintenance of fox baiting programs are recommended as necessary to ensure persistence of the northern jarrah forest quokka populations.
- There needs to be an improved understanding of the conservation significance of quokka populations/subpopulations throughout the species range to ensure managers and planners can accurately assess the potential impact from proposed operations (including burning and harvesting operations).

Future directions (next 12-18 months)

- Completion of the management plan.

CALM Regions

Swan, South West, South Coast, Warren.

IBRA Region

The demographic and genetic work was undertaken in Jarrah Forest IBRA region. Management recommendations are for the same region.

NRM Regions

South West, Swan.

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

SPP # 2006/006

Team members

P de Tores (0.15), J Jackson (0.2), W Manson (0.2 from 3 April 2006), J Dunlop.(0.2 from 12 June 2006); PhD Students - J Clarke, H McCutcheon, G Bryant; Murdoch University - K Warren, I Robertson, T Fleming.

Context

The ability to control introduced predators at a landscape scale is central to effective conservation

management and to the success of CALM's Western Shield program. CALM has been instrumental in demonstrating the conservation value of introduced predator control programs and translocation programs. However, the long-term success of Western Shield will be judged not only by the Department's ability to control foxes and cats at a landscape scale, but also by the outcome of the suite of translocation programs, often undertaken at a more localised scale. It is also critical to demonstrate these translocations can result in a long-term sustained fauna recovery for a suite of threatened species. To date, the outcome of many localised translocation programs has been varied. Possible causes for the lack of translocation success has been attributed to a suite of factors including drought, mesopredator release, prey switching, unsuitable habitat at release sites, anthropogenic disturbances (including fire and fire management practices), disease (including pre existing disease/poor health of released founding stock) and competition with sympatric native species (de Tores *et al.*, 2004).

The western ringtail possum translocation program commenced in 1991 and by 1998 appeared to have met the criteria for success (de Tores *et al.*, 1998; de Tores *et al.*, 2004). The primary translocation release site, Leschenault Peninsula Conservation Park, subsequently suffered a population collapse. Possible causes for the collapse at Leschenault include those listed above, with the additional confounding factor of changes made to the 1080 baiting regime. These changes may have resulted in an increase in fox abundance/presence. All other western ringtail possum translocation release sites are yet to meet the criteria for success.

Aim

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

Summary of progress and main findings

- A subset of 37 of the 100 western ringtail possums released at Leschenault since January 2004 has been radio-collared and monitored. Interim results have demonstrated a higher rate of predation-caused mortality at the baited site. At 1 June 2006, there had been 11 mortality events attributed to predation by pythons, 10 attributed to predation by cats, 3 attributed to predation by a fox/cat? and 1 attributed to predation by fox. 33 of the 55 released ringtail possums at the unbaited Yalgorup site since January 2004 have been radio-collared and there have been only 5 known predation events, 1 attributed to a raptor and 1 to a fox, 2 to a fox? and 1 to a cat. The results suggest a pattern of increasing predation events by cats and pythons in the presence of fox control. This is consistent with the concept of mesopredator release
- An ARC Linkage funding application was successfully submitted in 2004/2005 and work has now commenced under 3 PhD programs.
- Translocation outcomes for the western ringtail possum (*Pseudocheirus occidentalis*): An assessment of survivorship, habitat use, population demographics and health of western ringtail possums following translocation, and determination of the extent of competition between western ringtail possums and common brushtail possums (*Trichosurus vulpecula*)
- Ecology and Disease of the western ringtail possum (*Pseudocheirus occidentalis*) and common brushtail possum (*Trichosurus vulpecula*)
- The ecology of the South-west carpet python *Morelia spilota imbricata* in the northern jarrah forest of south-west Western Australia. Its role as a mesopredator – is it limiting success of translocated mammal populations?

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 developments. In the absence of demonstrated translocation success, CALM has no mechanism to deal with displaced or rehabilitated western ringtail possums.
- Translocation of the western ringtail possum has largely been driven by the need to relocate possums displaced from development sites where habitat is destroyed and the resident possum populations displaced. There will be an ongoing requirement to clear land for housing and for industry in the Swan Coastal Plain and this will continue to result in habitat loss and displacement of resident populations of the western ringtail possum. There will be a continued need to translocate these displaced possums and an additional requirement to release orphaned and

injured possums which have been nurtured and/or rehabilitated by wildlife carers. However, with the current high rate of loss to predation from cats, continued translocation of western ringtail possums displaced from development sites and ringtail possums ex wildlife carers can no longer proceed without an expectation of criticism from wildlife carers and the community in general. There will be an expectation that CALM address the issue of increases in the number of cat predation events at translocation sites where fox baiting occurs.

Future directions (next 12-18 months)

- The three PhD programs have just commenced and will assess translocation outcomes, the importance of competition with the common brushtail possum, the role of disease and the importance of predation by pythons to translocation success.
- Concurrent research will be undertaken (de Tores, Jackson, Manson and Dunlop) to assess fox and cat density at a subset of translocation release sites and will also monitor fox and cat movements through the use of satellite telemetry
- An additional honours project is now proposed to assess the availability of alternative prey (alternatives to the western ringtail possum as a prey species0 at the translocation release sites

CALM Regions
Swan, South West.

IBRA Region
Swan Coastal Plain.

NRM Region
South West.

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 (One of 4 projects carried out as part of the CALM and Invasive Animals Cooperative Research Centre (IA CRC) Western Australian Demonstration Site)

Team members
P de Tores (0.75); IA CRC funded technical support - J Jackson (0.8), W Manson (0.8), J Dunlop (0.8); IA CRC funded post doctoral research scientists - 2 scientists to commence in July 2006; PhD students - G Bryant – PhD undertaken in this project and in conjunction with python research at the western ringtail possum translocation sites.

Context
Fauna recovery within Western Australia is largely dependent upon the effectiveness of localized and large scale introduced predator control programs. CALM has been instrumental in demonstrating the conservation value of such programs. It is largely as a result of CALM's pioneering research and ability to demonstrate a response to fox control that the removal or mitigation of invasive species' impacts is now seen by other land management and conservation agencies as an essential component for the recovery of many species. However, recent research has demonstrated fauna abundance, distribution and recovery is highly unlikely to be a function of a single dimensional causal factor such as predation (de Tores *et al.*, 2004). Consistent with this hypothesis, some of CALM'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 unambiguously determine why translocation programs have been unable to demonstrate success.

In 2004, CALM agreed to participate in an application by the Pest Animal Control Cooperative Research Centre (PAC CRC) to the Commonwealth's CRC Program to develop a new Invasive Animals CRC (IA CRC). CALM has been a partner in the PAC CRC, and its predecessor (Vertebrate Pest Control CRC), since its inception in 1992. This partnership has provided substantial support to enable CALM to carry out research into fox and feral cat control measures, and impacts of

introduced predators on native fauna.

The IA CRC application was successful and the new centre is supporting a 'Demonstration Ste' in Western Australia. The northern jarrah forest research is one of four components in the WA Demonstration Site

Aims

- The mesopredator release hypothesis will be tested at the landscape and local scale.
- The importance of other factors to fauna recovery and translocation success will also be assessed, namely the importance of:
    - site specific habitat factors (e.g. floristics, vegetation structure, vegetation structural complexity / mosaic complexity).
    - prey switching and alternative prey availability.

Summary of progress and main findings

- The research is at the establishment stage.

Management implications

- The proposal is based largely on findings from CALM's *Operation Foxglove* (northern jarrah forest). *Operation Foxglove* resulted in recommendations to increase the standard operational 1080 baiting regime from a frequency of four baitings per year to six baitings per year for large areas of the multiple use northern Jarrah forest. The findings were based on a long-term study of survivorship of translocated populations of the brush-tailed bettong, or woylie, *Bettongia penicillata*. The study found the probability of woylie survivorship in areas baited six times per year was 10% higher than in areas baited at the standard operational baiting frequency of four times per year. Population modelling also showed translocated populations were unlikely to persist in the presence of the standard baiting regime. The project outcomes will provide managers with information on the effectiveness of increased levels of fox control
- The survivorship study (based on a sample size of 366 radio collared woylies, monitored continuously over a 33 month period) also indicated the number of radio-collared woylie mortality events attributed to predation by cats was greater in 2 of the 3 fox baited treatments than in the unbaited control. This pattern is consistent with the principle of mesopredator release. The project will examine if cats are increasing in abundance in the presence of fox control (mesopredator release) and will also determine if this leads to a net increase in the level of predation. The findings from the project will also provide managers with information on mesopredator release in relation to native predators' response in the presence of fox control – specifically it will determine if the chuditch and the 2 large species of predatory varaids (*Varanus gouldii* and *V. rosenbergi*) show a mesopredator release response.

Future directions (next 12-18 months)

- The research will provide managers with a better understanding of the implications of controlling and not controlling one or more predators and the importance and value of integrated control. It will quantify any indirect and adverse effects from fox control.
- The outcomes will enable CALM to determine if, in the presence of fox control, cat predation limits or prevents a native fauna response. The outcomes will also enable CALM to determine if cat control techniques, specifically use of a cat bait, ameliorates this mesopredator effect.

CALM Regions

Swan and South West.

IBRA Region

Jarrah Forest.

NRM Regions

South West, Swan, Avon.

The relictual Gondwanan invertebrate group Amycterinae in the south-west of Western Australia: distribution, diversity and possible threatening processes

SPP # to be allocated

Team members

J Farr (0.2); A Wills (0.1); Total (0.3).

Context

Understanding the effects of potentially threatening processes on the diversity of invertebrate Gondwana relics with limited capacity for dispersal. In line with Corporate Objective #1 'To protect, conserve and where necessary and possible, restore Western Australia's natural biodiversity'.

Strategy 1.5. Consistent with Corporate Objective #2 'To generate social, cultural and economic benefits through the provision of a range of services that are valued by the community and are consistent with the principles of ecological sustainability'.

Strategy 2.5. Corporate Priority 12 (for 2005-06), KRA 3 and 4, NC 3K, NC 4F.

Aim

To investigate the following hypotheses:

Null Hypothesis 1: Limited capacity for dispersal has not lead to localized endemism.

Null Hypothesis 2: Fire and/or forest disturbance does not affect Amycterine distribution.

Summary of progress and main findings

- Concept plan written and approved.
- Western Australian insect databases searched for Amycterine specimens.

Future directions (next 12-18 months)

- Project suspended pending completion of Forest Health project.
- SPP to be finalized when this completed.

CALM Regions

Swan, Warren, South Coast, South West.

IBRA Regions

Jarrah Forest, Swan Coastal Plain; Avon Wheatbelt, Esperance Plains, Mallee.

NRM Region

Avon, South Coast, South West, Swan.

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

SPP # 1993/0145

Team members

T Friend (0.05), new TO (0.5); Total (0.55).

Context

The numbat is Western Australia's State mammal emblem and although currently categorised as Vulnerable, a 2005 IUCN review recommended that it be ranked Endangered due to recent declines of some populations. After a vigorous reintroduction campaign led by CALM, there are now eight self-sustaining populations but less than 2000 animals in existence. Continued recovery relies partly

on private conservation organizations and this project is now orientated towards handing over to Districts for monitoring populations on CALM-managed estate.

This project has received new funding from SCRIPT under the Southern Prospects investment strategy through the South Coast Threatened Species project, for 2006, 2007 and 2008.

It aligns with Corporate Priorities 5, 8 and 12, KRA 4, KRA 6 and sub-outputs NC 4A and NC 4C for 2006/07.

Aims

- To measure the success of establishment of numbat populations through reintroduction.
- To attribute mortality to specific causes.
- To assess population abundance. 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 and main findings

- Due to loss of some young in the numbat breeding program at Perth Zoo, only nine individuals were available for translocation in December 2005. Input of new animals into the Stirling Range translocation ceased in 2004, so that the self-sustainability of the population could be determined. The translocation group was too small to found a new colony, so the captive-bred young were used to supplement previous translocations, at Boyagin NR, Tutanning NR and Batalling SF.
- A driven survey, to monitor numbers, was carried out in November 2005 at Dryandra Woodland, resulting in slightly higher sighting rates than last year. Other driven surveys (Montague Block at Dryandra, plus Boyagin and Tutanning) and diggings searches were not carried out this year due to lack of funds.
- A workshop to instruct district staff from Donnelly and Frankland districts in numbat diggings recognition was held at Perup in March 2006, with the aim of increasing District involvement in monitoring.
- The status of the most recent WA translocation, at the Stirling Range NP, was monitored by maintaining radio-collars on individuals. A previously collared individual was recaptured and recollared, and the four young of a collared female were captured and collared also.
- A five-year study to determine the effectiveness of 'predator training' of captive-bred individuals by comparing the survival of trained and untrained individuals after release, was completed. Additional data on the survival of wild-born-and-bred individuals is being collected in an attempt to put survival rates of captive-bred animals into perspective. A paper on this work was presented at the ARAZPA conference at Perth Zoo in April 2006.
    - The Numbat Recovery Plan is being revised and will be submitted in July 2006.
    - Support and assistance given for a proposal by the Arid Recovery Project to carry out a trial reintroduction of numbats to Roxby Downs, South Australia.

Management implications

- Further searches are required in the northern Jarrah forest and at Karroun Hill NR before concluding that these reintroductions have failed. fox control has been increased from 0-2 times to 4 times a year at Nockine since the releases and this site should be considered for further translocations. However due to the south coast emphasis through the funding, a new translocation site may be selected within the SCRIPT region.
- Numbats persist at all other translocation sites in WA, SA and NSW and management guidelines for all these areas will be developed with the responsible agencies.

Future directions (next 12-18 months)

- Monitoring of known numbat populations will be continued by involving District staff and handing over monitoring responsibility to Districts. Regular monitoring surveys will be essential in Dragon Rocks, Karroun Hill, northern Jarrah forest east of Mundaring, Dryandra and Boyagin. Other

areas will be included if possible.

- Another workshop to instruct district staff in numbat diggings recognition will be held at Dryandra in October 2006, with the aim of increasing District involvement in monitoring.
- A new study of the effect of fire on termite abundance and numbat density, with emphasis on development of suitable monitoring techniques will commence at Perup with Donnelly District involvement.
- A proposed numbat reintroduction site in Donnelly District will be assessed for a future translocation.
- A release of zoo-bred numbats will occur in December 2006, with recovery team input into the choice of location.
- A survey for numbats and feral cats at Dragon Rocks is proposed in 2006/07, with Narrogin District involvement. A survey for numbats will also be carried out at Karroun Hill NR.
- A revised recovery plan for the numbat will be submitted for adoption by the State and Commonwealth in July 2006.

CALM Regions

Swan, Wheatbelt, Warren, South Coast.

IBRA Regions

Swan Coastal Plain, Warren, Jarrah Forest, Avon Wheatbelt, Mallee, Yalgoo.

NRM Regions

South West, Swan, Avon, South Coast.

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

SPP # 1993/0149

Team member

T Friend (0.05); Total (0.05).

Context

The red-tailed phascogale is ranked Endangered on State, Commonwealth and IUCN threatened species lists, although a recent IUCN review recommended a reduction to Vulnerable. It 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.

This project aligns with Corporate Priorities 5, 8 and 12, KRA 4, KRA 6 and sub-outputs NC 4A and NC 4C.

Aim

To assess the effect of fox control on populations of the red-tailed phascogale *Phascogale calura*.

Summary of progress and main findings

- This project commenced in 1993 and 9 populations, in long-term baited, newly baited and unbaited reserves were monitored intensively by trapping for the next 4 yrs. Lack of funding prevented further intensive work, but some trapping was carried out in 1997 and 2000. Narrogin District requested that baiting cease on 2 of these reserves in 2003 so a trapping session was conducted in April/May 2003.
- A report on the results of the study was prepared in 2005.
- No monitoring was carried out during 2004/05and there is currently no monitoring program for RTPs being carried out by CALM (although they are occasionally caught in Western Shield trapping in Fitzgerald River NP, Dryandra Woodland, Tutanning, Boyagin and Lake Magenta

NRs). Fox control ceased on 2 reserves that had been baited since 1994, creating an opportunity to refine this investigation the effect of baiting.

Management implications

- At this stage there is little evidence that fox control is an important requirement for the persistence of remnant RTP populations, although it is likely that movement between habitat patches and along corridors between reserves is inhibited by fox presence.

Future directions (next 12-18 months)

- Results of this project will be written up during 2006/07. However it would be valuable to establish an ongoing (e.g. 2 yrly) monitoring round and this is likely to receive some District support.
- A recovery plan for the RTP is currently being completed involving community input and will be submitted in 2006/07. The plan recommends the continuation of this study and the strong involvement of landholders and local community members.

CALM Region
Wheatbelt.

IBRA Regions
Avon, Wheatbelt.

NRM Regions
South West, Avon.

Dibbler (*Parantechinus apicalis*) Recovery Plan

SPP # 1995/0011

Team members
T Friend (0.1), T Button (1.0); new TO (0.5) Total (1.6).

Context
The dibbler Recovery Plan 2003-2013 lays out a set of actions to improve the conservation status of this small marsupial, ranked Endangered in State, Commonwealth and IUCN threatened species lists.

This project aligns with Corporate Priorities 5, 8 and 12, KRA 4, KRA 6 and sub-outputs NC 4A and NC 4C.

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

- Protecting existing populations.
- Increasing the number of known populations by searching for undiscovered populations and re-establishing dibblers in areas where they have become extinct.

Summary of progress and main findings

- Increased funding for the Dibbler Recovery Plan has become available from 2 sources:
    - The South Coast Threatened Species project has taken on the funding of some aspects of dibbler recovery, in particular the more research-orientated actions including a detailed survey of dibbler distribution in the FRNP.
    - In addition, a Regional Competitive Component (cross-regional) project has been funded for three years, to cover translocations and monitoring in particular, in both the South Coast and Northern Agricultural regions. This project involves surveys for

dibblers and suitable dibbler habitat on the west coast and if appropriate, a translocation. It will also allow the project to incorporate the monitoring of the Jurien Bay island populations, as no students are currently working on dibblers there.

- Monitoring of the 2 Western Shield transects in the Fitzgerald River NP (FRNP) showed that numbers were high in 2005/06.
- A population study commenced in 2005 at a newly discovered dibbler site with all-weather access in the eastern FRNP. This will provide comparative data against which to assess population parameters in reintroduced populations.
- The first mainland translocation of dibblers, to Peniup NR, was carried out in three releases, in 2001, 2002 and 2003. Fox control by aerial or ground baiting, was carried out between 8 and 12 times a year. In spring 2004, 52 individuals, including 45 juveniles, were captured, indicating that a self-sustaining dibbler population had been established. However, heavy rain in April 2005 and subsequent wet conditions over winter prevented ground baiting under dieback hygiene guidelines. Regular monitoring by trapping was carried out in October 2005 and although capture rates are usually high in spring as juveniles enter the population, only three adult males were captured. No captures were recorded in December. It is hypothesized that a high level of predation followed fox invasion during the lapse of baiting. Consequently, District guidelines have been amended to allow baiting on foot should wet soil conditions prevent vehicle access.
- A translocation proposal to transfer dibblers from FRNP to Peniup in spring 2006 is being prepared.
- Releases in October 2004 and October 2005 followed the approval of a translocation proposal to transfer captive-bred dibblers from the Perth Zoo breeding colony to the Stirling Range NP. Baiting is carried out by air four times a year, supplemented by ground baiting around the NP boundary at the same frequency. Monitoring by trapping has shown that although a few dibblers survived the summer period, no dibblers have persisted in the area. A proposal to carry out monthly ground baiting around the dibbler release area is being prepared so that baiting will commence before the next scheduled release of zoo-bred dibblers in October 2006.
- Student projects continue to be supported on the Jurien Bay islands, although there are no dibbler-focused projects at present. A Stewart has submitted her PhD study on dibbler-mouse-dunnart interactions on the Jurien Bay islands (Boullanger, Whitlock and Escape). This work indicates that competition between dibblers and mice is rare, and that mice would be more severely affected than dibblers. This is valuable information in the light of suggestions that mice should be removed at all costs. A workshop to decide on action to be taken regarding mice on Boullanger and Whitlock islands will be held in 2008.
- Dibbler surveys in FRNP have focused on a hair-funnel resurvey of the Chapman and Newbey sites from the 1984-5 biological survey. Analysis of the presence-absence data generated will be carried out by Dr L Gibson using a digital elevation model.

Management implications

- Appropriate management for biodiversity depends on adequate knowledge of species distributions and habitat preferences, particularly threatened species.
- The study of mouse-dibbler interactions may have implications for mouse eradication on Boullanger and Whitlock Islands.

Future directions (next 12-18 months)

- Monitoring of the Peniup and Stirling Range translocations and the FRNP and Jurien Bay island populations will continue.
- Another release will be carried out at Stirling Range NP.
- Dibbler surveys will be continued eastwards in 2006/07, especially between Hopetoun and Esperance.
- The study of dibbler habitat preferences based on the distribution of captures on trapping grids will continue in 2006/07.

CALM Regions

Midwest, South Coast.

IBRA Regions
Geraldton Sandplains, Swan Coastal Plain, Jarrah Forest, Esperance Plains.

NRM Regions
Northern Agricultural, South Coast.

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

SPP # 1996/0008

Team members
T Friend (0.75), S Hill (1.0), V. Hack (0.5), S. Schreck (0.5); Total (2.75).

Context
Gilbert's potoroo is Australia's most endangered mammal. 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 receives funding from the SCRIPT investment plan under the South Coast Threatened Species Project and involves collaborative connections with Perth Zoo, universities, the Foundation for Australia's Most Endangered (FAME) and the Albany-based Gilbert's Potoroo Action Group.

It aligns with Corporate Priorities 5, 8 and 12, KRA 4, KRA 6 and sub-outputs NC 4A and NC 4C for 2006/07.

Aim
To implement the Gilbert's Potoroo Recovery Plan, and particularly to increase the numbers of individual Gilbert's potoroos known to be alive in the wild and to increase the number of locations in which they occur.

Summary of progress and main findings
- Following the success of a temporary translocation of 2 wild potoroos to Bald Island in February-March 2005, a translocation proposal was prepared for the transfer of 2-3 individuals a year for three years from Mount Gardner to Bald Island.
- Three animals were transferred to Bald I in August 2005 and one in December 2005. All adults have survived and three young have been born to the 2 females. Monitoring trips carried out at 1-2 month intervals have shown that these animals do well on Bald Island.
- A large furred male was the second pouch young taken from its mother in the wild in November 2005 and hand-reared by a local wildlife carer, before being introduced into the captive breeding colony. The removal of animals from the wild population as pouch young has a much smaller impact on the population than removal of independent animals.
- A collaborative health study of wild and captive Potoroos with Murdoch Veterinary Masters student R Vaughan continued in 2005/06. This stud focuses on several previously identified disease agents and overall health status assessed through hematology, blood biochemistry and bacteriology.
- Cross-fostering shows promise for application to Gilbert's potoroo, particularly as they are so closely related to long-nosed potoroos, a species in which husbandry is not demanding. We have now established a captive colony of long-nosed potoroos at a site over 20 km from Two Peoples Bay, thus avoiding any risk that the long-nosed potoroos might escape.
- Continued support of Gilbert's Potoroo Action Group's educational and fundraising activities.

Management implications
- Results of the Bald Island translocation so far indicate that a new population can be established there. If enough animals can be obtained to found a new population there, it could offer the security of a second population unaffected by introduced predators and lacking most native predators. Recovery of Gilbert's potoroo requires the assessment of a number of different

strategies as rapidly as possible as the threat of loss of the population through a wildfire is real.

Future directions (next 12-18 months)

- Continue to monitor the Mount Gardner population.
- Support cat-trapping efforts at Two Peoples Bay, and initiate a study of predation by Carpet pythons.
- Continue to monitor the Bald Island translocation and transfer more animals when available. Given that the Mount Gardner population has been at a low level since early 2004, there are limited possibilities to harvest adults or subadults for translocation, hence alternative means of producing Potoroos must be developed.
- Commence new cross-fostering trial using the long-nosed potoroo colony near Albany.
- Continue to evaluate removal and hand-rearing of large pouch young from the wild as a means to obtain new, less stress-prone captive animals.
- Modify the captive diet based on truffle analysis.
- Construct one or two 5-10 ha fenced enclosures within eucalypt plantations and release pairs of animals previously kept at the Two Peoples Bay facility. This new environment may stimulate breeding.
- Support Perth Zoo efforts to develop artificial insemination techniques in long-nosed potoroos and transfer these techniques to Gilbert's potoroos.
- Evaluate further translocation sites, both on the mainland and on other islands.

CALM Region
South Coast.

IBRA Region
Jarrah Forest.

NRM Region
South Coast.

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

SPP # 1993/0163

Team members
T Friend (0.05); Total (0.05).

Context
Bernier and Dorre Islands 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 consequent on the long isolation of island populations.

This project aligns with Corporate Priorities 5 and 12, KRA 4 and sub-outputs NC 4A and NC 4C for 2005/06.

Aims

- To achieve an understanding of the habitat requirements, habitat usage, breeding biology and spatial organization of the western barred bandicoot.
- To assess genetic difference between populations of western barred bandicoots on Bernier and Dorre islands, Shark Bay using PCR and DNA sequencing.
- To assess the viability and fertility of progeny from matings between Dorre Island and Bernier Island individuals.

- To investigate the conservation ramifications of disease issues in western barred bandicoots and to support veterinary investigations into pathological conditions.

Summary of progress and main findings

- Collaboration with Murdoch University Vet School academics and 2 PhD students working on the western barred bandicoot wart-like virus disease on an ARC Linkage Grant.
- PhD student S Smith at Griffith University is carrying out a study of the genetic variability of island populations and derived mainland populations of WBB including the Dryandra population that is descended from the cross-breeding experiment carried out at Kanyana. Pedigree analysis will also be carried out in order to determine the contribution of different founder individuals to the populations. We have provided Mr Smith with a strategic collection of ear tissue samples for this study.

Management implications

- The results of these studies, particularly relating to disease and genetics, will be of great value in managing wild populations and 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 commencing in 1994 will be written up in 2006.
- A paper on home range activity and nest use by WBB on Dorre Island is close to completion due in will be submitted for publication during 2006.

CALM Region
Midwest.

IBRA Regions
Geraldton Sandplains, Carnarvon.

NRM Regions
Rangelands, Avon.

Status and ecology of the heath mouse (*Pseudomys shortridgei*) in Western Australia

SPP # 2003/0001

Team members
B Johnson (0.30), K Morris (0.05), PhD student – D Cancilla; Total (0.35).

Context
In Western Australia, the heath mouse is known in recent times from only 2 areas, Lake Magenta NR and Fitzgerald River NP. It's range has contracted in the last 30-50 yrs. It is only one of two threatened rodent species in WA without either a draft or completed recovery plan. This study has been undertaken as a PhD project and will provide the information necessary to prepare a recovery plan for this species.

This project aligns with Nature Conservation Output KRA 4 (recovery of threatened species), specifically NC 4C.

Aims

- To determine the distribution, taxonomy and conservation status of the heath mouse.
- To examine the species' population dynamics and habitat relationships.

- To study the species' ecology with a view to identify potential threatening factors.
- To use predictive models to locate and examine new populations.
- To provide sufficient information to allow the development of a recovery plan.
- To facilitate the involvement of post-graduate studies.

Summary of progress and main findings

- Four of the five pre-1987 heath mouse sites have failed to show the persistence of this species.
- Ongoing ecological studies at Lake Magenta NR identify low population turnover (low recruitment), population density of 1.95/ha (Victoria 6/ha), considerable foraging movement, distinct actively defended territories, juveniles forced away from established territories, overlapping male/female pair home ranges suggesting possible monogamous reproductive strategy.
- Low density populations located at the Fitzgerald River NP (Twertup and Moir tracks) and UCL block 1040 immediately north of Moir Track site.
- Dietary work concluded.
- Habitat measurements undertaken.
- Ongoing collaborations with industry (BHP Billiton), Murdoch University and Deakin University (Victorian heath mouse studies).
- Bibliography updated and forwarded for publication.

Management implications

- Causes of rarity better understood.
- Climatic conditions, particularly rainfall, probably a significant factor in the fluctuation of population abundances.

Future directions (next 12-18 months)

- Completion of habitat parameter assessment.
- Analysis of ecological data.
- Completion of PhD thesis.
- Develop predictive modelling of occurrence.
- Commence draft of management guidelines.
- Commence draft of recovery plan.
- Ongoing monitoring of the Lake Magenta (East Rd) population as part of the mesopredator research project.

CALM Regions
Wheatbelt, South Coast.

IBRA Regions
Mallee, Esperance Plains.

NRM Regions
Avon, South Coast.

Rapid survey of quokka (*Setonix brachyurus*) in the southern forests
SPP # (Concept Plan to be submitted)

Team members
G Liddelow (0.1) and regional staff as required.

Context

Recent research on quokka populations in the northern Jarrah forest has shown an alarming decline in quokka 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 promote the protection and conservation of quokkas, and to guide decision-making with respect to fire management and timber harvesting.

Aims

- To survey quokka activity and distribution within the southern forest.
- To map quokka distribution.
- To provide management guidelines for district/region fire management plans.

Summary of progress and main findings

- Surveys completed for southern forests, although some gaps in survey area need to be filled. Draft report of findings completed.
- Surveys in northern jarrah forest commenced.
- The commencement of a PhD study into the ecology and management of the quokka in southern forests.

Management implications

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

Future directions (next 12-18 months)

- Complete data analysis and write-up of southern forests survey.
- Complete feild survey of northern forests.
- Analyse and publish findings.

CALM Regions

Warren, South West, Swan.

IBRA Regions

Jarrah Forest, Warren.

NRM Regions

South West, South Coast

Monitoring selected vertebrate communities in the Perup Nature Reserve

SPP # 1997/009

Team members

G Liddelow (0.1), B Ward (0.1); Total (0.2).

Context

Perup forest east of Manjimup contains a rich assemblage of medium-sized mammals that were once more widespread. Monitoring of mammals in the Perup forest commenced in the mid 1970s, and represents one of the longest ongoing forest mammal monitoring programs in Australia. Monitoring provides information about mammal population fluctuations, and responses to management practices, including fox control and fire management.

This project also involves community groups, including school groups, teachers and CALM Bushrangers.

Aims

- To monitor woylie (*Bettongia penicilata*) and other selected ground and arboreal mammal species in the Perup Nature Reserve (PNR) in different post-fire stages, twice per year (spring and autumn).
- To monitor introduced predators (fox and feral cat) using sand pads over time to assess the effectiveness of Western Shield baiting in the PNR.
- To train CALM Bushrangers in mammal conservation and handling.

Summary of progress and main findings

- Populations of woylies have declined significantly in the Perup / upper Warren area.
- Capture rates for woylies have declined from 60-70% to < 10% in some populations. This is similar to what was observed at Dryandra woodland in 2001/02.
- The relative activity of foxes and feral cats as assessed by sand pads appears to be low.
- A more detailed study into the woylie decline has been proposed.

Management implications

- Necessary to understand the reasons for this relative rapid population decline so that remedial action can be implemented. There is a need to improve techniques for assessment of activity of introduced predators and this will have implications for broader Western Shield monitoring.

Future directions (next 12-18 months)

- Continue monitoring woylie populations.
- Implement the detailed research program to understand causes of declines as proposed (A Wayne).
- Contribute to a review of the conservation status of the woylie.
- Prepare annual progress report and publication.

CALM Region
Warren.

IBRA Region
Jarrah Forest.

NRM Region
South West.

Assessing the distribution and status of the wambenger

SPP # 2003/11

Team members

N Marlow (0.50), C Ward (0.10), A Williams (0.50), J Rooney (0.10), C Vellios (0.10); regional staff – I Wilson, Total (1.30).

Context

Recent genetic work has suggested that the brush-tailed phascogale (*Phascogale* sp. nov.) in Western Australia (the wambenger) is a distinct species when compared with eastern Australian and northern populations of *Phascogale tapoatafa*. There is also some evidence that wambenger populations have declined recently, although the cause of these declines remains unknown. Whilst hypothetical 'natural' cyclical fluctuations may account for at least some of these declines it is also possible that management activities such as fox baiting, logging and/ or fire may also be causal factors. In this study the locality records of brush-tailed phascogales will be collated from museum and other sources and will be examined to determine if reporting frequency has declined recently

and if so when.

It aligns with Corporate Priorities 3 and 12, and KRA 4 (sub-outputs NC 4A and 4C).

Aims

- To determine if significant recent changes in distribution of wambengers have occurred.
- To determine the potential risk to wambengers from operational fox baiting campaigns using 'Probaits'.
- To determine the current conservation status of *Phascogale* sp. nov. using IUCN criteria.

Summary of progress and main findings

- Data on the historical and current distribution of wambengers have been obtained from all Australian museums.
- Data on distribution and abundance have been obtained from all previous (known) studies of wambengers.
- Field studies investigating the impact of toxic baiting programs on a population of Phascogales completed.

Management implications

- Wambengers were found to be unaffected by the 3 mg 1080 Probaits in the field Operational use of this bait type in all Western Shield operations can now proceed.

Future directions (next 12-18 months)

- Complete manuscript on bait development work and submit to journal for publication.

CALM Regions
Warren, South West.

IBRA Regions
Jarrah Forest, Warren.

NRM Region
South West.

Probait trials: phase 2

SPP # 2000/ 0014 (incorporates 99/ 0018)

Team members
N Marlow (0.35), A Williams (0.40); Total (0.75).

Context
A new fox bait, 'Probait', has been developed that will decrease the cost of CALM's operational baiting campaigns significantly. Previous experiments have shown that uptake of Probaits by foxes was less than that of the currently used dried meat baits. This difference in uptake was concluded to occur due to the lesser palatability of Probaits. Flavour additives were incorporated into the baits and then field tested for their ability to increase palatability and uptake. Trials were also conducted to ensure the addition of flavour enhancers did not decrease bait longevity.

It aligns with Corporate Priorities 3 and 12, and KRA 4 (sub-outputs NC 4A and 4C).

Aim
To improve the uptake of Probaits by foxes so that there is no significant difference between

Probaits and dried meat baits.

Summary of progress and main findings

- Field longevity trials completed, data analysis complete, report completed.
- Field trials to determine the effectiveness of different binders and foxes' preferences for flavour enhancers completed.
- Field trials to compare uptake of standard dried meat baits with 'improved' Probaits completed, data analysis complete. Uptake of 'improved' Probaits by foxes found to be equal to that of dried meat baits

Management implications

- The uptake of Probaits by foxes was increased to equal that of the dried meat bait, and so Probaits can be used operationally in all Western Shield sites.

Future directions (next 12-18 months)

- Complete manuscript on bait development work and submit to journal for publication.

CALM Regions
Goldfields, Wheatbelt, Warren, South West.

IBRA Regions
Avon Wheatbelt, Jarrah Forest, Coolgardie, Warren.

NRM Regions
Avon, South West, Rangelands.

Sustained fauna recovery in a fragmented landscape (Dryandra Woodland and Tutanning Nature Reserve): is there a mesopredator release effect?
SPP # 2006/007

Team members
N Marlow (0.35), A Williams (0.90), N Thomas (0.75), TO to be appointed (1.0).

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) will be investigated. Survival (#KTBA) will be measured as a function of fox abundance, cat abundance, and several other variables. Woylies will be radio-collared and monitored intensively to directly identify factors responsible for their demise. These may include predation from pythons or raptors, habitat productivity limitations or ineffective fox control (1080 loading too low, or bait shy foxes).

It aligns with Corporate Plan priority 5 and KRA 4 (sub-outputs NC 4A and 4C).

Aims

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

Summary of progress and main findings

- Initial trapping of woylies has been undertaken and 13 individuals are radio collared and are being tracked on a daily basis. One other collared woylie was taken by a python.

- Sandplots have been established in Tutanning (75 plots), Dryandra (129 plots) Highbury block (unbaited 31 plots) and Quinns block (unbaited 32 plots). These have been monitored both pre and post baiting and concerns about the effectiveness of the baiting regime especially in Tutanning NR have been raised.

Management implications

- If the current baiting regime is found to be inadequate or ineffective changes to the baiting program may need to be made.
- Woylies are being considered for relisting on the threatened species list.

Future directions (next 12-18 months)

- Continue to trap and monitor woylies to identify causes of mortality.
- Continue monitoring fox and cat abundance in all sites.
- Continue investigations of baiting effectiveness.
- Monitor the diet of foxes, cats (if possible) and wedge tailed eagles (if possible).
- If necessary and if cat baits available implement a cat baiting program.

CALM Regions
Wheatbelt.

IBRA Regions
Avon Wheatbelt,

NRM Regions
Avon, South West.

Implementation of the Recovery Plan for the chuditch, *Dasyurus geoffroii*

SPP # 1993/0053

Team members
K Morris (0.25); B Johnson (0.25), Total (0.50).

Context
The chuditch is currently listed as a threatened species under both the *Wildlife Conservation Act 1950* (Fauna that is rare or is likely to become extinct), and the Commonwealth *EPBC Act 1999* (Vulnerable). A Recovery Plan was prepared for this 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.

This project aligns with Nature Conservation Output KRA 4 (conservation of threatened species), specifically nature conservation output priority NC 4C, the enhancement of the conservation of threatened species.

Aims

- To ensure that chuditch persist within its present range at existing or increased population densities.
- To increase population numbers through the establishment of at least one population outside the present distribution.

- To review the conservation status of the chuditch using IUCN criteria, and revise the recovery plan if necessary.

Summary of progress and main findings

- Ongoing monitoring at key recovery/translocation sites completed confirming that chuditch have established at Lake Magenta, Julimar and Kalbarri, but not at Cape Arid or Mt Lindsey.
- Western Shield monitoring has detected chuditch at 25 sites in the south-west, and populations appear to have increased at 16 of these.
- Collation of Western Shield chuditch monitoring data in preparation for conservation status review.
- Trial to assess the impact of Probaits on chuditch at Julimar Conservation Park completed and report prepared.
- ARC linkage grant with University of NSW on Quoll genetics continuing.

Management implications

- Potential down-listing in conservation status of chuditch from Vulnerable to Lower Risk (Conservation Dependent).

Future directions (next 12-18 months)

- Finalize analysis of trapping monitoring data available from Western Shield sites.
- Resurvey semi-arid reintroduction sites.
- Undertake review of status against IUCN criteria.
- Recall recovery team to assist with status review.
- Revise Recovery Plan if necessary.
- Undertake chuditch feral cat bait uptake trials at Julimar.

CALM Regions

Wheatbelt, South Coast, Swan, South West, Warren.

IBRA Regions

Jarrah Forest, Esperance Plains, Mallee, Avon Wheatbelt.

NRM Regions

South West, Swan, Avon, South Coast.

Management of overabundant marsupials – North Island tammar wallaby case study

SPP # CP approved

Team members

K Morris (0.05), B Johnson (0.05), N Thomas (0.05), P Orell (Wildlife Branch), A Desmond (Midwest Region), Dr C Herbert (Uni NSW ARC linkage).

Context

Some native mammals have become overabundant and now require management to reduce population numbers. In particular those that are constrained artificially (e.g. behind fences) or on islands can have a detrimental impact on vegetation through over grazing. Tammar wallabies were introduced to North Island in the 1980s from East Wallabi Is (Abrolhos) and are now having an impact on native vegetation which is leading to increased rates of erosion.

This project aligns with Nature Conservation KRA 3 and 6.

Aims

- To determine the effectiveness of Suprelorin contraceptive treatment on individual tammar wallabies (including contraceptive duration, health and welfare of the animal).
- To compare the longevity of contraception at 2 different dosages, 4.7 mg and 9.6 mg.
- Determine the proportion of the (female) population that has to be treated.
- To determine the effectiveness of fertility control as a method to reduce the population size of tammar wallabies on North Island (using East Wallabi as a control Island).
- Do any reductions in population size result in an improvement in the vegetation on North Island?
- To determine the genetic diversity of the population, which should confirm that the animals were introduced onto the island from the neighbouring Wallabi Islands and there were low founder numbers.

Summary of progress and main findings

- Field trip undertaken in May 2006, report prepared.
- 150 females now implanted with Suprelorin.
- Population estimate 400-450.
- 60 Tammar wallabies removed to captive breeding facilities at UNSW and University of Melbourne.
- Vegetation assessment inside and outside enclosures on North Island continued (Mid west Region).

Management implications

- Restoration of over-grazed and over-browsed vegetation on North Island, reducing erosion problems.

Future direction (next 12-18 months)

- Spotlight monitoring of tammar wallabies in November.
- Final field trip in May 2007 to assess success of contraception.
- Integrated management plan developed to ensure complete removal of tammar wallabies by November 2007.

CALM Region
Midwest.

IBRA Region
Geraldton Sandplains.

NRM Region
Northern Agricultural.

Monitoring of mammal populations on Barrow Island

SPP # 2000/0012

Team members

K Morris (0.05), Pilbara Regional staff plus AA Burbidge (Post Retirement Research Fellow); Total CALM (0.05).

Context

Barrow Island is one of Australia's most important nature reserves, particularly for mammal conservation. Monitoring mammal populations was a requirement of the Interim management guidelines for Barrow Island. A large LNG development (Gorgon) is planned for the island.

It is relevant to the nature conservation output priorities relating to the management of the

conservation reserve system (NC 2C) and the conservation of threatened species (NC 4C).

Aim

To establish and implement a monitoring protocol for native and introduced mammals on Barrow Island. This information gathered will be used by CALM and ChevronTexaco (the oil field operators on Barrow Island) to measure significant changes in abundance of the native species and to detect the presence of exotic species. The islands around Barrow Island, which once supported Black rats, are also monitored.

Summary of progress and main findings

- No mammal monitoring undertaken in 2005/6.
- Investigated suspected quarantine breach in December 2005 – suspected **b**lack rat found in helicopter on Barrow Island, but a site investigation found it to be a native rock-rat. Better protocols now developed for identifying suspected introduced rodents.
- Draft paper on survey techniques for rock-wallabies prepared and submitted to *Australian Mammalogy*.
- Ongoing input into Departmental comments on the Gorgon EIS / ERMP.
- Ongoing supervision of a PhD project examining the social structure and genetics of boodies on Barrow Island (and other sites).
- Collected additional tissue from the threatened Barrow Island mouse *Pseudomys nanus ferculinus* for DNA analysis to determine taxonomic status – is it a distinct sub-species?

Management implications

- Provision of baseline information on mammal abundance, and presence / absence of introduced mammal species. Development of monitoring protocols for native mammals and detection of introduced species.

Future directions (next 12-18 months)

- Complete report on Boodie Island monitoring.
- Meetings between CALM and Chevron staff to determine future directions of monitoring program.
- Establish an additional mammal monitoring grid near the airport.
- More detailed analysis and publication of mammal trapping and spotlighting data.
- In the absence of a mammal monitoring program being developed by Chevron, undertake mammal monitoring in October 2006.

CALM Region

Pilbara.

IBRA Region

Pilbara.

NRM Region

Rangelands.

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

SPP#: submitted

Team Members

K Morris 0.40, B Johnson 0.90, B Muir 0.25; External Collaborators - Prof A Thompson (Murdoch University Veterinary School); Volunteer(s): at least 0.5 FTE.

Context

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

This project will provide information that will allow CALM to address the issue of better management of feral animals (Corporate Priorities special emphasis 2006/07 #3), and contributes to maintaining and developing a strong research program based on both in-house capacity and enhanced partnership (Corporate Priorities special emphasis 2006/07 #12). It is also relevant to NC KRA2 (NC2B), KRA 4 (NC4A), and to the Wheatbelt's priority to continue the implementation of the Western Shield wildlife recovery program.

Background and Aim

The European red fox (Vulpes vulpes) arrived in the south-west of WA in the late 1920s and has been implicated in the decline of several species of medium-sized marsupials. Like all canids, foxes are highly susceptible to the toxin sodium monofluoroacetate, or 1080 while most native WA mammals are tolerant to this poison. In areas of Western Australia where foxes were controlled with regular 1080 poisoning, populations of rock-wallabies (Petrogale lateralis), numbat (Myrmecobius fasciatus), tammar wallaby (Macropus eugenii), woylie (Bettongia penicillata), brushtail possum (Trichosurus vulpecula), and chuditch increased significantly. In 1996, the Western Shield fauna recovery program commenced, with fox baiting occurring over approximately 3.5 million hectares of conservation estate. In a short space of time, this led to a significant increase in woylie, quenda (southern brown bandicoot Isoodon obesulus) and tammar wallaby populations, and in 1998 these species were removed from the State and Commonwealth threatened fauna lists.

However, by 2000/2001 Western Shield monitoring started to detect declines in populations of some medium-sized mammals, most notably woylies, which had attained extremely high abundances (up to 60% trap success). In a review of Western Shield in 2003, Orell (2005) identified several sites in the south-west of WA where fauna had not recovered, or had declines, despite ongoing fox control. Lake Magenta nature reserve was one of these sites. Chuditch were reintroduced to Lake Magenta in 1996 and woylies were translocated there in 1997. Following 12 months of fox control, populations of the quenda and brushtail possum were also discovered. Presumably they had persisted at Lake Magenta prior to fox control commencing, but at undetectable levels. Trap success rates for all species increased in the period 1996-2001. However, after this time, trap success rates for quenda and woylies declined to a point where they are no longer trapped, and chuditch and brushtail possums have persisted, but at reduced abundances.

This 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

- To determine the causal factors responsible for the medium-sized mammal declines at Lake Magenta nature reserve.
- To identify the management required to ameliorate these declines.
- To develop adequate introduced and native mammal monitoring protocols that will enable future changes in population abundances to be quantified and explained.

Summary of progress and main findings

- This project commenced in January 2006. Trapping grids and transects to monitor native fauna abundance were established and sand pads to monitor fox, dog and feral cat activity were set up.
- Two trapping session were completed. One sand pad monitoring was completed. It is too early to present results at this stage.

Management implications

This project will provide knowledge of the causal factors responsible for declines of medium-sized

mammals at Lake Magenta nature reserve, leading to more effective management and species conservation. This will be achieved through:

- An assessment of the effectiveness of the current fox control program.
- Determining whether mesopredator release (i.e. increased cat abundance) occurs following fox control.
- Identifying periods of peak abundance of potential fox/cat prey items to assist in improving fox/cat baiting efficacy.
- If necessary, the development of a baiting regime to effectively control both foxes and feral cats, and the testing of the effectiveness of this through translocations of vulnerable species.
- An understanding as to the role disease may play in regulating wildlife populations in WA.

The benefits to CALM include having the information required to improve fauna recovery in the Wheatbelt, and to have available revised native and introduced fauna monitoring protocols which will allow future changes in populations to be adequately assessed and explained. This project is also part of CALM's contribution to the Invasive Animals CRC.

Future directions

- Continue trapping and sand pad monitoring program on Lake Magenta and Dunn Rock.
- Commence vegetation and flora assessment of trapping grids.
- Commence trials to examine the effectiveness of aerial fox baiting at Lake Magenta (uptake of baits located on tracks vs baits located in dense shrubland).

CALM Regions
Wheatbelt / Katanning work centre.

IBRA Region
Mallee.

NRM Region
Avon Catchment Council.

Ecology and conservation of threatened pythons in WA

SPP # 93/0159

Team members
D Pearson (0.1); regional staff in Denham - L Reinhold (0.1); Total (0.2).

Context
Four of WA's 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 project aligns with Corporate Priorities 1.4, 1.5, 3.1, 3.4, 3.5, 4.4, 4.7, and KRAs 4.1 and 6.1.

Aims

- Clarify 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.
- Undertake telemetry studies of woma and rough-scaled pythons.
- Collect material for future genetic work to aid wildlife forensics.
- Publish and disseminate research data to aid python conservation.

Summary of progress and main findings

- Successful radio-tracking of 7 woma pythons at Shark Bay and the collection of road-kills for morphometric and merisitc analysis.
- Nearly 900 marked pythons now on Garden Island with large numbers of recaptures to provide valuable information on growth rate and time to recruitment in the adult population.
- Publication of a CALM Bush Book on Snakes of WA.
- Collect of scale clips and liver samples for future genetics work on pythons.
- Assisted other researchers with implantation of transmitters into pythons.

Management implications

Pythons are disproportionately represented on WA threatened fauna lists. This research will identify; if the conservation status of each taxon warrants listing, the threats to python populations and the relevant aspects of their ecology to plan management to mitigate threats.

Future directions (next 12-18 months)

- Continue and conclude a telemetry study of woma pythons at Shark Bay in conjunction with Denham staff.
- Write up recently completed research work on Pilbara olive pythons.
- Continue a long-term mark recapture study on carpet pythons on Garden Island to understand population dynamics within a python species.
- Undertake searches in the Northern Wheatbelt for extant woma python populations.
- Develop a project in conjunction with Murdoch University to document the genetic diversity of various pythons and so enable the identification of the source of seized pythons or those within the pet trade.

CALM Regions

Swan, Midwest, Pilbara.

IBRA Regions

Swan Coastal Plain, Geraldton Sandplains, Wheatbelt, Murchison, Pilbara.

NRM Regions

South West, Rangelands, Northern Agricultural.

Implementation of the Lancelin Island Skink Recovery Plan

SPP# 1999/0011

Team members

D Pearson (0.1), Jurien Bay staff - K Himbeck (0.05); Total (0.15).

Context

The Lancelin Island skink is found only on Lancelin Island and a translocated population exists on Favorite Island in Jurien Bay. This project involves carrying out the actions identified in the recovery plan to improve the conservation status of the species.

It aligns with Corporate Priorities 1.4, 1.5, 3.1, 4.4; Nature Conservation output KRAs 4.1, 6.1 and 6.3.

Aims

- To implement the Lancelin Island skink (LIS) Recovery Plan (Pearson and Jones 2000), especially the establishment of a translocated population on Favorite Island.
- To revise the recovery plan in conjunction with the LIS recovery team to reflect research work over the last 5 yrs and plan future actions.

Summary of progress and main findings

- A translocation of captive-bred skinks to Favorite Island was commenced in March 2002. Its success has been monitored by twice yearly trapping sessions (December and March).
- Lancelin Island skinks have persisted on Favorite Island and have successfully bred, but capture rates are very low making it difficult to assess the effectiveness of the translocation.
- The Lancelin Island population was monitored in November 2005 and found to be still present across the island in abundance.

Management implications

The Lancelin Island skink has a very small geographic range. The translocation to Favorite Island will reduce its vulnerability to a natural or anthropogenic disturbance that may threaten the Lancelin Island population, thus improving its conservation status. Continued vigilance to manage tourism, prevent fires and avoid the introduction of exotic animals to either island will be required.

Future directions (next 12-18 months)

- Continued monitoring of the Favorite Island population to assess the success of the translocation with increased trapping intensity.
- Periodic monitoring of the Lancelin Island population.
- Survey for closely related sibling skink species in the Rockingham area.

CALM Regions

Swan, Midwest.

IBRA Regions

Swan Coastal Plain.

NRM Regions

South West.

Improving rock-wallaby conservation and management

SCP 2006/003

Team member

D Pearson (0.2)

Context

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

It aligns with Corporate Priorities 1.3, 1.4, 3.1, 3.4, 3.5, 4.4, 4.5, 4.7; Nature Conservation output KRAs 3.11, 4.1 and 6.1.

Aims

- Prepare a recovery plan for the 5 species of rock-wallabies that occur in WA.
- Survey rock-wallaby populations in Cape Range and Kalbarri National Parks, Western Desert and islands of the Recherché Archipelago.
- Evaluate the most appropriate techniques for monitoring rock-wallaby populations.
- Provide advice and assistance to CALM staff and other organizations carrying out translocations.

Summary of progress and main findings

- Consultation for the recovery plan well underway and a draft recovery plan is near completion.
- Surveys conducted of Cape Range National Park (with Cape Conservation Group); investigation of sightings at Cape Range NP; surveys of Salisbury, Westall and Wilson Islands in the Recherché Archipelago (with South Coast regional staff) and Pearson Island in South Australia (with SA DEH staff).

Management implications

- CALM commits substantial resources to the management of rock-wallabies every year across many regions of the State. At present, these activities are not co-ordinated by a Recovery Team or Plan. The Recovery Plan will allow CALM to improve its management of populations and will identify those taxa/ populations that require management intervention.

Future directions (next 12-18 months)

- Completion of draft Recovery Plan and circulation for comment and amendment.
- Write-up of papers on Cape Range rock-wallaby survey, Pearson Island survey and Recherché Archipelago survey.
- Survey of ranges in the Little Sandy Desert for rock-wallabies.
- Collaborative survey with Ngaanyatjarra communities in the Central Ranges bio-region.

CALM Regions

All, except South-west.

IBRA Regions

State-wide.

NRM Regions

State-wide.

Impact of cane toads on biodiversity in the Kimberley

SPP# 2006/004

Team member

D Pearson (0.4)

Context

Cane toads are rapidly advancing towards Western Australia. Our knowledge of their impacts on the fauna are fragmentary. Likewise our knowledge of existing fauna assemblages in the Kimberley is limited. This project will document pre-toad small mammal, reptile, frog and land snail assemblages in the East Kimberley and undertake cafeteria trials to identify those species susceptible to impacts from cane toads.

It aligns with Corporate Priorities 1.5, 3.1, 3.3, 3.5, 4.4; Nature Conservation output KRA 1.1, 2.1, 4.1, 6.1, 6.6.

Aims

- To determine the vulnerability of a range of vertebrate and invertebrate taxa to cane toad eggs, tadpoles, metamorphs and adults.
- To study the impact of cane toads on native taxa in field situations.
- To document existing vertebrate and land snail assemblages in the East Kimberley prior to the invasion of cane toads.
- To collect cane toads for future morphometric and dietary study.
- To make recommendations for management actions to reduce the impact of cane toads on biodiversity.

Summary of progress and main findings

- Study tour to the Northern Territory to speak to researchers and managers about their experiences and research on cane toads
- Production of project plan and animal ethics applications.
- Preparation and submission of an ARC-linkage proposal with the University of Sydney, Dept. of Environment and Heritage, Parks and Wildlife Commission of the Northern Territory.
- Review of the literature and acquisition of required equipment.
- Initial fieldwork to identify sites in the East Kimberley and western Northern Territory.

Management implications

- Despite their long presence in Australia, the impacts of cane toads are not well understood. The project will use cafeteria trials to identify those taxa at risk and behavioural responses of native fauna and radio-telemetry to study the impact on populations in the field.
- The identification of susceptible taxa and those that will persist in the face of the toad invasion will allow conservation funds to be directed to those taxa of highest priority.

Future directions (next 12-18 months)

- Establishment of study sites and acquisition of animals for cafeteria trials.
- Vertebrate and land snail surveys at sites in the East Kimberley and adjoining Northern Territory.
- Implantation of transmitters in some species of snakes and involvement of Kununurra community in their radio-tracking.

CALM Region
Kimberley.

IBRA Regions
Northern Kimberley, Central Kimberley, Ord Victoria Plains, Victoria Bonaparte.

NRM Regions
Rangelands.

Fire effects on desert vertebrates

SPP# 1993/0092

Team members
D Pearson (0.1)

Context
It aligns with Corporate Priorities 1.5, 2.4, 4.4; Nature Conservation output KRA 3- conservation of landscape scale ecological processes.

Aims

- To research the impacts of spring 'patchy' (= potential prescribed) fires and summer wildfires on small terrestrial vertebrates, invertebrates and flora of hummock grassland.
- Make recommendations for better management of spinifex desert areas.

Summary of progress and main findings

- Fieldwork complete.
- Spider data analysed by Honours student P Langlands and a paper of Journal of Arid Environments submitted.

- Rainfall found to be over-riding factor in spider assemblages while fire only had relatively short-term impact.

Management implications

The season and intensity of fires have profound effects on the fauna of spinifex grasslands. Understanding the effects of hot summer wildfires and fires lit in spring will aid the introduction of fire management plans that promote biodiversity.

Future directions (next 12-18 months)

- Publication of data on the response of reptiles and small mammals to fire in the Great Victoria Desert.

CALM Region

Goldfields.

IBRA Regions

Great Victoria Desert, Coolgardie.

NRM Region

Rangelands.

Conservation of marine turtles

SPP # 1993/0040

Team members

B Prince (0.75), K Morris (0.10), Total (0.85); District staff from Denham, Exmouth, Karratha and Broome.

Context

All marine turtles found in WA waters are listed as threatened species by the Commonwealth and the State.

This project aligns with Nature Conservation Output KRA 4, recovery of threatened species, particularly NC 4E, complete and implement the proposed State sea turtle and pinniped management plans.

Aims

- To gain an adequate understanding of the distribution and abundance of marine turtle populations utilizing 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 of importance for the maintenance of these adult turtle populations.
- To develop an understanding of the processes affecting maintenance and abundance of these marine turtle populations as an aid to addressing management needs.
- To develop appropriate management measures and interpretation packages.

Summary of progress and main findings

- Action continued on Limpus review recommendations, particularly in relation to monitoring abundance of nesting populations. Monitoring protocols finalized for Commonwealth turtle recovery team.
- Integrated tagging database developed.
- Ongoing liaison with State and Commonwealth agencies regarding management of threats to marine turtles.
- Input into Departmental response to the Gorgon EIS/ERMP in relation to flatback turtles on the

east coast of Barrow Island.

- Responded to media requests for information on the illegal take of turtles on Browse Island.
- Draft paper on the entanglements of leatherback turtles prepared for Marine Turtle Newsletter.
- Ongoing study into monitoring of nesting beach temperature profiles.
- Commenced preparation of WA marine turtle management plan with Pilbara Region staff.

Management implications

- Provision of knowledge to allow adequate management of marine turtle stocks.

Future directions (next 12-18 months)

- Complete WA marine turtle management plan in liaison with Regions/Districts, Marine Conservation and Species and Communities Branches.
- Continue to implement science based recommendations of turtle review, particularly with respect to developing monitoring protocols for nesting populations.
- Continue to liaise with Districts and other stakeholders regarding turtle management.
- Promote the use of the integrated turtle database – linking tagging, mortality and recruitment factors, and enlist expertise to undertake population modelling.
- Collect tissue for DNA analysis of Browse Island green turtles.
- Continue a study into the temperature profiles of nesting beaches along the north west coast and prepare report.

CALM Regions

Midwest, Pilbara, Kimberley.

IBRA Regions

Geraldton Sandplains, Carnarvon, Pilbara, Dampierland, North Kimberley.

NRM Regions

Rangelands, Northern Agricultural, Swan, South West.

Return to Dryandra

SPP # 2003/0002

Team members

N Thomas (0.25), N Marlow (0.25); Total (0.75).

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 project was established to investigate the best methodology to captively breed and maintain 5 locally extinct wheatbelt mammalian species within large enclosures (two 10ha) 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.

The RTD project aligns with Corporate Priority 12, KRA 4 (sub-outputs NC 4A and 4C).

Aims

- To provide a scientific basis for the establishment and maintenance of breeding populations of at least 5 CWR threatened marsupial species (dalgyte, boodie, marl, mala and merrnine) from remote areas in large enclosures at Dryandra.
- To establish self-sustaining populations of these CWR threatened marsupial species within

enclosures at Dryandra.

- To compare the success of different release and reintroduction methodologies and to develop optimal strategies for these CWR threatened marsupial species within Dryandra Woodland.
- To establish self-sustaining populations of these re-introduced CWR threatened marsupial species within Dryandra Woodland.

Summary of progress and main findings

- Dalgytes and boodies are breeding very well and more releases are needed in the near future to reduce overcrowding in the enclosures.
- Field trial of a new folding soft trap for mala completed allowing an increased trapping effort from 3 to 4 nights.
- Increased monitoring of mala indicates that numbers within the enclosure are higher than previously indicated.
- Final dalgyte translocations undertaken into Dryandra Woodland in autumn 2005, moratorium on any further releases until it can be determined that they have successfully established within the woodland.
- Effective monitoring of dalgytes using standard accepted methods (i.e. track counts) has proved to be ineffective within the Woodland, predominantly due to a lack of sand to monitor tracks. Surveys for dalgyte burrows and the use of remote (movement activated) cameras have proved to be the most efficient and effect method of monitoring dalgytes occurrence within the Woodland.
- Sightings and capture of wild born dalgytes within Dryandra Woodland proper indicate that they are persisting within the woodland.
- Boodie translocations carried out into Dryandra Woodland during 2003/04 failed predominately due to predation by exotic and native predators, in particular wedge-tailed eagles, and the apparent reluctance of the boodies to dig their own burrows.
- Ongoing supervision of District management of the RTD data base required.
- The re-emergence of the 'wart-like' syndrome infecting western barred bandicoots confirms that the disease has a long latent/dormant (3+ yrs) period. Further procurement of marl for RTD enclosures on hold until disease is investigated.
- Joint Murdoch University and CALM project to investigate western barred bandicoot wart-like syndrome underway, work to date has determine that the 'wart-like' syndrome is caused by a papoloma virus.
- Mala TP submitted and been reviewed by referees.

Management implications

- Current level of fox control within Dryandra Woodland may not be adequate for successful boodie reintroductions / establishment, implication for other species within the Woodland unknown.
- Limited prospects for reintroduction of the marl to mainland reserves until the 'wart-like' syndrome is resolved.
- Captive breeding of merrnine within large open plan pens limited due to predation from wedge-tail eagles.

Future directions (next 12-18 months)

- All future work dependent on funding.
- During 2006/07 investigate whether dalgytes are impacting on marl recruitment within the enclosures by manipulating dalgyte numbers through removal for reintroductions.
- Undertake a translocation of dalgytes to the Perup area.
- Spring 2006 undertake a release of boodies into soft release enclosures within Dryandra to investigate whether long term (up to 12 months) acclimatization to an area will encourage them to construct their own burrows.
- Mala translocation carried out into Tutanning Nature Reserve and radio-tracking/monitoring carried out by spring 2006 or autumn 2007.

- Top up release of mala to TNR by spring 2007, if practical and required.
- During 2006/07 determine feasibility and carry out a trip to Dorre Island to capture boodies to augment numbers in the RTD enclosure.

CALM Region
Wheatbelt.

IBRA Region
Avon Wheatbelt.

NRM Regions
South West, Avon.

The status of critical weight range (CWR) mammals in the Kimberley – a reassessment
SPP # 2003/0006

Team members
A Start (0.8), N McKenzie (0.1), Total (0.9); AA Burbidge (Post Retirement Research Fellow) and Kimberley Region staff.

Context
CWR mammals comprise an important and high-profile component of the State's fauna. Substantial funding is allocated to their recovery and management in the southwest. In view of evidence for continuing decline in tropical Australia, this project seeks to determine the status of CWR mammals in the Kimberley.

It aligns with Corporate Priority 12, KRA 3 and 4 and sub-outputs NC 3K and 4C.

Aim
To determine whether there has been a change (decline) in status of CWR mammals of the north and central Kimberley in recent years. If so, to make recommendations on work needed so that the issue can be addressed by research and management.

Summary of progress and main findings
- Field work in drier, central parts of Kimberley was undertaken in June 2004. All specimens, including sub-fossil material, have been identified.
- Preliminary analysis of results indicates that medium sized mammals have declined in this area and the decline is progressive. It was also noted that pastoral activities (cattle present, stock yards erected) have extended into conservation areas and this is having a detrimental impact on habitat.

Management implications
- Improved knowledge of status of Kimberley mammals.
- Advice on management of fire regimes and other disturbers in the Kimberley including better reserve boundary management and neighbour liaison.
- There are also important implications for management of islands and cane toads.

Future directions (next 12-18 months)
- The results from this field work should establish a clear indication of whether the status of CWR mammals in the wet coastal northwest and drier central parts of the Kimberley have altered in recent decades.
- As CWR mammal populations appear to have declined widely except in the wettest coastal areas

of the North Kimberley bioregion, we propose identifying sites where there are still extant populations of several species at which monitoring and research into causes of decline and management options to halt or reverse the effect of those causes can be conducted in future. Survey, reservation and management of islands are likely to be critical to conservation of mammals in the State's tropical savannas. Funding for Island surveys (under the Biogeography program) is being sought.

CALM Region
Kimberley.

IBRA Regions
North Kimberley, Central Kimberley. Dampierland.

NRM Region
Rangelands.

Ecology of the ngwayir (*Pseudocheirus occidentalis*) and koomal (*Trichosurus vulpecula hypoleucus*) in the jarrah forest

SPP # 02/0002

Team Members
A Wayne (0.2), C Ward (0.2), C Vellios (0.2); Total FTE: 0.6.

Context
Understanding the ecology of the possums in the jarrah forest is integral to their effective conservation and the development of ecologically sustainable forest management practices including timber harvesting, fire management and introduced predator control. This research began in 2001 in response to the findings from the Kingston Project (SPP # 1993/115 and # 1997/007) that identified these two species as potentially the most susceptible medium-sized mammals to jarrah forest timber-harvesting.

This study aligns with Corporate Priorities with special emphasis for 2005/06 including 3, 10 and 12, and aligns with Key Result Areas 2, 3, 4 and 6.

Aims
- Compare survey methods to identify the most effective means of detecting ngwayir and koomal.
- Describe the life histories of ngwayir and koomal within the Perup Jarrah forest (population demographics, fertility, etc).
- Examine the habitat selection and preferences of these possums within the Perup Jarrah forest.
- Investigate what factors explain the distribution and abundance of ngwayir and koomal in the Jarrah forest of the Upper Warren region.

Summary of progress
- All fieldwork associated with all components of this research program was completed in 2004.
- PhD thesis submitted and accepted - Wayne, A.F., 2005. The ecology of the koomal (*Trichosurus vulpecula hypoleucus*) and ngwayir (*Pseudocheirus occidentalis*) in the jarrah forests of south-western Australia. PhD thesis. Centre for Resource and Environmental Studies, The Australian National University, Canberra.
- 5 Scientific papers published.
- Two scientific papers submitted for publication in a scientific journal.

Management Implications
- The improved methods can be used to facilitate more efficient monitoring (e.g. Western Shield)

and research on the koomal and ngwayir necessary to clarify their conservation status and management issues.

- Improve ecologically sustainable forest management practices including timber harvesting, fire management, and introduced predator control.
- Improve the conservation of the threatened ngwayir and the koomal. Provide information directly relevant to the development and implementation of the Recovery Plan for the ngwayir. Identify key habitat and appropriate management and protection requirements for species recovery and maintenance of long-term viable populations.

Future directions

Complete analyses and publish the following:

- The home-ranges, movement and spatial patterns of habitat use by koomal and ngwayir.
- Nocturnal habitat selection by koomal and ngwayir to complement research into diurnal refuge selection.
- The distribution and abundance of ngwayir in the Upper Warren in relation to environmental factors (e.g. nutrients, climate, water, vegetation structure, floristics etc) at local and landscape scales.
- The distribution and abundance of koomal in the Upper Warren in relation to (a) anthropogenic factors and (b) environmental factors at local and landscape scales.

CALM Region

Warren.

IBRA Region

Jarrah Forest.

NRM Region

South West (SWCC).

Identifying the cause(s) of the recent declines of woylies in south-western Australia

SPP # TBA

Team Members

A Wayne (0.7), C Ward (0.5), C Vellios (0.5), M Williams (0.10), J Rooney (0.05), G Liddelow (0.05), B Ward (0.05); Total FTE: 1.95.

Context

Monitoring revealed that woylies were declining in Perup similar to what had been previously observed at Dryandra in 2001. Follow-up investigations have subsequently found that woylies at Dryandra have declined by about 90% since 2001. The Perup and surrounding Upper Warren region populations have so far declined by 90%. Similarly, woylies at Batalling (a 1982 reintroduction site east of Collie) have declined by 70% since 2003. A number of other Western Shield monitoring sites (Orell 2004), also indicate declines throughout south-western Australia, all of which remain at low to undetectable densities. The cause(s) for these declines remains unknown and the conservation status of the species is currently under review in light of these recent findings.

Aims

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

Summary of progress

- Since late October 2005, when the first indications of a woylie decline in the Perup were recognized, some of the key responses have included.
- The survey of 12 key transects throughout the Upper Warren region in October-December 2005 by Science and Donnelly District personnel to substantiate and assess the extent and magnitude of the declines.
- The identification and collation of existing available woylie data onto electronic databases to investigate:
    - The spatial and temporal patterns of the decline.
    - A preliminary assessment of the potential changes in demographic attributes of the woylie populations associated with the declines.
    - Associations between woylie declines and climate, attributes of the fox baiting history and attributes of fire history.
- The convening of a Workshop (16 February 2006) attended by 32 relevant Science and Nature Conservation CALM personnel to:
    - Provide an overview and understanding of the recent mammal declines in the southwest.
    - Examine the potential cause(s) of these recent declines and associated evidence.
    - Identify the priorities and strategies for a response to the recent declines.
- Establishment of a woylie Conservation Steering Group to co-ordinate and facilitate response activities including the development of a report and project proposal to Corporate Executive.
- The re-surveying of 11 key transects throughout the Upper Warren region in March-April 2006 to monitor the declines. More detailed and standardized data collection protocols were established and outlined in an Upper Warren Woylie Decline Monitoring Operations Handbook (Wayne *et al*. 2006) for this and future exercises. Results confirm that the declines are rapidly continuing with declines on some transects as great as 80% in the last 6 months.
- In collaboration with Murdoch University, extensive sampling of blood, faeces and ectoparasites during the March-April 2006 surveys are currently being analysed to screen animal health, identify parasites and diseases present in the populations in order to identify possible agents of decline.
- The design and development of a formal research project to investigate the plausible causes for the recent woylie declines.

Management Implications

The now substantial, rapid and extensive woylie decline throughout south-western Australia has a number of important biodiversity conservation and management implications including:

- The total abundance of woylies on CALM estate have returned to levels not seen for an estimated 20 years or more and constitute a nationally significant and major impact on this species. Without an appropriate management response the current trends bring to question the long-term viability of wild woylie populations in Western Australia.
- Woylies were delisted from State and Commonwealth threatened species lists in 1998. However, the conservation status of the woylie is currently being reviewed, with every expectation that it will qualify for an upgrade to at least the threatened 'Vulnerable' category based on IUCN criteria.
- Previously the flagship for earlier successes, the recent woylie declines no longer achieve CALM Corporate and Western Shield biodiversity conservation objectives for this species.
- The reasons for the declines remain unknown and no recoveries of impacted populations have yet been observed. It is therefore difficult to provide a reliable extinction risk assessment and detailed advice as to what the most effective conservation and management responses should be for their long-term sustainable persistence.
- Given the limited success of translocations and reintroductions in the wild, it is unlikely that this strategy will help mitigate current circumstances and may well exacerbate the problem. A moratorium on woylie translocations is strongly recommended until the risks can be better assessed.

Future directions

- Commence the proposed formal research program that includes;

- Meta-analysis of existing data.
- Ongoing monitoring of key transects at the regional scale.
- Intensive population comparison study with five specific sub-components:
- Density and demographics
- Survivorship and mortality
- Relative activity / abundance of predators
- Resource availability and accessibility
- Disease

CALM Region
Warren.

IBRA Region
Jarrah Forest.

NRM Region
South West.

Conservation of Western Australian butterflies
SPP # 1993/0022

Team members
M Williams (0.4), A Williams (0.1); Total (0.5).

Context
Invertebrates constitute a major part of the State's biodiversity. No biological survey can claim to be truly 'systematic' and no reserve system truly 'comprehensive', if invertebrates are overlooked. 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 organizations, it extends co-operative partnerships with the community.

This project aligns with Corporate priorities 2, 6 and 8; KRA 1, 2, 3 and 4; and sub-outputs NC 1C, 2B, 3H, 4C, and 6A.

Aims
- To undertake strategic 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.
- To review the taxonomic status of those taxa where systematics is uncertain, using genetic methods to better delimit those taxa.

Summary of progress and main findings
- Prepared manuscript on methods of surveying for butterflies and day-flying moths in Western Australia.
- Completed further abundance and habitat surveys of a proposed critically endangered butterfly (the Arid bronze azure, *Ogyris subterrestris petrina*) in Goldfields region.
- Published records of butterflies from the Kimberley region, expanding knowledge of butterfly distributions in WA.
- Published records of butterflies from the Recherché Archipelago increasing our knowledge of the butterfly fauna of WA's off-shore islands.

- Deposited samples of the Julimar population of *Neolucia* sp. for DNA analysis with Griffith University, leading to the recognition of a new WA endemic species.
- Drafted report and informed all stakeholders of results of metro region surveys.

Management implications

- More than 10 butterfly species are now locally extinct in the highly disturbed bushland remnants on the 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 endangered vertebrates, will be necessary to maintain butterfly biodiversity of the SCP.

Future directions (next 12-18 months)

- Complete papers on third year of fieldwork.
- Publish paper on survey methods for butterflies and day-flying moths in Western Australia.
- Conduct further surveys of potentially endangered WA taxa.
- Apply for funding for work on the arid bronze azure, a proposed critically endangered butterfly, and for the graceful sun moth.

CALM Regions
Swan, Goldfields.

IBRA Regions
Swan Coastal Plain, Coolgardie.

NRM Regions
Swan, Rangelands.

Native earthworms (Oligochaeta) of the Swan Coastal Plain: biodiversity, distribution and threatening processes

SPP # 2004/0001

Team members
A Wills (0.20), I Abbott (0.01), A Mellican (0.02), Total (0.23).

Context
As ecosystem engineers, earthworms contribute to and are sensitive to fundamental ecological processes. Understanding the status of earthworms in reserve systems is important for understanding effects of processes threatening fragmented ecosystems and developing ecologically appropriate strategies for long-term conservation of locally endemic invertebrates. Earthworms are one of the few invertebrate groups that are seen as beneficial by the public. Thus improved knowledge about native earthworms on the Swan Coastal Plain, where most Western Australians live, should help improve community understanding of the key roles of invertebrates in providing ecosystem services.

This study aligns with KRA 2 (NC 2B), KRA 3 (NC 3C), KRA 4 (NC 4C) and KRA 6 (NC 6A).

Aims

- To document the terrestrial Oligochaete fauna of the entire Swan Coastal Plain.
- To identify species with restricted ranges and their vulnerability to threatening processes.
- To evaluate the adequacy of the system of formal and informal conservation areas for terrestrial Oligochaete conservation.

Summary of progress and main findings

- 40 sites were sampled between Bunbury and Mandurah in July and August 2005.
- Limited sorting and identification done.

Management implications

- Development of an appropriate conservation strategy for earthworm fauna on the Swan Coastal Plain based on a dynamic ecosystem perspective.

Future directions (next 12-18 months)

- Continue to collect samples in July and August 2006 and 2007.
- Continue identification of specimens.

CALM Regions
Swan, South West.

IBRA Region
Swan Coastal Plain.

NRM Region
Swan.

FLORA CONSERVATION AND HERBARIUM

Program Leader: Dr David Coates

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

SPP # 1998/0003

Team members

M Byrne (0.3), D Coates (0.2), N Gibson (0.05) B Macdonald (0.4), S McArthur (0.1); Total (1.05).

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.

It aligns with Corporate Priorities 5 and 12, NC KRA 4 and NC 4C.

Aims

- To provide genetic information for the conservation and management of Western Australian flora, especially rare flora.
- To determine the genetic diversity between the 2 subspecies of *G. curviloba* to inform taxonomic status.
- To determine taxonomic identity of populations in the *Synaphea stenoloba* complex.
- To determine level of differentiation between populations of *Eremophila microtheca* and *E. rostrata* to inform taxonomic status.
- To determine the level of differentiation in *Calothamnus quadrifidus* to assist in the taxonomic revision of the group.

Summary of progress and main findings

- *G. curviloba* – investigation of genetic diversity within and between the 2 subspecies has shown that they both have extensive clonality in some populations. There is some differentiation between the subspecies but this is confounded by the level of clonality within the populations. Material from outgroup taxa has been collected and is being assessed to provide a comparison of level of differentiation.
- *Synaphea* sp. – Collections of leaf material from 25 populations representing 8 putative taxa have been made and AFLP analysis commenced.
- *Eremophila microtheca* and *E. rostrata* – DNA extractions have been made for collections from the known populations and appropriate outgroups.
- *Calothamnus quadrifidus* – Collections have been made from 40 populations throughout the range from Shark Bay to Esperance. DNA extractions have been made. Assays of the genetic diversity in the northern populations is being carried out.
- *Tetratheca* sp. - Taxonomic revision of the leafless *Tetratheca* species in the Koolyanobing area has been submitted to Australian Systematic Botany.
- Review 'Phylogeography informs the conservation of a diverse and ancient flora in south-western Australia' submitted to Australian Journal of Botany.

Management implications

- Clarification of the taxonomic status of the subspecies of *G. curviloba* will ensure appropriate management, and determination of the extent of clonality will enable correct DRF status to be assigned.

- 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.

Future directions (next 12-18 months)

- Report and journal paper on the genetic status of the subspecies in *G. curviloba* will be written.
- Journal paper on *E. bennettiae* as a hybrid between *E. sporadica* and *E. lehmannii* will be written.
- Analysis of *Synaphea* sp. will be completed to resolve the taxonomic identity of populations.
- Analysis of *E. microtheca* and *E. rostrata* will be completed to determine possible subspecies status within each species.
- Assessment of genetic structure within *Calothamnus quadrifidus* and allied taxa will be undertaken to inform taxonomic revision of the group.
- Commence study on *Laxmannia jamesii.*
- Commence Study on *Lambertia fairallii*.

CALM Regions

South Coast, Midwest, Swan, Wheatbelt, Goldfields.

IBRA Regions

Geraldton Sandplains, Esperance Plains, Swan Coastal Plain, Avon Wheatbelt, Yalgoo, Coolgardie, Mallee, Murchison.

NRM Regions

Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Genetic and ecological viability of plant populations in remnant vegetation

SPP # 2002/0001

Team members

D Coates (0.3), M Byrne (0.1), C Yates (0.2), S McArthur (0.3) Total (0.9).

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.

It aligns with Corporate Priorities 3, 5 and 12, NC KRA 3, 4 and sub outputs NC 3G, 4C.

Aims

- To 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. This will involve the integrated use of molecular genetic tools and demographic monitoring to examine 4 target taxa with varied ecologies.
- To examine and model the relationships between key genetic and demographic factors affecting viability and remnant vegetation characteristics such as size, disturbance and landscape position.
- To compare results among 3 target taxa with varied ecologies to assess how life history affects the impact of remnant characteristics on population viability.

- To develop specific genetic and demographic guidelines for management of remnant populations of the 3 target taxa and general landscape design principles for major plant life history types that will maximize the probability of population persistence.

Summary of progress and main findings

- Paper published on 'Gene flow and outcrossing in a fragmented landscape: implications for seed sourcing from small remnants, initial analyses of mating systems and gene flow in *C. quadrifidus* and *E. wandoo'.*
- Paper in press in Biodiversity and Conservation. 'Bird pollination and mating system variation for the shrub in fragments of species rich kwongan in south-west Western Australia'.
- Paper on Gene flow in *E. wandoo* submitted to Heredity.
- Paper on Gene flow in *C. quadrifidus* submitted to Molecular Ecology.
- Population size and to a lesser extent population isolation have been confirmed as key variables that will significantly influence the persistence of plant populations in remnant vegetation following fragmentation. In the case of both the bird pollinated *C. quadrifidus* and the insect/bird pollinated *E. wandoo* reproductive output in the form of seeds produced per fruit is dramatically reduced in small populations.
- A second key outcome from this study is the level of gene (pollen) flow into small isolated populations of both *C. quadrifidus* and *E. wandoo*. Although significant connectivity is not apparent across large sections of the Dongolocking landscape the importance of single trees or very small remnants as facilitators of pollen movement is evident. In particular, the high level of pollen movement into small isolated *E. wandoo* populations from at least 1km away appears likely to be a key factor in maintaining outcrossing rates, reducing inbreeding and maintaining seed production levels. A significant factor in ensuring gene flow between *E. wandoo* populations in this landscape will therefore probably depend on the maintenance of spatially critical paddock trees and small remnants.

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 1 large site vs. 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 prioritization 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 maximize 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 maximized.
- 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)

- Funding approved through Land and Water Australia with CSIRO for phase 2 two year program on 'Molecular ecological analysis of vegetation function in fragmented Australian biomes'.
- Based on above commence selection of additional species and site selection in Spring 2006.
- Commence phase 2 analysis of site/population characteristics – disturbance, density and isolation.
- Commence phase 2 seed set/reproductive output studies.
- Commence phase 2 genetic variation studies.

- Continue preparation of 8 publications from phase 1 of the project.
- Write papers on genetic diversity in *E. wandoo* and genetic diversity in *Calothamnus quadrifidus*.

CALM Region
Wheatbelt.

IBRA Region
Avon Wheatbelt.

NRM Regions
Avon, Northern Agricultural, South Coast, Swan.

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) Total (0.5).

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.

It aligns with Corporate Priorities 5 and 12, NC KRA 4 and sub outputs NC 4C, 4F.

Aims
- To assess the relationship between effective population size and levels of genetic diversity, and the minimum effective population size for maintaining genetic diversity.
- To assess the effects of population size and habitat degradation on mating system parameters that indicate inbreeding or the potential for inbreeding.
- To assess whether reduction in population size, increased inbreeding and reduced genetic variation are associated with any reduction in fitness.
- To 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 and main findings
- Paper in press in Conservation Genetics on 'Reduced genetic diversity and increased inbreeding in the rare *Acacia sciophanes* compared with its sister species *Acacia anfractuosa*'.
- Draft paper in preparation on 'Population genetic structure and mating system variation in *Verticordia fimbrilepis ssp. Fimbrilepis*'.
- Genetic structure allozyme analysis completed on *Verticordia staminosa.*
- Paper in press in Australian Journal of Botany on 'Plant mating systems and assessing population persistence in fragmented landscapes'. Findings from this work show that although the mating system will vary depending upon pollination biology and life -history, as populations get smaller, more isolated and habitat disturbance increases there is a trend towards increased inbreeding, smaller effective sizes of paternal pollen pools and greater variation in outcrossing among plants. From the species investigated in this study we have found that changes in the mating system can be useful indicators of population processes and can give valuable insight into the development of conservation strategies for plant species persistence following anthropogenic disturbance and landscape fragmentation.
- Paper in press in Australian Journal of Botany which includes a study on population genetic

structure in the critically endangered *Verticordia staminosa.*

Management implications

- Prescriptions for the prevention of inbreeding and maintenance of genetic variation in small fragmented populations of rare and threatened plants.
- Development of strategies for managing inbreeding and loss of genetics diversity during translocation programs.

Future directions (next 12-18 months)

- Finalize paper on 'Population genetic structure and mating system variation in *Verticordia fimbrilepis ssp. Fimbrilepis*'.
- Complete temporal mating system data analysis on *B. cuneata*.
- Complete genetic structure study on *Banksia brownii.*

CALM Regions

Wheatbelt, Midwest, Swan, South West, South Coast, Warren.

IBRA Regions

Avon Wheatbelt, Esperance Plains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren.

NRM Regions

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

SPP # 1999/0010

Team members

A Cochrane (1.0), A Crawford (1.0), V Cunningham (1.0), D Coates (0.05); Total (3.05).

Context

Seed conservation is a specific and targeted action to conserve biodiversity and entails the storage of genetic material in the form of seed. This material is available for *in situ* recovery actions, and seed research. Understanding the seed biology of plant species is important for the conservation and management of rare and threatened Western Australian taxa and for developing and implementing recovery plans for the flora.

It aligns with Corporate Priority 5 and 12, NC KRA 3, 4, 6 and sub outputs NC 3G, NC 3H, NC 3L, NC 4C, NC 6A.

Aims

- To provide a cost effective and efficient interim solution to loss of floral genetic diversity.
- To provide a focus for flora recovery in Western Australia.
- To collect and store seed of rare and threatened Western Australian plant species.
- To determine the germination and storage requirements of seed.
- To monitor the viability of stored seed over the long-term.
- To increase knowledge of seed biology using both field and laboratory based studies.
- To describe and categorize seed and gather phenological data.
- To incorporate all information into a corporate database (WASEED).
- To 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 and main findings

- Seed collections from 242 rare, threatened, poorly known and other taxa were made (298 accessions). This included 88 DRF, 63 Priority and 147 general collections of taxa associated with threatened ecological communities and biodiversity hotspots.
- All data pertinent to the collection, testing, storage and monitoring of seed-based data has been entered into the WASEED database, which continues to be updated.
- Paper published in *Journal of the Royal Society of Western Australia* 'Endozoochory and the Australian bluebell: seed consumption of *Billardiera fusiformis* by mammals at Two Peoples Bay Nature Reserve, Western Australia' A Cochrane, T Friend and S Hill.
- Paper accepted for *Australian Journal of Botany* 'The effects of temperature and dormancy breaking treatments on the germination of five endemic and geographically restricted herbaceous perennials from south west Western Australia' A Cochrane and R Probert.
- Book Chapter published in *The Australian Seed Book* 'The role of seedbanks in the long-term conservation of threatened plant species' A Cochrane and L Monks.
- Paper published in *Proceedings of the Fifth Australian Workshop on Native Seed Biology*. 'Conservation biology of a critically endangered shrub *Cyphanthera odgersii* (F. Muell.) Haegi subspecies *occidentalis* Haegi (Solanaceae)' A Cochrane and C Yates,
- Bushbook published 'Endemic Flora of the Stirling Ranges National Park' S Barrett and A Cochrane.
- *Landscope* article published. A safe haven for threatened plants' A Cochrane and S Barrett.
- Paper submitted *Australian Journal of Botany* 'Analysis of seed bank data confirms suitability of international seed storage standards for the Australian flora' A Crawford, K Steadman, J Plummer, A Cochrane and R Probert.
- Paper submitted Aus*tralian Journal of Botany* 'Seed quality for conservation is critically affected by pre-storage factors' R Probert, J Adams, J Coneybeer, A Crawford and F Hay.

Management implications

- Improved conservation of threatened and endemic plant taxa.

Future directions (next 12-18 months)

- Ongoing collection of seed for incorporation into the gene bank, including DRF and priority taxa, and common species associated with threatened ecological communities and biodiversity hotspots.
- Ongoing research into the seed biology and seed storage behaviour of a number of threatened plant taxa.
- Germination testing, storage and monitoring of existing accessions.
- Continuation of Phase 2 of international collaboration with Millennium Seed Bank Project, UK with increased seed collection targets and initiation of science research collaboration, including PhD by A Crawford.
- Reporting requirements to SCRIPT (cross regional NHT project) and MSB Kew.
- Submit paper to *Australian Journal of Botany* on 'The significance of *ex situ* seed conservation to threatened plant reintroduction' A Cochrane, A Crawford and L Monks.
- Other publications.

CALM Regions

All.

IBRA Regions

Avon Wheatbelt, Carnarvon, Coolgardie, Esperance Plains, Gascoyne, Geraldton Sandplains, Great Sandy Desert, Hampton, Jarrah Forest, Mallee, Murchison, Nullarbor, Swan Coastal Plain, Warren, Yalgoo.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Weeds of Western Australia: advice, liaison, publicity and documentation
SPP # 1997/0002

Team members
G Keighery (0.2), W Muir (0.1); Total (0.4).

Context
Understanding the nature and extent of feral plants in native and agricultural systems of Western Australia. Use these data to establish clear State and Federal priorities for weed management that are aligned to WA needs and major weed issues.

Aligns with Corporate Priorities 3, 5 and 12, KRA 2, 3 and sub output NC 2A and NC 3C.

Aim
To assist with the documentation of the occurrence, impact and control of environmental weeds of Western Australia.

Summary of progress and main findings
- To develop a major new checklist of W.A. weeds published in Plant Protection Quarterly.
- Western Weeds field guide update finalized.
- Major NRM grant obtained (Number 20-0608) for Strategic weed management in Swan Region
- Continue on assessment panel for remote weed projects by fire crews

Management implications
- Assists in prioritizing management of weeds at a local, State and federal level.
- Provide input into CALM training workshops on weeds.

Future directions (next 12-18 months)
- Complete survey of SW arboreta for naturalizing populations.
- Continue advice on weeds, weed issues ranging from targets for biological control, potential weeds for Environmental protection, provenance of plantings and proposed rehabilitation subjects for Regional Parks.
- Continue on WONS Steering Group for Bridal Creeper, ANZEEC Group for weeds of conservation concern and reviewing Rottnest weed and rehabilitation plans.
- Major weeds review for State of Environment report published.
- Publish second edition of Western Weeds.
- Undertake Spiny Rush workshop.
- Prepare review of Geophytic weeds of WA for Workshop.
- Prepare list of major/minor weeds and impacts for Swan NRM region.
- Review Buffel grass control for Dirk Hartog Island rehabilitation.
- Review, collect weeds of Pilbara Bioregion.

CALM Regions
All.

IBRA Regions
All.

NRM Regions

Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Systematic studies of DRF with taxonomic problems: publish the results and formally describe unpublished DRF taxa

SPP to be advised

Team member

G Keighery (0.1).

Context

Many Declared Rare Flora have nomenclatural and taxonomic issues that require resolution for their conservation and management.

It aligns with Corporate Priorities 5 and 12, NC KRA 4 and NC 4C.

Aims

- To provide informative, stable taxonomy of conservation dependent taxa to aid their conservation and management, especially rare flora. Studies are being undertaken on the following endangered taxa with taxonomic issues:
    - *Adenanthos pungens*; *T*axonomic status of two named subspecies;
    - *Calytrix breviseta*; status of hills population and taxonomic status of two named subspecies;
    - *Darwinia carnea*; taxonomic status of Mogumber and Narrogin Populations;
    - *Hypocalymma angustifolum;* taxonomic status of Yerina Springs;
    - *Adenathos eyeri*/*A. forrestii*/*A. ileticos* species complex;
    - Taxonomy of Dryandra nivea species complex;
    - *Grevillea curviloba* and Grevillea evansecens taxonomy;
    - Publication of ms DRF Darwinia species.

Summary of progress and main findings

- A paper describing the six DRF *Darwinia* species with phrase names has been completed.
- *Grevillea evanescens* considered critically endangered by the last revision has been found to be a form of *Grevillea obtusifolia*.
- *Hypocalymma longifolium* has been shown to be a distinct species and a new subspecies name is required for the Yerina Springs population of *Hypocalymma angustifolium*.
- A paper formally naming the rare subspecies of *Apium prostratum* is in press.
- Morphometrics unable to distinguish between Scott Plains and Swan Coastal Plains populations of *Dryandra nivea* subsp. *uliginosa.*

Management implications

- *Grevillea evanescens* is not a species, it is not extinct and is more common than previously considered.
- *Hypocalymma longifolium* and the new subspecies will both be rare.
- Several highly restricted new species have been discovered during field work in the Wicher Range and require description (they have or are being been allocated phrase names). Several of these should be considered for gazettal.

Future directions (next 12-18 months)

- Complete field work on *Adenanthos forrestii* complex.
- Taxonomic Notes on *Hypocalymma* in press.

- Taxonomic Notes on *Adenanthos pungens* in press.
- New Taxa of Conservation Concern in *Darwinia* published.
- Taxonomy notes on *Calytrix breviseta* prepared.
- Taxonomic notes on *Darwinia carnea* prepared.

CALM Regions
South Coast, Midwest, Swan, Wheatbelt.

IBRA Regions
Geraldton Sandplains, Esperance Plains, Swan Coastal Plain, Avon Wheatbelt, Coolgardie, Mallee.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Wattles of the Pilbara
SPP # 2004/0022

Team member
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 the ability to readily identify taxa in this Region is critical to facilitate their conservation and management.

Aligns with Corporate Priorities 5, 12, KRA 3, 4 and sub outputs NC 3C, NC 4C.

Aim
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 utilization .

Summary of progress and main findings
- Web page created in WorldWideWattle describing the Pilbara project (http://www.worldwidewattle.com/infogallery/misc/pilbara.php).
- Field studies conducted to acquire relevant taxonomic information and photographs of species.
- Research conducted resulting in 10 new species being recognized (draft descriptions prepared) and taxonomic problems in many other taxa resolved.
- Draft distribution maps prepared based on Herbarium records and field observations.
- Draft descriptions prepared of most taxa summarizing relevant information on morphology, biology, ecology, distribution, utilization and conservation status.
- Available photograph assembled for publication in field guide (and now posted on the web).

Management implications
- Identification and information dissemination of Pilbara *Acacia* species primarily to facilitate their management and conservation.

Future directions (next 12-18 months)
- Complete taxonomic resolution of Pilbara Acacia species and publish results.
- Conduct field studies to acquire additional photographs and resolve outstanding taxonomic problems.
- Illustrate (line drawings) of Pilbara taxa where drawings do not already exist.

- Construct and test electronic database (electronic key) for Pilbara species.
- Publish field guide to the Wattles of the Pilbara.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Acacia biology, conservation and utilization

SPP # 2003/008

Team member
B Maslin (0.5); Total (0.5).

Context
Acacia species are coming under increasing consideration for utilization 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 utilization is to be sustainable and their conservation effective.

Aligns with Corporate Priorities 5, 12, NC KRA 4 and sub outputs NC 4C, NC 3F.

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

Summary of progress and main findings
- *Acacia saligna*: collaboration with CSIRO colleague established to progress taxonomic study; summary of *A. saligna* research posted on WorldWideWattle website.
- Curation of Herbarium *Acacia* collections on-going (as basis for re-assessment of conservation status of the WA taxa).
- Draft descriptions of 2 new WA taxa of *Acacia* completed; new species, *A. splendens* (with C Elliott), submitted for publication.
- Field and herbarium study of *A. verniciflua* group undertaken in Victoria (with D Murphy); taxonomic review paper in progress.

Management implications
- Identification of *Acacia* species with agroforestry potential that facilitate conservation.

Future directions (next 12-18 months)
- Complete write-up of *A. microbotrya* project.
- Progress taxonomic elucidation of *A. saligna* group.
- Commence reassessment of conservation status of WA *Acacia* flora.
- Publish taxonomic descriptions of new W.A. species and review of *A. verniciflua* group.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Wattles in the Shire of Dalwallinu
SPP # 2000/0013

Team member
B Maslin (0.2); Total (0.2).

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.

Aligns with Corporate Priorities 5, 12, NC KRA 4 and sub outputs NC 4C, NC 3F.

Aim
- To research and promote Acacias of the Dalwallinu Shire.
- To publish a book (field guide) and scientific papers.
- To conduct an Acacia Symposium in Dalwallinu.
- To develop an Acacia website (called WorldWideWattle).
- To participating in the creation of an Environmental Interpretive Centre in Dalwallinu.

Summary of progress and main findings
- Major developments to WorldWideWattle website undertaken resulting in increased functionality and content.

Management implications
- Greater understanding of *Acacia* conservation.

Future directions (next 12-18 months)
- WorldWideWattle: maintain and further develop the website.
- Dalwallinu Environmental Interpretive Centre: determine future direction of this initiative.
- Progress field guide to *Acacias* of the Dalwallinu Shire.

CALM Region
Wheatbelt.

IBRA Region
Avon Wheatbelt.

NRM Region
Northern Agricultural.

WATTLE: a computer-based information system for the genus *Acacia*
SPP # 1999/0005

Team member
B Maslin (0.1); Total (0.1).

Context
Interactive multi–access electronic keys are proving increasingly valuable in the identification of plant taxa. The development of such a key for *Acacia* provides an important tool for conservation biologists and land managers to identify all the known taxa of this key Australian genus.

Aligns with Corporate Priorities 5, 12, NC KRA 4 and sub outputs NC 4C, NC 3F.

Aim
To produce an electronic identification key and information delivery system for Australian species of *Acacia*.

Summary of progress and main findings
- WATTLE data transferred from DELTA to Lucid database.
- Delivered (with B Durrant) a 2 day Lucid Workshop (22 attendees).
- Sought support to maximize chances of ratification at International Botanical Congress (IBC) in Vienna (July 2005) of the Orchard and Maslin proposal to retypify *Acacia*; to this end papers published in international and Australian journals, public lecture (in Canberra) delivered and in media interviews conducted.
- Successful outcome at IBC in Vienna to conserve the name *Acacia* for Australian species of subg. Phyllodineae.

Management implications
- Improved ability to identify *Acacia* species.

Future directions (next 12-18 months)
- Structure and populate Lucid database in which WATTLE now resides (a large backlog of information needs to be incorporated).
- Explore ways of delivering new WATTLE data via the web (WorldWideWattle).
- Facilitate appropriate generic name changes for *Acacia* following decision at IBC in July 2005.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Experimental translocation of Critically Endangered plants
SPP # 2001/0004

Team members
L Monks (1.0), D Coates (0.05); Total (1.05).

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.

The flora translocation program aligns with Corporate Priorities 5,12, NC KRA 4, sub-output NC 4C.

Aims

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

Summary of progress and main findings

- 23 translocations planted in previous years were monitored.
- Assisted District CALM staff with planting and monitoring of new flora translocations for *Grevillea althoferorum* and *Synaphea quartzitica*.
- 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 utilized immediately in other flora translocation projects.
- Development of flora translocation database continuing in collaboration with WA Threatened Species and Communities Unit.
- Completed draft paper for mating systems study on *Lambertia orbifolia* translocation, commenced writing paper of Acacia translocation success.
- Assisted in running 3 workshops on Australian threatened flora translocations in Newcastle, Coffs Harbour and Adelaide. These training workshops are designed to ensure that translocations are used in appropriate situations and undertaken with adequate knowledge of information, planning and commitment required.
- Invited speaker at the Threatened Flora Translocation Workshop in Pune, India, sponsored by Botanic Gardens Conservation International.
- Assisted in organizing a Symposium entitled 'Advances in plant conservation biology: implications for flora management and restoration'.
- Presented a talk entitled 'Assessing translocation success for the critically endangered *Lambertia orbifolia* subsp. *Orbifolia*' at the Advances in Plant Conservation Biology Symposium.

Management implications

- Improved conservation status for critically endangered plant taxa.
- Improved awareness of best practice translocation methodologies for CALM staff and communities members undertaking such work.

Future directions (next 12-18 months)

- Continue the planting of experimental translocations of 23 critically endangered plant species where further plantings are deemed necessary.
- Assist District and Regional staff in planning and planting at least 6 more translocations of Threatened plant species.
- Continued the monitoring of the 23 translocations and analyses of population biology data.
- Publish translocation methodology data, *Lambertia orbifolia* mating systems study, and Acacia translocation success study.
- Finalize development of rare flora translocation database.

CALM Regions

Midwest, South Coast, South West, Swan, Wheatbelt.

IBRA Regions

Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren.

NRM Regions
Avon, Northern Agricultural, South Coast, South West, Swan.

Confirmation of the conservation status of rare and poorly known flora thought to be endangered or critically endangered

SPP # 1999/0020

Team member
S Patrick (0.15); Total (0.15).

Context
Accurate assessment of the conservation status of rare and poorly known flora underpins our understanding of the Western Australian flora.

This aligns with Corporate Priority 5, 12, NC KRA's 1, 2 and 4 and suboutputs NC 1A, NC 2B, NC 4C.

Aim
To accurately assess the conservation status of Western Australian flora listed as poorly known but considered to be rare (CALM Priority Flora.) Approximately 200 taxa have been targeted for survey after assessment for those most likely to be critically endangered.

Summary of progress and main findings
- Survey work has been undertaken in 3 CALM Regions.

Management implications
- Improved knowledge of status and the need for listing threatened plant taxa.

Future directions (next 12-18 months)
- To be re-assessed following retirement.

CALM Regions
Midwest, Wheatbelt, Swan, South West, Warren, South Coast, Goldfields, Pilbara.

IBRA Regions
Avon Wheatbelt, Carnarvon, Coolgardie, Esperance Plains, Gascoyne, Geraldton Sandplains, Great Sandy Desert, Jarrah Forest, Mallee, Murchison, Pilbara, Swan Coastal Plain, Warren, Yalgoo.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Declared rare and poorly known flora in the Goldfields region, wildlife management program

SPP # 2003/0007

Team member
S Patrick (0.4); Total (0.4).

Context
Current information on all Rare and Priority Taxa in a CALM Region is required before management of those taxa can be carried out, and before research effort can be directed to the most urgent areas.

This aligns with Corporate Priority 5, 12 and NC KRA 4, NC 4C.

Aim

To provide a source of current information on all Rare and Priority taxa in the Goldfields Region, with management and research actions listed for each taxon.

Summary of progress and main findings

- Species information updated for new taxa added to list and information passed to Goldfields Region.
- Treatments for all taxa are near completion
- Mapping of populations for final report completed for all taxa.
- Management implications.
- Up to date assessment of the conservation status of all conservation taxa in the Region.

Future directions (next 12-18 months)

- To be re-assessed following retirement.

CALM Region

Goldfields.

IBRA Regions

Gibson Desert, Great Victoria Desert, Nullarbor, Coolgardie, Murchison, Gascoyne, Mallee, Ord Victoria Plains.

NRM Region

Rangelands.

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

SPP # 93/0068

Team members

B Shearer (0.5), C Crane (0.5); Total (1.0).

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.

It aligns with Corporate Priorities 3, 12, NC KRA 2 and 3 and sub-outputs NC 2B, NC 3I, NC 3L, NC 4C and PVS 5F.

Aim

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

Summary of progress and main findings

- With funding from NHT in 2003/004 grouped plant species in a Jarrah forest site and south coast site into either phosphite non-responsive, such as *Lambertia inermis,* and phosphite responsive, such as *Banksia grandis.*
- Determined inter-specific differences in phosphite effectiveness within *Lambertia*. Phosphite was not effective in all *Lambertia* species. Re-testing is progressing using a different testing method.
- Phosphite stem and aerial application techniques were compared in 2005.

- Published: Shearer BL, Fairman RG, Grant M (2006) Effective concentration of phosphite in controlling *Phytophthora cinnamomi* following stem injection of *Banksia* species and *Eucalyptus marginata*. *Forest Pathology* 36, 119-135.

Management implications

- Effective methods of *P. cinnamomi* control using phosphite.

Future directions (next 12-18 months)

- Continue determination of inter-specific differences in phosphite effectiveness within *Lambertia* in order to better protect rare and endangered *Lambertia* species currently being treated with phosphite, but dying from *P. cinnamomi* infection.
- Test the use of Pentrabark for stem application of phosphite.
- Prepare for publication injection and spray trials.

CALM Regions

South West, South Coast.

IBRA Regions

Esperance Plains, Jarrah Forest, Swan Coastal Plain.

NRM Regions

Avon, South Coast, South West, Swan.

Susceptibility of rare and endangered flora to *Phytophthora*

SPP # 1999/0019

Team members

B Shearer (0.5), C Crane (0.5); Total (1.0).

Context

Determination of the susceptibility of threatened flora to *Phytophthora cinnamomi* is important for prioritizing 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.

It aligns with Corporate Priorities 3, 12, NC KRA 2 and 3 and sub-outputs NC 2B, NC 3I, NC 3L, NC 4C and PVS 5F.

Aims

- To determine variation in susceptibility to *P. cinnamomi* between and within families.
- To identify within species variation in susceptibility.
- To rank taxa according to susceptibility to identify those at risk.

Summary of progress and main findings

- Tested 137 taxa for susceptibility in 2006.
- To date 50+ taxa transferred to pots for testing in 2007.
- Database of 200 + taxa updated.
- Provisional susceptibility list distributed within CALM.
- Test *Lambertia* species for within species variation in susceptibility.
- Published: Shearer B, Crane C, Cochrane A (2005) A thief of time: *Phytophthora cinnamomi* and threatened flora. *Australian Plant Conservation* 13(4): 14-15.

Management implications

- Quantification of the threat of *P. cinnamomi* to flora conservation.
- Identifies flora at risk of infection.

Future directions (next 12-18 months)

- Plant up germinates as received from Threatened Species Seed unit throughout 2006.
- Inoculate plants in 2007 and record mortality.
- Update database.
- Test survivors for root infection.

CALM Regions

Midwest, Swan, Wheatbelt, South West, Warren, South Coast.

IBRA Regions

Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren.

NRM Regions

Avon, South Coast, South West, Swan.

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

SPP # 93/0112

Team member

M Stukely (0.25); Total (0.25).

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. Selected 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 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.

The project aligns with Corporate Priority 3, 12, NC KRA 3 and sub-outputs NC 3L.

Aims

- To collect and screen a wide range of Jarrah provenances (half-sib families) for resistance to *Phytophthora cinnamomi* (Pc).
- To select outstanding individuals from Pc-resistant families for propagation, field validation testing, and inclusion in seed orchards.
- To test clonal lines of Pc-resistant Jarrah in field inoculation trials to validate their selection for inclusion in seed orchards.
- To establish a CALM/FPC seed orchard for production of Pc-resistant Jarrah (NHT Project 003072 – 'Producing Dieback Resistant Jarrah for land and forest rehabilitation').

Summary of progress and main findings

- Analysis of data has been completed, and a draft paper on the field validation of clonal DRJ prepared (see below). The project has been reviewed and will now be closed. It will be replaced with a new research project investigating aspects of dieback and the formulation of Jarrah forest silviculture guidelines, aligned with SFM goals (KRA 3 – SFM 3M). A Science Project Concept

Plan has been approved.

- A journal paper arising from the PhD project of Margaret Wheeler (Murdoch University) was completed and is currently under review: 'Intraspecific variation in seed viability and seed production in clones and wild trees of *Eucalyptus marginata* (Myrtaceae)' [amended title].

Field Validation trials:

- The superiority (in terms of both survival and growth rate) of DRJ clones in earlier field trials has now been maintained for up to 18 yrs. Survival and growth of the DRJ has generally been good in 2 major field validation trials of DRJ clones that were established in winter 1999 on dieback-infested sites in the Jarrah forest (these provide a harsher environment than the earlier validation trials planted on former bauxite pits). Some early drought deaths were recorded at both sites. There were minimal additional losses in 2002-06.
- A draft journal paper was completed: 'Field survival and growth of clonal, micropropagated *Eucalyptus marginata* selected for resistance to *Phytophthora cinnamomi*.'

Clonal DRJ Seed Orchard, CALM/FPC (NHT Project 003072):

- No further infill planting has been done since 2004 due to unavailability of clones; the total number of unrelated DRJ lines planted in the seed orchard to date is 29.
- DRJ clones will be produced at Alcoa's lab for final infill planting by FPC, to reach the goal of 35 DRJ lines and complete the seed orchard.
- First seed is expected to be produced in the orchard within about 2 yrs.

Seedling inoculation trials (NHT Project 003072):

- The analysis of the final series of glasshouse inoculation trials, using seedlings derived from surviving resistant lines in early field inoculation trials, was carried out. Progeny have shown good levels of resistance in general.

Management implications

- Once seed production starts in the seed orchard (expected from 5 yrs after planting), DRJ seedlings will be grown in the nursery and made available to CALM managers, community groups and land holders for use in rehabilitation plantings of degraded forest and cleared sites. 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 will now be closed.
- Infill planting of DRJ Seed Orchard at Manjimup PPC will be done by FPC when clones are available from Alcoa.
- 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 (arising from recent work at Murdoch University), elimination of inferior lines based upon performance data, and possibly the focused selection and cloning of additional resistant lines to maintain the required level of genetic diversity in the orchard in the long-term.

CALM Regions

Warren, South West, Swan, Wheatbelt.

IBRA Regions

Jarrah Forest, Swan Coastal Plain, Avon Wheatbelt, Warren.

NRM Regions

Avon, South Coast, South West, Swan.

Dieback-resistant Jarrah establishment in operational forest rehabilitation sites

SPP # 94/0006

Team member

M Stukely (0.15); Total (0.15).

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* (SPP 93/0112). Seedling DRJ will be available for operational plantings when the DRJ seed orchard (SPP 93/0112) becomes productive. During the 1990s, trial plantings of clonal Dieback Resistant Jarrah (DRJ) were established in operational forest rehabilitation sites in several CALM 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 (see SPP 93/0112), rather than directly planting them into operational forest rehabilitation sites. A new approach addressing the broader problem of poor survival of Eucalypt seedlings in CALM's operational Dieback Forest Rehabilitation sites was started in 2003, with support from Alcoa and in collaboration with Perth Hills District.

The project aligns with Corporate Priority 3, 12, KRA 3 and sub-outputs NC 3L.

Aims

- To re-establish Jarrah, initially using clonal, dieback-resistant plants, in operational Dieback Forest Rehabilitation (DFR/FIRS) sites.
- To test a range of site treatments aimed at maximizing the survival of seedlings planted in dieback graveyard sites.

Summary of progress and main findings

- First-year and second-year survival assessments were completed on the trial established in 2004 at Willowdale on a dieback graveyard site including black gravel and sheet laterite caprock.
- Data were analysed and progress reports completed.
- Overall there was a very high level of survival in this trial, with probing of the soil to 40cm prior to planting having been done for all trees to ensure adequate soil depth for root penetration. The novel use of 10-metre wide strip plantings, running north-south to provide some shading and wind protection, rather than planting in a single, open, broadscale area, was also beneficial. Trees that were watered through the first summer (watering was done when no rain had fallen for at least 3 weeks) showed better survival than non-watered trees. However, the application of mulch and slow-release fertilizer at a low rate made no difference to survival.

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 93/0112) 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 paper is in preparation for publication.
- The project will then be closed.
- Advice will be provided on the design and treatments for a final trial to be set up by Alcoa and Perth Hills District to determine the combination of treatments for optimum Jarrah seedling survival in the Black Gravel sites, based on the results achieved in this project so far.

CALM Regions
South West, Swan.

IBRA Region
Jarrah Forest.

NRM Regions
Avon, South Coast, South West, Swan.

Mundulla Yellows disease in Western Australia

SPP # to be allocated

Team member
M Stukely (0.15): Total (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. Once its cause, 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.

The project aligns with Corporate Priority 3, 12, KRA 2, sub-output NC 2A.

Aims
- To monitor Mundulla Yellows (MY) disease occurrence and spread in Western Australia.
- To conduct trials to investigate mechanisms of spread and conditions contributing to the development of MY (ARC Linkage Project 2004-2006).

Summary of progress and main findings
- Paper published in *Australasian Plant Pathology*: 'Mundulla Yellows disease of eucalypts: descriptors and preliminary studies on distribution and etiology'.
- Monitoring of MY in WA by CALM has continued, in collaboration with Dr D Hanold, Dr N Thompson and Prof J Randles (University of Adelaide). Several reports of possible MY-affected trees have been received from CALM staff, and these have been checked and sampled.
- A 3-yr ARC Linkage Grant, with CALM as an Industry Partner, commenced in March 2004 - 'A comparative study of the distribution and spread of potential molecular markers for Mundulla Yellows disease.' Seed has been collected and germinated for transmission trials.
- MY symptoms have been recorded in WA in remnant *Eucalyptus marginata*, *E. todtiana*, *E. rudis*, *E. camaldulensis*, *E. salmonophloia*, *E. loxophleba*, *E. pleurocarpa* and *Corymbia calophylla*; in planted *E. camaldulensis*, *E. gomphocephala*, *E. conferruminata*, *E. platypus*, *E. salubris*, *E. occidentalis*, *C. calophylla* and *C. ficifolia*, and in several eastern states Eucalypt species grown in WA (e.g. *E. botryoides*, *E. cladocalyx*, *C. citriodora*, *C. maculata*). Samples have been sent to Dr Hanold in Adelaide to be tested for MY-RNAs.
- MY-RNAs have been detected in symptomatic trees of those species for which the present molecular test (Hanold & Randles) can be used - *E. camaldulensis, E. rudis, E. salubris, E. salmonophloia, E. loxophleba, E. gomphocephala* and *Corymbia calophylla*.
- Soil and foliar samples have been collected from MY-affected and asymptomatic Eucalypts at a variety of sites, and chemically tested. Soil pH levels under MY-affected trees in WA range from strongly acidic to mildly alkaline. This conflicts with recent data reported from Victoria, where only

strongly alkaline soils have been implicated.

- MY-affected trees have been recorded by M Stukely from Northampton to Esperance. They occur on disturbed sites including roadsides, parks and gardens, and symptoms have also been observed in remnant paddock trees several hundred metres from the nearest road. However, affected trees have still not been observed within undisturbed forest or woodland stands.
- Symptom development in affected trees can be rapid once the dieback phase begins.
- Spread of MY symptoms between trees at any given site does not appear to be rapid; however, the number of known affected sites is still increasing. Numbers of affected trees at most newly observed sites are small.
- Visited MY sites at Lara and Geelong, Victoria, and met with Victorian researchers.
- The national Mundulla Yellows Task Group (MYTG) submitted its final report in May 2004 to the Natural Resource Policies and Programs Committee (NRPPC) [formerly the LWBC] of the Natural Resource Management Ministerial Council. The group now continues informally for consultation and discussion, and M Stukely has continued to represent CALM and WA there.

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, 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)

- Continued monitoring of existing and new occurrences of MY in WA.
- Prepare scientific paper on soil and foliar nutrient data for publication.
- Set up seed transmission trials in the glasshouse (CALM in-kind contribution to the ARC Linkage Grant).
- Further education of CALM and FPC staff in relevant areas in identifying and reporting possible MY symptoms.
- Continued collaboration with, and assistance to, Dr Hanold and the Adelaide researchers.
- Additional field transects are to be established in WA for monitoring spread of MY from known infections to healthy vegetation.

CALM Regions

Swan, South West, Midwest, Wheatbelt, South Coast, Warren.

IBRA Regions

Swan Coastal Plain, Geraldton Sandplains, Jarrah Forest, Avon Wheatbelt, Esperance Plains, Warren.

NRM Regions

Northern Agricultural, Swan, Avon, South West, South Coast, Rangelands.

Vegetation Health Service

Core Function

Team members

M Stukely (0.35), J Webster (0.6), J Ciampini (0.4); Total (1.35).

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 based at Murdoch University.

This scientific service aligns with Corporate Priority 3, 12, KRA 2, 3, 4 and sub-outputs NC 2A, NC 4C.

Aims

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

Summary of progress and main findings

- A total of 1423 samples were processed for *Phytophthora* between 1st July 2005 and 31st May 2006, and all isolates of *Phytophthora* spp. (other than *P. cinnamomi*) were subcultured for identification to species.
- Unusual *Phytophthora* isolates were again sent to the Centre for *Phytophthora* Science and Management based at Murdoch University for DNA analysis. This service is now available on a regular basis.
- An undescribed *Phytophthora* sp., that has been found with unexpectedly high frequency in association with dying plants since 2003, was again found. While it is morphologically similar to *P. citricola*, its DNA sequence is quite distinct, and suggests a separate species. An Honours student project (Melissa Bexley) has started in 2006 at Murdoch University: 'Biology and pathology of *Phytophthora citricola*-like organism'. A paper reporting this new species is in preparation.
- *Phytophthora inundata*, a recognized pathogen of woody trees and shrubs named in 2003 in the UK, has recently been isolated from a jarrah forest site. DNA sequencing of two earlier isolates in our culture collection, from a National Park (sampled in 1986) and a reserve (1997), has revealed that *P. inundata* is also present on the South Coast and inland in the Great Southern. A paper reporting this is in preparation.
- The services and facilities of the VHS were made available through the Centre for *Phytophthora* Science and Management to two PhD student projects at Murdoch University.
- A presentation on the VHS was made to the annual Land for Wildlife staff meeting on 9th May.
- Reports were prepared on a eucalypt canker disorder: 'Observations of marri and Jarrah crown decline near North Bannister', and dieback at Bluff Knoll: 'Report on mass plant deaths near Bluff Knoll, Stirling Range National Park'.
- Advice and consultations concerning other plant diseases were given to various CALM staff and members of the public as required, including several NatureBase inquiries.

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.
- The availability of DNA sequencing technology through the Centre for *Phytophthora* Science and Management 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 have previously been grouped 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 for strategies for their management and control to be developed.

- Advice provided on other plant disease problems will assist in the management of these problems.

Future directions (next 12-18 months)

- The VHS will continue to verify field dieback-interpretation by testing of soil and plant samples.
- Efforts will be made to encourage Departmental staff to make more use of the VHS, particularly in conservation areas where regular sampling is necessary to give accurate, up-to-date information about the *Phytophthora* status of the area. This information is crucial for the conservation of rare and endangered species that are *Phytophthora*-susceptible.
- The VHS and culture collection will be available for use by the Centre for *Phytophthora* Science and Management, at Murdoch University, and to assist student projects.
- Further work will be done on the recently isolated *Phytophthora* spp. nov., with a view to publishing these. Papers to be completed and published on *P. inundata,* and the *P. citricola*-like new species.
- The *Phytophthora* Culture Collection and WA *Phytophthora* database will be maintained and expanded, and available to researchers.
- Additional student projects will be initiated under joint supervision with the Centre for *Phytophthora* Science and Management to investigate undescribed and newly recorded *Phytophthora* taxa and their role in native ecosystems, with a view to the early introduction of monitoring and management strategies where necessary.
- Testing for Mundulla Yellows disease in WA will be co-ordinated through the VHS, when a routine diagnostic test becomes available.

CALM Regions

Midwest, Swan, South West, Warren, South Coast, Wheatbelt.

IBRA Regions

Geraldton Sandplains, Swan Coastal Plain, Jarrah Forest, Warren, Esperance Plains, Avon Wheatbelt.

NRM Regions

Northern Agricultural, Swan, Avon, South West, South Coast.

The population ecology of Critically Endangered flora

SPP # 2000/015

Team members

C Yates (0.6); Total (0.6).

Context

Understanding 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.

The project aligns with Corporate Priority 5, 10 and 12, KRA 2, 3 and 4 and sub-outputs NC 2B, NC 3K and NC 4C.

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 and research findings

- The fire ecology of the Eastern Stirling Range Montane Heath and Thicket community – A Critically Endangered Ecological Community.
- Monitored demography of DRF and other taxa of conservation significance.
- Monitored plant species richness and abundance in fire ecology quadrats.
- This research 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 in the Montane Heath and Thicket Community.
- The relative importance of reproductive biology and establishment ecology for the persistence of a rare shrub *Verticordia fimbrilepis* ssp. *fimbrilepis.*
- Factors affecting seed germination and seedling establishment (especially fire) are more important than factors affecting seed production for the persistence of *V. fimbrilepis* in habitat fragments.
- Began development of population viability analyses examining the effect of different fire regimes on the persistence of *V. fimbrilepis* populations in wheatbelt remnant vegetation.
- Continued monitoring demography in populations with different fire histories.
- Landscape Fragmentation and Rare Plant Species: Can We Develop a General Framework of Population Responses? ARC Linkage project with A Franks (PhD candidate) and R Hobbs, Murdoch University.
- Defined and allocated DRF to floral architecture and fire life-history functional groups.
- Completed surveys of insect pollinator communities across range of habitat fragments.
- Completed measurements of rates of pollination and reproductive output on selected plant species across habitat fragments.
- PhD candidate Andrew Franks continuing data analyses and writing up thesis.
- Hierarchies of cause: understanding rarity in an endemic shrub, *Verticordia staminosa* ssp. *staminosa* with a highly restricted distribution.
- Synthesized our previous research on reproductive biology and plant demography
- Completed population viability analyses examining effects of climate change and fire on population persistence.
- Presented integrated results at Advances in Plant Conservation Biology symposium.
- Submitted manuscript to Australian Journal of Botany.

Management implications

- Ecologically appropriate fire regimes for the conservation of vascular plant diversity in Eastern Stirling Range Montane Heath and Thicket Community.
- Prescribed fire will be needed to maintain populations of *V. fimbrilepis* spp. *fimbrilepis* in habitat fragments.
- Under current conditions the only known population of *V. staminosa* ssp. *staminosa* is stable and ongoing management should focus on protecting adult plants because of the large contribution stasis makes to population stability. If continued monitoring shows increases in adult mortality we should be concerned, fire may be particularly important in this respect. If predictions from climate change models of decreased rainfall in the south west Australia are correct the taxon may be less secure and the practicalities of translocation to other granite outcrops may need investigation.
- Future directions (next 12-18 months).
- Continue to monitor the Fire Ecology of the Eastern Stirling Range Montane Heath and Thicket Community. Begin preliminary analyses of data.
- Model influence of fire and rainfall on population viability of *V. fimbrilepis* in habitat fragments.
- Continue to co-supervise A Franks and Landscape Fragmentation and Rare Plant Species: Can We Develop a General Framework of Population Responses? ARC Linkage project.

CALM Regions

Goldfields, Midwest, South west, South Coast, Swan, Wheatbelt.

IBRA Regions
Geraldton Sandplains, Avon Wheatbelt, Jarrah Forest, Esperance, Coolgardie, Swan Coastal Plain.

NRM Regions
Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan.

Causes of rarity in 4 *Tetratheca* taxa in the goldfields ranges

SPP Concept plan in preparation

Team members
C Yates (0.2), N Gibson (0.25), R Dillon (1.0), M Langley (0.18); Total (1.63).

Context
The Eastern Goldfields Ranges are local hotspots of plant diversity with many endemic taxa. This project centres on the critically endangered *Tetratheca paynterae* ssp. *paynterae* m.s. found at Portman Iron Ore Ltd's Windarling mine, and 3 other threatened *Tetratheca* taxa on adjacent ironstone ranges with mining prospectives; *Tetratheca paynterae* ssp. *cremnobata* found on the Diehardy Range; *Tetratheca harperi* found on the Mount Jackson Ranges; and, *Tetratheca aphylla* found at the Helena and Aurora Ranges. The project is investigating the environment, reproductive biology and demography of the ironstone *Tetratheca* taxa.

The project aligns with Corporate Priority 5 and 12, KRA 4 and sub-output NC 4C.

Aim
To investigate the reproductive biology and demography of rare *Tetratheca* taxa impacted by mining. Model the distribution patterns of the 4 *Tetratheca* taxa to determine environmental drivers of rarity and aid selection of possible translocation sites. Provide population viability models for the 4 *Tetratheca* taxa.

Summary of progress and research findings
- Quantified the environments of the four *Tetratheca* taxa.
- Described species composition of upland plant communities on each of the ironstone ranges where the four *Tetratheca* taxa occur.
- Measured population demography, for the second year, and rates of pollination and reproduction for the third year for each of the four *Tetratheca* taxa.

Management implications
- The comparative investigations of the four taxa will elucidate why adjacent ironstone ranges each have an endemic *Tetratheca*, rank the biological factors that are most important for maintaining viable populations, assist in assessing the impact of mining on *T. paynterae* ssp. *paynterae*.

Future directions (next 12-18 months)
- Continue measurements of population demography, pollination and reproduction for each of four species.
- Model the environments of the four *Tetratheca* taxa to determine the environmental drivers of rarity.
- Model species composition in upland plant communities on each of the four ironstone ranges to further understand phytogeographic patterns on banded ironstone ranges in the Eastern Goldfields.

CALM Region
Goldfields.

IBRA Region
Coolgardie.

NRM Region
Rangelands.

Herbarium Collections Management

Core Function

Team members

K Knight (1.0), Manager (0.1, vacant), R Cranfield (0.4), R Rees (1.0), C Parker (0.5), P Spencer (0.5), S Carroll (0.6), K Veryard (0.6), M Falconer (1.0), BS Mahon (0.2), R Davis (0.8) S Arkeveld (1.0), A Chapman (0.1), M Hislop (1.0, contract); Total 8.8.

Aim

To ensure the permanent preservation of the plant collections of Western Australian Herbarium and to care for and extend those collections so as to provide a framework for systematic research and biological information systems critical to the conservation of the state's flora and fauna.

Summary of progress and main findings

- 22 020 specimens were added to the collection, which now stands at 641 286.
- The major plant groups now in the collection are as follows:

Myxomycetes	496
Fungi	10 152
Algae	20 599
Mosses	6 535
Liverworts	1 818
Lichens	12 274
Ferns	3 292
Gymnosperms	1 862
Monocots	99 655
Dicots	484 603
Total	**641 286**

Curation

- Significant curatorial work accomplished in the genera Eucalyptus, Allocasuarina, Leucopogon, Lepidosperma, Eremophila, Goodenia, Acacia, Lichens, Thryptomene, Micromyrtus.
- Declared Rare Flora taxa curated, see under WACensus and WAHerb.
- Significant collections added to the Herbarium holdings were as follows:
    - FORESTCHECK
    - Woodland Watch
    - Cassis collection - Pilbara
    - Barrow Island Survey
    - Salinity Action Plan
    - A Coates collection
    - Pilbara Regional Herbaria - moved to Perth
    - Wildflower Society Bushland Survey
    - R Barrett Lepidosperma collection
    - BJ Carter Algal collection

    - Threatened Ecological Communities
    - S Patrick collections
    - G Cockerton collections
    - DJ Edinger collections
    - Exchange material
    - G Byrne collection
    - CALM Regional Offices
    - Flora Conservation (S Patrick)
- Loans and exchange
    - Loans outward - 36 consisting of 2 144 sheets
    - Loans inward - 24 consisting of 1 447 sheets
    - Exchange outward - 2 010 sheets
    - Exchange inward - 1 339 (including CD images from Kew and lichens)
- Managed and supported by the curatorial staff, volunteer participation again was significant, totaling 11 289 hours (equivalent 6.5 FTE).
- Tasks Managed by curation staff with the assistance of volunteers were as follows:
    - Volunteer Newsletter
    - Mounted 13 800 specimens
    - Assisted in curation of specimens
    - Assisted in the incorporation of specimens into the collection
    - Validating plant chemistry vouchers
    - Validated 2 031 doubtful location outliers
- Specialist Volunteer Projects:
    - Continuing the validation of 6 000 WE Blackall collections
    - Curated Austrostipa, Eucalyptus, Pterostylis, Verticordia, Calandrinia and native grasses
    - Photographed type specimens
    - Captured and prepared composite images for FloraBase (see below)
    - Increased the collection and documentation of Myxomycetes
    - Validating collection information on 2 300 M Koch collections

Reference Herbarium

- Maintained and increased the number of taxa represented in the Reference Herbarium. The Reference Herbarium currently has 13 771 specimens.
- Over 2 412 visitors have used this resource to identify plant specimens.

Regional Herbaria Project

- 2 145 specimens from the Regional herbaria were vouchered, identified, databased and added to the collection.
- Total number of specimens contributed from Regional Herbaria since its inception has reached 26 379.

Future directions (next 12-18 months)

- To continue extending and maintaining the collection.
- To provide information on the flora of Western Australia.
- To plan and prepare collection for move to new building.

CALM Regions

All.

IBRA Regions
All.

NRM Regions
All.

WA Marine Plants Online Project

Core Function

Team members
C Parker (0.2), J Huisman (0.6), E McGough (0.6), M Baister (0.6), J Dale (0.2). Total (2.2).

Aims
This project is the second phase of a larger project to capture information on the State's marine plants (flowering plants and seaweeds) from existing herbarium specimens housed in various facilities in WA. The project will database the remaining 13 000 specimens (out of a total 21 000), provide on-line information about these collections through the established information delivery system used for flowering plant data, FloraBase, verify the identity of specimen images and initiate the identification on an estimated 6 500 unnamed specimens. The project will initiate a training program to ensure that marine studies efficiently collect and document new collections of marine flora to extend the information base available to community groups and researchers.

On-line access on the state's marine plants will be provided via the Department of Conservation and Land Management's information system FloraBase.

This project is externally funded (NHT).

Summary of progress and main findings

- Electronically captured information on the State's marine plants is integrated within CALM's information delivery system, FloraBase. Current names, specimen information, images where available, descriptions where available and the known distribution of marine plants can now be accessed on-line through the Marine Plants theme page.
- Published guidelines on 'How to Collect and Document Marine Plants' (Huisman & Parker 2005)
- Over 13 000 herbarium specimens from other state agencies, namely CSIRO, Murdoch University and University of WA, are now databased and permanently housed at the WA Herbarium, brining the total marine plant holdings at the Herbarium to over 21 000.
- Verifying the identification of 300 marine plant images for incorporation into the FloraBase marine plant pages.
- Verifying the identification of 3 872, out of a total of 6 500, marine plant herbarium specimens.
- Delivering training to the community on how to use and contribute to the information system.

Management implications
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)

- Depending on funding:
    - Add descriptions for species into the WA Herbarium's Descriptive Taxonomic Database (DESCAT).
    - Identify remaining unnamed specimens.
    - Continue collection techniques training program.

CALM Regions

Kimberley, Pilbara, South Coast, South West, Swan, Warren.

IBRA Regions

Central Kimberley, Dampierland, Northern Kimberley, Victoria Bonaparte, Geraldton Sandplains, Swan Coastal Plain, Jarrah Forest, Warren, Esperance Plains.

NRM Regions

Rangelands, Northern Agricultural, Swan, South West, South Coast.

Perth Urban Bushland Fungi Project

Core function

Team members

N Bougher (0.1), R Hart (1.0); Sarah de Bueger (0.6) Total 1.7.

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 is raising the previously low level of awareness and knowledge about fungi and working towards the inclusion of fungi in bushland management.

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

This project is externally funded (LotteryWest).

Aims

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

Summary of progress and main findings

- Relocation to the WA Herbarium of the CSIRO Fungal collection comprising ca 11 000 specimens.
- Conducted 68 workshops and forays in 29 urban bushlands.
- Details of 2094 fungi recorded.
- 309 fungi specimens collected for WA Herbarium collection.
- Publication of fungi species new to Science. The Violet stemmed Fibre-head, *Inocybe violaeocaulis* published in 2005 and found in many Perth bushlands.
- New records for fungi in Australia including the lovely Pin Wheel Mushroom, *Agaricus rotalis* which is found in bushlands such as Churchlands and Kings Park. .
- First records for several fungi species in Western Australia including decomposers such as the Cone Head Fungus *Panaeolopsis nirimbii* and the Waxy Wrinkled Skin Fungus, *Phlebia rufa*.
- Recognition and documentation of some species of introduced fungi as weeds.
- Development of georeferencing system to record fungi data using aerial map.
- PUBF website created at www.fungiperth.org.au.
- Online Perth Urban Bushland Fungi fieldbook created at www.fungiperth.org.au

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)

- A number of forays and workshops are being conducted during the 2006 season.
- Increased interaction with Local Government Bushcare and Environment Officers to incorporate fungi into their bushland management.
- Incorporation of PUBF and ex CSIRO fungal specimen data and species images into WA Herbarium databases?
- Incorporation of PUBF fungi reports into DoE Reference site data files.
- Input into the updated census of Western Australia's larger fungi.
- Online access to fungal specimen data via FloraBase.

CALM Region
Swan.

IBRA Region
Swan Coastal Plain.

NRM Region
Swan.

Australia's Virtual Herbarium (AVH)
Core Function

Team members
A Chapman (0.1), C Parker (0.1), S Carroll (0.1), E McGough (0.6), M Ware (0.2), C Douropoulos (0.4), J Dale (0.4), M Humphreys (1.0), M Baister (0.3); Total 3.2.

Context
The WA Herbarium's component of the AVH project aims to add up to 91,000 electronic collections records into the national pool of over 6 million herbarium specimens.

Access to validated and verifiable collections data fundamentally underpins biodiversity conservation management. The incorporation and electronic capture of the backlog of vouchered plant specimens in the WA Herbarium, will make more readily available all material held in the collection. Taxonomic and data validation across the full collection will provide improved data quality and reliability, therefore ensuring subsequent analysis of these data is improved. The availability of this integrated and maintained dataset across continental Australia will be a significant step forward in understanding and managing change in the Australian flora.

Aim
To progress the databasing of the backlog of herbarium specimens at the Western Australian Herbarium, ultimately contributing to all Australian Herbaria making their full holdings accessible online by the end of 2006.

Summary of progress and main findings

- Staff equivalent to 2 FTE have been employed in curating, identifying, databasing and validating the material to be incorporated into the main herbarium collection.
- Approximately 11 150 records will have been processed this financial year. This added to the 59 700 in previous financial years yields a total of c. 71 000 specimens processed as part of the AVH since project commencement in 2001.

- 766 AVH records were given an improved identification as a result of taxonomic validation in this period. In total, 10 000 specimens databased as part of the AVH backlog have been given an improved identification as a result of taxonomic or spatial validation.
- Having dealt with the more well-documented specimens in the AVH backlog, the remaining 20 000 specimens to be processed as part of the project will be found to be increasingly time-consuming to curate, identify and database due largely to lack of adequate collection data accompanying the specimens.
- Some additional funds to extend the term of the AVH contract staff became available from the State Land Information Project, which in part replaced the shortfall in funding from the AVH Trust.

Management implications

- On completion, AVH will bring to bear all the major national vouchered plant collections, providing a significant verifiable plant conservation resource for Australia. This will aid planners, land managers and conservation staff by providing a continental view of Australian native and naturalised plant distributions. Work will still be required to provide a consensus classification of the flora to ensure optimal names-based data retrieval.

Future directions (next 12-18 months)

- The AVH project will end in 2006-07. Databasing, validation of geocode statement and identification will all continue to the end of the project.
- Testing progresses on the associated distributed web mapping application for AVH, with PERTH staff providing useful guidance and feedback. Implementation is expected by the end of 2006.
- Mechanisms for the distributed sharing of plant name usage and correspondence between States are being developed by national groups such as the Herbarium Information Systems Committee (HISCOM), and the Australian Plant Census project continues this process.

CALM Regions

All.

IBRA Regions

All.

NRM Regions

All.

Biosystematics of the WA flora

Core function

Team members

T Macfarlane (1.0), N Marchant (0.2), N Lander (0.8), B Rye (0.5), A Chapman (0.9), A Spooner (0.2), R Cranfield (0.4), J Wege (0.2), BS Mahon (0.4), B Richardson (0.6), R Davis (0.2), S Carroll (0.1), M Hislop (0.1), AR Williams (0.1), P Wilson (0.2), F Obbens (associate); Total 8.3.

Context

Plants (and fungi, lichens) are a major part of the state's biodiversity and landscapes, so knowledge of what species we have, how they relate to each other, where they grow, and how to identify them are fundamental requirements for conservation.

Aligns with NC KRA 1, 2, 4, 5, 6.

Aims

- To provide an inventory and overview of the flora in WA through reliable censuses and classifications of organism groups, definition of species, and provision of authoritative scientific nomenclature.

- To increase knowledge of the WA flora through taxonomic publications in scientific journals.
- To augment scientific collections of organisms and relevant database systems. Making the results available and useful through descriptive and image information and providing means of identifying organisms.

Summary of progress and main findings

1. Native plant taxonomy

- Taxonomic studies of species on the Declared Rare and Priority Flora List.
- Several species formally described, separately and as part of taxonomic revisions.

Taxonomy of Conservation Priority species

- Taxonomy studied in *Tetratheca, Hydatella, Wurmbea* and other plant groups, especially in Warren Region (T Macfarlane).
- Taxonomic input to Warren Region Flora Recovery Plan (in review) and continued botanical support for Region flora conservation activities including staff training (T Macfarlane, R Cranfield).

Taxonomy of the family Poaceae

- Austrodanthonia revision in WA continued with fieldwork which led to identification of one presumed new species in the lower south west (T Macfarlane).
- Botanical support for Quarram grassland management team, including participation in post-wildfire plot recording (T Macfarlane, R Cranfield).
- Revision drafted for salt tolerant genus *Puccinellia* in WA (AR Williams).

Taxonomy of the family Epacridaceae

- 2 new species in Brachyloma published in *Nuytsia* 15(3) (R Cranfield).
- Progress with defining additional species in *Brachyloma* and initial preparation of a revision of the genus (R Cranfield).
- Research into the relationships of WA *Monotoca* and *Oligarrhena* based on morphological and molecular evidence progressed (A Chapman).
- Continued collaboration on generic concepts with specialists in other genera within the tribe Styphelieae, and involving the WA Herbarium, Edith Cowan University and Royal Botanic Gardens, Sydney (A Chapman, R Cranfield, M Hislop).
- Paper, maps and illustrations prepared for the publication of 5 new species of *Leucopogon* (M Hislop, A Chapman).
- Standard character list for comparative morphological data capture across the family expanded to include a range of fruit characters, in preparation for the inclusion of the tribe Epacrideae (A Chapman).
- Collection and re-determination *of Brachyloma, Leucopogon* and *Monotoca* specimens in particular, in the WA Herbarium and other Australian collections, improving the standard of identification in the collection, and veracity of FloraBase output (A Chapman, R Cranfield, M Hislop).

Taxonomy of the family Myrtaceae

- Taxonomic revisions underway on genera related to Baeckea and Thryptomene; these include *Astartea, Babingtonia, Micromyrtus, Scholtzia*, reinstated genera such as *Cyathostemon* and *Oxymyrrhine* and several new genera such as *Enekbatus* and *Seorsus* and flora treatments in preparation (B Rye and M Trudgen).
- Papers published for *Astus* (M Trudgen and B Rye) and in press for Astartea and Micromyrtus (B Rye).
- One paper submitted and many others in preparation (B Rye and M Trudgen).
- An interactive key to Western Australian members of tribe Chamelaucieae has been produced (B Rye and M Trudgen).

- Paper on *Agonis* and relatives in press (J Wheeler and N Marchant).
- Revision of *Chamelaucium* in advanced draft after significant further progress (N Marchant).

Taxonomy of the family Asteraceae

- Work has continued on the genus *Chrysocephalum*, an endemic group that is found over most of the continent. Studies to date suggest that there are a number of undescribed species. A revision of the genus will be published and a text prepared for Flora of Australia (P Wilson).
- Manuscripts for two other Asteraceae genera, *Xerochrysum* and *Cornonidium* (a new genus), have been completed and will be submitted for publication (P Wilson).
- Continuing studies of tribe Astereae, including manuscript preparation for descriptions of new species of *Olearia*, a review of *Erodiophyllum*, and description of 2 new genera from the Pilbara region (N Lander).
- Interactive key to WA genera of Asteraceae deployed for testing on Development Server and in Reference Herbarium (N Lander).
- Interactive key to Australian species of *Olearia* deployed for testing on Development Server and in Reference Herbarium (N Lander).

Taxonomy of the family Proteaceae

- Paper published with taxonomic update of *Petrophile* sect. *Arthrostigma* (B Rye, M Hislop).
- New species and a review of *Isopogon*, new species of *Petrophile* (M Hislop, B Rye).
- Systematics and Conservation of Lambertia: significant field and laboratory work towards a reassessment of the taxonomy of this group (A Spooner).
- Interactive Key to *Dryandra* completed and deployed on Development Server and in Reference Herbarium (N Lander, volunteer).
- Interactive key to *Petrophile* and *Isopogon* completed and deployed on Development Server and in Reference Herbarium (N Lander, volunteer).
- Interactive key to *Conospermum* completed and deployed on Development Server and in Reference Herbarium (N Lander, volunteer).
- Interactive key to *Banksia* commenced (N Lander, volunteer).

Taxonomy of the family Rhamnaceae

- Publication of a paper describing the new genus *Polianthion* (B Rye, two interstate botanists).
- Paper in preparation naming two new genera of Rhamnaceae and redefining *Blackallia* (B Rye, 2 interstate botanists).
- Paper in preparation naming new species of *Cryptandra* and *Stenanthemum* (B Rye).

Taxonomy of the family Lamiaceae

- Publication of a taxonomic review of *Dicrastylis* sect. Corymbosae (B Rye).

Taxonomy of the family Chenopodiaceae

- Paper drafted describing a new species of *Atriplex* (R Cranfield).

Taxonomy of lichens (R Cranfield)

- Census of lichens for WA being maintained, and being prepared as a new section of FloraBase.
- Fieldwork with international and national lichen specialists.
- Liaison with external specialists for identification of difficult specimens.
- Collections from Canberra herbarium borrowed for study in order to assess WA lichen records not represented in WA Herbarium collection.
- Identification of lichens for FORESTCHECK.
- Identification of lichens for Walpole Fine Grain Mosaic project.
- Digital image project continuing for illustrating lichens for FloraBase and field guides. Standard

descriptions of genera prepared for submission to FloraBase.

- Organized and hosted 17th Annual Australasian Lichenologists meeting and held field excursion at Manjimup.

Taxonomy of the family Stylidiaceae (J Wege)

- Taxonomic resolution of several species complexes within *Stylidium*, including the identification of 9 new species and the reinstatement of 1 species.
- Significant curatorial work accomplished at the WA Herbarium and at a variety of European research institutions.
- Examination of type specimens and other historically significant collections in herbaria across Europe.
- Substantial progress made on several taxonomic publications and the Flora of Australia account of *Stylidium*.

Taxonomy of the family Portulacaceae

- Paper revising the tuberous-rooted species of *Calandrinia*, including description of new species, was completed and submitted to Nuytsia (F Obbens).

Taxonomy of Phytopthora

- Interactive Key to species of *Phytophthora* (N Lander).
- Revision of the interactive key to *Phytophthora* species created in 1998 completed and deployed to Development Server for testing. This revision includes additional data, new species and references from recent literature. The key is world-wide in scope and is in daily use by CALM's Vegetation Health Service.

2. Weed taxonomy, biosecurity assessment and incursion monitoring

- Weed status list for WA maintained; name changes reported to affected agencies (BS Mahon).
- Selection and installation of field plots; collection of field data for biological control feasibility study (R Cranfield, CSIRO).
- Participation in Manjimup Weed Action Group, including botanical support, weed priority assessment, weed occurrence recording (T Macfarlane, R Cranfield).

3. Scientific names

Participation in the Australian Plant Census (Consensus Census) national project (T Macfarlane, C Parker, S Carroll, M Falconer, P Wilson)

- In order to increase the rate of processing of the species lists the team was increased to three technical officers totaling 0.6 FTE.
- Approximately 30 lists of names distributed to the national Working Group were checked, annotated and returned.
- The first phase, covering the Environment Protection and Biodiversity Conservation (EPBC) data has been completed, involving nationally agreeing on names for a substantial proportion of WA's DRF taxa.
- Progress through the vascular flora on a family-to-family basis is following the volumes of Flora of Australia. Some of the major families completed in consultation with relevant WA specialists include: Caesalpiniaceae, Chenopodiaceae, Goodeniaceae, Liliaceae, Mimosaceae and Thymelaeaceae.
- Incorporation of changes as a result of the lists is taking place at the specimen level and to the corporate database WACensus, enhancing the information we deliver through FloraBase. Changes include which current names should be accepted including whether particular species should be recognized or not, acceptance of infraspecific taxa, synonymies, correction to author citations and bibliographic references, all of which feed back to an updated and improved WACensus.
- In accordance with guidelines set out by a decision of the Council of Heads of Australasian Herbaria (CHAH) manuscript names are being systematically replaced with informal phrase

names. Phrase names are being standardized to include correct voucher citation and source.

- Approved lists for families and genera are available on the WWW and for WA plants are incorporated in FloraBase.

Management implications

- Taxonomic research relates particularly to conservation of flora by providing a system of defined species which are communicated by their scientific names (which may be formal or the informal manuscript (ms) or phrase (pn) names).
- It also aims to provide the means for conservation staff to confirm the identity of the plants they are dealing with. The researchers also contribute to the maintenance of the herbarium collections which manages the vouchers on which the botanical identity of plants from populations is based, and present information to user via FloraBase.

Future directions (next 12-18 months)

- Focus on assessing and formalizing the taxonomy of as many presumed new species as possible.
- Progress with ongoing taxonomic studies of various plant groups to improve knowledge of the flora.
- Contribute major new content to FloraBase, particularly interactive identification keys.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

4. Managing the Herbarium's taxonomic journal, *Nuytsia*

Core function

Team members
A Chapman (0.2), BS Mahon (0.2), M Falconer (0.2); Total 0.6.

- Publication of 2 parts, containing 36 papers and short communications, with the formal recognition of 63 new taxa in 12 plant families, including a new fungus and two lichens species.
- Preparation of 1 further part for publication, containing approx. 10 papers and short communications.
- Maintenance of an online presence for the journal allows greater access to contents, abstracts and the download of recent papers. Resources include a search tool across all papers and short communications since the journal began in 1970, simple standard mapping templates and a Latin plant name dictionary for Word.
- Greater integration with curation processes ensures a better-quality and more scientifically rigorous publication, while also providing for a more efficient incorporation of newly published names into Herbarium information systems and therefore to the public via FloraBase.

FloraBase

Core Function

Context
FloraBase, the web information system for the Western Australian flora, has increasingly become the main means of communicating botanical taxonomic information. Regular updates have provided

corrections of problems and some features new to the site. Note that this project draws on the efforts of staff and volunteers from all Herbarium Programs.

Design and system aspects

- Implementation of a BioCASe provider to support alternative methods for serving data (e.g. To AVH or GBIF) - commenced.
- Implementation of a staged roll-out of features and improvements in subsequent versions - ongoing.
- Installation of a new production server and increased storage capacity - completed.
- Development of infrastructure and methods for adding interactive keys - commenced.
- Addition of infrastructure to support the presentation of cryptogamic elements of the flora - commenced.
- System analysis on short description capture and delivery processes - commenced.
- Addition of a FloraBase HTML report to Max v.3, allowing users to produce and maintain web pages linking directly to FloraBase content - completed.

Botanical content aspects

- Addition of interactive map for IBRA regions - completed.
- Addition of standard elements such as taxon maps and composite images - ongoing.
- Addition of a phylogenetic tool for exploring higher-level systematics of WA Flora - progressing.
- Maintenance of standard descriptive data for new and revised species. In this year 292 descriptions have been added, bringing the total number of short descriptions managed to 13 996 (A Spooner) - ongoing.
- Maintenance of generic and family descriptions from the WAGenera project (T Macfarlane) - ongoing.
- Maintenance of flora statistics page, publishing the latest summary data on the numbers of WA flora - ongoing.
- Technology transfer and promotion aspects.
- Training workshops to community conservation groups, CALM staff and the education sector - ongoing.
- Increased collaboration with CALM's Eco-Education unit, including the regular provision of FloraBase Plant of the Month content for the Eco-Ed Newsletter.

Management implications

- Since the introduction of the latest version of FloraBase, access to authoritative and accurate information on the State's flora has been greatly enhanced. Both the community and conservation staff are able to retrieve the most recent information on the name, features, status and distribution of all 12 978 currently recognized native and naturalised WA plant taxa. Consequently, conservation efforts across the State are made more effective by building on quality 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 maximize 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)

- Maintain the quality of the information and the adequacy of the software and hardware systems.
- Add new content to FloraBase, including interactive keys for identification of several plant groups.
- Integrate available PDF's of Nuytsia journal protologues more tightly into FloraBase.
- Plan for the expansion to other groups, especially the algae, lichens and fungi of WA, when funding becomes available.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

WACensus

Core Function

Team Members
S Carroll (0.6) [N.S.1].

Context
WACensus enables the management of taxonomic and nomenclatural changes to WA plant names. It is also a basic component for a number of related datasets within CALM such as the Wildlife Branch DRF database and the Herbarium WAHerb specimen database, as well as the species master list for databases developed using the MAX database utility.

Summary of progress and main findings
- A total of 1973 new names were added to WACensus, with 170 being new manuscript or phrase names and 1803 names published. (Please note addition of Lichen and Algae Census)
- A total of 305 edits were made to WACensus.
- WACensus updates are regularly distributed to over 327 registered Max users on a monthly basis.
- The WACensus system has been completely rewritten and implemented. The most important enhancements include: support for higher-level taxonomic hierarchies, common names, support for alternative taxonomies, and a GUI interface.

Management implications
- All CALM systems utilizing WA plant names should be based on, or integrated with the WACensus database.
- Staff maintaining plant databases should be using Max and the regular WACensus updates to check name currency.

Future directions (next 12-18 months)
- A number of further developments are planned to fully accommodate other larger taxonomic groups such as fungi, algae and lichens.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

WAHerb – the WA Herbarium's Specimen Database

Core Function

Aim

To manage the design, development and maintenance of the specimen database (spatial, phenological, population & habitat data) and procedures, which enable the management of the curation, movement and storage of the collection.

It also forms the core of the Regional Information Network where community-based Regional Herbaria contribute duplicate collections to the state herbarium in return for maintenance of the specimens' identity in both collections.

Summary of progress and main findings

- A total of 22 020 records were added during the last financial year, including over 2646 lower plants and fungi.
- Of these, about 9 950 were entered as part of the AVH project.
- Totals for conservation taxa are now: P1 - 3 955, P2 - 6 367, P3 - 12 095, P4 - 8 432, R - 5 727.

Management implications

- WAHerb represents the most comprehensive database on WA Plants available. Managers should therefore consult with the Herbarium in a range of different situations including: updates on biodiversity or conservation status, plant identification, prior to surveys to clarify what is already known for a given area, identify knowledge gaps, etc.

Future directions (next 12-18 months)

- The WAHerb data structure will be improved to accommodate site-based data entry from systematic surveys.
- Data fields will continue to be split into categories to accommodate normalized data entry.

CALM Regions

All.

IBRA Regions

All.

NRM Regions

All.

LANDSCAPE CONSERVATION

Program Leader: Dr Lachlan McCaw

FORESTCHECK – Integrated site-based monitoring of the effects of timber harvesting and silviculture in the Jarrah forest

SPP #2006/003

Team members

R Robinson (0.2), L McCaw (0.2), J Farr (0.2), K Whitford (0.2), T Burbidge (0.2), R Cranfield (0.2), A Mellican (0.2), G Liddelow (0.2), J Neal (0.2), R Smith (0.2), V Tunsell (0.2), B Ward (0.2), A Wills (0.2), P Van Heurck (0.2); Total (2.8).

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 previous Forest Management Plan, FORESTCHECK has been incorporated in the new Forest Management Plan 2004-13 as a strategy for increasing knowledge on the maintenance of biodiversity in WA's forests.

FORESTCHECK aligns with Corporate Priorities 9 and 12, and KRA 2.2, 3.8 and 4.3.

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 and main findings

- Eleven monitoring sites were established in the Blackwood Plateau area of Blackwood District (1000 mm annual rainfall zone). Grids were established in Barrabup, St Johns, Layman, Cambray and Butler blocks. In addition the to shelterwood and gap release treatments, 3 grids were also established in areas of forest that had undergone selective cutting.
- Stand structure (basal area and stocking of overstorey species) was measured at all sites.
- Spring and autumn sampling on soils compaction, cryptogams (lichens, liverworts and mosses), vascular plants, invertebrates, terrestrial vertebrates and birds have been completed, and macrofungi surveys are scheduled for June 2006 according to seasonal conditions.
- Data are undergoing analysis for inclusion in the annual FORESTCHECK report.
- Annual progress reports for FORESTCHECK are available on the Science Division page of the CALM Web at: http://www.calm.wa.gov.au/science/science.html.

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)

- Prepare and present 2005-06 Annual Report at a project meeting in August 2006.
- Major analysis of data for the first 5 yrs of monitoring is to be undertaken in 2006.

CALM Region

Warren, South West, Swan.

IBRA Regions
Jarrah Forest, Warren.

NRM Region
South West, Swan.

Long-term effects of various fire regimes on species richness and composition of southern Jarrah forest understorey
SPP # 93/099

Team members
N Burrows (0.05), B Ward (0.25), R Cranfield (0.05), G Liddelow (0.1); Total (0.45).

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 for the protection of life and property. This study, established in 1972, was designed as a long-term experiment.

It aligns with Corporate Priority 10, KRA 2 and 3 and sub-output NC 3K.

Aims
- To understand and quantify the long-term effects of different fire regimes on species richness, composition and structure of southern Jarrah forest understorey.
- To determine the effects of different fire regimes on tree health and growth rate.

Summary of progress and main findings
- Spring and autumn burn treatments. Lindsay (Boundary Rd) experimental site has been abandoned because of infection by *Phytophthora*.
- Tree growth rates were re-measured at the Perup site to compare tree diameter growth rates over 20 years and across different fire treatments.

Management implications
- Ecologically appropriate fire regimes for the conservation of floristic diversity and structure in southern Jarrah forest uplands. Fire diversity can benefit biodiversity in these ecosystems.

Future directions (next 12-18 months)
- Maintain fire treatments.
- Analyse and write up tree growth data for publication.
- Sample and analyse soil nutrients across all treatments in summer 2006/07.
- Re-measure floristics on all plots (except Lindsay forest) in spring 2007.
- Preliminary analysis of data in summer 2007/08 and review future of study.

CALM Regions
South West, Warren.

IBRA Region
Jarrah Forest.

NRM Region
South West.

Demography of Australian Boab (*Adansonia gregorii*) stands in relation to fire and grazing

SPP # 2000/04

Team members

N Burrows (0.01) T Start (0.01); Total (0.02).

Context

There is concern that altered fire regimes in Kimberley savanna woodlands may be adversely impacting on the structure and recruitment of boabs, a Kimberley icon species.

This project aligns with KRA 3 (NC 3K).

Aim

To gather preliminary data on the impacts of current regimes of fire and grazing by cattle on the regeneration and size/age class structure of selected stands of boab trees in the Kimberley.

Summary of progress and main findings

- Survey data have been partially analysed.

Management implications

- Preliminary observations about the impact of current fire regimes on boabs in the Kimberley region and if necessary, fire management guidelines appropriate to the regeneration and protection of boabs.

Future directions (next 12-18 months)

- There was no action on this project over 2005/07. Further data analysis will consist of comparing the structure of stands across sites and seeking patterns and relationships with fire and grazing history. Importantly, the analysis will seek to identify obstructions to recruitment that could be attributed to fire or to grazing or to both. A brief paper will be written in the next 12 months and submitted to the *Journal of the Royal Society of Western Australia*.

CALM Region

Kimberley.

IBRA Region

Central Kimberley.

NRM Region

Rangelands.

Project Desert Dreaming: Developing sustainable management systems for the conservation of biodiversity at the landscape scale in the Gibson Desert and Gascoyne bioregions

SPP # 2003/004

Team members

N Burrows (0.1), 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, Prof T Bragg; Total (1.25).

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 Goldfields Region, this project will aim to reconstruct some assemblages of the original native mammal fauna on Lorna Glen, a pastoral lease recently acquired by CALM. This to be achieved by an integrated approach to controlling introduced predators and herbivores, ecologically appropriate fire management and fauna translocations.

This project aligns with 2005/06 Corporate priorities 3 and 12 and KRA 2 (NC 2A, NC 2B), KRA 3 (NC 3K), KRA 4, (NC 4A, NC 4B).

Aims

- To develop efficient, effective and safe introduced predator (fox and feral cat) control technologies for the interior rangelands and the arid region.
- To reconstruct the original suite of native mammal fauna through translocations when sustainable feral cat control can be demonstrated.
- To implement a patch-burn strategy to create a fine-grained, fire-induced habitat mosaic to protect biodiversity and other values.
- To describe and predict pyric (post-fire) plant succession and describe the life histories of key plant species.
- To 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.
- To model the relationship between seasons (rainfall) and the frequency and size of wildfires.

Summary of progress and main findings

- Following successful feral cat baiting operations in 2004, a follow-up operation over a considerably larger area was carried out in 2005, as part of the Western Shield program, to examine the rate of re-invasion by cats. Baiting successfully reduced the feral cat density by about 85%. Foxes were eradicated and the wild dog/dingo population was significantly reduced. Re-invasion by feral cats into the core area of the baited zone has been slow with very low cat densities recorded almost 12 months after baiting. This has demonstrated that the scale of baiting influences re-invasion rate.
- Fire ecology (plants) and invertebrate monitoring sites were re- assessed. Data are being analysed.
- Fire history and fuel age maps have been prepared.
- A fire management plan was prepared.

Management implications

- Guidelines for the proactive management of fire in the arid zone 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 will be produced over the next 12 months. This project should also lead to the reconstruction and protection of arid zone mammals and other elements of the biota.

Future directions (next 12-18 months)

- Implement and assess the effectiveness of a fourth annual feral cat baiting program in July 2006.
- Continue to monitor extant fauna.
- Rationalise monitoring sites.

- Carry out a sub-fossil survey.
- Continue assessments of fire plant ecology sites.
- Complete analysis and write-up of first stage of fire ecology (plants) study.
- Write-up and publish results of baiting trials at Lorna Glen.
- Prepare a translocation plan, and if baiting is successful, implement the plan in 2007.
- Commence the implementation of the fire management plan.
- Continue assessment of vascular plants and invertebrates.
- Establish FIREWATCH grids to monitor impacts of fire on biodiversity.
- Continue to support a PhD study on the effects of fire on arid zone spiders.
- Encourage research partnerships to further knowledge of arid zone ecology.

CALM Region
Goldfields.

IBRA Regions
Murchison, Gascoyne.

NRM Region
Rangelands.

Walpole fine grain mosaic burning trial
SPP 2004/004

Team members
N Burrows (0.1), J Farr (0.1), R Robinson (0.1), G Liddelow (0.1), B Ward (0.25), R Cranfield (0.05), P Van Heurck (0.1); Total (0.75). 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 WA. 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 homogenizing wildfires.

This study aligns with Corporate Priority 10, KRA 2.2 and 3.8 and sub-output NC 3K.

Aims
- To use the frequent and planned introduction of fire into the landscape (patch-burning) to create a fine-grained mosaic of interlocking patches of vegetation at different stages of post-fire development.
- To monitor at both the patch scale and the landscape scale, the effects of the resultant mosaic on biodiversity; specifically:
- Abundance of fire regime specific plant taxa, DRF and reserve listed taxa (e.g. *Synaphaea* sp., *Lambertia rariflora* subsp. *lutea*, *Banksia quercifolia*, *B. occidentalis*, *Dryandra formosa*, *Hakea oliefolia*).
- Geophytes (Orchidaceae, Droseraceae especially).
- Abundance of fire regime specific fauna and condition of associated habitats (e.g. honey possum (*Tarsipes rostratus*), quokka (*Setonix brachyurus*), mardo (*Antechinus flavipes*), sunset frog (*Spicospina flammocaerulea*)).
- Reptile assemblages.

- Bird assemblages.
- Invertebrate assemblages.
- Vascular plant assemblages.
- Fungi and cryptogams.

Summary of progress and main findings

- Aerial patch-burning of London Block using a helicopter was carried out over the summer/autumn of 2006, resulting in <20% of the block being burnt. Most of the burnt patches were confined to pockets of older vegetation and some forested areas that had re-accumulated sufficient fuel to carry fire. Heathlands and wetlands did not burn, apart from a few very small patches. An assessment of the biodiversity monitoring grids confirmed that the burning was patchy and mostly low intensity.

Management implications

- Development of ecologically appropriate fire regimes for managing fire in varied landscapes of the southern forests. Fire diversity can benefit biodiversity in these ecosystems.

Future directions (next 12-18 months)

- Detailed analysis of satellite imagery to determine patch-burn mosaic and distribution of seral stages.
- Mapping of seral stages.
- Re-assess monitoring grids in spring/autumn 2007.
- Patch-burning is scheduled for autumn 2007 and spring 2008.

CALM Region
Warren.

IBRA Region
Jarrah Forest.

NRM Region
South West.

Genetic analysis for the development of vegetation services and sustainable environmental management

SPP # 98/007

Team members
M Byrne (0.2), B Macdonald (0.5); Total (0.7).

Context
Understanding the genetic structure and function of plants is important for their effective utilization for revegetation and provision of ecosystem services, such as hydrological balance, pollination and habitat connectivity.

It aligns with KRA 3.7, 3.8 and 3.11 and Nature Conservation Priority 3G.

Aim
To provide genetic information for the conservation and utilization of revegetation species. Current work aims to identify the mating system and reproductive biology of *Acacia saligna*; determine pollen dispersal in DRJ clonal orchard of *Eucalyptus marginata*; investigate the mating system and diversity in sandalwood, and determine genetic relationships between trees in a salinity/waterlogging trial in *E. occidentalis*.

Summary of progress and main findings

- *A. saligna* –Mating system showed high outcrossing rates (mean *tm* = 0.89) in 4 populations and some correlated paternity as expected from the polyad structure of the pollen. Reproductive biology studies have identified some difference in seed set between variants and differences in flowering times. Mating system paper has been submitted to *Australian Journal of Botany*. Genetic diversity paper is in press in *Tree Genetics and Genomes*, and fodder quality paper is accepted in *Animal Feed Science and Technnology*.
- *E. marginata* –Journal paper on Phylogeographic analysis has been published in *Australian Journal of Botany*. Analysis of pollen dispersal in a clonal Dieback Resistant Jarrah orchard has shown dispersal across the orchard and some pollen immigration from the surrounding forest.
- *S. spicatum* – Journal paper on Mating system analysis has been submitted to *Silvae Genetica*.
- *S. album* – Genetic diversity has been analysed in a representative collection of germplasm in trials.
- *E. occidentalis* – Trees in a salinity/waterlogging trial are being genotyped to determine genetic relationships. DNA extractions and primer trials have been carried out.

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 2 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 hybridization in natural populations.
- *E. marginata* – Extent of pollen dispersal in a clonal orchard will inform the design of orchards, ensure adequate outcrossing within the orchard and identify requirements for isolation from surrounding forest.
- *S. spicatum* – The preferential out crossed mating system means seed orchards are an effective means of seed production in *S. spicatum*, although the species is clearly self compatible and may show asynchronous flowering therefore knowledge of flowering times will be critical to design of the orchards.

Future directions (next 12-18 months)

- Reports and journal papers will be written for *A. microbotrya*, *E. cladocalyx*, *E. marginata* and *S. album*.
- Genetic relationships between *E. occidentalis* trees will be determined and correlated with fitness of progeny from crossing experiment involving close and distance crosses.

CALM Regions

Goldfields, South Coast, Midwest, Wheatbelt, South West, Warren.

IBRA Regions

Geraldton Sandplains, Esperance Plains, Swan Coastal Plain, Avon Wheatbelt, Yalgoo, Coolgardie, Mallee, Murchison, Jarrah Forest.

NRM Regions

Avon, Northern Agricultural, Rangelands, South West, South Coast.

Identification of seed collection zones for rehabilitation

SPP # 2006/008

Team members

M Byrne (0.1), D Coates (0.1), S McArthur (0.5), L Wong (0.5); Total (1.2).

Context

The Sustainable Forest Management Division of CALM 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 the species to the sites in order to manage these sites on an ecologically sustainable basis. This requires an understanding of the genetic structure and local adaptation of the species.

It aligns with KRA 2.2 and 3.8 and Sustainable Forest Management Priorities 3A and 3C.

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 and main findings

- Project plan for genetic analysis and field trials has been developed in conjunction with FPC. Species to be investigated are *Acacia pulchella*, *A. saligna*, *Allocasuarina fraseriana*, *Bossiaea ornata* and *Kennedia coccinea*.
- *Bossiaea ornata* – Microsatellite marker development is being carried out. An enriched library has been developed and is currently being screened for microsatellite sequences.
- *Kennedia coccinea* – DNA extractions have been carried out and microsatellite marker development commenced.

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)

- Microsatellite marker development will be completed and genetic analysis will be undertaken for *B. ornata*.
- Microsatellite marker development will be completed and genetic analysis of *K. coccinea* will be commenced.

CALM Regions

South West, Warren.

IBRA Region

Jarrah Forest.

NRM Regions

Avon, South West.

Management of weed risk in perennial landuse systems

SPP# 2004/003

Team members

M Byrne (0.2), L Stone (1.0), J Sampson (1.0); Total (2.2).

Context

The development of perennial-based land use systems for the 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, hybridization with native species and gene flow from cultivated populations into natural populations.

It aligns with KRA 3.7, 3.8 and 3.11 and Nature Conservation Priority 3G.

Aims

- To develop and implement procedures for management of weed risk in the form of assessment and management protocols to be applied to all germplasm under development within the CRC for Plant-Based Management of Dryland Salinity (CRC PBMDS).
- To determine the mechanisms, extent, implications and management of genetic risk for selected taxa in commercial development.

Summary of progress and main findings

- Database of field trial species and sites is being maintained.
- Weed risk management framework has been finalized following consultation with CRC for PBMDS and CRC for Australian Weed Management researchers.
- Weed risk management protocols have been developed following consultation with CRC for PBMDS and CRC for Australian Weed Management.
- Involvement in National discussions on improvements to border and post-border weed risk assessment.
- Small research study commenced 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.
- Leaf and seed collections of planted *E. loxophleba* ssp *lissophloia* and natural *E. loxophleba* ssp. *supralaevis* have been made from a site near Wubin. DNA has been extracted. Primers have been trialed and suitable ones selected for assay.
- Seedlings of *E. absita* have been assayed to determine extent of pollen dispersal. Full analysis is currently being undertaken but initial results show very restricted pollen dispersal among *E. absita* and high levels of hybridization with *E. loxophleba*.
- Microsatellite markers are being developed for *Atriplex numularia*. Primers have been designed for 12 sequences and are currently being trialed. Collections have been made from 10 Western Australian populations and DNA has been extracted. Collections have been made from 4 eastern Australian populations.
- Chapter on 'Environmental risk in agroforestry' written for book on 'Agroforestry for Natural Resource Management'.

Management implications

- Introduction of a weed risk assessment procedure and culture into the Salinity 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 hybridization to be assessed and lead to development of risk management guidelines.

Future directions (next 12-18 months)

- Continue database management as part of weed risk management strategy.
- Weed risk management training workshops to be delivered to CRC PBMDS researchers.
- Continue technical advice to CRC PBMDS researchers on weed issues.
- Continue liaison between CRC PBMDS and CRC AWM.
- Complete comparative study on Australian weed risk assessment protocols.
- Continue research into flower: fruit production in *A. saligna.*
- Continue involvement in national discussions on approaches to post-border weed risk assessment.
- Complete genetic analysis to determine gene flow between *E. loxophleba* subspecies.
- Complete genetic analysis to quantify gene flow and hybridization in *E. absita*.
- Carry out analysis of genetic structure in *Atriplex nummularia.*

CALM regions
Midwest, Wheatbelt, South Coast.

IBRA regions
Geraldton Sandplains, Avon Wheatbelt, Esperance Plains, Mallee.

NRM Regions
Avon, Northern Agricultural, South Coast.

Biology of the new psyllid *Cardiaspina jerramungae* in the lower great southern of WA on flat-topped yate
SPP # N/A (combination of several previous research projects).

Team member
J Farr (0.2); Total (0.2).

Context
In 1982 *Eucalyptus occidentalis* suffered extensive defoliation from a then unknown species of psyllid in the Lower Great Southern region of Western Australia.

In line with Corporate priority 5 and 12, KRA 2 and 3.

Aim
To understand the biology and population dynamics of this new outbreaking psyllid on *E. occidentalis*.

Summary of progress and main findings
- Manuscript submitted to authority on psyllid outbreaks for critical review.

Management implications
- Use of resistant trees for reclamation of salt affected lands will help break the outbreak cycle and help improve the integrity of vegetation in these areas.

Future directions (next 12-18 months)
- Re-write manuscript.
- Submit manuscript to journal (*Australian Journal of Entomology*).

CALM Regions
Wheatbelt, Warren, South Coast.

IBRA Regions
Avon Wheatbelt, Esperance Plains, Mallee, Jarrah Forest.

NRM Region
Avon, South Coast.

Quantitative population monitoring of gumleaf skeletonizer (GLS, *Uraba lugens*)
SPP # 93/0103

Team member
J Farr (0.01); Total (0.01).

Context

In 1982 an extensive outbreak of *Uraba lugens* occurred on Jarrah throughout the southern Jarrah forest and persisted for nearly 10 yrs.

In line with Corporate Strategy 1.5 (protect biodiversity from threatening processes), Corporate Priority 12, KRA 2 and 3 and sub output SFM 3K.

Aim

To understand the biology of GLS in WA and monitor population levels of the outbreaking insect.

Summary of progress and main findings

- Data on population levels (using a cherry picker) are yet to be incorporated into an internal report.

Management implications

- Although an outbreak of GLS has occurred only once in the history of Jarrah forest management, this insect has the potential to increase in population to 110 larvae per kg dry weight of host foliage or more. This can cause serious defoliation in the Jarrah forest. Two consecutive warm winters can induce a 2-generation per year population which contributes to a rapid population increase and thus a potential for population outbreak.

Future directions (next 12-18 months)

- Prepare an internal report to enable finalization of the project. This achievement has been given low priority.
- To incorporate findings from this study into the development of a forest health surveillance program.

CALM Region

Warren.

IBRA Regions

Jarrah Forest, Warren.

NRM Regions

South Coast, South West.

State Salinity Strategy wetland monitoring

SPP # 1998/0018

Team members

Fauna - S Halse (0.1), D Cale (0.5), K Sutcliffe (0.2); Flora - M Lyons (0.4), N Gibson (0.05), D Mickel (0.5); Surface water - J Lane (0.35), G Pearson (0.1), A Clarke (0.2), S Elscot (0.1), Y Winchcombe (0.3), B Johnson (0.05); Groundwater - S Halse (0.05), contracts; Total (3.3).

Context

Substantial loss of biodiversity is known to have occurred across the Wheatbelt of Western Australia over the past 100 yrs. The most pronounced physical changes at wetlands have been associated with clearing and salinization. Clearing has more or less ceased but salinization will continue to be expressed or many decades. While it is known that salinization is a major threat to wetland biodiversity, the relationship between its physical expression and loss of biodiversity are poorly documented and understood. This project began in 1997 and is intended to be a long-term project.

It addresses Corporate Priority 3, KRA 2 and 3 and Sub-outputs NC 2D and 3NC E, F and G.

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 and main findings.

- Program summary presented at Wetlands Co-ordinating Committee in March resulted in WCC statement of support and intra-departmental review of program at workshop in April endorsed continuation of the project in current form.
- Fauna monitoring – 2004 monitoring completed, A4 sheets on waterbird results to date circulated, work began on scientific paper reporting whole of project results for Paperbark Swamp and Eganu Lake.
- Surface water monitoring – Finalized analysis of 1977-2004 depth, salinity and pH data of 152 wetlands and commenced preparation of report.
- Wetland bathymetry – assisted CALM Wheatbelt Region in arranging field surveys and mapping of lake bed, shoreline, inflow and outflow contours of Lakes Brown and additional areas of Mollerin Lake.
- Vegetation monitoring for 2004 completed, vegetation history at Paperbark and Eganu documented from aerial photographs as part of scientific paper, another scientific paper on 5 yrs monitoring of vegetation monitoring in the Lake Muir-Unicup wetland system published in the *Journal of the Royal Society of Western Australia*.
- Ground water monitoring for 2004 completed, shallow groundwater monitoring bores and vegetation quadrated surveyed to DLI benchmarks and thereby to depth gauges.
- Management – contributed to Bryde, Buntine-Marchagee, Drummond, Muir, and Toolibin TAGs and provided advice to Warden Biodiversity Recovery Catchment, put together scheme for assessing the suitability of wetlands to receive drainage for Wetlands Co-ordinating Committee (endorsed by Cabinet Sub-Committee for the Environment).

Management implications

- Analyses of trends in depths, salinities and pH of 60 wetlands monitored for 20 or more yrs have revealed a number of wetlands undergoing diverse changes that warrant further investigation and corrective management.
- The loss of vegetation is continuing even at long-saline wetlands where the physical expression of salinity in water is more or less stable. Such wetlands also show declines in faunal use.
- Surface water management is as important in some wheatbelt wetlands (such as Coomalbidgup Swamp) as groundwater management in maintaining wetland health and greater focus on surface water is required.

Future directions (next 12-18 months)

- Continue monitoring according to current protocols.
- Report on trends in depth, salinity and pH (acidity/alkalinity) of monitored wetlands from 1978-2004 to be completed.
- Investigations into causes of changes in depths and/or salinities of several monitored wetlands to be initiated.
- Complete paper analysing trends in surface and groundwater salinities, vegetation condition and fauna at Paperbark Swamp and Eganu Lake.
- Arrange to publicize results of the monitoring to date through media and presentation to NRM groups.
- Complete preparation of bathymetric maps and depth-volume calculators of Lakes Brown and Campion.

CALM Regions

Midwest, South Coast, Wheatbelt, South West, Swan, Warren.

IBRA Regions

Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee.

NRM Regions
Avon, Northern Agricultural, South West, South Coast.

Monitoring stream biodiversity (KPI 20 for Forest Management Plan)

SPP # 2006/002

Team members
S Halse (0.05), B Smith (0.8), H Barron (0.05) Total (0.9).

Context
Key Performance Indicator 20 of the Forest Management Plan requires that monitoring of aquatic macroinvertebrates be undertaken 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. It is intended that no widespread and sustained loss should occur as a result of human activities.

This project was initiated in 2004/05 to meet KPI 20 and aligns with Corporate Priority 9 and KRA 2.

Aim
To monitor richness of aquatic macroinvertebrate families (and species richness within selected orders) at 50 sites in south-west Jarrah and Karri forest each spring.

Summary of progress and main findings.
- Sites were selected, groups to be identified to species level were determined, and a sampling protocol adopted (the AusRivAS box-sampling method).
- The first round of sampling was completed in 2005. Macroinvertebrate identification and water chemistry analysis have been completed for these samples.

Management implications
- None to date.

Future directions (next 12-18 months)
- Data from the first round of sampling to be analysed using the AusRivAS model.
- Second round of sampling to begin in spring 2006. Three additional sites will be added to the sampling regime in this round to provide information about possible impacts of groundwater extraction from the Yaragadee aquifer.
- Publish a paper describing typical biodiversity of forest stream sites.

CALM Regions
South West, Swan, Warren.

IBRA Regions
Jarrah Forest, Warren.

NRM Regions
Swan, South West, South Coast.

Efficacy of stream buffer zones in protecting stream biodiversity and water quality in Jarrah forest subject to timber harvesting

SPP # not allocated

Team members

S Halse (0.1), J Kinal (0.5), B, Smith (0.5), R Hill (0.5); Total (1.6).

Context

This study was initiated by Action 33.1 in Forest Management Plan 2004-2013. Action 33.1 states that CALM and FPC, in co-operation with Water and Rivers Commission and Water Corporation, shall conduct research to determine the adequacy of stream reserves in protecting biodiversity and water quality in areas subject to timber harvesting.

This study aligns with SFM KRA 3F.

Aim

To investigate the efficacy of streamzone buffers in protecting stream biodiversity and water quality in Jarrah forest subject to timber harvesting.

Future directions (next 12-18 months)

- The Forest Management Plan Implementation Coordination Committee - Policy Group accepted a recommendation from CALM that current and proposed experimental studies and monitoring being undertaken by CALM, and as part of the proposed Wungong catchment project, provides the most cost effective way to meet the requirements of Action 33.1. As a result of this decision, there will be no further work to develop a specific experimental study to address this action.

CALM Regions

Swan, South West, Warren.

IBRA Region

Jarrah Forest.

NRM Regions

South West, Swan.

Bushfire CRC Project 1.4: Improved methods for the assessment and prediction of grassland curing

SPP # to be allocated

Team members

J Hollis (CRC-funded TO) (0.3), L McCaw (0.05), I Radford (0.05), K White (0.05), E Hatherly (0.05), R Butler (0.05); Total (0.55).

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.

It aligns with Corporate Priorities 3 and 10, and KRA's 2.1, 3.11 and 3.12.

Aims

- To 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.
- To enable and contribute to the development and validation of improved methods for the assessment and prediction of grassland curing by;
    - establishing 5 regional sampling sites representative of the major grasslands of Western Australia and
    - collecting, analysing and providing grassland curing data from these various grasslands.

Summary of progress and main findings

- Field sampling sites have been established at:
    - Parry Lagoons (1) Wyndham, East Kimberley Region.
    - King Leopold National Park (3) West Kimberley Region.
    - Lorna Glen (1) Goldfields Region.
    - Katanning Agricultural Research Station.
    - Simcocks Private Property (1) South West Region.
- Field work has included site characterization and grass sampling to validate the methodology for assessment of grass curing and fuel moisture content. Preliminary grass curing results have captured the early curing process for the Kimberley region.

Management implications

- Development of methods for assessing and predicting current and future levels of curing in grasslands, focusing on 2 main areas, remote sensing applications and pasture (grass) growth modeling.

Future directions (next 12-18 months)

- Field data collection is required to provide data that will enable the development and validation of methodology.

CALM Regions

Kimberley, Goldfields, Wheatbelt, Warren.

IBRA Regions

Jarrah Forest, Pentecost, Carnegie, Victoria Bonaparte P1.

NRM Regions

Rangelands, Avon, South West.

Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the Jarrah forest

SPP # 2000/03

Team members

J Kinal (0.5), R Hill (0.5); Total (1.0).

Context

This study is a long-term experiment that was established in 1999 to address part of Ministerial Condition 12-3 attached to Forest Management Plan 1994-2003. Min Con 12-3 states that CALM shall monitor and report on the status and effectiveness of silvicultural measures in the intermediate rainfall zone to protect water.

This study aligns with KRA 2.2, 3.8 and 3.11 and SFM sub-output 3N.

Aim

To investigate the hydrologic impacts of timber harvesting and associated silvicultural treatments in the intermediate rainfall zone (IRZ, 900 – 1100 mm/yr) of the Jarrah forest.

Summary of progress and main findings

- Overstorey crown density, basal area and stocking were remeasured in spring/summer 2005.
- Monitoring of groundwater levels, stream flow, stream salinity and stream turbidity in the 2 treatment catchments and in the control catchment has continued throughout the year.
- Groundwater levels have continued to rise, relative to the control catchment, and do not appear to have reached a peak response 5 yrs after the harvesting and silvicultural treatments and 3 yrs after the silvicultural burn. Groundwater has risen an average 1.18 m in the intensive-treatment catchment and an average 0.84 m in the in the standard-treatment catchment.
- The treatments have had no measurable effect on water quantity or quality in either the intensive- or the standard-treatment catchments.

Management implications

- Results will enable an informed assessment of the adequacy of Jarrah forest silvicultural practices in protecting water quality from the impact of timber harvesting and a sound basis on which revision of the practices can be made.

Future directions (next 12-18 months)

- Monitoring of groundwater levels, stream flow, stream salinity, stream turbidity and rainfall should be continued for at least another year or until the responses to the treatments have peaked.
- Apply WEC-C hydrological model to simulate hydrological responses to alternative timber harvesting and silvicultural treatments, and to different climate patterns.
- Continue data analysis and writing-up of the response in the first 5 yrs following treatment.

CALM Region

Swan.

IBRA Region

Jarrah Forest.

NRM Regions

South West, Swan.

Directory of important wetlands in Australia: revised editions

SPP # 1999/0014

Team members

J Lane (0.15), G Pearson (0.2), A Clarke (0.6), S Elscot (0.25); Total (1.2).

Context

The first edition of *A Directory of Important Wetlands in Australia* was published in 1993, as a co-operative project between the State, Territory and Commonwealth Governments of Australia. Second and third editions were published in 1996 and 2001. The *Directory* provides a listing of wetlands identified as being of national significance. It is an ongoing project; more wetlands are added as knowledge of Australia wetlands and their many values grows and as circumstances change. The *Directory* provides a basis, but not the only basis, for prioritizing wetland conservation activities in Western Australia and nationally. The Team leader has had responsibility for this project in WA since its inception.

This study aligns with Corporate Priorities 5, 6, KRA 3 and sub-output NC 3C. Current work (commenced 2003) is on wetlands of remote and under-represented IBRA Regions of WA.

Aims

- To prepare revised editions of the Western Australian Chapter of *A Directory of Important Wetlands in Australia*, incorporating additional wetlands and information as knowledge increases and circumstances change.
- To periodically update the national database of Directory wetlands.

Summary of progress and main findings

- Site managers and others with substantial relevant knowledge of remote wetlands have been contacted and site visits and surveys conducted to collect field data and other information to support site listings.
- Aquatic invertebrate specimens have been sorted in preparation for specialist taxonomic identification.
- Botanical specimens have been identified and mounted for lodgment in the WA Herbarium collection.
- Waterbird data has been analysed and synthesized for inclusion in site descriptions.
- Information concerning cultural values, site management, threats and related issues has been collated.
- Preparation and enhancement of descriptions of candidate and existing remote Directory sites has largely been completed.
- The Western Australian component of the National Directory will be updated in 2006 to include new sites and enhanced site descriptions.

Management implications

- Literature search, field survey results and interviews has led to identification of nationally important wetlands, values and threats and provide a basis for conservation and wise management of these wetlands.

Future directions (next 12-18 months)

- Specialist taxonomic identification of aquatic invertebrate from remote wetlands will be completed, data analysed and information synthesized.
- Descriptions of proposed new sites for the Directory will be finalized, together with enhanced descriptions of existing sites.
- The Western Australian component of the Directory will be updated in 2006 to include new sites and enhanced site descriptions.

CALM Regions

The Directory is an important resource document for all CALM Regions. Current work is focused on the Kimberley, Pilbara, Goldfields, Midwest, South Coast and Wheatbelt CALM Regions.

IBRA Regions

The main focus at present is on Central Ranges, Coolgardie, Gibson Desert, Great Victoria Desert, Hampton, Little Sandy Desert, Mallee, Nullarbor, Ord Victoria Plains, Tanami and Yalgoo.

NRM Regions

The Directory is an important resource document for all NRM Regions. Current work is focused on the Rangelands NRM Co-ordinating Group.

Management of the Vasse - Wonnerup wetlands

SPP # 1999/0017

Team members

J Lane (0.15), Y Winchcombe (0.1), Total (0.25).

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 2 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, CALM led the establishment of an inter-agency technical working group to co-ordinate relevant agency activities. This lead role is being maintained.

This project aligns with Corporate Priorities 3, 5 and 12, KRA 2 and sub-output NC 2D.

Aims

- To perform a lead role in the management of water levels, flows and salinities in the Vasse-Wonnerup wetland system.
- To 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 and main findings

- A meeting of the inter-agency Vasse Estuary Technical Working Group was convened to decide arrangements for 2005/06 summer opening of the sandbar at the wetland system mouth; for water level, water quality and fish monitoring, and for floodgate openings to release fish and manage water levels.
- Monitoring of fish activity and water levels at the floodgates was undertaken by team members with CALM Blackwood District backup during 2005/06. 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 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.
- Advice was supplied in response to public queries about management of the wetland system and places to see waterbirds. Scientific advice was provided to the Busselton Shire concerning its proposal to establish a Busselton Wetlands Interpretive Centre and associated wetland experiences.

Management implications

- Water levels, flows and fish movements were successfully managed throughout summer-autumn of 2005/06. There were no mass fish deaths, and adverse impacts on waterbird populations and fringing plant communities that would result from excessive water levels and salinities were avoided.

Future directions (next 12-18 months)

- The VETWG will be convened as necessary to decide on management, monitoring and other responsibilities during 2006/07.
- Monitoring of water levels and fish activity during summer-autumn will continue. Gates will be opened as necessary to manage water levels and release fish.
- Public enquiries concerning management of the wetlands will continue to be responded to.
- A concise report will be prepared, recording 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.

CALM Region

South West.

IBRA Region
Swan Coastal Plain.

NRM Region
South West.

Monitoring post-fire effects from the 2001 Nuyts wildfire

SPP # 2006/001

Team members
G Liddelow (0.1), B Ward (0.05), R Cranfield (0.05) P Van Heurck (0.1) L McCaw (0.05), R Smith (0.05) Frankland District Staff as required; Total (0.4).

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.

The study aligns with Corporate Priority 10, KRA 2 and 3 and sub-output NC 3K.

Aim
To monitor impact of severe wildfire in Karri / Tingle forest on plants, invertebrates, vertebrate fauna and stand structure.

Summary of progress and main findings
- Fourth year of post-fire data collected for plants, mammals, reptiles, amphibians and stand structure.
- Crown condition and seedling regeneration were assessed in December 2005. Crown condition of mature Karri and Red Tingle has stabilized, although isolated mortality of trees continues. Karri, Red Tingle and Marri have regenerated vigorously in areas where the overstorey canopy has been fire damaged, with dominant saplings up to 5 m tall.
- Vascular plant species richness and abundance data were collected for the fourth year post fire in early May 2005. Species from 20 1x1m quadrats per plot ranged in number from 15 to 35 per plot depending on landform. Vouchering of species was done at time of measurement and less than 10% of species were flowering.
- The number of bird species recorded in the study area has varied between 31 and 39 over the 5 yrs since fire. Some of the birds typical of open country that were present in the early post-fire stages have disappeared as the understorey has become denser. The normal suite of birds associated with dense forest understorey Karri/Tingle forest have become well established in the area and the densities of birds appears to be the same as similar types of forest. The red-eared firetail finch became widespread in the study area in the third year after fire.
- Quokka have become established in all the suitable habitat within the burn area, and currently occupy some sites that could be considered marginal habitat. This is probably a temporary consequence of fire-induced changes in vegetation structure.

Management implications
- This study contributes to the development of ecologically appropriate fire regimes for tall forests in southern Western Australia. Results to date have indicated 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 fires can have undesirable ecological outcomes including simplification of plant population structure and depletion of seed banks.

Future directions (next 12-18 months)
- Spring field trip to collect voucher specimens for vascular plants.

- Continue monitoring fifth year post-fire.
- Review monitoring program after 2006 sampling and publish report on first 5 yrs of response.

CALM Region
Warren.

IBRA Region
Warren.

NRM Regions
South Coast, South West.

Long term monitoring of timber harvesting on bird populations in south-west forest areas

SPP # 1994/008

Team Members
G Liddelow (0.1), C Vellios (0.1); Total (0.2).

Context
Understanding the long term effects of timber harvesting on the bird populations in Karri and Jarrah forests is important for predicting how bird species and numbers of individuals change with time since regeneration.

Aim
To quantify the effects of timber harvesting and silvicultural practices in the Karri and Jarrah forests on birds.

Summary of Progress
- This year's count at Gray were 20 yrs since regeneration. Numbers of birds this year were lower than 5 yrs ago probably due to the senescing of the vegetation. Only long lived understorey species now persist
- Counts were carried out at the 16 Kingston Jarrah sites in spring 2005.
- Numbers at Kingston were consistent with last year and as crown separation is now occurring the suites of birds should separate out into their own niches.

Management Implications
- This study evaluates the effect of past silvicultural practices in the Karri and current silvicultural practices in the Jarrah forests.

Future directions (next 12-18 months)
- Counts at Grey will be repeated in 2010, 25 yrs after regeneration, or prior to any harvesting that may occur in the interim.
- Counts to be done in the Kingston sites spring 2006 (10 yrs since regeneration).
- Review and analyse both sites data at the end of 2006.

CALM Region
Warren.

IBRA Region
Jarrah Forest, Warren.

NRM Region
South West.

Project Vesta – prediction of high intensity fire behaviour in dry Eucalypt forest

SPP # 97/03

Team members
L McCaw (0.3), R Smith (0.2), J Neal, (0.2); Total (0.5).

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 recognized limitations in previous fire behaviour prediction models for dry Eucalypt forests.

It aligns with Corporate Priority 10, KRA's 2 and 3, and sub-outputs SFM 3D and SFM 3H.

Aims
- To develop a national fire behaviour prediction system for dry eucalypt forests.
- To quantify changes in fire behaviour as fuels develop with age.
- To develop new algorithms describing the relationship between fire spread, wind speed and fuel characteristics.
- To characterize wind speed profiles in forests with different overstorey and understorey structures.

Summary of progress and main findings
- Fire spread and fuel data have been analysed to identify the key variables influencing fire spread. Fuel variables that describe vegetation structure and condition are more strongly correlated with rate of spread than is surface litter fuel load alone. Fuel variables can account for site-related differences in vegetation structure and density, making models transportable across a range of site conditions. Fuel structure and condition can be described for operational purposes using a simple hazard scoring system that can replace more labour-intensive methods of fuel assessment for application in rate of spread prediction.
- The project has also demonstrated that fire size has a significant effect on the potential rate of spread and that existing fire behaviour models tend to consistently under-estimate rate of spread for fires that are 100 m or wider at the headfire zone.
- A comprehensive final project report has been prepared describing the experimental methods, key findings and the development of a new fire spread model for dry Eucalypt forest. This report is accompanied by a DVD containing selected video clips illustrating important fire behaviour phenomenon.

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)
- Further work is required to prepare manuscripts for publication in scientific journals and to develop material for training and technical transfer purposes.
- Additional experimental fires to validate the results of Project Vesta in a range of south-eastern Australian forest types are being undertaken through the Bushfire Cooperative Research Centre.
- The findings of Project Vesta will need to be integrated into the Departments fire management system, necessitating a revision of key documents and training manuals.

CALM Regions
South West, Swan, Warren.

IBRA Regions
Jarrah Forest, Warren.

NRM Regions
South Coast, South West, Swan.

Increasing productivity of Karri regrowth stands by thinning and fertilizing

SPP # 93/106

Team members
L McCaw (0.05), R Smith (0.1), J Neal (0.1); Total (0.25).

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 number of different stands on a range of site types and contributes important information on long-term growth and stand development.

This study aligns with Corporate Priority 9, and KRA's 3.8 and 4.3.

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.

Treatments in experimental designs include:

- thinning from below,
- fertilizing with macronutrients and trace elements,
- coppice control.

Summary of progress and main findings

- Re-measurement of the Warren thinning experiment was completed during 2005 (tree height, stem diameter, bark thickness, crown radius). This is 5 yrs since the last measurement, and 20 yrs since the experiment was established in a stand that was 13 yrs old at the time.
- The incidence of *Armillaria* scarring on trees was also assessed. Indications are that since 2000 there has been only limited tree mortality, and many bole scars have occluded.
- The epiphytic fern *Asplenium aethiopicum* has successfully recolonized regrowth forest within 3 decades of disturbance by clearfelling and fire. Deep moss beds on large fallen logs are the preferred habitat for *A. aethiopicum.* Thinning did not diminish opportunities for recolonization. A paper reporting results of a survey of *A. aethiopicum* within the thinning experimental site has been accepted for publication in the *Journal of the Royal Society of Western Australia*.

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)

- Continue monitoring growth at 5 yr intervals, with Treen Brook experiment to be measured during

2006/07.

CALM Region
Warren.

IBRA Region
Warren.

NRM Region
South West.

Effect of fire on groundwater recharge to the Jewel Cave karst system
SPP # 2003/009

Team members
L. McCaw (0.05); B Smith (0.05), J Neal (0.05), S. Eberhard (honorary collaborator), I Dumbrell (FPC), CaveWorks (external collaborators); Total (0.15).

Context
Limestone karst landforms underlie several regionally significant conservation reserves in the south-west of Western Australia. Prescribed fire is used to manage vegetation condition and fuel loads used in these reserves, and there is a need to better understand how fire regimes affect the quantity and characteristics of subterranean water flow. This study investigates the relationship between fire and groundwater in a Karri forest ecosystem at Jewel Cave in the Leeuwin Naturaliste National Park. Declining groundwater levels in the cave over the past 5 decades cannot readily be explained by climatic variation, but are considered to represent a threat to subterranean root mat communities.

This project aligns with Corporate Priority 10, KRA's 2.1, 3.11 and 4.1, and sub-outputs NC 4C.

Aim
To quantify the effects of a prescribed burn on groundwater recharge in a karst aquifer, through measurement of rainfall, leaf area, fuel load, soil water content and movement, infiltration rate and chemistry of cave dripwater, cave groundwater levels.

Summary of progress and main findings
- Monitoring of selected variables over a second rainfall year post-burn was undertaken. This included monitoring of daily rainfall, dripwater chemistry (Mg and Cl), infiltration rate and cave water levels (most field work undertaken by CaveWorks, Augusta-Margaret River Tourism Association). Fuel accumulation was measured in Jan 2005 and Feb 2006. Limited monitoring of soil water content and movement was undertaken.
- Post-burn monitoring has now been completed.
- The overall multi-year declining trend in cave groundwater levels continued in response to the long term trend in declining rainfall.
- Groundwater levels in the Jewel Cave karst system have declined to a critically low level and the conservation status of the Threatened Ecological Community (TEC Cave Root Mat Community No. 1) remains Endangered (critical). The potential effects of land uses on private property adjoining Jewel Cave has been examined by the Department of Environment.

Management implications
- Long term climate modelling predicts that the trend of declining rainfall in the south west will continue. This has implications for both fire management and the management of groundwater resources and groundwater dependent ecosystems including the TECs in the Jewel Cave karst system and other listed TECs in the Leeuwin Naturaliste region and elsewhere in WA (e.g. Yanchep). Fire clearly affects recharge to groundwater, so fire management planning needs to consider the effects on groundwater recharge and groundwater dependent ecosystems,

especially in karst areas. Quantification of the effect of fire on groundwater recharge in karst systems of SW WA will assist planning and management of fire regimes in context with climate change and the conservation of groundwater dependent ecosystems.

Future directions (next 12-18 months)

- Data analysis.
- Writeup and publication of the research.

CALM Region
South West.

IBRA Region
Warren.

NRM Region
South West.

Identification and monitoring of benthic invertebrate communities of tropical intertidal mudflats

SPP # 1999/15

Team member
G Pearson (0.2); Total (0.2).

Context
It is important to facilitate a better understanding of the wildlife values of intertidal mudflats at Roebuck Bay, Eighty-mile Beach, King Sound and other tropical intertidal habitats through scientific examination and community interaction. Collection of baseline data, establishment of long-term monitoring and engagement of community are important for developing and implementing ecologically appropriate management regimes within a marine conservation reserve system (Roebuck Bay, Eighty-mile Beach). The monitoring programs, established in 1996 were designed as long-term studies involving international science input and volunteer recruitment.

They align with Corporate Priority 11, KRA 1-6 and sub-outputs NC2B, 2D, 3B, 3H, 4F and 6A.

Aim
To facilitate and participate in research on the wildlife conservation values of tropical intertidal mudflats including Roebuck Bay and Eighty-mile Beach and to foster local and wider community involvement and understanding of the wildlife conservation values of intertidal mudflats.

Summary of progress and main findings
Roebuck Bay

- Continued participation in a postgraduate study of the bivalves of Roebuck Bay in collaboration with RNIOZ. PhD Project - T Compton, Comparison of tropical and temperate bivalves in 2 intertidal mudflats. Supervisors: Dr T Piersma, G Pearson.
- Collaboration with community groups to establish a second Celebrate the Bay community based information forum in Broome in 2006.
- Continued collaboration in the Shorebird Conservation Project at Roebuck Bay with WWF, Rubibi and CALM.
- A study of the food webs of Roebuck Bay using stable isotopes was initiated in 2003. Preliminary results were reported in August 2004 and at the Celebrate the Bay community forum in Broome in June 2006.

Eighty-mile Beach

- A study of the food webs of Eighty-mile Beach using stable isotopes was initiated in 2003. Results will be reported in 2006/07.
- Funding was obtained from CALM's Wetland Project proposals. Initiated analysis of data collected from the Eighty-mile Beach monitoring ('Monanna') Project. Results to be reported in 2006.
- Completed collaboration with District staff to progress the development of a dual use management zone between the Ramsar site and pastoral activities.

Management implications

- Roebuck Bay is a Ramsar site and proposed marine conservation reserve. The information gathered from these projects will assist better understanding of relevant management issues at Roebuck Bay and its hinterland. Similar implications apply to Eighty-mile Bach and its hinterland.
- Management strategies and opportunities for research for both sites will be enhanced by collaboration with external research institutions and involvement of local and wider community.
- Improved community understanding of management issues at Roebuck Bay and Eighty-mile beach.

Future directions (next 12-18 months)

Roebuck Bay

- Monitoring of the benthos at 4 sites in Roebuck Bay continues through collaboration with Broome Bird Observatory.
- Consider development of criteria for a program that examines the value of cattle grazing on buffel grass plains to shorebirds.
- Facilitate research by tertiary institutions on aspects of intertidal mudflat ecology and management.

Eighty-Mile Beach

- Monitoring of the benthos continues through Broome Bird Observatory.
- There is progress towards the production of a book on Eighty-mile Beach that illustrates the conservation values of the Ramsar site and its hinterland.
- Consider development of criteria for a program that examines the value of cattle grazing on buffel grass plains to shorebirds.
- Facilitate research by tertiary institutions on aspects of intertidal mudflat ecology and management.

CALM Region

Kimberley.

IBRA Region

Dampierland.

NRM Region

Rangelands.

Armillaria spread in Karri

SPP # 98/0006

Team members

R Robinson (0.2), R Smith (0.05); Total (0.25).

Context

Armillaria root disease impacts significantly on the silviculture and management of karri regrowth 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.

It aligns with Corporate Priorities 3 and 9, and KRA 3. SFM output priorities 1, 2, 3, 4 ans 5, and sub-outputs SFM 3A, 3J and 3P.

Aims

- To investigate control methods of *Armillaria* root disease in Karri regrowth forest.
- To investigate the effects of management on *Armillaria* root disease in Karri regrowth forest.
- To investigate how *Armillaria* root disease affects Karri tree growth.

Summary of progress and main findings

- Survey of the Warren Thinning Trial, 20 yrs after thinning, was completed in April 2006.
- Stump pulling as a control measure is ongoing in Warren and Dombakup blocks.
- Scientific paper published: Robinson, R.M. (2005) Volume loss in thinned karri regrowth infected by *Armillaria luteobubalina* in Western Australia. Proceedings of the 11th IUFRO International Conference on Root and Butt Rots of Forest Trees. Poznań and Białowieża, Poland, 16-22 August 2004).
- Sites selected for long-term monitoring plots in Warren block.

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)

- Analyse data from the Warren Thining Trial to determine the effects of thinning after 20 yrs.
- Install long-term monitoring plots to assess stump-pulling operations in Warren block.

CALM Region
Warren.

IBRA Region
Warren.

NRM Region
South West.

The effect of wildfire on fungi

SPP # 98/0015

Team members
R Robinson (0.2), R Smith (0.1): Total (0.21).

Context
Fungi are amongst the most important of forest organisms in terms of their biodiversity and ecosystem functions. They 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.

It aligns with Corporate Priorities 1, 3, 8, 10 and 12, and KRA 3, sub-outputs NC 3C and 3K and SFM 3A and 3D.

Aims

- To investigate the effects of wildfire on fungi in Karri forest.
- To monitor the succession of fungi on burnt sites in Karri forest.

Summary of progress and main findings

- Fieldwork completed (5 yrs of results).
- Annual report completed.
- 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 5 yrs. Fire mosaics have the potential to enhance fungal diversity across a landscape.
- Scientific paper accepted for publication in *Austral Ecology*: Robinson, RM, Mellican, A and Smith, RH. The succession of macrofungi following a wildfire in Karri regrowth forests in Western Australia.
- Scientific paper submitted. Robinson, RM and Tunsell, VL. Preliminary list of macrofungi recorded in burnt and unburnt *Eucalyptus diversicolor* regrowth forest in the south-west of Western Australia: 1998-2002. Conservation Science.
- Scientific paper published. 2006 Robinson, R.M. 2006. Varying fire regimes to promote fungal diversity across the landscape. Australasian Plant Conservation 14: 16-17.

Management implications

- Results contribute to information on the management of fire for enhancing biodiversity in eucalypt forest.

Future directions (next 12-18 months)

- Ten year post-fire survey to be undertaken in 2007.
- Laboratory work continues to catalogue and identify voucher specimens collected throughout the project.
- Collaborate with colleagues from other agencies with identification of voucher specimens.

CALM Region
Warren.

IBRA Region
Warren.

NRM Region
South West.

Forest health and vitality surveillance and monitoring

SPP # to be allocated

Team members

R Robinson (0.15), J Farr (0.15) Total (0.30).

Context

Key Performance Indicator 17 of the Forest Management Plan requires that CALM report on the severity status of weeds and pests, and invesitigate the cause of any increase in severity status as a result of management actions. This forms part of the adaptive management process. CALM requires a structured approach to monitoring to identify significant weeds, diseases and pests and track their

status over time.

This project directly addresses Corporate sub-output SFM 3K.

Aim
To devise, establish and implement a Forest Health Surveillance (FHS) system for Western Australian forests.

Summary of progress and main findings.

- An options paper has been prepared and submitted to Sustainable Forest Management Division for consideration.

Management implications

- None to date.

Future directions (next 12-18 months)

- The FHS system will be administered and implemented by Sustainable Forest Management Division and Regional Services Division with advice and input from Science Division.
- Confirm sampling strategies and methodology for FHS.
- Develop an implementation plan for FHS.

CALM Regions
South West, Swan, Warren.

IBRA Regions
Jarrah Forest, Warren.

NRM Regions
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

SPP # 2003/03

Team members
P Van Heurck (0.5), I Abbott (0.02), A Mellican (0.02); district staff - E Middleton; Walpole-Nornalup Parks Association and Walpole community volunteers; Total (0.54).

Context
The tall wet Tingle and Karri forests contain a high proportion of short range relict invertebrate species. In March 2001 a wildfire in the Nuyts Wilderness forests provided an opportunity to assess the impact of a high intensity wildfire on the species composition of these relict invertebrate communities. Species composition was also compared with relict invertebrate communities in prescribed burnt and long unburnt tall wet forests. Understanding effects of a single intense wildfire on invertebrate biodiversity is important for developing and implementing ecologically appropriate fire regimes and for managing fire for the protection of life and property. This study, established in December 2001, was designed to involve and educate the local volunteers in the establishment of a long-term invertebrate collection.

It aligns with Corporate Priorities 1, 3, 6, 8 and 10 and KRA 1, 2, 3 and 6 and sub-outputs NC 2B, 3B, 3K and 6A and PVS 2A and 6B).

Aim

To describe the differences in species compositions of the arthropod litter communities containing short range endemics, at forest sites long unburnt, prescribed burnt and burnt in a recent wildfire.

Summary of progress and main findings

- 16 trapping sites established in December 2001.
- Dec. 2004 and April 2005 yearly site trapping complete.
- Local curator Jember Manning and trained volunteers sorted and incorporated over 1000 morphospecies into the Nuyts Collection. There are now 6580 specimens in the collection.
- Nature photographer D Annison was sub-contracted to develop a coloured digital microphotography manual.
- Workshop by D Annison to train volunteers in the use of new digital camera, microscope, and Auto-montage software.
- High resolution photography of 250 identified beetle species completed by C Steele and D Parkes.
- G Muir (Walpole Wilderness Eco-cruises) managed the setup of website (http://www.lukasrinnhofer.at/wow2/), access database, and incorporation of first beetle images.
- Funding provided to WA Museum for taxonomists to identify arachnid and millipede taxa.
- Funding provided to Curtin University for a taxonomist to identify ant and wasp taxa and employ a zoological illustrator to complete the illustrations for a key to south-west ant species.
- A *Landscope* article on the role of the local volunteers in this project is in progress.

Management implications

- The Nuyts Invertebrate Collection contains a large proportion of invertebrate species previously undescribed from the old growth forests of the south coast. The distribution of these species within the wide range of fire ages surveyed will provide fire managers with important conservation information on a large segment of the local biodiversity, including short range endemic taxa.
- Analysis of the 310 beetle species collected to date indicates that more than two thirds of species are site-specific and are restricted to particular fire ages and microhabitats (floor, log, tree butts or hollows) within forest types (Karri, Tingle, Marri and Jarrah).
- Beetles occur in most feeding guilds present in forest ecosystems and are thought to represent c. 20% of biodiversity. The Nuyts beetles probably represent a significant proportion of the biodiversity of the old growth forests. This beetle fauna is proving to be a sensitive indicator of fire management impacts and indicates a need to manage for a diversity of fire ages, of both recently and long unburnt patches within each forest type.
- Due to the training of volunteers in biosurvey techniques, from the Walpole-Nornalup National Parks Association and the Walpole community, it has been possible to sort large numbers of specimens collected over the last 4 yrs. Volunteers have gained a greater understanding of the use of prescribed fire in the conservation of old growth forest biodiversity and are becoming increasingly interested and skilled in invertebrate biosurvey. Highly skilled volunteers are available to effectively train other staff in future biosurvey projects.
- The provision of high resolution morphospecies images on the website for the use of international taxonomists will facilitate rapid identification of reference collection morphospecies. This integrated approach may provide a model suited to broader use by local communities working in partnership with scientists and land managers.

Future directions (next 12-18 months)

- Provide information to the local community via the Walpole Wilderness Invertebrate website, Discovery Centre displays and talks.
- Provide ecological information to local tour guides and operators.
- Educate and attract eco-tourists.
- Make available the species collection of an entire litter community for the use of local and international taxonomic specialists.
- Provide the database, reports and recommendations to fire managers and planners of old growth forest parks.

- Publish aspects of this project as a comparative study of para-taxonomy training by local volunteers.

CALM Region
Warren.

IBRA Region
Warren.

NRM Regions
South Coast, South West.

Effects of timber harvesting on terrestrial vertebrates in medium rainfall Jarrah forest
SPP # 93/0115

Team members
A Wayne (0.1), C Ward (0.3), C Vellios (0.3), J Rooney (0.1); Total FTE: 0.8.

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. Data collection at the field sites was conducted in 2004/05 to support data collected 1994-2000.

This study aligns with Corporate Priorities 3, 10 and 12, and aligns with Key Result Areas 2.2, 3.8, and 4.3.

Aims
- To investigate the impacts of current silvicultural practices on Jarrah forest ecosystems.
- To determine what factors contribute to observed impacts.
- To develop or modify silvicultural prescriptions to ensure the ecologically sustainable management of timber harvesting in the Jarrah forest.

Summary of progress
- Publication of Wayne, AF, Cowling, A, Rooney, JF, Ward, CG, Wheeler, IB, Lindenmayer, DB, Donnelly, CF, 2005. Factors affecting the detection of possums by spotlighting in Western Australia. *Wildlife Res*. 32, 689-700.
- Spotlight monitoring on the 3 standardized transects was maintained at 6 repeat surveys per transect per year.
- Data collation and validation for trapping and spotlighting is complete and up-to-date.
- Data analysis is underway in preparation for the publication of medium-sized mammal responses to timber harvesting.

Management implications
- Improve ecologically sustainable forest management practices and the conservation of biodiversity.
- Improve 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)
- Analyse and publish the 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.

CALM Region
Warren.

IBRA Region
Jarrah Forest.

NRM Region
South West.

Characteristics of hollow-bearing Jarrah (*Eucalyptus marginata*) and Marri (*Eucalyptus 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 # 93/0095

Team member
K Whitford (0.2), Technical officer (0.1); Total (0.3).

Context
Hollow bearing trees and logs are elements of forest structure that are essential for the conservation of hollow dependant birds and mammals. The knowledge gained from studying the availability of these hollows and identifying the attributes of trees and logs that bear hollows improves CALM's ability to manage for this aspect of ecological sustainable forest management. This study, which is largely complete, is currently focusing on hollows in logs on the ground.

This study aligns with Corporate Priority 9, and KRA 3. The study of logs on the forest floor will contribute to sub-output SFM 3I.

Aims
- To describe the range of hollow sizes used by hollow dependant species from the Jarrah forests.
- To establish the relationship between tree size and tree age for Jarrah and Marri trees.
- To determine what types of trees and crowns bear hollows in the Jarrah forest and where in the tree crowns these hollows occur.
- To examine the distributions of the sizes, shapes and orientations of these hollows.
- To determine the ages of trees bearing hollows.
- To determine if hollows can be reliably detected from the ground.
- To examine the relationship between tree and crown attributes and the abundance of hollows.
- To develop predictive relationships for hollow occurrence and provide descriptions of the type of trees most likely to bear hollows.
- To determine the relative size of hollows used by all hollow dependant fauna species in the Jarrah forest and the minimum age and size of trees bearing hollows potentially suited to these fauna species.
- To identify fauna species most likely to be threatened by any future shortage of suitable hollows.
- To examine the occurrence of hollows suited to the species most at risk.
- To examine the relationship between logging history and the abundance of hollows and logs on the forest floor in various forest types.
- To examine the impact of log removal from the forest on the number and types of logs present on the forest floor and the number and types of hollows on the forest floor.
- To examine the relationship between burning history and the abundance of hollows and logs in various forest types.

- To examine the potential for modeling of recruitment, decay and removal of logs from the forest floor.
- To identify the types and sizes of log hollow that are likely to be used by hollow dependent fauna in the Jarrah forest.
- To determine the density of log hollows required by various hollow dependent fauna in the Jarrah forest.

Summary of progress and main findings

- Five papers in scientific journals, one book chapter and a *Landscope* article have been published from this research.
- Completed the measurement of hollows and ground logs on plots at 2 sites in unlogged Jarrah forest.

Management implications

- This research contributed to knowledge of hollows and hollow use in standing trees in the Jarrah forest.
- Findings from this research were used to revise the silviculture guidelines for the Jarrah forest.

Future directions (next 12-18 months)

- Establish and measure additional plots in unlogged Jarrah forest sites to extend the data on the availability of hollows and logs on the forest floor.

CALM Regions
South West, Warren.

IBRA Region
Jarrah Forest.

NRM Regions
South West, Swan.

Evaluation of key soil indicators of sustainability in Australian Mediterranean forests (Indicators 4.1d, 4.1e)

SPP # 1999/021

Team member
K Whitford (0.4); Total (0.4).

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 currently contributes to the development of standards for soil management during timber harvesting activities in the Jarrah and Karri forests.

This study contributes directly to Corporate Priority 9, KRA 3 and specifically sub-outputs SFM 3C, SFM 3E and SFM 3N.

Aims

- To investigate the use of soil organic matter as an indicator of ecologically sustainable forest management in the jarrah and karri forests.
- To examine the impact of fire on organic C and N in the jarrah and karri forest.
- To develop and refine the survey techniques proposed in the nationally agreed survey protocol for estimating soil disturbance.

- To establish base data on the intensity and extent of soil disturbance in jarrah harvesting coupes.
- To 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.
- To compare techniques for measuring snig track area.
- To investigate the impact of snig track compaction on tree and stand growth in the Karri forest.
- To assist with the development and application of soil disturbance monitoring and management system for the jarrah and karri forests.
- To provide a scientific basis for the soil disturbance monitoring and management system applied in the jarrah and karri forests.

Summary of progress and main findings

- The final report to the funding body has been submitted, and published on the Forest and Wood Products Research and Development Corporation's website.
- Three manuscripts from this work are being prepared for publication in scientific journals.
- Training in soil disturbance assessment was provided to Forest Management Branch staff, and FPC staff.
- Adaptive trials of cording were undertaken, reported on and presented at a CALM FPC and timber industry workshop.
- A report on these adaptive trials of cording has been submitted for publication in a scientific journal.

Management implications

- This work contributed to development and implementation of Appendix 6 of FMP 2004-2013.
- Advice was provided to the Policy and Practices Branch of the Sustainable Forest Management Division for the development of the *Interim Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests*.
- Completed adaptive management trials in conjunction with the timber industry and FPC to examine alternative approaches to managing soil disturbance to those proposed in the Forest Management Plan (2004-2013).
- Contributed to the review of the system used for the protection of soil in native forest harvesting and the workshop on this review.

Future directions (next 12-18 months)

- Finalize the publication of manuscript on adaptive trials of cording.
- Revise and submit 3 manuscripts that have been prepared for publication.
- Advise and assist with any further research on soil disturbance during timber harvesting.
- Continue to advise and assist where appropriate with the implementation of Appendix 6 of the FMP (2004-2013) and the development of the *Soil and Water Conservation Guidelines.*

CALM Regions
South West, Warren.

IBRA Regions
Jarrah Forest, Warren.

NRM Regions
South West, Swan.

Effect of stand density and fertilizing on seed-fall. Exp B. Establishment of Jarrah (*Eucalyptus marginata*) in shelterwood areas and on dieback 'graveyard' sites
SPP # 93/0094

Team member
K Whitford (0.1); Total (0.1).

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 has enabled more accurate specification and prediction of the seed available in stands that are to be harvested to shelterwood specifications.

This study aligns with Corporate Priority 9 and KRA 3.

Aims
- To determine the effect of stand density and fertilizer on the quantity of seed-fall in the Jarrah forest.
- To examine seasonal variations in seed-fall.
- To examine the production and loss of buds, flowers and capsules to increase understanding of the seed production cycle.
- To provide knowledge of seed-fall relevant to improving the management and regeneration of shelterwood logged Jarrah forest.

Summary of progress and main findings
- Final SPP report completed.
- Manuscript for prepared for scientific journal requires revision and preparation for publication.

Management implications
- Results from this research have been used to revise the silvicultural guidelines – *Silvicultural Practice in the Jarrah Forest* – in the section on seed crop assessment and in the formulation of Appendix 4 on the calculation of capsule and seed crop. These results will also be used in the *Silvicultural Survey Procedures Manual.*

Future directions (next 12-18 months)
- Provide advice and assistance to FMB in developing a field based seed crop assessment procedure.
- Revise manuscript and submit for publication in refereed journal.

CALM Regions
South West, Swan.

IBRA Region
Jarrah Forest.

NRM Regions
South West, Swan.

Control of Jarrah leafminer: selective retention of JLM resistant trees and ground coppice in a demonstration forest plot

SPP # 93/97

Team members
A Wills (0.01), P Van Heurck (0.01), I Abbott (0.01); Total (0.03).

Context

Jarrah leafminer is an important pest species of Jarrah, with significant effects on Jarrah biomass production. Few management options are available to control Jarrah leafminer (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.

This JLM demonstration trial aligns with KRA 3.11 and 6.1 and sub-outputs SFM 3J and 6A.

Aim

To provide a visual demonstration of improvement in stand health and productivity by management practices.

Summary of progress and main findings

- Site inspected, no maintenance required.

Management implications

- Leafminer outbreaks have abated since the demonstration coupe was established. When JLM outbreaks again 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.

CALM Region

South West.

IBRA Region

Jarrah Forest.

NRM Region

South West.

Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity

SPP # 01/005

Team members

A Wills (0.3), I Abbott (0.01); Total (0.31).

Context

It is important to understand the factors controlling the distribution of invertebrates in the Jarrah forest landscape, and whether specialized 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 protection of life and property.

This study aligns with KRA 3.8 and sub-outputs SFM 3A and 3D and NC 3K.

Aims

- To document the effects of topography on the distribution and abundance of invertebrates in Jarrah forest.
- To determine whether landscapes provide natural fire and climatic refuges in the Northern Jarrah forest.

Summary of progress and main findings

- Sorting of minor taxa to morphospecies level completed. Statistical ordination of ants, beetles and spiders completed. There are differences within and between catenas in ant, beetle and spider assemblages. Aspect is an important determinant of assemblages across geographical scales of several hundred metres.

Management implications

Incised valleys are important contributors to β and γ diversity of invertebrates. Management implications not yet apparent as analysis of data not completed.

Future directions (next 12-18 months)

- Update database and analyse the combined dataset.
- Write up and publish in refereed journal.

CALM Region
Swan.

IBRA Region
Jarrah Forest.

NRM Region
Swan.

Monitoring the northern extent of Jarrah leafminer outbreak

SPP # to be allocated

Team members
A Wills (0.02), P Van Heurck (0.01); Total (0.03).

Context

Jarrah leafminer is an important pest species of Jarrah, with significant effects on Jarrah biomass production. Monitoring the incursion of Jarrah leafminer 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.

This monitoring program aligns with Objective18.4 and Key Performance Indicator 17 in the Forest Management Plan 2004-2013. JLM monitoring aligns with KRA 3.11 and sub-outputs SFM 3J and 3K.

Aims

- To monitor and document the northern extent of Jarrah Leafminer outbreak in Jarrah forest.
- To provide warning of change in forest health and productivity caused by incursion of Jarrah leafminer into as yet unaffected forest.

Summary of progress and main findings

- No action required. There have been no casual reports of progress northwards of JLM populations since the last survey in 2004.

Management implications

- Biomass productivity of Jarrah in the Northern Jarrah forest is unaffected by Jarrah leafminer.

Future directions (next 12-18 months)

- Continued monitoring of the outbreak at 5 yrly intervals is recommended, unless expansion of outbreak eventuates sooner. Next monitoring due 2009.

CALM Region
Swan.

IBRA Region
Jarrah Forest.

NRM Region
Swan.

Bushfire CRC Project B1.1: Managing fires in forested landscapes in South-west WA
SPP# to be allocated

Team members
R Wittkuhn (CRC-funded postdoctoral researcher) (1.0), L McCaw (0.2), R Robinson (0.2), J Farr (0.2), B Ward (0.2), B Smith (0.2), J Neal (0.2), G Liddelow (0.1); R Smith (0.1), T Hamilton (0.5), L Shu (0.1), F Metcalfe (0.2), C Carpenter (0.1), J. Hollis (0.3). Total (3.6).

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.

It aligns with Corporate Priorities 10 and 12, KRA 2 and 3 and sub-output NC 3K.

Aim
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 5 decades.

Summary of progress and main findings
- Progress to date has focused on the interrogation of the fire history database (GIS information relating to fire history of the Warren Region since 1953).
- Contrasting patterns of fire intervals have been identified for a study area identified in southern Jarrah forest and associated vegetation complexes north of Walpole. The contrast lies in the occurrence of areas with successive short fire intervals and areas with successive long fire intervals.
- More than half of the monitoring grids have been established to date.

Management implications
- Provision of scientifically-based guidelines for the appropriate frequency, season, intensity and extent of burning to 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.

Future directions (next 12-18 months)
- Finalize site establishment.
- Retrospective measures fire intensities for all forest sites.
- Conduct floristic surveys in spring 2006 and spring 2007.
- Conduct fauna trapping in autumn 2007 and 2008.
- Conduct macro fungi surveys in autumn 2007 and / or 2008.

- Conduct invertebrate surveys in late spring/early summer 2006.
- Complete manuscripts on:
    - Design and construction of the fire history database.
    - Development of methodology for mapping fire regimes in a spatial environment.
    - Description of the fire history for the Warren Region.

CALM Region
Warren.

IBRA Region
Warren.

NRM Regions
South Coast, South West.

SCIENCE APPLICATIONS

Program Leader: Dr Ian Abbott

Science Division corporate data directory and repository

Core Function

Team members

M Choo (0.5), P Gioia (0.1); Total 0.6.

Context

Numerous biological datasets exist in Science Division and in other Divisions of CALM, but little is corporatized and conveniently accessible to users in CALM and in the community. There is an increasing expectation that data collected by officers of Science Division should be better integrated and managed.

It directly supports the NatureBank vision and aligns with Corporate Priority 6,11 and KRA 1 (NC 1A), 2(PVS 2A), 6 (NC 6A, SFM 6A).

Aim

To manage and disseminate corporate information and knowledge held in Science Division.

Summary of progress and main findings

- Review and consolidation of metadata and corporate data.
    - CALM's newly installed ORACLE HTMLDB software is able to provide the software platform for providing online access to existing databases and integrating them to their metadata held at WALIS (WA Land Information System).
    - Progress is dependent on the outcomes of the ANZLIC Metadata Project group, regarding the establishment of a national format and the development of metadata management software.
    - Two databases (Mammals on Australian islands database and Seabird breeding islands database) are being used as case studies to determine the requirements for setting up procedures and protocols for corporatizing databases and to identify resources needed to maintain the online versions and answer subsequent queries. With these systems, textual data and queries were easily duplicated but the spatial component of the existing systems could not be accommodated within the HTMLDB environment. Provision for liaison with external agencies was another identified requirement.
    - The procedure for using the Division's Guideline 16 (Databases and their management), together with its associated form RF28, was reviewed, particularly in terms of converting the manual process to an online one.
- Establishment of a framework for managing corporate databases. A set of procedures and protocols for managing databases is being developed.
- Development and integration of the Science Project Plan system (WASPP) within this online corporate framework.
- Development and implementation of the framework as the textual component/interface for online GIS biodiversity mapping (NatureMap).
    - Integration of the first set of NatureMap data into the Corporate Register within the test environment and steps are being taken to move these into the production environment in line with the installation of NatureMap.
- Establishment and chairing of the Corporate Data Group within CALM and contribution to the group towards a consistent and integrated approach for managing corporate data.

Management implications

- Improves security and integrity of Science Division's databases, ensuring that data are not lost when a scientist retires or resigns.
- Satisfies the provision of the Records Management Act by preventing loss of data through retirement and resignation.
- Provides facility to satisfy FOI requirements.
- Facilitates communications within and outside the Division and Department.
- Provides easy and seamless access to all of the Division's data (and knowledge) from both within and outside the Division.

Future directions (next 12-18 months)

- Provide infrastructure and establish formalized procedures for identifying and managing corporate datasets
- Establish a uniform approach for the management and online presentation of corporate data.
- Provide a better mechanism for backing up and archiving data currently held across the Division.
- Consolidate metadata and corporate data.
- Improve access to the Division's corporate databases and their metadata.

Development of biodiversity indices

Core function

Team members

P Gioia (0.05); Total CALM (0.05). S Hopper, A Burbidge (external).

Context

The current CALM 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. CALM 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 use to represent floristic diversity in Western Australia. A more ecologically appropriate set of boundaries is highly desirable.

It aligns with Corporate Priority 1, 2, 5, 12 and KRA 1 (NC 1A), 2 (NC 2B, PVS 2A), 3 (NC 3C, NC 3G, NC 3I,) 6 (NC 6A, SFM 6A).

Aim

To develop a range of biodiversity indices using corporate databases and involving ongoing collaborative research into species distribution, richness and endemism, as well as new areas including biodiversity response to climate change and phylogeographic studies.

Summary of progress and main findings

- Paper presented at 2005 Flora Conservation Symposium.

Management implications

- Species richness and endemism maps are currently being trialled in 2 NRM regions, Recovery catchments from Salinity Action Plan.

Future directions (next 12-18 months)

- Submit technical paper by October 2006.
- Contribute to a book on endemism in 2007.
- Develop a set of richness and endemism indices for vertebrate fauna.

CALM Regions
South West, Warren.

IBRA Regions
Jarrah forest, Warren, Avon.

NRM Regions
South West, Northern Agricultural.

Science Division knowledge management

Core function

Team members
P Gioia (0.2), M Choo (0.2); Total (0.4).

Context
Biodiversity information is collected as part of Science Division activities. That information is in demand from a wide variety of clients, actual and potential. However, there are a number of issues relating to how information is collected, managed, published and distributed within the Division. This project involves a set of processes for reviewing and improving how information is managed, not just within Science Division, but across the Department, and a set of subprojects for managing information in a more corporate, integrated and effective manner so that there can ultimately be a single point of entry into the knowledge held by the Division.

It directly supports the NatureBank vision and aligns with Corporate Priority 1, 2, 3, 5, 6, 8 and KRA 1 (NC 1A), 2 (NC 2B, PVS 2A), 3 (NC 3C, NC 3J), 4 (NC 4C), 6 (NC 6A, SFM 6A).

Aim
To integrate Divisional information assets and develop a single, on-line entry point into knowledge held within the Science Division.

Summary of progress and main findings

- Presented findings of study tour on information management to Corporate Executive, EIMC, GIS Section strategic meeting and Science Management Team (Science Division).
- Appointed to Information Management Working Group and contributed to formation of new IT governance structure and funding models within CALM.

Management implications

- Key recommendations from the study tour are currently being implemented, including formation of a three-tiered governance structure that separates strategic management from technical discussion. A more corporate funding model for IT infrastructure is also being discussed.

Future directions (next 12-18 months)

- Gain endorsement of new information management policies by Corporate Executive, and implementation of new standards and protocols by Science Division, GIS section, ISS section.
- Implement strategic projects, including corporate data register, corporate data repository, enhanced Science Division web site, NatureMap, sites of significance, etc.
- Use findings from NatureMap project to promote improved data management standards and policies.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Provision of authoritative names of WA plant taxa

Core function

Team member
P Gioia (0.05); Total (0.05).

Context
CALM, academia and the community rely on authoritative plant names to manage floristic databases. Without authoritative names, the ability to provide and integrate information is substantially minimized. The WA Herbarium is the recognized custodian of the names of Western Australian plants. WACensus, a database system, is the Herbarium's primary mechanism for managing those names. It captures both current names and synonymies and information is disseminated widely throughout Western Australia. CALM 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.

It is an essential component of the NatureBank vision and aligns with Corporate Priority 2, 3, 6 and KRA 1 (NC 1A), 2 (NC 2A, NC 2B, PVS 2A), 3 (NC 3C), 4 (NC 4C), 6 (NC 6A, SFM 6A).

Aim
To provide accurate and timely information on the names of WA plant taxa to assist in management of floristic databases within CALM and the wider community.

Summary of progress and main findings
- WACensus V2 has been in production since November, 2004. Minor issues have required addressing system operation.

Management implications
- The development of any database in CALM that involves plant 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 CALM's information systems.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Online GIS biodiversity mapping (NatureMap)

Core function

Team member

P Gioia (0.45); M Choo (0.15) Total (0.6).

Context

CALM staff allocate large amounts of time and money in using desktop GIS software for mapping biodiversity. In many cases staff must undergo difficult learning curves to master the software to undertake activities such as generating information for conservation areas. A cheaper and more effective mechanism is required for CALM staff and the wider community to generate this information.

It aligns with Corporate Priority 1, 2, 4, 6 and KRA 1 (NC 1A), 2 (NC 2B, NC 2F,). 3 (NC 3H, NC 3J), 4 (NC 4C, NC 4F), 6 (NC 6A).

Aim

To develop an online system for spatially and textually querying a range of corporate biotic and abiotic datasets; provide real-time GIS functionality over the web without the need for purchasing expensive desktop GIS software and focus on the most common GIS query tasks that CALM staff perform.

Summary of progress and main findings

- NatureMap received $120 000 of CALM funding in 2006 to implement the project within CALM's corporate environment.
- Collaborative agreement reached with Western Australian Museum to publish WAM specimen data through the NatureMap interface.
- Software is currently in development and scheduled for production release in August/September, 2006.
- Development of the Corporate Register suite of applications as the textual component to NatureMap.
- Incorporation of Salinity Action Plan Data, Swan Coastal Plain data, Banksia Atlas data, Orchid Atlas data and Museum Fauna data.

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)

- Integration of GIS capability into FloraBase via the NatureMap GIS engine.
- Provision of extra biodiversity layers, such as predictive species distribution, landsat imagery, etc

CALM Regions

All.

IBRA Regions

All.

NRM Regions

All.

Species database management software (Max)

Core function

Team member

P Gioia (0.05); Total (0.05).

Context

There is a need to provide a standard mechanism for volunteers, consultants and CALM staff to collect and manage 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.

It aligns with Corporate Priority 2, 6 and KRA 1 (NC 1C), 2 (PVS 2A), 3 (NC 3J), 6 (NC 6A, SFM 6A).

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 provides facilities from entering specimen label information.

Summary of progress and main findings

- The latest version of Max, V3, was released in May, 2005. The new version is a substantial improvement of the previous version and provides better support for name checking, specimen data entry and integration within existing CALM systems.
- Fauna names are now available as a Max database, and new processes within the WA Museum are aiming to maintain faunal names in a similar manner to WA plant names from the WA Herbarium.
- A new interface to support faunal specimen data is under development.

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. This will aid the Department in better integrating its information.

Future directions (next 12-18 months)

- To implement better support for site/species organized databases through customized forms.
- Bring the new fauna specimen collecting book to production.

CALM Regions

All.

IBRA Regions

All.

NRM Regions

All.

Taxonomic Descriptive Data software (DELIA)

Core function

Team member

M Choo (0.1); Total (0.1).

Context

Taxonomic and other descriptive data maintained within the Science Division and other Divisions in CALM are based on authoritative databases managed by the WA Herbarium. These data are dynamic and there is a need to integrate data not only between the descriptive databases and the WA Herbarium's information systems but also between the various descriptive databases themselves. DELIA is a database software that provides this Integration.

It aligns with Corporate Priority 2, 6 and KRA 1 (NC 1C), 3 (NC 3J), 6 (NC 6A).

Aim

To effectively manage Taxonomic Descriptive data in an integrated database environment.

Summary of progress and main findings

- DELIA is being used to manage a number of Herbarium based descriptive databases (e.g. FloraBase, and is currently being used for integrating the Kimberley Weeds with Weeds of Western Australia).
- It provides a useful tool for generating new descriptive data projects by creating templates based on existing corporate data stored in WACENSUS (e.g. It generated templates for the Baeckea project).
- Some code modifications have to be carried out to cater for format changes associated with the release of the new version of WACENSUS.

Management implications

- DELIA provides the necessary integration of CALM's descriptive data with its corporate databases.
- Provides the mechanism for streamlining and simplifying the creation and management of descriptive databases.
- Extends the contribution to descriptive data to those without in-dept knowledge of the DELTA format and applications (e.g. volunteers and other available resources).

Future directions (next 12-18 months)

- Continue to strategically support DELIA software (currently used for flora descriptive data projects) and extend the application of descriptive data to include fauna projects.

CALM Regions

All.

IBRA Regions

All.

NRM Regions

All.

Divisional WAN and corporate database support

Core function

Team member

P Gioia (0.1); Total (0.1).

Context

The Science Division relies on the wide area network and locally based servers to communicate information. It also maintains a number of corporate information systems that utilize the LAN and are based on high-end server technology. In conjunction with ISS (Corporate Services), this infrastructure must be overseen and supported at a whole-of-Division level to meet Divisional requirements.

It aligns with Corporate Priority 12 and KRA 1 (NC 1A, NC 1C), 3 (NC 3C, NC 3J), 6 (NC 6A).

Aim

To maintain the Divisional wide area network through regular maintenance of and updates to

infrastructure; to support the physical maintenance of infrastructure that houses corporate data such as the Divisional website and key corporate systems such as WAHerb.

Summary of progress and main findings

- LAN servers in each major research center are up to date and meeting requirements.
- There are some major performance issues in the line speed between Woodvale and Kensington. Options for improving line speed are being investigated.
- The link between Woodvale and Kensington has been upgraded to a 512k BDSL line, providing a substantial improvement in LAN performance.
- Corporate databases and associated hardware and software licenses (e.g. WAHERB specimen database) are being supported and maintained.

Management implications

- The Division relies on the LAN/WAN infrastructure to communicate effectively. The Woodvale line speed problem needs to be urgently dealt with.

Future directions (next 12-18 months)

- Take advantage of a whole-of-Department improvement in WAN infrastructure. While the current changes have provided a short term improvement in productivity, all links from major remote sites should ideally be serviced by a 1-2Mb link.

Implementation of climate change activities in CALM

Core Function

Team members

R McKellar (0.80), Total (0.80).

Context

Climate is a fundamental determinant of a region's biological systems and taxa. For many years climate was treated as a variable factor within relatively fixed boundaries, with major changes in key climate parameters assumed to occur beyond planning horizons. Climate change is now apparent in the State's southwest and research indicates significant potential climate change impacts throughout Western Australia. International and national agreements and actions in response to global climate change can support the Department's interests or impede progress towards ecological sustainability.

It aligns with Corporate Priority 3, 6 and KRA 2 (NC 2B, PVS 2A), 3 (NC 3C, NC 3I), 6 (NC 6A, SFM 6A).

Aims

- To contribute to state, national and international understanding, agreements and activities related to climate change and biodiversity.
- To promote possible benefits from climate change initiatives such as carbon sequestration credit values.
- To integrate climate change within the Department's policy, planning and management initiatives.
- To represent the Department on state and national climate change bodies.
- To co-ordinate the implementation of State climate change initiatives for which the Department is responsible.

Summary of progress and main findings

- WA Greenhouse Strategy completed and released.
- CALM climate change - biodiversity strategy drafted.
- Reviewed existing climate change – biodiversity modelling study (Pouliquen-Young, 2001) for AGO. Reviewed international approaches to climate change – biodiversity modelling. Developed

plan for climate change – biodiversity research (including modelling) for WA.

- Contacts and discussions with CALM's south-west regions and with CALM's planning branches to advise on climate change science and implications.
- Department represented on Greenhouse IDC, IOCI, state carbon sequestration working group and national NRM climate change working groups.
- Contributed to implementation of key WA Greenhouse Strategy Action 5.5 concerned with integrated assessment of vulnerability of SW WA to climate change.
- Provided core input and support for ongoing climate research for WA (IOCI3).

Management implications

- Climate change is likely to have implications for all aspects of CALM's activities.

Future directions (next 12-18 months)

- Advise internally regarding the implementation of Departmental activities and reporting for WA Greenhouse Strategy actions not related to biodiversity (e.g. greenhouse gas emissions, etc).
- Implement Departmental reporting for National Climate Change and Biodiversity Action Plan.
- Represent WA in development of national climate change adaptation framework.
- Co-ordinate or liaise with KP Article 3.4 research (revegetation, rangeland regeneration, etc).
- Test the updated BioClim modelling framework and investigate options for effective climate modelling for WA circumstances; co-ordinate climate change–biodiversity modelling.
- Provide updated climate change data in central information system for policy and planning use.
- Provide climate change – biodiversity information to public on website and through Landscope, and other mechanisms.
- Develop collaborative research initiatives with overseas (e.g. South African) and local scientists.

CALM Regions

Potentially all.

Management of terrestrial bioprospecting in CALM

Core Function

Team members

R McKellar (0.20), D Coates (0.05); Total Science Division (0.25). K Atkins, G Wyre (Nature Conservation Division).

Context

Bioprospecting is a means of generating knowledge about the capacity for Western Australia's biota to provide materials used to develop or improve medical, botanical or veterinary treatments or pesticides. CALM is responsible for licensing access to terrestrial biota; CALM is able to form licensing agreements for access to terrestrial flora with a view to ensuring sustainability and appropriate benefit sharing.

It aligns with Corporate Priority 1 and KRA 6 (NC 6A).

Aim

To manage access to Western Australia's terrestrial flora for bioprospecting purposes in a manner that is efficient, and equitable.

Summary of progress and main findings

- Bioprospect Pty Ltd licence admended.

Management implications

- There is potential for revenues from royalties should drug discovery and development from bioprospecting succeed.

Future directions (next 12-18 months)

- Amend Bioprospect Pty Ltd licence further in line with Government's response to draft Business Plan.
- Resolve differing legislative approaches (a) to flora and other terrestrial biota and (b) to terrestrial and other (e.g. marine) biota.
- Contribute to WA Biodiversity Conservation Act and Strategy as they are completed.
- Respond to further commercial and institutional interest in bioprospecting as it arises.

CALM Regions

Potentially all.

Biometrics

Core Function

Team members

M Williams (0.60), A Mellican (0.8); Total (1.4).

Context

Scientific studies into any aspect of the State's biota must be underpinned by a statistically sound project design and the results analysed with suitable methods. Just as every one of the Science Division's projects are assessed by Program leaders, for relevance to the Department's aims, every project is also assessed by the Biometrics staff to ensure that the project design is efficient and has the necessary rigour to answer the research questions posed.

It aligns with Corporate Priority 6, 12.

Aims

- To raise and maintain standards of research planning and analyses by: (i) Collaborating with staff in statistical analysis of data sets; (ii) Training staff in new methods of analysis; and (iii) Assessing all draft manuscripts ready for publication for statistical appropriateness and rigour.
- To ensure efficient experimental design by: (i) Assessing all science project plans for statistical rigour; and (ii) Providing biometrical advice to Science Division and other parts of CALM upon request.
- To extend links with regional and district staff, providing a statistical consulting service within CALM.

Summary of progress and main findings

- Science Project Plan and Manuscript databases acquired and upgraded.
- Paper on sampling groundwater fauna drafted (S Eberhard and S Halse).
- Paper on effects of mining on *Tetratheca paynterae* drafted (C Yates).
- Statistical advice provided to Birds Australia project on Carnaby's Cockatoo and WESTERN SHIELD.
- Paper on decline of Australian mammals drafted (N McKenzie).

Management implications

- Biometrical scrutiny before studies commence and of scientific papers prior to submission helps safeguard technical standards, and provides confidence to managers that recommended changes to policy and operations have a sound statistical basis

Future directions (next 12-18 months)

- Continue to assess all SPPs and manuscripts for statistical rigour.
- Analysis of FORESTCHECK data at the completion of first 5 yrs.
- Finalize analysis of Tutanning, Stirling Range, Gray and Kingston datasets.
- Review Western Shield monitoring protocol and woylie decline data.
- Provide ongoing advice within and outside Science Division as required.

CALM Regions
All.

Management of Science Division corporate web sites

Core Function

Team members
B Richardson (0.2), BS Mahon (0.05), B Mathiesen (0.05), L Wright (0.05), M Choo (0.05); Total (0.40).

Context
A final step in biodiversity research is to communicate the research results to the general community (KRA 6.1). Science Division's Intranet and Internet websites perform this role. Educators, students, environmental consultants, the tourism and mining industries and other sectors of the community rely on the availability of scientific information for their day-to-day work.

A web presence for the Division aligns with this need, and provides real-time access to the information generated by Divisional staff.

The Intranet site provides staff with access to information with an internal focus, including documents crucial to the day-to-day management of the Division.

It aligns with Corporate Priority 8 and KRA 2 (PVS 2A), 6 (NC 6A, SFM 6A).

Aim
To maintain Science Division's presence both on the Intranet and Internet.

Summary of progress and main findings

- Incorporated Annual Research Activity Report 2004–2005 into Internet site (09/2005).
- Published latest Conservation Science WA journal issue—Volume 5 Number 2 (09/2005).
- Reworked Dreamweaver templates so they use the newer nested template feature available in Dreamweaver 2004. This permits easier site-wide changes (as may be required in NatureBase upgrade) (12/2005).
- Fixed issue with CONSLib database mirror that prevented librarian from changing to a new database structure that required over 150,000 records to be stored (02/2006).
- Fixed software associated with the CONSLib mirror database so it continued to function after the upgrade (02/2006).
- Completed an upgrade to Staff Profiles such that email addresses are hidden from email harvester software used by spammers (04/2006).
- Completed migration of Staff Profiles into a database (04/2006).
- Managed upgrade of MySQL database system on Biome for the benefit of WorldWideWattle and the Staff Profiles databases (05/2006).
- Presented proposal to SMT on migration of Science Division Internet web site into the new NatureBase, planned for release in mid-June (04/05/2006).
- Managed consultant's work on WorldWideWattle, specifically his access to the Biome server,

MySQL database system, and other issues (ongoing).

- Upgraded content in Staff Profiles, including Find An Expert keywords (ongoing).
- Began work to migrate Science Division Internet web site into the new NatureBase (05/2006).
- Maintenance of all sites (ongoing).

Management implications

- Need for well written articles on topics of interest to CALM from Science Division, particularly those that explain scientific concepts in a way that the lay person might find interesting.
- Continue to fill the gap in publishing focus between NatureBase (very breezy) and the scientific literature (very technical).
- Avoid reliance on time-dependent content (particularly news items) so that the sites require changes less often but maintain currency for a longer period.
- Consider how the new NatureBase affects the way in which information is contributed to the Division's web presence.

Future direction

- Training in use of Joomla Content Management System (CMS) for some staff in the Division may be a priority.

PERTH OBSERVATORY

Program Leader: Dr James Biggs

Astronomical Outreach and Education

Core Function

Team members

J Biggs (0.2), D Frew (0.35), R Martin (0.2), A Verveer (0.3), J Bell (0.2), A Williams (0.25), J Pearse (0.3), R. Tonello (0.5), G Lowe (0.5), D Johns (0.4); Total (3.2).

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 projects are long-term worldwide collaborations.

Aims

- To provide relevant and timely education services.
- To demonstrate science in action.
- To facilitate the development of the tourism potential of astronomy.

There is a significant demand for astronomy education services from many different groups and individuals within the community. Conduct of this project directly addresses the State Government's 'Innovate WA' Policy objective of *'strengthen and improve the educational and research capacity of the state'*.

Summary of progress and main findings

- Provision of lectures, talks, workshops etc.
- Provision of astronomy activities for visitors; star viewing, guided tours, astronomy field nights etc.
- Measurement of customer satisfaction and perception of quality, that is then used to assist improve service delivery.
- Development and marketing astronomy education resources.

Most of the milestones for these activities involved the maintenance of the level of activity and user participation. Activity 2 was enhanced by providing comet viewing nights for the public around the time of the impact on Comet Tempel 1 space mission, Deep Impact. Also, astronomy education was delivered to the public via the world's first 'Astronomy Comedy Sky Night' at a professional observatory. Both events were well attended.

Observatory educational resources were expanded by collaborators in the US (the University of California, Berkeley, and the Lawrence Hall of Science) who provided a telescope (the Real Astronomy Experience telescope, RAE), and ancillary equipment and software that is to be accessed by students world wide via the Internet. This telescope was formally opened by the Minister for the Environment in December, 2005. Our external partners have written many times praising the Observatory's efforts that directly contributed to the success of this project. The telescope has been accessed by many students in the USA and Japan, and in Perth.

The Observatory was formally entered on the State Heritage Register in July 2005, not only in recognition of its rarity and historical importance, but also because of its ongoing educational, scientific and social values.

Activity Measures

Star Viewing Sessions	183	151	212	178	185
Night Visitors	5420	5170	7246	5653	6107
Daytime guided tours	37	48	80	146	122
Day visitors	1179	1716	2504	4119	3607
Astronomy Field Nights	24	29	18	23	27
Field Night attendance	1244	3293	1524	2496	2833
Lectures and Talks	47	71	49	82	89
Talk attendance	1748	3067	1283	1990	2899
Student consultations	19	15	17	86	57
Customer satisfaction (star viewing and guided tours)	-	98%	98%	94%	94%
Astronomy awareness raised	-	97%	98%	95%	95%
Educational quality	-	98%	98%	98%	96%

(*for 1 July 2005 to 31 May 2006)

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. Promotion and training students in the use of the Internet telescope will consume a significant amount of Observatory resources.

Future directions

It is planned to continue the current activities, with similar milestones. Additional milestones include:

Activity 2 - Provide an infra red night vision activity on star viewing nights.

Activity 4 - Develop and market astronomy education resources - creation of a new educational resource – teacher resource kit, promote and train students in the use of the RAE Internet telescope, construct and test a second Internet telescope provided in collaboration with Clarion University, USA.

Astronomical Information Services

Core function

Team members

J Biggs (0.2), D Frew (0.2), R Martin (0.1), A Verveer (0.1), J Bell (0.2), A Williams (0.1), J Pearse (0.1), R. Tonello (0.1), G Lowe (0.1), D Johns (0.2); Total (1.4).

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.

Aim

To provide relevant and timely astronomical information.

There is a significant demand for astronomical information from many different groups and individuals within the community. Furthermore, State law requires provision of certain astronomical information. Conduct of this project addresses the State Government's 'Innovate WA' Policy objective of '*strengthen and improve the educational and research capacity of the state'*.

Summary of progress and main findings

Key activities in this core function include:

- Provision of astronomical information in response to enquiries (via telephone, email etc).
- Communication with the media regarding astronomical issues and events.
- Provision of up-to-date information resources.
- Provision of astronomical information via the WWW.
- Promotion of Perth Observatory astronomy.
- Restoration and preservation of Perth Observatory archives.

Most of the milestones for these activities involved the maintenance of the level of activity and user participation. During the course of the year the Observatory produced 9 minor publications of an information/education nature.

Activities 2 and 5 were advanced with the wide ranging interest in Perth Observatory's major role in the discovery of an Earth-like planet. The discovery was mentioned in over 50 newspapers or other publications, ranging from local publications and Australian papers, such as the 'Sydney Morning Herald' and 'The Australian', international ones like 'National Geographic News', 'The Independent' (UK), and 'CBC News', Canada, all the way to regional newspapers like the 'Calcutta Telegraph' and the 'Jackson Hole Star Tribune', from Jackson Hole, Wyoming.

Another source of communicating astronomy via the media occurred during the Deep Impact comet collision experiment. ABC radio conducted a live broadcast from the Observatory on the night of this event.

Observatory informational resources were expanded by collaborators in the US (the University of California, Berkeley, and the Lawrence Hall of Science) who provided a telescope (the Real Astronomy Experience telescope, RAE), and ancillary equipment and software, that can to be accessed by students world wide via the Internet.

Observatory promotion and information provision via Activity 4 has been dramatically enhanced by a substantial upgrade of the Observatory website. An in-kind donation of approximately $2,000 worth of web design has improved the aesthetics of the site and its number of pages was more than doubled.

Activity 5 has also involved the creation and display of 2 posters that highlight the Observatory activities.

Activity Measures

Activity	2005/2006*	2004/2005	2003/2004	2002/2003	2001/2002
Telephone enquiries	14,655	11,516	19,095	9,872	11,138
Information line	2935	1996	3416	1,462	1,001
Email enquiries	447	543	519	562	535
No. talks, lectures etc	47	20	49	82	89
Talk attendance	1748	1532	1283	1,990	2,899
Consultations	36	20	20	86	57
Newspaper, radio & TV	161	105	147	136	149
www page hits	880,000	709,572	2,200,704	1,116,079	875,783
Positive responses to 'quality' question in customer surveys	-	98%	98%	98%	98%
Satisfaction of information requests as they occur	-	98%	92%	98%	99%

(*for 1 July 2005 to 20 June 2006)

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. Promotion and training students in the use of the Internet telescope will consume a significant amount of Observatory resources.

Future directions

The activities and milestones remain essentially the same for 2005/065. The activities are detailed above and most milestones entail the maintenance of the level of activity at least at the previous year's level. Activities 3 and 4 include the promotion, and training students in the use, of the RAE Internet telescope, and establishment of a second Internet telescope provided in collaboration with Clarion University, USA.

Astronomical research

Core function

Team members – (details are provided under each SPP, below)

Context

This core function involves the utilisation of research facilities and capitalises on its isolated location. Most of its projects are long-term worldwide collaborations. It aligns with Corporate Priority 12.

Aims

- To provide astronomical research in the following areas:
- Monitoring brightness changes in stars, comets, gravitational lensing events and other celestial bodies, and participate in their further study.
- Determining positions of minor bodies (asteroids and comets) and targets of opportunity and forwarding these to the International Astronomical Union for publication and dissemination.
- Searching for extra-galactic supernovae in low-redshift spiral galaxies.
- Testing the suitability of appropriate Western Australian sites for astronomical observations.

This program directly addresses the State Government's 'Innovate WA' Policy objective of *'strengthen and improve the educational and research capacity of the state'*, and with a recommendation in the Final Report of the (Australian) Innovation Summit Implementation Group; Innovation: Unlocking the Future (2000), 'Publicly funded basic research plays an important role in supplying much of the knowledge, skills and new ideas critical to a competitive and innovative economy.'

Summary of progress and main findings

Progress in individual projects is detailed below for each SPP. Observatory staff published one paper in refereed international journals and another 2 in minor publications (poster papers, abstracts etc). 100% of referred papers submitted were published (100% in 04/05).

Management implications

- There is ongoing external demand for scientific collaborations that exploit the Observatory's isolated location.
- Continued government support of the Observatory's scientific activity provides substantial evidence that it is serious in its endeavours to attract to the state the SKA, the world's largest radio telescope.

The details for each SPP are discussed below.

Variable star observations

SPP # 98/0009

Team members

J Biggs (0.01), D Frew (0.1), R Martin (0.01), A Verveer (0.02), A Williams (0.01), J Pearse (0.02), R Tonello (0.03), G Lowe (0.03); Total (0.23).

Context

This SPP involves a long-term worldwide collaboration involving the study of variable stars. It aligns with Corporate Priority 12.

Aim

To monitor the brightness of variable stars. This will lead to an increased knowledge of the structure and processes within stars.

Summary of progress and main findings

- Staffing shortages led to a minimal number of observations being undertaken.

Future direction

Participation in international variable star monitoring programs will continue as time and resources permit, with the milestone remaining 'the successful observations and reduction of data for publication'.

Imaging and spectrophotometry of comets

SPP # 98/0010

Team members

J Biggs (0.01), D Frew (0.01), R Martin (0.01), A Verveer (0.02), A Williams (0.01), J Pearse (0.02), R Tonello (0.03), G Lowe (0.03); Total (0.23).

Context

This SPP involves a long-term collaboration with US astronomers in the study of comets. It aligns with Corporate Priority 12.

Aims

- To monitor cometary brightness changes in specific wavelength bands.
- To observe comets over a wide range of heliocentric distances both pre-perihelion and post-perihelion.
- To image the coma and tail(s) for specific structural features. This will facilitate a comparison between the various cometary families and build a database of cometary properties.

Summary of progress and main findings

Observations were acquired in July 2005 with the Perth Lowell 61cm reflector of 9P/Comet Tempel1 as part of the Deep Impact mission.

Future directions

- Commissioning of an automated focuser for the PLAT in 2005 should facilitate an increased number of observations.
- Our partners at Lowell Observatory will undertake high priority observations as they occur.

Imaging and CCD photometry of transient and variable sources

SPP # 98/0011

Team members

J Biggs (0.04), D Frew (0.1), R Martin (0.01), A Verveer (0.02), A Williams (0.01), J Pearse (0.02), G Lowe (0.03), R Tonello (0.03); Total (0.17).

Context

Suitable targets are imaged and processed as appropriate. It aligns with Corporate Priority 12.

Aims

- To 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.
- To increase knowledge of the structure and processes within stars.

Summary of progress and main findings

A student project report detailing the monitoring of the star SS2883 was published. An upper limit of 2% to its change in brightness was calculated. Astrophysical interpretation of this result is required.

Another student project has been initiated to obtain basic photometry of stars being occulted by asteroids. This can provide accurate size and shape information for the occulting asteroid.

Future directions

Suitable targets will be observed as time and resources permit. Future observations will be conducted using the 35-cm Real Astronomy Experience (RAE) telescope and Clarion University telescope.

Astrometry of minor planets, comets and targets of opportunity

SPP # 98/ 0012

Team members

J Biggs (0.20), D Frew (0.01), R Martin (0.01), A Verveer (0.02), A Williams (0.01), J Pearse (0.02), G Lowe (0.24), R Tonello (0.24); Total (0.75).

Context

This SPP involves a long-term worldwide collaboration to track and discover asteroids and comets. Targets of opportunity are also observed as appropriate. It aligns with Corporate Priority 12.

Aims

- To measure the position of minor bodies, so as to determine their orbits. This 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 specialized types of observation (and these not need be restricted to the visible part of the electromagnetic spectrum).
- To 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 and main findings

In 2005/2006*, a total of 16 (13 asteroid and 3 comet) minor body positions were published. Observations are now acquired with 35-cm Real Astronomy Experience (RAE) telescope.

Future directions

Monitoring of NEOs will continue with the milestone an increased number of published positions. The internet telescopes ability to observe in a scheduled mode should increase the number of observations acquired. Also, the search of the Earth's Lagrangian points for asteroids will be continued.

*As at 20 June 2006.

Monitoring gravitational microlenses

SPP # 98/0013

Team members

J Biggs (0.01), D Frew (0.01), R Martin (0.25), A Verveer (0.03), A Williams (0.30), J Pearse (0.03), G Lowe (0.03), R Tonello (0.03); Total (0.69).

Context

This SPP involves a worldwide collaboration that uses the gravitational microlensing effect to gain information about our galaxy, its stars and their planetary companions. It aligns with Corporate Priority 12.

Aims

- To use precise light curve measurements in order to characterize the statistics and kinematics of Galactic microlensing events.
- To detect extra-solar planets.
- To gather information on the stellar population in and around the Galactic Bulge.

This is achieved through an international collaboration - PLANET - with 32 members affiliated with 18 institutions in 10 countries. Access to telescopes in Perth, South Africa, the Canary Islands, Chile, Hawaii and Tasmania (ranging from 0.6m to 2m) allows 24-hour monitoring during the bulge season (May - August).

Summary of progress and main findings

Discovery of an extra-solar planet, the smallest ever discovered, and the most like the planets in our solar system. Perth Observatory data was crucial for this discovery. This resulted in a paper in the journal 'Nature', and worldwide publicity. Perth Observatory was mentioned in over 50 newspapers or other publications, ranging from local publications and Australian papers, such as the 'Sydney Morning Herald' and 'The Australian', international ones like 'National Geographic News', 'The independent' (UK), and 'CBC News', Canada, all the way to regional newspapers like the 'Calcutta Telegraph' and the 'Jackson Hole Star Tribune', from Jackson Hole, Wyoming.

The Perth-Lowell Automated Telescope is used in fully automated mode, with PLANET members anywhere in the world able to adjust target selection and sample rates (based on real-time data reduction and automatic modelling), via an online 'homebase' control system. Perth observatory is the only telescope in the collaboration with this facility - most other telescopes require an observer to be present all night, every night. The telescope was used to contribute to the data gathering during the previous PLANET observing season, as well as staff contributing to the data reductions. Perth Observatory staff constructed the web pages and homebase control system for the PLANET site. One refereed paper and one other were published.

Future directions

A supplementary paper concerning the planet discovery is in preparation. The May-September 2006 ‘bulge season’ is underway, with several promising events already. A commercial automated focuser for the PLAT has been purchased, and is still awaiting work to fit it to the telescope - this should result in a large improvement in the data quality and number of useful images taken.

Supernova search

SPP # 98/0014

Team members

J Biggs (0.01), D Frew (0.01), R Martin (0.3), A Verveer (0.02), A Williams (0.25), J Pearse (0.02), G Lowe (0.03), R Tonello (0.03); Total (0.67).

Context

This SPP involves a long-term study of supernovae - an endpoint in stellar evolution. It aligns with Corporate Priority 12.

Aims

- To contribute to the broader study of supernovae by employing methodical search techniques to detect supernovae at early stages of their evolution.

- To make an independent determination of the supernovae rates within late spiral galaxies.
- To do additional research on the supernovae found. For example collect photometric light curves of supernovae discovered by Perth Automated Supernova Search.

The Perth Automated Supernova Search is a search for extra-galactic supernovae in low redshift spiral galaxies. The search uses the 61-cm Perth Lowell Automated Telescope (PLAT) at the Perth Observatory.

Summary of progress and main findings

- One supernova was discovered, SN2006BC, and photometry of the event was collected on 25 nights. Two other supernovae were recovered.
- Work began on the preparation the supernova rates paper based on the observing logs (database) of the supernova search. Initial supernova rates have been calculated.
- The light curves for SN2004S have been modeled and the distance to it host galaxy has been calculated. A draft paper has been written, however a search for a technique to support the modeling in still in progress. No other independent estimates have been made of the distance to the host galaxy MCG -05-16-21.

Future directions

A paper concerning SN 2004S will be submitted for publication and detailed analysis of observations of SN 2005BC will commence. Also, the list of galaxies monitored will be increased. .A commercial focus unit has been purchased and will be used to automatically focus for the PLAT. Development of the software to control the focuser and the mounting of the unit on the telescope should be finished this year.

Astronomical evaluation of sites in WA for observation

SPP# 00/0006

Team members

J Biggs (0.02), D Frew (0.01), R Martin (0.06), A Verveer (0.02), A Williams (0.01), J Pearse (0.02), G Lowe (0.01), R Tonello (0.01); Total (0.16).

Context

This SPP involves evaluation of various sites regarding their suitability for astronomical observations. It aligns with Corporate Priority 12.

Aim

Testing appropriate Western Australian sites regarding their suitability for astronomical observations. This will provide information necessary for the planning of future facilities.

Summary of progress and main findings

Diminished financial and staff resources precluded any progress in this project in 2005/2006.

Future directions

This site evaluation project will result in a paper detailing the preliminary results of conditions for optical astronomy observing in WA. Also, observations at other sites will be conducted as resources allow.

STUDENT PROJECTS – PROGRESS REPORT

The following reports were supplied.

Scientist: **I Abbott**
Student: T Simmons

Project title
Establishing bird community indices in the Jarrah forest of southwest Western Australia

Progress report
Statistical analysis of the data collected in the period 2001-4 has been completed and writing of the thesis has commenced.

Scientist: **I Abbott**
Student: M Williams

Project title
Conservation and ecology of Western Australian butterflies

Progress report
The field work component of the 3 main projects in this study, namely (i) a methodological study to determine optimum sampling strategies; (ii) mark-recapture studies of 2 rare butterfly species to examine population changes after fire; and (iii) regular surveys to quantify changes in abundance and richness of the day-flying Lepidoptera following fire) has been completed.

A draft manuscript prepared for the project has been completed and a report on the butterfly faunas of the over 40 sites included in the project has been distributed to stakeholders.

Scientist: **I Abbott**
Student: P Van Heurck

Project title
The compositional, structural, and functional succession of beetle communities in habitat mosaics created by 3 different fire regimes in the southern forests of Western Australia

Progress report
In March 2003 an intense wildfire, in heavy fuels, burnt approximately 20 000 ha 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 2 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.

Initially 18 sites have been established (3 fire regimes x 3 landscape types: forest ridge, forest slope or swamp heaths x 2 replicates each). Within each site a number of distinct projects have been designed to: 1) inventory the regional beetle fauna and locate short range endemic species; 2) monitor the appropriate spacing between pitfall traps to most effectively analyse the local beetle fauna; 3) collect litter samples to compare the fire impact on the beetle fauna of this microhabitat; 4) determine the reliability of using morphospecies within the beetle families; and 5) seasonally trap each site to compare the impact of the differing fire regimes on the composition and productivity of local beetle communities as surrogates of overall invertebrate biodiversity.

At each site, pre-mosaic fire pitfall trapping and litter collection commenced in December 2004 and was repeated in January, February, April, July and October 2005, and February and April 2006. 203 arthropod morphospecies have been distinguished to date, of which 20.7% are beetles as predicted. The first 'small grain' mosaic fire was lit by helicopter in mid April 2005, but went out after burning about 5% of the forest block, due to low fuel quantity and high litter moisture. This treatment was re-applied in January 2006, when fuel loadings were heavier. These January 2006 fires resulted in approximately 20% of London block being burnt with a diversity of fire intensities and in a patchy mosaic pattern.

Scientist: **D Algar**
Student: S Hilmer

Project title
Energetics and thermoregulation of feral cats

Progress report
The thesis has been completed and the student is now furthering research on the topic through a PhD.

Scientist: **M Byrne**
Student: E Dalmaris

Project title
Wandoo decline: ecophysiological and genetic variation among provenances

Progress report
Eucalyptus wandoo is an endemic species of the south-west of WA and is one of the main tree species of the wheatbelt region. Over past decades Wandoo has suffered huge habitat losses due to the clearing of forest and woodlands for agricultural production. Now it is under the threat of crown decline.

This project is investigating the complex ecophysiology of Wandoo and its environment and characterizing Wandoo germplasm. A glasshouse experiment using ecophysiological techniques (e.g. water potential measurements, gas exchange measurements) to investigate the tolerance of Wandoo to moderate levels of salinity has been completed for 30 populations that cover the distribution. Data analysis is currently being carried out. A second glasshouse experiment to assess drought tolerance of the same 30 populations is in progress.

Scientist: **M Byrne**
Student: N George

Project title
The development of Koojong (*Acacia saligna*) as a deep-rooted perennial crop species for southern Australia

Acacia saligna is native to south-western Australia, and is used widely around the world as a source of livestock feed. .*Acacia saligna* has the potential to be used more widely as a fodder crop in southern Australia, where it will assist with dryland salinity management. The aim of this project is to gather information about *A. saligna* that will facilitate its development as a crop plant.

A study of the genetic variation in *A. saligna* has been completed and shows the presence of three genetic groups that are significantly divergent and likely to represent different taxa. A research article based on the findings from this work has been submitted to the journal *Tree Genetics and Genomes*. Variation in the feed quality of *A. saligna* at the population level has been completed and shows that one of the genetic variants has feed quality values that would be suitable for stock. A research article based on the findings from this work is about to be submitted to the journal *Animal Feed Science and Technology*. The findings will contribute towards the domestication and use of *A. saligna.* Other research work examining the mating system and reproductive biology of *A. saligna* is currently being analysed.

Scientist: **M Byrne**
Student: D Nicolle

Project title
Systematics of the southern Australian mallees, *Eucalyptus* series Subulatae (Myrtaceae)

Progress report
Eucalyptus series Subulatae is a group of poorly known mallee and tree species distributed across the southern half of the Australian mainland, with greatest taxonomic diversity in the highly fragmented wheatbelt regions of Western Australia and South Australia. This study aimed to delimit taxa within the series and establish evolutionary relationships between the delimited taxa within the series, as well as assessing the relationship with other putatively closely related series. Both morphological and molecular methodology has been used to fulfil these aims. A better understanding of taxonomic limits and relationships will enable the conservation assessment and management of the taxa within the series, which includes some rare and poorly known taxa.

Taxonomic revision of three groups within the series Subulatae has been published. Phylogeographic patterns within the series show broad geographical lineages within the series although co-occurring taxa do not share haplotyes. Therse geographic lineages show substantial divergence from approximately 2 million years ago.

Scientist: **M Byrne**
Student: M Millar

Project title
An assessment of genetic risk to natural biodiversity from agroforestry revegetation

Progress report
Acacia saligna is a native woody perennial identified as warranting further commercial development for use in agroforestry. Wide-scale plantings of *A. saligna* as a perennial crop will produce environmental and economic benefits, however they may also pose risks to natural biodiversity in certain areas through invasiveness and gene flow via pollen. This project aims to make recommendations for use in assessing and minimizing the risk posed by *A. saligna* plantings due to invasiveness in South Australia and develop guidelines for determining suggested isolation distances between agroforestry plantings and natural populations in Western Australia.

An *A. saligna* microsatellite library has been developed for use throughout the project and gene flow studies for two sites are in progress. This will provide information on the levels and distances of gene flow occurring at these sites. Assessments of flowering phenology for different variants were made in spring and will be repeated this year. Seedlings in a glasshouse trial are being monitored for variant and provenance variation in morphological characteristics.

Scientist: **M Byrne**
Student: C Tauss

Project title
Phylogeny, phylogeography and conservation of *Reedia spathacea* in south-western Australia

Progress report
The high rainfall zone of south-west Western Australia is a globally significant centre of diversity for the large family Cyperaceae (sedges). However the evolutionary relationships within the family locally have been unclear. *Reedia spathacea* is a rare, monotypic genus restricted to a small number of disjunct wetlands that have Threatened Ecological Community conservation status. These wetlands are regionally atypical as they are maintained by factors largely independent of climate (such as artesian flow from the deep Yarragadee aquifer). These habitats may be long-term refugia for the putative relictual species *Reedia spathacea*.

Chloroplast DNA analysis is being used to investigate the historical genetic variation in the species as significant differentiation between populations would be expected if the species has been occupying refugial habitat over long time frames. RFLP assays have been completed and the data is currently being analysed. Three research papers are currently in preparation: Cyperaceae pollen morphology; A phylogeny of the SW Cyperaceae genera; and A taxonomic treatment of a new species of sedge from the *Reedia* habitat. *Reedia spathacea* was recently recommended by the Threatened Species Scientific Committee as Declared Rare Flora as a result of the monitoring of populations undertaken during this research.

Scientist: **M Byrne**
Student: R Hendrati

Project title
Development of *Eucalyptus occidentalis* Endl. for revegetation

Progress report
Eucalyptus occidentalis is a species that grows naturally in south-western Australia and has been widely grown and utilized. Experiments both in controlled conditions and in the field have shown that this species can be classified as highly tolerant to salt and/waterlogging. *Eucalyptus occidentalis* is potentially an effective species for rehabilitation and reclamation of saline areas.

This project will provide genetic improvement for this species through selection and crossing of trees with improved saline and waterlogging tolerance. Genetic assessment of the germplasm will enable wide crossing to maximize the genetic gains in the traits. Gene flow through pollen dispersal will be studied to determine the mating pattern within stands.

Illegal harvesting of wood is a worldwide problem in both developing and developed countries and certification and identification of wood is becoming an important issue. Illegal harvesting of timber from protected areas is an issue for CALM and genetic identification of logs would enable greater regulation of this problem. Trials of DNA extraction from wood of 3 species *Eucalyptus occidentalis*, *Eucalyptus marginata* and *Eucalyptus globulus*, have commenced.

Scientist: **M Byrne**
Student: C Jones

Project title
Indian Sandalwood: Genetic diversity and essential oil biochemistry of the Australian germplasm collection

Progress report

The heartwood of mature Sandalwood trees contains sesquiterpene essential oils which have been used for centuries in the manufacture of perfumes, incense and joss sticks. The timber is extremely valuable and harvesting from natural stands has led to deterioration of the natural populations. Plantation sandalwood provides an alternative source of timber to meet the demand for sandalwood products. Both Western Australian Sandalwood, *S. spicatum*, and Indian Sandalwood, *S. album*, are highly variable in oil yield and heartwood content and successful plantation development requires an understanding of this variation and the factors that influence it.

The genetic diversity of the Australian germplasm of Indian Sandalwood will be determined and correlated with the heartwood contents, oil yields and compositions. DNA has been extracted from collections of *S. album*, *S. austrocaledonicum* and *S. macgregorii* and genetic analysis is being carried out. The biosynthetic pathway of sesquiterpene biosynthesis in sandalwood will be investigated through cell-free extracts of oil-containing heartwood and isotopic labelling experiments, as well as cDNA library construction, gene probing and cloning.

Scientist: **M Byrne**

Student: S Stankowski

Project title

Pollen dispersal in the rare, bird pollinated shrub, *Calothamnus* sp. Whicher

Progress report

Calothamnus sp. Wicher is a rare, narrow endemic shrub that is restricted to the Whicher range in south-western Australia. Due to extensive habitat clearing for mining and agriculture, the species is fragmented across most of its distribution. While some large populations do exist in remnant native vegetation, most populations are small and restricted to road verges where habitat quality is poor.

The aims of the project are to determine mating system and extent of pollen dispersal in the populations in relation to spatial isolation, habitat quality and population. This will be achieved using paternity assignment techniques using molecular markers. Parental plant material has been collected from all plants in seven populations, and DNA has been extracted from each sample. Genetic analysis is currently being undertaken. Seed has been collected from 10 plants in three of the populations and is currently being grown for DNA extraction.

Scientist: **M Byrne**

Student: H Nistelberger

Project title

Assessment of genetic differentiation between subspecies of the rare shrub *Grevillea curviloba*

Progress report

Grevillea curviloba is restricted to the Muchae limestones and is known from very few populations. There are currently two subspecies recognized and these are both ranked critically endangered, Recognition of the subspecies is based on differences in leaf morphology but this character is not reliable as a morphometric analysis did not separate the two subspecies. A genetic analysis is being undertaken to determine whether the two subspecies show any genetic differentiation that would support maintenance of their subspecific rank.

Genetic analysis showed high levels of clonality within populations of *G. curviloba* in both subspecies. Genetic diversity was high but most of the variation was maintained between populations. This would be due to the level of high clonality as this would increase the genetic drift between populations. There was little differentiation between subspecies and no evidence of genetic structure within the species. The genetic analysis is consistent with the morpholmetric analysis and does not support the recognition of 2 subspecies within *G. curviloba*. This study suggests a taxonomic revision and reassessment of the conservation status of the species is required.

Scientist: **D Coates**
Student: C Waters

Project title
Developing seed provenance zones for Australian native grasses

Progress report
The use of native grasses either as an understorey or grassland community is largely ignored in revegetation activities due to lack of available seed. Adequate supply of seed is an issue of great strategic importance if revegetation activities are to expand towards large-scale plantings. To increase availability of seed and ensure the adaptive and low input advantages of native grasses are retained we require an understanding the scales of ecotypic variation within a species, its adaptive consequence and the relevance of issues of local provenance. *Austrodanthonia caespitosa* will be used as a model system to investigate these issues.

This study commenced in April 2003, when 2 seminars (CSIRO, Canberra; NSW Agriculture, Trangie) were given outlining the study methodology in accordance to the CSU post-graduate scholarship requirements.

20 - 30 *Austrodanthonia caespitosa* plants have been collected from 23 sites thoughout central and western New South Wales. For each of these, whole plants have been transplanted into a parent nursery at the NSW Agricultural Research Centre, Trangie.

Transplant and common garden experiments are near completion and data analysis underway. Plants from 15 populations throughout the range have been sampled for DNA and AFLP analysis will commence in August 2006.

Scientist: **T Friend**
Student: J Whelan

Project title
To examine the effects of *Phytophthora cinnamomi* on the productivity of fungi and its impacts on mycophagous mammals in south coastal heaths

Progress report
The target species is the bush rat (*Rattus fuscipes*) with comparisons made with the critically endangered Gilbert's potoroo (*Potorous gilbertii*). *P. cinnamomi* has the potential to eliminate susceptible plant species in an area which may form a symbiotic relationship with mycorrhizal fungi, thereby threatening the food resources consumed by these species.

The study sites are located in Waychinicup Nature Reserve and Waychinicup National Park, 65 km east of Albany, and comprise areas unaffected by *P. cinnamomi* and those previously infected by this pathogen. Initial trapping in these sites has been conducted using Elliott traps (1 200 trap-nights so far) and preliminary fungal surveys have been carried out. The various components of the bush rat's diet will be examined, as currently no dietary studies on this mammal have been conducted in Western Australia. The identified fungal material will be compared to the fungi in the diet of the Gilbert's potoroo, to determine if any resource overlap exists and if the fungal species consumed by this critically endangered mammal are potentially affected by *P. cinnamomi.* Differences in fungal productivity between pre- and post-*Phytophthora* infestation will also be assessed.

Scientist: **S Halse**
Student: E Lowe

Project title

Macroinvertebrates and diatoms as indicators of acidity in wetlands of Western Australia

Progress report

The project is examining the merits of diatoms and macroinvertebrates as biomonitors of acidity. The main aim of the project is to identify assemblages of diatoms and invertebrates that are indicative of acidic waters. A further aim is to compare the effectiveness of macroinvertebrates and diatoms as indicators of pH change. 30 wetlands in the south-west of Western Australia were sampled seasonally over a 12 mth period. 20 of these wetlands have been selected for use in the final study. Sampling included diatoms and macroinvertebrates and the measurement of physico-chemical parameters.

Enumeration of samples has been completed. Work is continuing on species level identification of some specimens of diatoms and macroinvertebrates. Drafted sections of the thesis are being reviewed and prepared for first draft submission. Statistical analysis of environmental data is in progress with species data analysis to follow.

Scientist: **S Halse**
Student: C Gouramanis

Project title

Ostracods as indicators of lake conditions and fine–scale climate change in southern Australia

Progress report

The purpose of this project is to obtain environmental and ostracod species data from fresh to saline lakes in south-west Western Australia. These are to be used in conjunction with a larger dataset obtained from Victoria and South Australia by Lynda Radke in order to calibrate and compare the current environmental conditions with past conditions. As such, 26 lakes and swamps were sampled from south-west Western Australia (with J Cocking of CALM), including Rottnest Island, with a number of physical and chemical parameters were measured and analysed by the Department of Industry and Resources Chemistry Centre. The results are currently being analysed using a number of statistical procedures and will soon be applied to a series of cores obtained from Barker Swamp (Rottnest Island) and Two Mile Lake (Stirling Ranges). A number of species have been discovered (approximately 20) with at least 1 new species to be described. These data have already been discussed with S Halse, and will be used for environmental monitoring, palaeoenvironmental reconstruction and biodiversity applications.

Scientist: **L McCaw**
Student: R Archibald

Project title

The role of fire in the decline of Tuart (*Eucalyptus gomphocephala*) woodlands

Progress report

This study is part of a larger ARC Linkage grant that is looking at the possible roles of plant pathogens, insect pests, fire, water relations, nutrition and environmental correlates on Tuart decline. The fire component of the work commenced in February 2003 and is examining the role of fire on Tuart regeneration by seed and resprouting, understorey dynamics, individual fire characteristics and fire regimes.

Experimental fires were conducted at 2 study sites (Yalgorup National Park and Yanchep National Park) in spring 2004 to examine the effect of fire intensity on tree recovery, seedling regeneration and understorey composition following prescribed burning. Both fires were of low intensity and patchy in extent. Initial post-fire measurements have been taken in autumn 2005. The control site for

the study area in Yanchep National Park was accidentally burnt by a wildfire in January 2005.

A historical component is also included in the study. The resurveying of vegetation monitoring plots established in various locations in Yalgorup National Park in the 1970s has commenced. In combination with fire history data and aerial photography time-series, structural and compositional patterns in Tuart woodlands of the park in relation to the fire history are being explored.

Preliminary results have confirmed the capacity of Tuart saplings to recover rapidly after moderate-high intensity fires as well as the importance of the immediate post-fire environment for seedling germination and growth. Tuart seedling growth and survival on ashbeds has been superior to other seedbed types, and *Agonis flexulosa* has been found to not have allellopathic effects on Tuart seedlings.

Studies are currently being written up with a target date of September 2006 for thesis submission.

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 will draw 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 yrs 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.

Work commenced in March 2006 compiling fire history information and a field trip was undertaken to the study area in May.

Scientist: **G Pearson**
Student: T Compton

Project title
Bivalves in a tropical and temperate mudflat: physiological and morphological comparisons

Progress report
Biodiversity differences between tropical and temperate locations are well-known, for instance

Roebuck Bay. Northwest Australia has over 65 bivalve species, whereas the Wadden Sea, North Western Europe has only 15 bivalve species. Reasons for these biodiversity differences are numerous, but there is still a lack of fundamental comparison studies in tropical and temperate locations.

Physiological tolerance tests and morphological measurements have been completed on bivalves from both locations. Experiments have included temperature tolerance tests, hypoxia tolerance, and internal organ measurements. Finally, spatial data from Roebuck Bay will be compared with that of the Wadden Sea to make a comparison of the 'niche' space used by bivalves in both locations.

Practical work is completed. The following year will be a period of analysis and write-up.

Scientist: **C Yates**
Student: A Franks

Project title

Landscape fragmentation and rare plant species: Can we develop a general framework of population responses?

The aims of the project are:

- To categorize threatened plant taxa on the basis of functional attributes, and choose taxa for detailed investigation on the basis of their distribution across the landscape and potential to deliver quantitative data.
- To develop models for each floral architecture functional group on how rates of pollination, seed production, genetic diversity and seed fitness are affected by population size and landscape context.
- To extrapolate information from models for each floral architecture functional group to other taxa in that group to provide guidelines for flora conservation, including translocations, threatened ecological communities and restoration/revegetation programs.

Progress report

- Defined and allocated DRF to floral architecture functional groups.
- Surveyed insect pollinator communities across habitat fragments.
- Measured rates of pollination and reproductive output on selected plant species in each of the functional across habitat fragments.
