ANNUAL RESEARCH ACTIVITY REPORT

July 2004 – June 2005

Science Division

Discovering the nature of WA
http://www.naturebase.net/science/science.html

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 2004/2005.

Over this period staff produced 237 publications, were active on 130 research projects, assisted or supervised 55 mostly PhD students, and developed some 93 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 nine 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	48	Jarrah forest	61-70
Warren	48	Warren	41-50
Swan	42	Avon Wheatbelt, Swan Coastal Plain	31-40
South Coast	35	Esperance Plains, Geraldton Sandplains, Mallee	21-30
Wheatbelt	34	Pilbara, Murchison, Gascoyne, Coolgardie	11-20
Midwest	29		
Pilbara	19		
Goldfields	19		
Kimberley	11		

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

Celebrating 20 Years of Science in CALM

The Science Division constitutes CALM's major investment in terrestrial biological research and survey, which underpins conservation and land management in Western Australia. 2005 represents the 20th anniversary of the formation of CALM and during this period, Science Division staff have produced some 6 075 reports and publications on conservation biology and land management relevant to the Department's mission. This includes 1 085 refereed scientific papers, 91 books and manuals, 395 conference/workshop/symposium papers, 970 popular articles, newsletters etc., 773 abstracts, posters, lecture notes and book reviews, 1 823 reports, recovery plans, management plans, prescriptions and

guidelines, and 938 species accounts. A list of these documents is available online at http://science.calm.wa.gov.au/papers/ or from CALM's Woodvale library.

In addition to this body of knowledge generated by the Division, highlights of the activities of the Division that have made a significant contribution to conservation and land management in Western Australia over the last 20 years include:

- Systematic biological surveys of the Nullarbor, Kimberley Rainforests, Southern Carnarvon Basin and Wheatbelt, and commencement of a biological survey of the Pilbara bioregion. In addition to regional surveys, more than 30 sub-regional and local surveys have been completed over the period. Biological surveys are vital for understanding and documenting the composition and distribution of the State's biodiversity, for assisting with the implementation and management of a comprehensive, adequate and representative conservation reserve system and for informing resource development decisions. About 25-30% of the State has now been surveyed.
- The highly successful fauna conservation program 'Western Shield' was a direct outcome of research that identified the Red Fox as a major threat to native mammals and some birds in south-west Australia. In conjunction with fox control, other key elements of Western Shield's success include fauna translocations and captive breeding programs, which for many species, were pioneered by CALM scientists working in partnership with scientists from other agencies such as Perth Zoo.
- Development and implementation of FORESTCHECK, one of the world's most comprehensive forest biodiversity monitoring programs consistent with best practice in ecologically sustainable forest management.
- Science-based investigations into the effects of disturbances such as logging and fire on forests and other ecosystems, generating knowledge important for appropriate management of these disturbances. Well known examples include the Gray forest Karri avifauna study, the Kingston Jarrah foest integrated study, and the long-term fire impact study at Lindsay, McCorkhill and Yendicup Jarrah forests.
- Development of effective broad-scale aerial baiting strategies to control feral Cats in the interior arid zone.
- Development of integrated strategies for the control of *Phytophthora cinnamomi* using phosphite.
- Establishment of the WA Threatened Flora Seed Centre in partnership with Kew Gardens, Millennium Seed Bank Project.
- Preparation of the first Threatened Flora species list and ongoing systematic assessment of the conservation status of WA flora listed as poorly known but considered to be rare.
- The first formal experimental translocations of critically endangered native plants.
- Addition of more than 300 000 specimens to the CALM Herbarium collection, which now stands at 614 020.
- 84 herbaria are now participating in the Regional Herbaria Network program.
- Development of Florabase, an electronic flora information system widely accessible via the internet for finding out information about the distribution, description and identity of the State's flora.
- Sponsorship of a symposium on fire ecology and management and the editing of a book synthesizing knowledge of fire behaviour and fire ecology in south-west ecosystems.
- Significant advances in understanding fire danger forecasting and fire behaviour prediction in dry sclerophyll forests, heathlands and hummock grassland ecosystems.
- Analysis and reporting on the results of 23 years of monitoring water depth and salinity of significant wetlands in south-west Australia.
- Development of site assessment guidelines for the establishment of hardwood plantations and tree crops in south-west Australia.
- Numerous contributions by Divisional officers to the preparation and implementation of 217 fauna

and flora published and interim recovery plans.

- Investigations into the ecology and biology of threatened species, generating knowledge important for their management and conservation.
- Sustained effort by past and present scientists, in some cases exceeding 25 years, has enhanced the national and international reputation of CALM.
- Partnerships with universities, other research institutions, the private sector and community groups has increased more than five-fold during this period.

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

Dr Neil Burrows
Director, Science Division

July 2005

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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 centres 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.

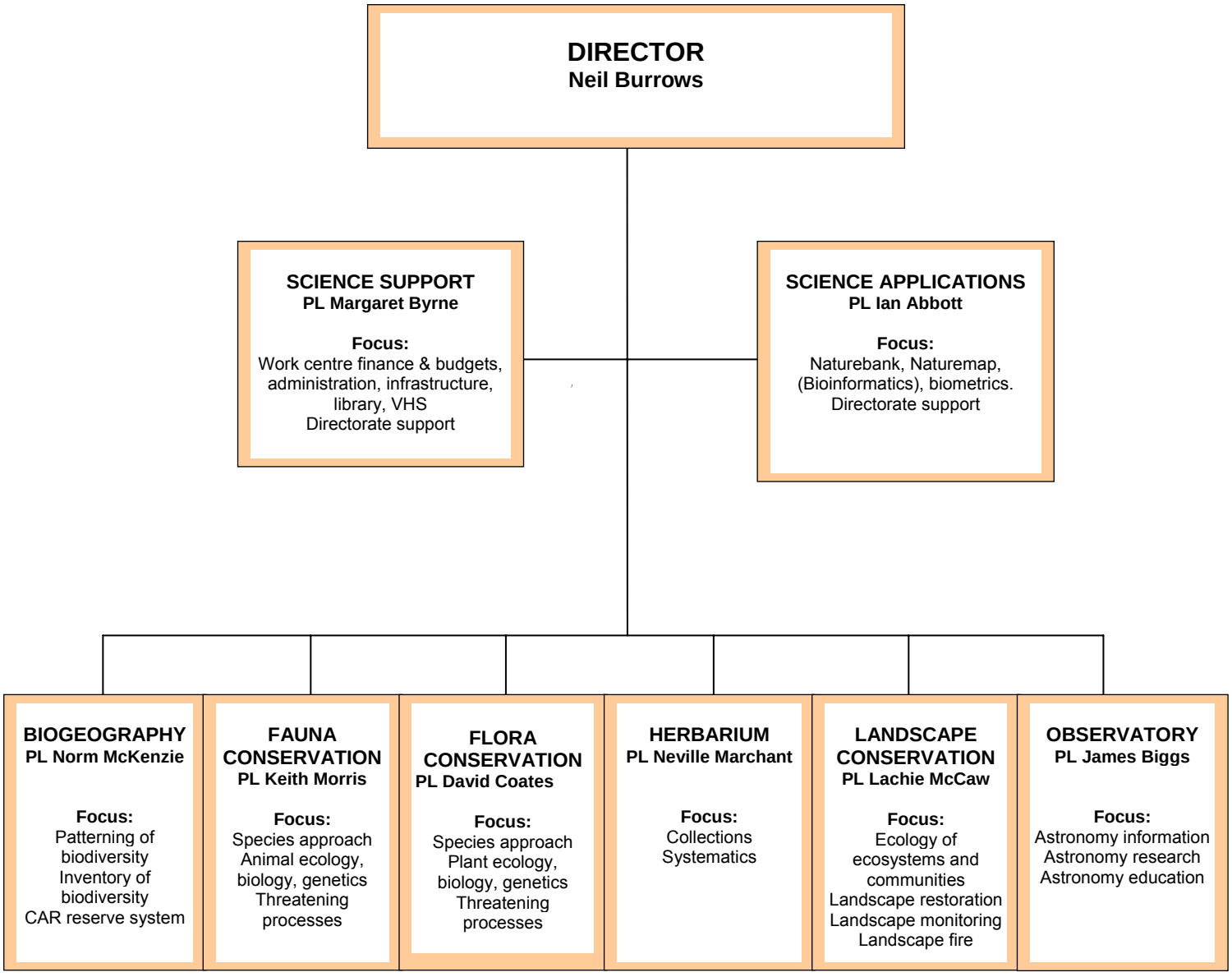
ROLE

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



PUBLICATIONS

1. Abbott I (2004) Aborigines, settlers and native animals: a zoological history of the south-west. *Early Days* **12,** 231-249.

2. Abbott I (2005) Appendix 4: Fauna. In *Western Australian Exploration. Volume One, December 1826-December 1835: the Letters, Reports & Journals of Exploration and Discovery in Western Australia* (ed. J Shoobert), pp. 556-558. Hesperian Press, Perth.

3. Abbott I (2005) An overlooked record of the malleefowl in the interior of Western Australia. *Western Australian Naturalist* **24,** 253

4. Abbott I, Burrows N (2004) Monitoring biodiversity in jarrah forest in south-west Western Australia: the ForestCheck initiative. In *Conservation of Australia's Forest Fauna. - 2nd ed.* (ed. D Lunney), pp. 947-958. Royal Zoological Society of New South Wales, Sydney.

5. Algar D (2005) Feral cats under examination. *Conservation News* **May,** 6

6. Algar D, Angus GJ, Williams MR, Mellican AE (2004) An investigation of bait uptake by feral cats on Peron Peninsula, Western Australia. Department of Conservation and Land Management, Perth.

7. Algar D, Burrows ND (2004) Feral cat control research: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 131-163.

8. Barrett B (2004) Finding the cryptic western ground parrot: a needle in a haystack. *South Coast Threatened Birds News* **9,** 5-6.

9. Barrett B (2004) The first step for a ground dwelling parrot. *Western Australian Bird Notes* **111,** 9

10. Barrett B (2004) History turns another corner for the western ground parrot. *Western Australian Bird Notes* **112,** 14-15.

11. Barrett B (2004) Hit the ground running!. *South Coast Threatened Birds News* **8,** 8

12. Barrett B (2004) The plight of the elusive western ground parrot. *PsittaScene* **16,** 7

13. Barrett B (2004) A riddle is no joke. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **9(1),** 14-15.

14. Barrett B (2004) Western ground parrot recovery project. *Western Australian Bird Notes* **109,** 13-14.

15. Barrett S, Cochrane A (2004) Seedling survival, soil seed bank status and disturbance response of the endangered *Dryandra ionthocarpa* A.S. George ssp. *ionthocarpa* ms (Proteaceae): final report to BankWest Landscope Visa Conservation Card Trust Fund, July 2004. Department of Conservation and Land Management, Perth.

16. Barrett S, Cochrane A (2005) Wildflowers of the Stirling Range. Department of Conservation and Land Management, Western Australia, Bush Books

17. Barrett SR, Shearer BL, Hardy GE St J (2004) Phytotoxicity in relation to *in planta* concentration of the fungicide phosphite in nine Western Australian native species. *Australasian Plant Pathology* **33,** 521-528.

18. Blinn DW, Halse SA, Pinder AM, Shiel RJ, McRae J (2004) Diatom and micro-invertebrate communities and environmental determinants in the western Australian wheatbelt: a response to salinization. *Hydrobiologia* **528,** 229-248.

19. Blyth J, Burbidge AA (2004) Threatened fauna issues not covered under Western Shield: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 164-173.

20. Bougher N (2004) Fascinating fungi. Perth Urban Bushland Fungi, Perth.

21. Bougher N (2004) PUBF fungi kit for Fungi Workshop, Baldivis Bushland, July 25th 2004. Perth Urban Bushland Fungi, Perth.

22. Bougher N (2004) PUBF fungi kit for Fungi Workshop, Forrestdale Bushland, July 3rd 2004. Perth Urban Bushland Fungi, Perth.

23. Bougher N (2004) PUBF fungi kit for Fungi Workshop, Star Swamp, June 20th 2004. Perth Urban Bushland Fungi, Perth.

24. Bougher N (2004) PUBF fungi kit for Fungi Workshop, Talbot Road Bushland, July 11th 2004. Perth Urban Bushland Fungi, Perth.

25. Bougher N (2005) Perth urban bushland fungi field book: a self managed format. Perth Urban Bushland Fungi, Perth.

26. Bougher N (2005) Perth urban bushland fungi field book: a self-managed format. Available at http://www.fungiperth.org.au [accessed 25 Jul 2005]. Various pagings Perth Urban Bushland Fungi, Perth.

27. Bougher N (2005) PUBF fungi kit for Fungi Workshop, Hartfield Park, July 10th 2005. Perth Urban Bushland Fungi, Perth.

28. Bougher N (2005) PUBF fungi kit for Fungi Workshop, Mindarie Foreshore Reserve, June 19th 2005. Perth Urban Bushland Fungi, Perth.

29. Bougher N (2005) PUBF fungi kit for Fungi Workshop, North Lake Bushland, July 3rd 2005. Perth Urban Bushland Fungi, Perth.

30. Bougher N (2005) PUBF fungi kit for Fungi Workshop, Warwick Bushland, July 24th 2005. Perth Urban Bushland Fungi, Perth.

31. Broadhurst L, Byrne M, Craven L, Lepschi B (2004) Genetic congruence with new species boundaries in the *Melaleuca uncinata* complex (Myrtaceae). *Australian Journal of Botany* **52,** 729-737.

32. Broadhurst LM, Coates DJ (2004) Genetic divergence among and diversity within two rare *Banksia* species and their common close relative in the subgenus *Isostylis* R.Br. (Proteaceae). *Conservation Genetics* **5,** 837-846.

33. Bullen R, McKenzie NL (2004) Bat flight-muscle mass: implications for foraging strategy. *Australian Journal of Zoology* **52,** 605-622.

34. Burbidge AA (2004) Montebello renewal: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 194-201.

35. Burbidge AA (2004) Threatened animals of Western Australia. Department of Conservation and Land Management, Perth.

36. Burbidge AA, Fuller PJ (2004) Numbers of non-burrowing breeding seabirds of the Houtman Abrolhos: 1991-1993 and 1999. *Corella* **28,** 96-103.

37. Burbidge AH (2004) Corvids near Carnarvon. *Western Australian Bird Notes* **111,** 17-18.

38. Burbidge A (2005) The mystery of the Jarnadup bristlebird. *South Coast Threatened Birds News* **9,** 2

39. Burbidge A, Mather S (2004) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. - No. 109, March, 2004.

40. Burbidge A, Mather S (2004) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. - No. 110, June 2004.

41. Burbidge A, Mather S (2004) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. - No. 111, September 2004.

42. Burbidge A, Mather S (2004) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. - No. 112, December 2004.

43. Burbidge A, Mather S (2005) Western Australian bird notes: quarterly newsletter of Birds Australia Western Australia Inc. - No. 113, March 2005.

44. Burbidge AH, Rolfe JK, McKenzie NL, Roberts JD (2004) Biogeographic patterns in small ground-dwelling vertebrates of the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 109-137.

45. Burbidge T, Wills A (2005) Northern extent of jarrah leafminer infestation: survey November 2004. Department of Conservation and Land Management, Perth.

46. Burrows ND (2004) Fire management strategies for a south west Australian biodiversity hotspot: TNC, WWF, IUCN Global Fire Partnership Experts Workshop: Sigrisvil, Switzerland, 15-18 May 2004. 1-4. Department of Conservation and Land Management, Perth.

47. Burrows ND (2004) Implementing fire mosaics to prevent large wildfires and enhance ecosystem health (ABSTRACT). In *Are We Prepared for Future Challenges?: Program & Abstracts: the 11th Annual AFAC Conference and Inaugural Bushfire CRC Conference, 7-9th October 2004, Perth, Western Australia, p.* 42. Conference Secretariat, West Perth.

48. Burrows ND (2004) Proposed new organizational structure for the Science Division. - Draft. Department of Conservation and Land Management, Perth.

49. Burrows N (2004) Review of Science Project Plans (SPPs): summary of outcomes: meeting held in Yanchep, 20-22 September 2004. Department of Conservation and Land Management, Perth.

50. Burrows ND (2004) Workforce planning in the Science Division. Department of Conservation and Land Management, Perth.

51. Burrows N (2005) Burning rocks. *Landscope* **20(4),** 54-61.

52. Burrows N, Abbott I (2004) Critique of a paper submitted to the Environmental Protection Authority (EPA) of Western Australia entitled Fire regimes and biodiversity conservation a brief review of scientific literature with particular emphasis on southwest Australian studies by Grant Wells, Stephen D. Hopper and Kingsley W. Dixon. Department of Conservation and Land Management, Perth.

53. Burrows ND, Liddelow G (2004) Adaptive fire management: interim guidelines for forest populations of quokka (*Setonix brachyurus*). Department of Conservation and Land Management, Perth.

54. Burrows ND, Wardell-Johnson G (2004) Implementing fire mosaics to promote biodiversity and reduce the severity of wildfires in south-west Australian ecosystems. In *11th Annual AFAC Conference and Inaugural Bushfire CRC Conference, 7-9 October 2004, Perth, Western Australia,* pp. 1-9.

55. Byrne M (2004) Recognition of *Eucalyptus quaerenda* (Myrtaceae) at specific rank. *Nuytsia* **15,** 321-323.

56. Byrne M, Hines B (2004) Phylogeographical analysis of cpDNA variation in *Eucalyptus loxophleba* (Myrtaceae). *Australian Journal of Botany* **52,** 459-470.

57. Byrne M, Millar M (2004) Genetic systems and issues in the development of woody perennials for revegetation. In *Proceedings of the Conference, Salinity Solutions: Working with*

Science and Society, 2-5 August, 2004, Bendigo, Victoria (eds A Ridley, P Feikema, S Bennet, MJ Rogers, R Wilkinson, J Hirth), pp. 1-5. CRC for Plant-Based Management of Dryland Salinity, Perth.

58. Cale D, Halse S, Walker C (2004) Wetland monitoring in the wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5,** 20-136.

59. Clarke AG, Lane JAK (2003) A waterbird census of selected wetlands along the coastal margins of the Esperance District, Feb.-Mar. 2003: report. Department of Conservation and Land Management, Perth.

60. Clarke A, Muir B, Elscot S, Lane J (2004) Banded stilt breeding attempt at Lake Disappointment. *Stilt* **46,** 39

61. Coates DJ, Byrne M (2005) Genetic variation in plant populations: assessing cause and pattern. In *Plant Diversity and Evolution: Genotypic and Phenotypic Variation of Higher Plants* (ed. RJ Henry), pp. 139-164. CAB International, Wallingford.

62. Coates DJ, Byrne M, MacDonald B, Hankinson M, Ward J (2004) Genetic structure in the priority one species Genus sp. Yalgoo (J.M.Ward s.n. 11/7/1999). Department of Conservation and Land Management, Perth.

63. Cochrane A (2004) Salinity and plant diversity: the role of *ex situ* conservation. *Australasian Plant Conservation* **13(2),** 2-4.

64. Cochrane A (2004) Seed bank pays dividends. *Landscope* **20(2),** 27-31.

65. Cochrane A, Barrett S (2005) Voyage to the Bay of Isles. *Landscope* **20(4),** 32-39.

66. Cochrane A, Barrett S, Gilfillan S (2005) The feather-leaved banksia. *Landscope* **20(3),** 22-28.

67. Comer S, Burbidge A, Danks A (2005) Mt Manypeaks fires: impacts on threatened birds. *South Coast Threatened Birds News* **9,** 1, 13.

68. Comer S, Danks A, Burbidge A (2005) Noisy scrub-birds, western whipbirds and wildfire at Mt Manypeaks. *Western Australian Bird Notes* **113,** 16-17.

69. Courtenay J, Friend T (2004) Gilbert's potoroo recovery plan, July 2003-June 2008. *Department of Conservation and Land Management, Western Australia, Wildlife Management Program* **32,**

70. Cranfield RJ (2004) *Grevillea bipinnatifida* subsp. *pagna* (Proteaceae), a new subspecies from south-west Western Australia. *Nuytsia* **15,** 187-192.

71. Cranfield RJ (2004) Lichen census of Western Australia. *Nuytsia* **15,** 193-220.

72. Cranfield R (2004) Strange parasite. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **8(4),** 8

73. Craven LA, Lepschi BJ, Broadhurst L, Byrne M (2004) Taxonomic revision of the broombush complex in Western Australia (Myrtaceae: *Melaleuca uncinata* s.l.). *Australian Systematic Botany* 255-271.

74. Davis RW (2004) Two new species of *Ptilotus* (Amaranthaceae) from Western Australia. *Nuytsia* **15,** 221-226.

75. De Tores P (2004) A proposal for translocation of the western ringtail possum, *Pseudocheirus occidentalis*, an arboreal marsupial endemic to the south-west of Western Australia. Department of Conservation and Land Management, Perth.

76. De Tores PJ, Hayward MW, Rosier SM (2004) The western ringtail possum, *Pseudocheirus occidentalis*, and the quokka, *Setonix brachyurus* case studies: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 235-257.

77. Durrant BJ (2004) Biogeographical patterns of zodariid spiders (Araneae: Zodariidae) in the wheatbelt region, Western Australia. *Records of the Western Australian Museum Supplement* **67,** 217-230.

78. Durrant BJ, Guthrie NA (2004) Faunas of unflooded saline wetland floors of the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 231-256.

79. Eberhard SM (2004) Ecology and hydrology of a threatened groundwater-dependent ecosystem: the Jewel Cave karst system in Western Australia (ABSTRACT). In *XVII International Symposium on Biospeleology: Raipur, India, 25-30 November, 2004: Abstracts* (eds AK Pati, RK Pradhan, A Parganiha, A Agrawal), p. 43. Pt Ravishankar Shukla University, Raipur.

80. Eberhard S, Halse S (2004) Assessment and conservation of aquatic life in the subsurface of the Pilbara region in Western Australia (ABSTRACT). In *Symposium on World Subterranean Biodiversity: Villeurbanne, 8, 9 and 10 December 2004: Programme and Abstracts,* p. 29. Université Claude Bernard, Lyon.

81. Eldridge MDB, Kinnear JE, Zenger KR, McKenzie LM, Spencer PBS (2004) Genetic diversity in remnant mainland and pristine island populations of three endemic Australian macropodids (Marsupialia): *Macropus eugenii*, *Lagorchestes hirsutus* and *Petrogale lateralis*. *Conservation Genetics* **5,** 325-338.

82. Farr JD, Swain D, Metcalf F (2004) Spatial analysis of an outbreak of *Uraba lugens* (Lepidoptera: Noctuidae) in the southwest of Western Australia: does logging, vegetation type or fire influence outbreaks?. *Australian Forestry* **67,**

101-113.

83. Finston T, Johnson M, Eberhard S, Halse S (2004) Allozyme and haplotype diversity in *Pilbarus millsi*, a widespread groundwater species of amphipod from the Pilbara, Western Australia (ABSTRACT). In *Symposium on World Subterranean Biodiversity: Villeurbanne, 8, 9 and 10 December 2004: Programme and Abstracts*, p. 32. Université Claude Bernard, Lyon.

84. Francis A, Bougher NL (2004) Sequestrate Cortinariales in Western Australia: keys and descriptions. *Australasian Mycologist* **23,** 1-26.

85. Friend JA (2004) Dibbler recovery plan, July 2003-June 2013. *Department of Conservation and Land Management, Western Australia, Wildlife Management Program* **38,**

86. Friend T (2004) Gilbert's potoroo recovery: nutrient analysis of hypogeal fungi: final report, BankWest Landscope Conservation Visa Card Trust Fund grants. Department of Conservation and Land Management, Perth.

87. Friend T (2004) Tracking shows potoroos are on the move. *Conservation News* **May,** 2

88. Friend T, Beecham B (2004) Return to Dryandra: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 174-193.

89. George N, Byrne M, Yan G (2004) Preliminary observations of the reproductive biology of *Acacia saligna*. In *Proceedings of the Conference, Salinity Solutions: Working with Science and Society, 2-5 August, 2004, Bendigo, Victoria* (eds A Ridley, P Feikema, S Bennet, MJ Rogers, R Wilkinson, J Hirth), pp. 1-4. CRC for Plant-Based Management of Dryland Salinity, Perth.

90. Gibson N (2004) Flora and vegetation of the eastern goldfields ranges. Part 6, Mt Manning Range. *Journal of the Royal Society of Western Australia* **87,** 35-47.

91. Gibson N (2004) Flora and vegetation of the eastern goldfields ranges. Part 7, Middle and South Ironcap, Digger Rock and Hatter Hill. *Journal of the Royal Society of Western Australia* **87,** 49-62.

92. Gibson N, Keighery GJ, Lane JAK (2004) Five years monitoring of the Lake Muir-Unicup wetland system, south western Australia. *Journal of the Royal Society of Western Australia* **87,** 29-33.

93. Gibson N, Keighery GJ, Lyons MN, Webb A (2004) Terrestrial flora and vegetation of the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 139-189.

94. Gongora J, Fleming P, Spencer PBS, Mason R, Garkavenko O, Meyer J-N, Droegemueller C, Lee JH, Moran C (2004) Phylogenetic relationships of Australian and New Zealand feral pigs assessed by mitochondrial control region sequence and nuclear GPIP genotype. *Molecular Phylogenetics and Evolution* **33,** 339-348.

95. Gould JS, McCaw L (2004) Risk and behaviour of fires in hardwood plantations (ABSTRACT). In *Are We Prepared for Future Challenges?: Program & Abstracts: the 11th Annual AFAC Conference and Inaugural Bushfire CRC Conference, 7-9th October 2004, Perth, Western Australia*, p. 49. Conference Secretariat, West Perth.

96. Gould JS, McCaw WL, Cheney NP (2004) Project Vesta : findings, extension and validation for south-eastern Australian eucalypt forests. In *Proceedings of Bushfire 2004 Conference, Adelaide SA, 25-28 May 2004.* Department of Environment and Heritage, Adelaide

97. Graham G, McKenzie NL (2004) A conservation case study of Western Australia's Mitchell subregion (North Kimberley 1) in 2003. Department of Conservation and Land Management, Perth.

98. Guevara MA, Chagné D, Almeida MH, Byrne M, Collada C, Favre JM, Harvengt L, Jeandroz S, Orazio C, Plomion C, Ramboer A, Rocheta M, Sebastiani F, Soto A, Vendramin GG, Corvera MT (2005) Isolation and characterization of nuclear microsatellite loci in *Pinus pinaster* Ait.. *Molecular Ecology Notes* 57-59.

99. Guthrie NA (2004) Do summertime temperatures form hotspots of jumping spider endemicity? (POSTER). In *International Congress of Entomology, 15-21 Aug 2004, Brisbane* 1 poster

100. Guthrie NA, Waldock JM (2004) Patterns on the composition of the jumping spider (Arachnida: Araneae: Salticidae) assemblage from the wheatbelt region, Western Australia. *Records of the Western Australian Museum Supplement* **67,** 203-216.

101. Halse SA (2004) Impacts of drainage disposal on biodiversity in wetlands of the Western Australian wheatbelt. In *Engineering Salinity Solutions: 1st National Salinity Engineering Conference, 2004: Conference Proceedings: 9-12 November 2004, Burswood International Resort, Perth, Western Australia* (eds S Dogramaci, A Waterhouse), pp. 373-378. Institution of Engineers, Australia, Canberra.

102. Halse S (2004) Western Australia. In *The State of Australia's Birds 2004: Water, Wetlands and Birds* (eds P Olsen, M Weston), p. xvii. Birds Australia, Melbourne.

103. Halse SA, Lyons MN, Pinder AM, Shiel RJ (2004) Biodiversity patterns and their conservation in wetlands of the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 337-364.

104. Halse SA, McRae JM (2004) New genera and

species of giant ostracods (Crustacea: Cyprididae) from Australia. *Hydrobiologia* **524,** 1-52.

105. Hampton J, Pluske JR, Spencer PBS (2004) A preliminary genetic study of the social biology of feral pigs in south-western Australia and the implications for management. *Wildlife Research* **31,** 375-381.

106. Hampton JO, Spencer PBS, Alpers DL, Twigg LE, Woolnough AP, Doust J, Higgs T, Pluske J (2004) Molecular techniques, wildlife management and the importance of genetic population structure and dispersal: a case study with feral pigs. *Journal of Applied Ecology* **41,** 735-743.

107. Harper RJ, Gilkes RJ (2004) Aeolian influences on the soils and landforms of the southern Yilgarn Craton of semi-arid, southwestern Australia. *Geomorphology* **59,** 215-235.

108. Harper RJ, Gilkes RJ (2004) The effects of clay and sand additions on the strength of sandy topsoils. *Australian Journal of Soil Research* **42,** 39-44.

109. Hart R, Bougher N (2004) Perth Urban Bushland Fungi Project. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **8(3),** 6-7.

110. Harvey MS, Waldock JM, Guthrie NA, Durrant BJ, McKenzie N L (2004) Patterns in the composition of ground-dwelling araneomorph spider communities in the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 257-291.

111. Hayward M (2004) Mainland quokkas. *Nature Australia* **27(12),** 26-33.

112. Hayward MW (2005) Diet of the quokka (*Setonix brachyurus*) (Macropodidae: Marsupialia), in the northern jarrah forest of Western Australia. *Wildlife Research* **32,** 15-22.

113. Hayward MW, de Tores PJ, Augee ML, Fox BJ, Banks PB (2004) Home range and movements of the quokka, *Setonix brachyurus* (Macropodidae: Marsupialia), and its impact on the viability of the metapopulation on the Australian mainland. *Journal of Zoology* **263,** 219-228.

114. Hopper SD, Gioia P (2004) The southwest Australian floristic region: evolution and conservation of a global hot spot of biodiversity. *Annual Review of Ecology, Evolution and Systematics* **35,** 623-650.

115. Kay WR (2004) Movements and home ranges of radio-tracked *Crocodylus porosus* in the Cambridge Gulf region of Western Australia. *Wildlife Research* **31,** 495-508.

116. Kay WR (2004) A new method for attaching electronic devices to crocodilians. *Herpetological Review* **35,** 354-357.

117. Keighery G (2004) *Balaustion* (native pomegranates). *Australian Plants* **22,** 272-273.

118. Keighery G (2004) Impact of weeds on our WA plant biodiversity. Available at http://www.everlastingconcepts.com.au/HTML/summerhandouts.htm [accessed 25 Jul 2005]. In *Everlasting Concepts Four Season Seminars (Summer Seminar, WA Plants: Exposing the Myths), January 20 and 21, 2004, Edith Cowan University, Joondalup Campus.* Everlasting Concepts, Perth.

119. Keighery G (2004) Ironstone communities of south-western Australia [PowerPoint presentation]. In *Busselton Ironstone Workshop, November 2004*, 1 CD-ROM Department of Conservation and Land Management, Perth.

120. Keighery G (2004) A new species of *Bulbine* (Asphodelaceae) from Western Australia. *Nuytsia* **15,** 241-244.

121. Keighery GJ (2004) State Salinity Strategy biological survey of the Western Australian wheatbelt: background. *Records of the Western Australian Museum Supplement* **67,** 1-6.

122. Keighery G (2004) Taxonomic notes on the *Angianthus drummondii* complex (Asteraceae: Gnaphaliinae). *Nuytsia* **15,** 253-260.

123. Keighery G (2004) A taxonomic review of the genus *Agrostocrinum* (Phormiaceae). *Nuytsia* **15,** 245-252.

124. Keighery G (2004) Taxonomy of the *Calytrix ecalycata* complex (Myrtaceae). *Nuytsia* **15,** 261-268.

125. Keighery G (2005) Status of the vegetation of the Greenough alluvial flats. Department of Conservation and Land Management, Perth.

126. Keighery GJ, Halse SA, McKenzie NL, Harvey MS (2004) A biodiversity survey of the Western Australian agricultural zone. *Records of the Western Australian Museum Supplement* **67,** 1-384.

127. Keighery G, Keighery B (2004) Not all thistles are weeds. *Landscope* **20(2),** 49-54.

128. Keighery G, Keighery B (2004) Not all thistles are weeds. *Wildflower Society of Western Australia Newsletter* **43(1),** 14-17.

129. Lamont BB, Wittkuhn R, Korczynskyj D (2004) Turner review. No. 8: Ecology and physiology of grasstrees. *Australian Journal of Botany* **52,** 561-582.

130. Lane J, Pearson G, Clarke A, Winchcombe Y, Munro D (2005) Depths and salinities of wetlands in south-western Australia, 1977-2000. Department of Conservation and Land Management, Perth.

131. Lee KM, Abbott I (2004) Precautionary forest management: a case study from Western Australian legislation, policies, management plans, codes of practice and manuals from the

period 1919-1999. *Australian Forestry* **67,** 114-121.

132. Lepschi BJ, Trudgen ME, van Leeuwen SJ (2004) Two new species of *Dampiera* (Goodeniaceae) from the Pilbara region, Western Australia. *Nuytsia* **15,** 269-276.

133. Lewington M (2004) Correction of type locality and flowering time for *Melaleuca apostiba* (Myrtaceae). *Nuytsia* **15,** 324

134. Lyons MN, Gibson N, Keighery GJ, Lyons SD (2004) Wetland flora and vegetation of the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 39-89.

135. Macfarlane TD (2004) Grass taxonomy. In *Viruses and Virus Diseases of Poaceae (Gramineae)* (eds H Lapierre, P-A Signoret). INRA Editions, Versailles.

136. Macfarlane TD (2005) Tribe Amphipogoneae. In *Flora of Australia. Volume 44B, Poaceae 3* (ed. K Mallett), pp. 9-18. ABRS, Melbourne.

137. Maslin BR (2004) Response to Walker and Simpson's views on the ICBN Proposal 1584 by Orchard and Maslin to conserve the name *Acacia* with the conserved type: ASBS Newsletter 117: 17-21 (2004). *Australian Systematic Botany Society Newsletter* **118,** 15-19.

138. Maslin BR, McDonald MW (2004) *Acacia* search: evaluation of *Acacia* as a woody crop option for southern Australia. Rural Industries Research and Development Corporation, Canberra.

139. Maslin B, Orchard T (2004) Most Australian wattles likely to remain *Acacia*. *Western Wildlife: Newsletter of the Land for Wildlife Scheme* **8(4),** 4-5.

140. Matheny PB, Bougher NL (2005) A new violet species of *Inocybe* (Agaricales) from urban and rural landscapes in Western Australia. *Australasian Mycologist* **24,** 7-12.

141. Mawson PR, Start AN (2004) Summary review of public submissions on the 2003 independent review of the Western Shield program. *Conservation Science Western Australia* **5(2),** 12-18.

142. McCaw L, Hamilton T, Rumley C (2004) Application of fire history records to contemporary management issues in south-west Australian forests. In *A Forest Conscienceness: Proceedings 6th National Conference of the Australian Forest History Society Inc., 12-17 September 2004, Augusta, Western Australia* (eds M Calver, H Bigler-Cole, G Bolton, A Gaynor, P Horwitz, J Mills, G Wardell-Johnson), pp. 555-564. Millpress Science, Rotterdam.

143. McCaw L, Round-Turner R (2004) Blackwood District fire 18, Bridgetown 27 December 2003: fire narrative. Department of Conservation and Land Management, Perth.

144. McKenzie NL, Gibson N, Keighery GJ, Rolfe JK (2004) Patterns in the biodiversity of terrestrial environments in the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 293-335.

145. McKenzie N, Keighery G, Gibson N (2005) IBRA sub_ regions in WA. - Rev.. Department of Conservation and Land Management, Perth.

146. Mell R, Byrne M (2004) Science Division, Science Support Program. Department of Conservation and Land Management, Perth.

147. Meyer C, Beer T, Müller J, Gillett R, Weeks I, Powell J, Tolhurst K, McCaw L, Cook G, Marney D, Symons R (2004) Dioxin emissions from bushfires in Australia. Department of Environment and Heritage, Canberra. National Dioxins Program Technical Report 1.

148. Meyer CP, Müller JF, Beer T, Tolhurst K, McCaw L, Cook GD, Ivory A, Mobbs C (2004) Dioxin emissions from bushfires in Australia: paper to be presented at the 17th International Clean Air and Environment Conference, Hobart, 2005. Department of Conservation and Land Management, Perth.

149. Mills HR, Moro D, Spencer PBS (2004) Conservation significance of island versus mainland populations: a case study of dibblers (*Parantechinus apicalis*) in Western Australia. *Animal Conservation* **7,** 387-395.

150. Monks L, Spencer M, Grant A (2004) Threatened ironstone flora translocations, 1998-2004 [PowerPoint Presentation]. In *Busselton Ironstone Workshop, November 2004*, 1 CD-ROM. Department of Conservation and Land Management, Perth.

151. Morris K, Sims C, Himbeck K, Christensen P, Sercombe N, Ward B, Noakes N (2004) Project Eden: fauna recovery on Peron Peninsula, Shark Bay: Western Shield review, February 2003. *Conservation Science Western Australia* **5(2),** 202-234.

152. Neaves L, Zenger K, Prince B, Beveridge I, Snaith E, Cooper D (2004) Does hybridisation of eastern grey kangaroos and western grey kangaroos occur in the wild: a microsatellite study (ABSTRACT). In *Australasian Wildlife Management Society, 17th Scientific Meeting and AGM, Kingscote, Kangaroo Island, South Australia: 29 November-2 December 2004: AWMS Conference Abstracts*, p. 109. Australasian Wildlife Management Society, Melbourne.

153. Nguyen VP, Needham AD, Friend JA (2005) A quantitative dietary study of the critically endangered Gilbert's potoroo, *Potorous gilbertii*. *Australian Mammalogy* **27,** 1-6.

154. O'Hara AJ, Warren KS, Swan RS, Sims C, Friend JA (2004) Cutaneous papillomatosis and

carcinomatosis in the highly endangered western barred bandicoot (ABSTRACT). *Veterinary Dermatology* **15S1,** 25

155. Orchard T, Maslin B (2004) Australian *Acacia* to (mostly) remain *Acacia*. *Australian Systematic Botany Society Newsletter* **119,** 5-6.

156. Patrick SJ (2005) Georgiana Molloy and early forest botany in the Augusta to Busselton area of Western Australia. In *A Forest Conscienceness: Proceedings 6th National Conference of the Australian Forest History Society Inc., 12-17 September 2004, Augusta, Western Australia* (eds M Calver, H Bigler-Cole, G Bolton, A Gaynor, P Horwitz, J Mills, G Wardell-Johnson), pp. 131-141. Millpress Science, Rotterdam.

157. Pearson D, Comer S, Cochrane A, Gilfillan S (2005) Return to Mondrain. *Landscope* **20(1),** 40-44.

158. Pearson D, Hopper S, Cochrane A, Comer S, Danks A (2004) Fire in the arc. *Landscope* **20(1),** 10-17.

159. Pearson D, Shine R, Williams A (2005) Spatial ecology of a threatened python (*Morelia spilota imbricata*) and the effects of anthropogenic habitat change. *Austral Ecology* **30,** 261-274.

160. Perth Urban Bushland Fungi Project (2004) Common fungi of the Perth region [poster]. 1 poster Department of Conservation and Land Management, Perth.

161. Pinder AM (2003) Australian faunal directory: checklist for superclass: Clitellata. Available at http://www.deh.gov.au/cgi-bin/abrs/fauna/tree.pl?pstrVol=OLIGOCHAETA&pintMode=1 [accessed 25 Jul 2005]. Department of the Environment and Heritage, Canberra

162. Pinder AM (2004) Annelida: Aphanoneura. In *Freshwater Invertebrates of the Malaysian Region* (eds CM Yule, YH Sen), pp. 191-193. Academy of Sciences Malaysia, Kuala Lumpur.

163. Pinder AM (2004) Annelida: Clitellata, Oligochaeta. In *Freshwater Invertebrates of the Malaysian Region* (eds CM Yule, YH Sen), pp. 162-174. Academy of Sciences Malaysia, Kuala Lumpur.

164. Pinder AM, Halse SA, McRae JM, Shiel RJ (2004) Aquatic invertebrate assemblages of wetlands and rivers in the wheatbelt region of Western Australia. *Records of the Western Australian Museum Supplement* **67,** 7-37.

165. Pinder AM, Halse SA, McRae JM, Shiel RJ (2005) Occurrence of aquatic invertebrates of the wheatbelt region of Western Australia in relation to salinity. *Hydrobiologia* **543,** 1-24.

166. Powell R, Williams M (2004) Butterfly gardening. *Landscope* **19(4),** 40-45.

167. Pringle HJR, Hopkins AJM (2004) Biodiversity monitoring or biodiversity management systems : which is the cart and which is the horse?. In *Conference Papers: Australian Rangeland Society 13th Biennial Conference, Living in the Outback: Alice Springs, Northern Territory, 5-8 July 2004* (eds G Bastin, D Walsh and S Nicholson), pp. 195-200. Australian Rangeland Society, Perth.

168. Reid T (2004) Science Division 2004 Biennial Forum: program theme, Connections, 10-11th June, 2004, Muresk Institute of Agriculture Conference Centre: wash up report. Department of Conservation and Land Management, Perth.

169. Richardson J, Keighery G, Manson W (2005) A baseline of vegetation health for the Buntine Marchagee recovery catchment. Department of Conservation and Land Management, Perth.

170. Richardson J, Langley M, Meissner R, Hopkins A (2005) Biodiversity assessment and vegetation mapping of the northern agricultural region, Western Australia. Department of Conservation and Land Management, Perth.

171. Richardson J, Pringle H (2004) Deleterious effects of grazing on the biodiversity of breakaway footslope thickets. In *Conference Papers: Australian Rangeland Society 13th Biennial Conference, Living in the Outback: Alice Springs, Northern Territory, 5-8 July 2004* (eds G Bastin, D Walsh and S Nicholson), pp. 349-350. Australian Rangeland Society, Perth.

172. Robinson RM, Jensen DG, Morrison DJ (2004) Necrophylactic periderm formation in the roots of western larch and Douglas-fir trees infected with *Armillaria ostoyae*. I, the response to abiotic wounding in non-infected roots. *Forest Pathology* **34,** 105-118.

173. Robinson RM, Morrison DJ, Jensen DG (2004) Necrophylactic periderm formation in the roots of western larch and Douglas-fir trees infected with *Armillaria ostoyae*. II, the response to the pathogen. *Forest Pathology* **34,** 119-129.

174. Robinson R, Scott P, Williams K, Hardy G (2004) Identification of the causal organism associated with stem canker diseases in the rare and endangered Meelup mallee (*Eucalyptus phylacis*): final project report, July 2004. Department of Conservation and Land Management, Perth.

175. Rogers D, Piersma T, Lavaleye M, Pearson G, de Goeij P (2004) Crabbing around at Roebuck Bay. *Landscope* **19(4),** 18-23.

176. Rooney J (2004) Exmouth firearms training course. *Conservation News* **Sep,** 6

177. Rooney JF (2004) A guide to living with snakes in the south west (Warren region), Western Australia (PAMPHLET). Department of Conservation and Land Management, Perth.

178. Sage LW, Pigott JP (2004) Conservation status of

Goodenia (Goodeniaceae) in Western Australia, including a review of threatened, rare and poorly known species. *Journal of the Royal Society of Western Australia* **86,** 123-132.

179. Science Division, Department of Conservation and Land Management, Western Australia (2004) Annual research activity report, July 2003-June 2004. Department of Conservation and Land Management, Perth.

180. Science Division, Department of Conservation and Land Management, Western Australia (2004) Business plan, July 2004-June 2006. Department of Conservation and Land Management, Perth.

181. Science Division, Department of Conservation and Land Management, Western Australia (2004) Conservation science Western Australia. - Vol. 5, no. 1. Department of Conservation and Land Management, Perth.

182. Science Division, Department of Conservation and Land Management, Western Australia (2004) Conservation science Western Australia. - Vol. 5, no. 2. Department of Conservation and Land Management, Perth.

183. Science Division, Department of Conservation and Land Management, Western Australia (2004) ForestCheck: report of progress, 2003-2004. Department of Conservation and Land Management, Perth.

184. Science Division, Department of Conservation and Land Management, Western Australia (2004) Nuytsia. - Vol. 15, no. 2. 157-330. Department of Conservation and Land Management, Perth.

185. Science Division, Department of Conservation and Land Management, Western Australia (2004) Science communications. - April 2004-June 2004. Department of Conservation and Land Management, Perth.

186. Science Division, Department of Conservation and Land Management, Western Australia (2004) Science communications. - July 2004-September 2004. Department of Conservation and Land Management, Perth.

187. Science Division, Department of Conservation and Land Management, Western Australia (2005) Science communications. - October 2004-February 2005. Department of Conservation and Land Management, Perth.

188. Shearer BL, Crane CE, Cochrane A (2004) Quantification of the susceptibility of the native flora of the South-West Botanical Province, Western Australia to Phytophthora cinnamomi. *Australian Journal of Botany* **52,** 435-443.

189. Shearer B, Crane C, Cochrane A (2005) A thief of time: *Phytophthora cinnamomi* and threatened flora. *Australasian Plant Conservation* **13(4),** 14-15.

190. Shepherd KA, Macfarlane TD, Colmer TD (2005) Morphology, anatomy and histochemistry of Salicornioideae (Chenopodiaceae) fruits and seeds. *Annals of Botany* **95,** 917-933.

191. Shepherd KA, Macfarlane TD, Waycott M (2005) Phylogenetic analysis of the Australian Salicornioideae (Chenopodiaceae) based on morphology and nuclear DNA. *Australian Systematic Botany* **18,** 89-115.

192. Smith J, Morris K (2004) Animal ethics. *Landscope* **19(4),** 6-8.

193. Smith JA, Wright LJ, Morris KD (2004) BiblioBarrowIsland: an annotated bibliography of the natural history of Barrow Island, 1622-2004. Department of Conservation and Land Management, Perth.

194. Smith JA, Wright LJ, Morris KD (2004) BiblioChuditch: the chuditch, *Dasyurus geoffroii* (Gould 1841): a Wildlife Science Library bibliography. *Conservation Science Western Australia* **5,** 6-19.

195. Spooner A (2004) Procedures for updating the plant of the month webpage: user's guide. - Version 1.0, May 2004. Department of Conservation and Land Management, Perth.

196. Stukely M, Webster J, Ciampini J (2004) Vegetation Health Service: annual report, 2003-2004. Department of Conservation and Land Management, Perth.

197. Thomas N, Macmahon B, Marlow N, Friend T (2004) Return to Dryandra: reintroduction of the boodie and dalgyte to Dryandra: progress report, June 2004. Department of Conservation and Land Management, Perth.

198. Thomas N, Marlow N, Macmahon B, Friend T (2004) Return to Dryandra: field breeding centre progress report, June 2004. Department of Conservation and Land Management, Perth.

199. Tutt M, Fekete S, Mitchell S, Brace P, Pearson D (2004) Unravelling the mysteries of Pilbara olive python ecology: Threatened Species Network community grants final report, Project WA11/101. Nickol Bay Naturalists' Club, Karratha.

200. Vallee L, Hogbin T, Monks L, Makinson B, Matthes M, Rossetto M (2004) Guidelines for the translocation of threatened plants in Australia. - 2nd ed.. Australian Network for Plant Conservation, Canberra.

201. Walshe TV, Halse SA, McKenzie NL, Gibson N (2004) Towards identification of an efficient set of natural diversity recovery catchments in the Western Australian wheatbelt. *Records of the Western Australian Museum Supplement* **67,** 365-384.

202. Wheeler JR (2004) An interim key to the Western Australian species of *Hibbertia* (Dilleniaceae). *Nuytsia* **15,** 311-320.

203. Wheeler JR (2004) Miscellaneous new *Hibbertia*

species (Dilleniaceae) from the south coast and adjacent interior of Western Australia. *Nuytsia* **15,** 299-310.

204. Wheeler JR (2004) Nomenclatural notes on two species of *Hibbertia* (Dilleniaceae). *Nuytsia* **15,** 327-328.

205. Wheeler JR (2004) A review of *Hibbertia hemignosta* and its allies (Dilleniaceae) from Western Australia. *Nuytsia* **15,** 277-298.

206. Whitford K, Stoneman G (2004) Management of tree hollows in the jarrah, *Eucalyptus marginata*, forest of Western Australia. In *Conservation of Australia's Forest Fauna. - 2nd ed.* (ed. D Lunney), pp. 807-829. Royal Zoological Society of New South Wales, Sydney.

207. Whitford K, Stoneman G, Mellican A (2004) Effect of stand density and fertilizing on seed-fall: final report. Department of Conservation and Land Management, Perth.

208. Wildy DT, Pate JS, Bartle JR (2004) Budgets of water use by *Eucalyptus kochii* tree belts in the semi-arid wheatbelt of Western Australia. *Plant and Soil* **262,** 129-149.

209. Wildy DT, Pate JS, Sefcik LT (2004) Water-use efficiency of a mallee eucalypt growing naturally and in short-rotation coppice cultivation. *Plant and Soil* **262,** 111-128.

210. Wills A (2004) Crown decline in wandoo: update for 2004: observations from Wundabiniring Brook, 1999-2004. Department of Conservation and Land Management, Perth.

211. Wills AJ, Burbidge TE, Abbott I (2004) Impact of repeated defoliation on jarrah (Eucalyptus marginata) saplings. *Australian Forestry* **67,** 194-198.

212. Wittkuhn R, Hamilton T, McCaw L, Metcalfe F, Carpenter C (2005) Learning from the past: the many uses of fire history mapping (POSTER). In *Bushfire CRC Fire Managers' Research Meeting, Beechworth, Victoria, 6-9 June 2005,* 1 poster

213. Wright L, Richardson B, Mathiesen B (2004) Copyright policy. Department of Conservation and Land Management, Perth.

214. Yates CJ, Ladd PG (2004) Breeding system, pollination and demography in the rare granite endemic shrub, *Verticordia staminosa* ssp *staminosa* in south-west Western Australia. *Austral Ecology* **29,** 189-200.

215. Yates CJ, Ladd PG (2005) Relative importance of reproductive biology and establishment ecology for persistence of a rare shrub in a fragmented landscape. *Conservation Biology* **19,** 239-249.

216. Young A, Broadhurst L, Coates D, Byrne M, Yates C, Elliott C, Field D, Gage C, Hobbs R (2005) Land and Water project number CPI 10: Genetic and ecological viability of plant populations in remnant vegetation. CSIRO, Canberra.

Astronomical component

1. Alcroft, J. ed. (2004). Perth Observatory Volunteer Newsletter #76.

2. Alcroft, J. ed. (2004). Perth Observatory Volunteer Newsletter #77.

3. Alcroft, J. ed. (2004). Perth Observatory Volunteer Newsletter #78.

4. Alcroft, J. ed. (2004). Perth Observatory Volunteer Newsletter #79.

5. Alcroft, J. ed. (2004). Perth Observatory Volunteer Newsletter #80.

6. Alcroft, J. ed. (2005). Perth Observatory Volunteer Newsletter #81.

7. Alcroft, J. ed. (2005). Perth Observatory Volunteer Newsletter #22.

8. Alcroft, J. ed. (2005). Perth Observatory Volunteer Newsletter #83.

10. Alcroft, J. ed. (2005). Perth Observatory Volunteer Newsletter #84.

11. Alcroft, J. ed. (2005). Perth Observatory Volunteer Newsletter #85.

12. Biggs, J Star Viewing Night Manual, Perth Observatory January 2005.

13. Biggs, J. 'Are we ETs? An Update on the Panspermia Hypothesis', Proceedings of the Iron and Sulphur Bacteria Workshop, Murdoch University, 11-14 February, 2004, eds Scott, B. and Walker, C., ISBW Planning Committee, 2004.

14. Bilki, F.P. and Freeman, M.J. Shoemaker Impact Structure and three other impact features of Western Australia Perth Observatory Volunteer Group Publication September 2004.

15. D.W. Kurtz, C. Cameron, M.S. Cuntha, N. Dolez, G. Vauclair, E. Pallier, A. Ulla, S.O. Kepler, A. da Costa, A. Kanaan, L. Fraga, O. Giovannini, M.A. Wood, N. Silvistri, S.D. Kawaler, R.L. Riddle, M.D. Reed, T.K. Watson, T.S. Metcalfe, A. Mukadam, R.E. Nather, W.E. Winget, A. Nitta, S.J. Kleinman, J.A. Guzik, P.A. Bradley, J.M. Matthews, K. Sekiguchi, D.J. Sullivan, T. Sullivan, R. Shobbrook, X. Jiang, P.V. Birch, B.N. Ashoka, S. Seetha, V. Girish, S Joshi, P. Moskali, S. Zola, D. O'donoghue, G. Handler, M. Mueller, J.M. Gonzalez Perez, J–E Solheim, F. Johnanessen, and L. Bigot. Pushing the Ground Based Limit: 14 uma photometric precision with the Definitive Whole Earth Telescope Asteroseismic data set for the roAp star HR 1217. Monthly Notices of the Royal Astronomical Society – Vol 358, Issue 2, Page 651. April 2005.

16. Ghoshi H. with 11others (uFUN Collaboration) and Abe, F with 21 others (the MOA Collaboration) and Udalski, A with 6 others (The OGLE Collaboration) and Albrow, M, Martin, R and Williams , A with 18 others (The PLANET Collaboration) Potential Direct Single Star Mass Measurement. The Astrophysical Journal Vol 615, pp 450 – 459. 2004 November 1.

17. Guangfei Jiang with 10 others (The uFUN Collaboration) and Udalski, A with 6 others (The OGLE Collaboration) and Albrow, M, Martin, R and Williams, A with 18 others (The PLANET Collaboration). OGLE-2003-BLG-238: Microlensing Mass Estimate of an Isolated Star. The Astrophysical Journal Vol 617, pp 1307 – 1315. 2004 December 20.

18. Martin, R (2005) SUPERNOVA 2005ae IN ESO 209-9, IAUC 8480.

19. Martin, R (2005) SUPERNOVA 2005am IN NGC 2811, IAUC 8490.

20. Martin, R (2005) SUPERNOVA 2005at IN NGC 6744, CBET 119.

21. Penny D Sackett, with R. Martin, A. Williams and 16 others (The PLANET Collaboration) PLANET II: A Microlensing and Transit Search for Extrasolar Planets. Bioastronomy 20022: Life among the Stars, IAU Symposium, Vol 213, 2004.

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	2001-04 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 three different fire regimes in the southern forests of Western Australia.	PhD	2005-11 (0.5 FTE)	Prof J Majer	Curtin University
Angus, John	M Lilith	Benefits arising from the exclusion of domestic Cats through local government by-laws	PhD	2003-07	Dr M Calver and Dr M Garkaklis	Murdoch University
Burbidge, Allan	L Fox	Individual call recognition in birds	PhD	2004-07	Dr D Roberts	University of Western Australia
Burrows, Neil	J Cargill	Effects of fire regimes on Jarrah forest geophytes	Hons	2004-05	Prof William Stock	Edith Cowan University
Burrows, Neil	A Wayne	Ecology of the Ngwayir (*Pseudocheirus occidentalis*) and Koomal (*Trichosurus vulpecula hypoleucus*) in the Jarrah forest	PhD	2001-04	Dr M Calver	Australian National University
Byrne, Margaret	N George	Development of *Acacia saligna* for revegetation	PhD	2002-05	Dr G Yan	University of Western Australia
Byrne, Margaret	D Nicolle	Taxonomic revision of *Eucalyptus* series *Subulatae*	PhD	1998-05	Dr M Whalen	Flinders University
Byrne, Margaret	R Butcher	Systematics of the south-western Australian endemic genus *Synaphea* R.Br. (Proteaceae: Conospermineae)	PhD	1997-05	Dr J Chappill	University of Western Australia
Byrne, Margaret	C Tauss	Phylogeny, phylogeography and conservation of *Reedia spathacea* in south-western Australia	MSc	2002-06	Dr J Chappill	University of Western Australia
Byrne, Margaret	M Millar	An assessment of genetic risk to natural biodiversity from agroforestry revegetation	PhD	2004-07	Dr I Nuberg	University of Adelaide
Byrne, Margaret	R Hendrati	Development of *Eucalyptus occidentalis* for revegetation	PhD	2004-08	Dr J Plummer	University of Western Australia

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Byrne, Margaret	E Dalmaris	Physiology of Wandoo decline (ARC project)	PhD	2003-06	Prof H Lambers and Dr E Veneklaas	University of Western Australia
Byrne, Margaret	C Jones	Oil biochemistry and genetic diversity of Indian Sandalwood	PhD	2004-07	Dr J Plummer and Dr E Ghiz	University of Western Australia
Chapman, Alex	A Spooner	Systematics and Conservation of Lambertia Sm. (Proteaceae)	MSc	2004-06	Dr K Lemson	Edith Cowan University
Coates, Dave	C Gage	Genetic and ecological viability of fragmented populations of the long lived woody shrub *Eremaea pauciflora*	Hons, PhD	2002-05	Prof J McComb	Murdoch University
Coates, Dave	C Waters	Developing seed provenance zones for Australian native grasses	PhD	2002-05	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	MSc, PhD	2005-09	Dr J Plummer	University of Western Australia
de Tores, Paul	I Bertram	Translocation outcomes for the Western ringtail possum, *Pseudocheirus occidentalis.* Interim survivorship analysis of populations in 1080 baited and unbaited translocation release sites	MSc	2004-05		University of Glasgow, Scotland
Friend, Tony	J Lee	Haemoparasites and ectoparasites of Gilbert's potoroo	Hons	2004	Dr P Irwin	Murdoch University
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	2003-06	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	2002-05	Dr R Bencini	University of Western Australia
Halse, Stuart	E Lowe	Macroinvertebrates and diatoms as indicators of acidity in wetlands of Western Australia	PhD	2000-05	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	2003-06	Prof P De Deckker	Australian National University
Lyons, Michael	K Voltchanskii	Adaption of *Melaleuca* spp. to waterlogging and salinity: morphological and physiological aspects	PhD	2003-06	Prof Z rangel	University of Western Australia
Macfarlane, Terry	K Shepherd	Taxonomic and evolutionary study of the samphires (Chenopodiaceae subfamily Salicornioideae	PhD		Dr T Colmer	University of Western Australia
McCaw, Lachie	R Archibald	The role of fire in the decline of Tuart (*Eucalyptus gomphocephala*) woodlands	PhD	2003-06	Dr G Hardy and Dr B Bowen	Murdoch University

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Morris, Keith	D Cancilla	Ecology of the Heath mouse *Pseudomys shortridgei*	PhD	2003-05	Dr G Hardy	Murdoch University
Morris, Keith	H Owen	Looking at the transmission of rickettsia disease by native animals	PhD	2003-05	Dr S Fenwick	Murdoch University
Morris, Keith	F Donaldson	Social structure of burrowing bettongs	PhD	2003-05	Dr R Bencini	University of Western Australia
Morris, Keith	D Waayers	Sustainable turtle based tourism	PhD	2002-04	Dr D Newsome	Murdoch University
Morris, Keith	M Cardosa	Genetic consequences of translocation in Chuditch	PhD	2005-07	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	2003-6	Dr M Pennachio, Dr D Groth and Dr J Wetherall	Murdoch University
Pearson, David	L Turner	To be determined	Hons	2005	Dr A Needham	Edith Cowan
Pearson, Grant	T Compton	The phenotypic response of the local Tellinidae to their environment	PhD	2003-07	Prof T Piersma	Royal Netherlands Institute for Sea Research
Pearson, Grant	D Rogers	Conservation and Ecology of Migratory Shorebirds in Roebuck Bay	PhD	2002-04	Prof T Piersma	Charles Sturt University
Shearer, Bryan	A Koning	Processes in lateritic soil in Western Australia	PhD		Prof B Gilkes	University of Western Australia
Shearer, Bryan	R Pilbeam	Phosphonate distribution in *Eucalyptus marginata* Donn ex Sm. forest and colonization by *Phytophthora cinnamomi* Rands	PhD		Dr G Hardy	Murdoch University
Shearer, Bryan	B Komorek	Mode of action of phosphonate in native hosts to *Phytophthora cinnamomi*	PhD		Prof K Sivasitham param	University of Western Australia
Shearer, Bryan	S Collins	Survival of *Phytophthora cinnamomi* in rehabilitated bauxite mining areas	PhD		Dr G Hardy	Murdoch University
Shearer, Bryan	T Papp	Epidemiology of Marri canker	PhD	2002-04	Dr G Hardy	Murdoch University
Shearer, Bryan	K Smith	The role of chlamydospores in the survival of *Phytophthora cinnamomi*	PhD	2003-05	Dr G Hardy	Murdoch University
Shearer, Bryan	P Scott	Tuart decline	PhD	2004-07	Dr G Hardy	Murdoch University
Shearer, Bryan	R Hooper	Wandoo decline	PhD	2004-07	Prof K Sivasitham param	University of Western Australia
Shearer, Bryan	J Ellery	*Ramularia* leaf infection	Hons		Dr G Hardy	Murdoch University
Start, Tony	T Partridge	Study of fire, small mammals and Cats in Purnululu National Park	PhD	2003-05		Macquarie University
Start, Tony	C Palmer	Study of 4 CWR mammals, their habitat requirements and the effect of fire on those requirements	PhD	2003-05	Dr J Woinarski	Northern Territory University

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	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	2002-2005	Prof R Hobbs	Murdoch University
Yates, Colin	K Maher	Fire, fragmentation and mammals, synergistic impacts on ecosystem dynamics	PhD	2004-07	Prof R Hobbs	Murdoch University
Yates, Colin	C Buscomb	Ecological consequences of habitat fragmentation in *Banksia sphaerocarpa* ssp. *sphaerocarpa*	Hons	2004	Prof R Hobbs	Murdoch University

Astronomical component

CALM Officer	Student	Project Title	Degree/ level	Duration (yr - yr)	University Academic	University
Biggs, James	Katherine Reynolds	Photometry of SS2883	3rd Yr research project	2004-2005	Prof M Zadnik	Curtin University
Biggs, James	Anthony O'Brien	Automation of 8-m Gemini Telescope South Enclosure Controls	Hons	2005	Prof P Puxley	Gemini Telescope, Chile

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	$72k for 3 yrs	Curatorial (0.05)
ABRS	Taxonomy of Baeckea: 1 Scientist	$36k for 3 yrs	B Rye (0.5), Curatorial (0.05)
ABRS	Taxonomy of Asteraceae: 1 Scientist	$20k	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 $15k	S Halse (0.05)
ANU	Pilbara Biological Survey: I scientist	$10k for 4 yrs	Taxonomic and authorship - P de Dekker
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 Lidelow (0.2) R Cranfield (0.1) J Farr (0.1) A wills (0.1) P Van Heurck (0.1) T Burbidge (0.1) R Robinson (0.1) B Smith (0.1) K Bain (0.0-5) D Green (0.05) T Middelton (0.05) L Shu (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, R Smith, J Neal; Total 0.3 FTE pa. Other collaborators include National Research Centre for Environmental Toxicology and University of Melbourne.
BHP Billiton Iron Ore Ltd	Pilbara biological biological bibliographical database	$7.5k – CALM in 2004	S van Leeuwen (0.0)
Bushfires CRC	Managing fires in forest landscapes SW Australia	$40k pa over 7 yrs 2003-10 contributed by CALM. $94k for next 4 yrs to fund PhD	L McCaw (0.4), R Robinson (0.2), J Farr (0.2), B Ward (0.2), G Liddelow (0.2), B Smith (0.2), J Neal (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	2002-03 - $180k 2003-04 - $150k	K Tinley (1.0), J Richardson (0.6), G Burke (0.5), J Richardson (1.0) for 25 days
CRC for Greenhouse Accounting	Project A2 Developing carbon accounting systems		R McKellar (0.1), 1.3 FTE
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

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	**Project**	**Cash funding and source ($)**	**CALM Involvement (in kind)**
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, 2005-7	G. Keighery (0.2)
Dept of Environment (Cwth)	AVH: Australia's Virtual Herbarium: 2 databasers, curator	$96k for 5 yrs	A Chapman (0.05), Database (3.0)
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)
Dept of Planning & Infrastructure	SWALE: Surveying WA's Land Edge: 1 Scientist	$20k for 2 yrs	N Lander (0.05), R Davis (0.05),
Dept of Planning & Infrastructure	MPP: Marine Plants Project: 1 curator	$24,750 plus 2004/2005	C Parker (0.2), Database (1.0)
Dept of Premier and Cabinet	Bushplan	$100k for 2003-04	A Hopkins (1.0)
Dept of Primary Industries Victoria	PAPP toxicosis	To be advised	D Algar (0.02), K Morris (0.02)
Desert Knowledge CRC	2 Scientists	No $ contribution	M Cowan (0.25), A Hopkins (0.5), K Tinley (1.0) + 1 more to be advised
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	$105k yr to 2010	A Cochrane (0.8), D Coates (0.1)
Morgan	Feral Cat research	$951k over 5 yrs	D Algar (1.0), N Hamilton (1.0), M Onus (1.0), J Angus (1.0)
Murdoch University	Western barred bandicoot, Gilbert's potoroo, Quenda – 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)
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	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 CALM	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	B Johnson (0.4), K Morris (0.05), + $5 k yr for 2003-5 from Stipend funds (CALM contribution)
Netherlands Institute for Sea Research (NIOZ)	Benthic studies – Roebuck Bay, NHT + Wettenhall – Roebuck Bay book	$27k	G Pearson (0.15)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	**Project**	**Cash funding and source ($)**	**CALM Involvement (in kind)**
Netherlands Institute for Sea Research (NIOZ)	PhD – T Compton	$5k from Stipend funds (CALM)	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), J Rolfe (0.05)
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 2003-05	S Elscot (0.25), G Pearson (0.1), A Clarke (0.2), J Lane (0.15)
NHT 2	Pilbara Biological Survey	$500k in 2004/05, a separate application has to be made each year	Funding – N McKenzie (0.5), S Halse (0.7) , AH Burbidge (0.8), S van Leeuwen (0.7), N Gibson (0.3), G Keighery (0.2), L Gibson (1.0), M Lyons (0.5), D Pearson (0.5), B Maslin (0.1), K Morris (0.1), S Patrick (0.3).
NHT2	Dibbler recovery program	$40 500	T Friend (0.1)
NHT2	Gilbert's potoroo recovery program	$73k	T Friend (0.75)
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)
PEST Animal Control CRC	Honours project: Fox re-invasion rates	Nil	N Marlow (0.05)
Pilbara Iron Pty Ltd	Pilbara biological bibliographical database	$7.5k – CALM in 2004	S van Leeuwen (0.0)
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 2002-05 $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)

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	**Project**	**Cash funding and source ($)**	**CALM Involvement (in kind)**
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 2002-03 $55k for 2002-04 CALM contributes $10k pa into CRC - Sally Black's contract was paid for by CALM	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) and 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)
University of Western Australia	PhD – F Donaldson Social structure of burrowing bettongs	$5k pa for 2003-05 from Stipend funds (CALM)	K Morris (0.05) and equipment
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)
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)
UWA	Pilbara Biological Survey: I scientist	$20K for 4 yrs	Taxonomic - D Roberts
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.
Walpole - Nornalup National Parks Association and Walpole Wilderness Eco-Cruises	The impact of wildfire on invertebrate communities in old growth forests	$45k for 2004-05	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)
Western Mining	Mulgaras and associated rare dasyurids of the North-Eastern Goldfields	$30k pa for 3 yrs finishes 2004	D Pearson (0.3)

Astronomical component

Partnership Name i.e. CRC, Govt Depts, Universities, Industries, Other (sponsorships etc)	**Project**	**Involvement ($)**	**CALM Involvement (in kind)**
Kent State University, USA; University of Cincinnati, USA, Edith Cowan University and Curtin University	ASTRONET - Perth Observatory education and information core functions	$2k	0.05 FTE Scientist
University of California, Berkeley, Lawrence Hall of Science & Clarion U.	Hands on Universe - Internet telescope	$5k	0.05 FTE Scientist, 0.2 FTE TO
Curtin University and University of Western Australia	Lecturing - Perth Observatory education core function	-	0.2 FTE scientist
Curtin University	Student project supervision (at tertiary level) - Perth Observatory education core function	-	0.05 FTE scientist
Bureau of Meteorology	Weather monitoring - Perth Observatory information core function	-	0.01 FTE TO
Fire Protection Services, CALM	Fire monitoring - Perth Observatory information core function	-	-
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; South 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	Astronomy education	-	0.05 FTE scientist
GCN (Gamma Ray Burst Communication Network), USA	Supernova search- SPP #98/0014	-	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
Biogeography: Norm McKenzie			
Pilbara	Rangelands	Pilbara Regional Survey	46
Wheatbelt, South Coast, Midwest, Swan, South West, Warren	Avon, South West, Northern Agricultural, Rangelands	Biological Survey of the Agricultural Zone (SAP Survey)	47
All	All	Biodiversity Audit	48
All	All	National Reserve System working group	49
All	All	Ecomorphological clues to community structure, bat echolocation studies	50
All	All	Provision of biogeographical information for CALM management plans, NRM advice scientific liaison and membership of scientific advisory committees	51
Kimberley	Rangelands	Kimberley Nature Conservation output liaison, including submissions to acquire funding support for Kimberley Island Biodiversity Survey	51
Swan	Swan, South West	Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain	52
Goldfields, Midwest	Rangelands	Floristic survey of the banded ironstone and greenstone ranges of the Yilgarn	53
Swan, South West, Warren	South West, Swan	Floristic survey of the Darling Scarp	54
Pilbara	Rangelands	Biological survey of the Barlee Range Nature Reserve	55
Pilbara	Rangelands	Botanical survey of the Hamersley Range uplands	55
Pilbara	Rangelands	Botanical survey of the Pilbara tussock grasslands	56
Pilbara	Rangelands	Biological survey of the south-western Little Sandy Desert	57
All	All	Conservation of Western Australia's vegetation assemblages	58
All	All	Interim framework for developing a CAR reserve system for WA	58
All	All	Land-use and vegetation mapping	58
Fauna Conservation: Keith Morris			
Midwest, Goldfields	Rangelands	Development of effective broad-scale aerial baiting strategies for the control of feral Cats	60
South Coast, Warren	South Coast, South West	Conservation of south coast threatened birds	62
Swan, South West	South West, Swan	Conservation management of the Quokka, *Setonix brachyurus*	63
Swan, South West	South West	Conservation management of the Western ringtail possum, *Pseudocheirus occidentali*	66

CALM Region	NRM Region	Project Title	Page
Swan, South West, Wheatbelt, Midwest	South West, Swan, Avon, Northern Agricultural, Rangelands	Mesopredator Release and CALM's involvement in the Australasian Invasive Animals Co-operative Research Centre (AIA CRC)	68
Swan, Warren, South Coast, South West	Avon, South Coast, South West, Swan	The relictual Gondwanan invertebrate group Amycterinae in the south-west of Western Australia: distribution, diversity and possible threatening processes	70
Swan, Wheatbelt, Warren, South Coast	South West, Swan, Avon, South Coast	Factors affecting establishment in the Numbat (*Myrmecobius fasciatus*) recovery program	71
Wheatbelt	South West, Avon	An assessment of the effect of Fox control on *Phascogale calura* (Red-tailed phascogale) populations	73
Midwest, South Coast	Northern Agricultural, South Coast	Dibbler (*Parantechinus apicalis*) recovery plan	73
South Coast	South Coast	Gilbert's potoroo (*Potorous gilbertii*) recovery plan	75
Midwest	Rangelands, Avon	Genetics and ecology of the Western barred bandicoot (*Perameles bougainville*)	76
Wheatbelt, South Coast	Avon, South Coast	Status and ecology of the Heath mouse (*Pseudomys shortridgei*) in Western Australia	77
Warren, South West, Swan	South West, South Coast	Rapid survey of Quokka (*Setonix brachyurus*) in the southern forests	78
Warren	South West	Monitoring selected vertebrate communities in the Perup Nature Reserve	79
Warren, South West	South West	Assessing the distribution and status of the Wambenger	80
Goldfields, Wheatbelt, Warren, South West	Avon, South West, Rangelands	Probait trials: phase 2	81
Wheatbelt, South Coast, Swan, South West, Warren	South West, Swan, Avon, South Coast	Implementation of the recovery plan for the Chuditch, *Dasyurus geoffroii*	82
Midwest	Northern Agricultural	Management of overabundant marsupials – North Island tammar wallaby case study	83
Pilbara	Rangelands	Monitoring of mammal populations on Barrow Island	84
Swan, Midwest, Pilbara	South West, Rangelands, Northern Agricultural	Ecology and conservation of threatened pythons in WA	85
Goldfields, Pilbara, South Coast, Midwest	Rangelands, South Coast	Protocols for monitoring rock-wallaby abundance and preparation of a recovery plan for WA rock-wallabies	86
Goldfields	Rangelands	Fire effects on desert vertebrates	87
Midwest	Northern Agricultural	Implementation of the Lancelin Island skink recovery plan	88
Goldfields	Rangelands	Population dynamics of rare arid zone dasyurids; improving knowledge for monitoring and management	89
Midwest, Pilbara, Kimberley	Rangelands, Northern Agricultural, Swan, South West	Conservation of marine turtles	89
Wheatbelt	South West, Avon	Return to Dryandra	90
Kimberley	Rangelands	The status of critical weight range (CWR) mammals in the Kimberley – a reassessment	92
Warren	South West	Ecology of the Ngwayir (*Pseudocheirus occidentalis*) and Koomal (*Trichosurus vulpecula hypoleucus*) in the Jarrah forest	93
Swan, Goldfields	Swan, Rangelands	Conservation of Western Australian butterflies	94
Swan, South West	Swan	Native earthworms (Oligochaeta) of the Swan Coastal Plain: biodiversity, distribution and threatening	95

CALM Region	NRM Region	Project Title	Page
		processes	
Flora Conservation: Dave Coates			
South Coast, Midwest, Swan, Wheatbelt, Goldfields	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora	97
Wheatbelt	Avon, Northern Agricultural, South Coast, Swan	Genetic and ecological viability of plant populations in remnant vegetation	98
Wheatbelt, Midwest, Swan, South West, South Coast, Warren	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance	100
All	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	101
All	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	Weeds of Western Australia: advice, liaison, publicity and documentation	102
Pilbara	Rangelands	Wattles of the Pilbara	103
All	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	*Acacia* biology, conservation and utilization	104
Wheatbelt	Northern Agricultural	Wattles in the Shire of Dalwallinu	105
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	106
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	108
Goldfields	Rangelands	Declared rare and poorly known flora in the Goldfields region, wildlife management program	108
South West, South Coast	Avon, South Coast, South West, Swan	Integrated strategies for the control of *Phytophthora cinnamomi* using phosphite	109
Midwest, Swan, Wheatbelt, South West, Warren, South Coast	Avon, South Coast, South West, Swan	Susceptibility of rare and endangered flora to *Phytophthora*	110
Warren, South West, Swan, Wheatbelt	Avon, South Coast, South West, Swan	Selection, screening and field testing of Jarrah resistant to *Phytophthora cinnamomi*	111
South West, Swan	Avon, South Coast, South West, Swan	Dieback-resistant Jarrah establishment in operational forest rehabilitation sites	113
Swan, South West, Midwest, Wheatbelt, South Coast, Warren	Northern Agricultural, Swan, Avon, South West, South Coast, Rangelands	Mundulla Yellows disease in Western Australia	114
Midwest, Swan, South West, Warren, South Coast, Wheatbelt	Northern Agricultural, Swan, Avon, South West, South Coast	Vegetation Health Service	115
Goldfields, Midwest, South west, South Coast, Swan, Wheatbelt	Avon, Northern Agricultural, Rangelands, South Coast, South West, Swan	The population ecology of Critically Endangered flora	117

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Goldfields	Rangelands	Causes of rarity in 4 *Tetratheca* taxa in the goldfields ranges	118
Herbarium: Neville Marchant			
All	All	Collections management	120
Kimberley, Pilbara, South Coast, South West, Swan, Warren	Rangelands, Northern Agricultural, Swan, South West, South Coast	WA Marine Plants Online Project	121
Swan	Swan	Perth Urban Bushland Fungi Project	122
Al	All	Australia's Virtual Herbarium (AVH)	123
Al	All	Biosystematics of the WA flora	125
Al	All	FloraBase	128
Al	All	WACensus	129
Al	All	WAHerb	130
Landscape Conservation: 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	132
South West, Swan, Warren	South West, Swan	FORESTCHECK – Soil assessment	133
South West, Warren	South West	Long-term effects of various fire regimes on species richness and composition of southern Jarrah forest understorey	134
Kimberley	Rangelands	Demography of Australian Boab (*Adansonia gregorii*) stands in relation to fire and grazing	135
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	135
Warren	South West	Walpole fine grain mosaic burning trial	137
Goldfields, South Coast, Midwest, Wheatbelt, South West, Warren	Avon, Northern Agricultural, Rangelands, South West, South Coast	Genetic analysis for the development of vegetation services and sustainable environmental management	138
South West, Warren	Avon, South West	Identification of seed collection zones for rehabilitation	139
Midwest, Wheatbelt, South Coast	Avon, Northern Agricultural, South Coast	Management of weed risk in perennial landuse systems	140
Wheatbelt, Warren, South Coast	Avon, South Coast	Biology of the new psyllid *Cardiaspina jerramungae* in the lower great southern of WA on flat-topped yate	141
Swan, Wheatbelt, Warren, South Coast, South West	Avon, South Coast, South West, Swan	Pest incursion of *Cardiaspina fiscella* in WA	142
South West, Warren	South Coast, South West	Distribution of gumleaf skeletonizer (GLS) in the central and southern forests of WA	143
Warren	South Coast, South West	Quantitative population monitoring of gumleaf skeletonizer (GLS, *Uraba lugens*)	143
Midwest, South Coast, Wheatbelt, South West, Swan, Warren	Avon, Northern Agricultural, South West, South Coast	State Salinity Strategy wetland monitoring	144
South West, Swan, Warren	Swan, South West, South Coast	Monitoring stream biodiversity (KPI 20 for Forest Management Plan)	146
Swan, South West	South West, Swan	Efficacy of stream buffer zones in protecting stream biodiversity and water quality in Jarrah forest subject to timber harvesting	146
Swan	South West, Swan	Hydrological response to timber harvesting and	147

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South West	South West	Management of the Vasse - Wonnerup wetlands	149
Warren	South Coast, South West	Monitoring post-fire effects from the 2001 Nuyts wildfire	150
Warren	South West	Long term monitoring of timber harvesting on bird populations in south-west forest areas	152
South West, Swan, Warren	South Coast, South West, Swan	Project Vesta – prediction of high intensity fire behaviour in dry Eucalypt forest	152
Warren	South West	Increasing productivity of Karri regrowth stands by thinning and fertilizing	153
South West	South West	Effect of fire on groundwater recharge to the Jewel Cave karst system	154
Warren	South Coast, South West	Bushfire CRC Project B1.1: Managing fires in forested landscapes in South-west WA	156
Kimberley	Rangelands	Identification and monitoring of benthic invertebrate communities of tropical intertidal mudflats	157
Warren	South West	Armillaria spread in Karri	158
Warren	South West	The effect of wildfire on fungi	159
Warren	South Coast, South West	The impact of wildfire, in old growth forest of the Walpole-Nornalup National Park, on short-range endemic invertebrates and their forest floor communities	160
Warren	South West	Effects of timber harvesting on terrestrial vertebrates in medium rainfall Jarrah forest	162
South West, Warren	South West, Swan	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	163
South West, Warren	South West, Swan	Evaluation of key soil indicators of sustainability in Australian Mediterranean forests (Indicators 4.1d, 4.1e)	164
South West, Swan	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	166
South West	South West	Control of Jarrah leafminer: selective retention of JLM resistant trees and ground coppice in a demonstration forest plot	167
Swan	Swan	Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity	167
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Science Applications Program: Ian Abbott			
Potentially All		Science Division corporate data directory and repository	170
South West, Warren	South West, Northern Agricultural	Development of biodiversity indices	171
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All	All	Provision of authoritative names of WA plant taxa	172

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All	All	Online GIS biodiversity mapping (NatureMap)	173
All	All	Species database management software (Max)	174
All	All	Taxonomic Descriptive Data software (DELIA)	175
Potentially All		Divisional WAN and corporate database support	175
Potentially All		Implementation of climate change activities in CALM	176
Potentially All		Management of terrestrial bioprospecting in CALM	177
Potentially All		Biometrics	178
Potentially All		Management of Science Division corporate web sites	179

SIGNIFICANT ACHIEVEMENTS ANTICIPATED for 2005/06

ALIGNED WITH CALM's KEY RESULT AREAS

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**: Continue the field program of systematic terrestrial biological survey with emphasis on the Pilbara Bioregion. Promote the SW Agricultural Zone biological survey findings, including communication of results to key stakeholders. Complete analysis and write-up of some 12 sub-regional biological surveys. Commence floristic surveys of Whicher Range and banded ironstone ranges in the goldfields. Prepare proposal for Kimberley Islands survey.
	Information management: Employ database manager to 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)	Ongoing program of biological survey and protected area network gap analysis. Commence planning for biological survey of Kimberley Islands and parts of the south-west forest region. Represent WA in NLWRA's Biodiversity Audit mark2 – Australia-wide project awaiting final approval for funding from NHT before milestones can be defined. Compile recent sub-fossil lists from Napier & Oscar Ranges (SW Kimberley). Also to audit WA biodiversity and conservation activities as part of NLWRA program, producing IBRA sub-regional synopses, IBRA bioregional summaries, case studies for two sub-regions, and analysis of mammal, Acacia, Eucalypt and bird status by bioregion. Participate and contribute to the National Reserves System program and IBRA. Herbarium Identification facilities service research, operations and Nature Conservation Division staff, and CALM consultants undertaking surveys of conservation reserves and forests; survey of conservation taxa completed in southern forests.
KRA 3. Conservation of landscape /seascape scale ecological systems and processes (integrating reserve and off-reserve conservation)	**Adaptive Experimental Management:** Progress adaptive experimental management by embedding Science Division staff in priority operational programs, e.g. managing fire and feral animals on Lorna Glen (Goldfields Region); managing fire for biodiversity in the Walpole Wilderness Area (Frankland District); feral predator control and Mallee fowl recovery on Mt Manning Nature Reserve (Goldfields region); fire regimes for mainland Quokka populations; weed control. With Nature Conservation and Sustainable Forest Management

Key Result Area	Anticipated outcomes or achievements
	Divisions, identify other corporate priority projects that will benefit from this approach. **Fire:** Appoint fire research ecologist, Kimberley region. Coommence investigation into Kimberley fire and mammals. Complete fire management plan, hummock grasslands, Lorna Glen case study. Commence 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. **Feral animals:** Maintain development and field trialling of feral Cat bait at Lorna Glen. Complete Probait non-target trials. Initiate mesopredator release studies (fox/dog/cat interactions) (pending funding from IA CRC). Investigate introduced predator control in the lower Murchison rangelands and Dirk Hartog Isl. Benchmark survey of feral camel populations in WA arid zone. Initiate feral Pig impact studies, south-west ecosystems (ARC Link). Initiate pre-arrival monitoring of cane toads. **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. Animal diseases – Western barred bandicoot **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. Participate in development of Rangelands monitoring protocol. 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:** Develop a framework for managing (warehouse, disseminate, value add) critical biophysical information to support biodiversity conservation and decision making (Naturebank). Assist WWF Woodland Watch Project, provide education and support for conservation of private lands; identification of key species for development of

Key Result Area	Anticipated outcomes or achievements
	management of Biosphere reserves and world heritage properties; outstanding contribution has been made to community-based coastal ecosystems survey (SWALE Project); plant surveys of Lorna Glen, Buntine Marchagee projects etc.
KRA 4. Recovery of threatened species and ecological communities and conservation and sustainable use of other significant species	**Threatened species:** Improved 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-wallaby, Quokka, Noisy scrub bird, Western bristle bird – leading to better conservation management decisions. **Translocations proposed:** Gilbert's potoroo, Western bristlebird, Dibbler, Boodie. Possible translocations of arid zone mammals to Lorna Glen pending success of introduced predator trials. **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. Provide advice on the impacts of proposed mining operations on conservation values of flora and vegetation of the Goldfields and Swan Coastal Plain. Gain an understanding of the reproductive biology and demography of rare Tetratheca impacted by mining. Develop appropriate translocation techniques for a range of critically endangered flora and develop detailed protocols for assessing and predicting translocation success. Continue experimental translocations of 21 critically endangered flora. 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. 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). Complete analysis of population characteristics in relation to connectivity and isolation in remnant vegetation.

Key Result Area	Anticipated outcomes or achievements
	Develop appropriate translocation techniques for a range of critically endangered flora and develop detailed protocols for assessing and predicting translocation success. 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. Commence reassessment of conservation status of WA Acacias. Commence major project to elucidate variation in mulga, a keystone rangelands taxon. **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:** Re-assess Kingston Project sample sites and report on post-logging recovery of vertebrates and invertebrates. Re-assess long-term bird study - Grey forest. Commence investigation into seed collection zones for rehab. Prepare paper on forest health monitoring. Continue monitoring run-off and groundwater in response to logging in IRZ – prepare report. Finalize study design to monitor forest stream biodiversity and water quality. Ongoing establishment, assessment and 5-yearly reporting of FORESTCHECK forest biodiversity monitoring. Expand.
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. Bushbooks), 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	Flora conservation symposium spring 2005. Development of biodiversity information management systems (Naturebank). Landscope expeditions throughout WA. Landscope articles.

Key Result Area	Anticipated outcomes or achievements
	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. Progress World Wide Wattle project and assist with establishment of interpretive centre – Shire of Dalwallinu. 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.

PRIORITIES and ANTICIPATED ACHIEVEMENTS

for 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:** Completion of field component, data analysis and write-up of Pilbara biological survey. Complete data analysis and write-up of sub-regional surveys. Recommendations for strategic acquisition of land for a CAR reserve system. Commence biological survey of Kimberley islands. Commence biological survey of priority forest areas (consistent with Forest Management Plan). **Herbarium:** WA holdings of marine plant specimens databased through external grants in collaboration with Marine Branch. The herbarium will continue to support systematic terrestrial biological survey and has developed a voucher specimen based support and fee dback system to assist ongoing surveys.
KRA 2. Maintenance of a terrestrial /marine protected area network (IUCN management categories I to VI)	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. **Information Management Systems:** Progress the development of *Naturebank* – an integrated biophysical information management system.
KRA 3. Conservation of landscape /seascape scale ecological systems and processes (integrating reserve and off-reserve conservation)	**Adaptive Experimental Management:** Involvement in an additional 6 adaptive ecosystem management programs concentrating on managing threatening processes (fire, ferals, weeds, disease) and translocations. **Fire:** Commencement of 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

Key Result Area	Anticipated outcomes or achievements
	up associated with a range of short and long-term fire ecology projects in s-w forest, woodland and desert ecosystems. A model for predicting the behaviour of high intensity Jarrah forest fires. Completion of field work – fire and biodiversity program – Bushfires CRC. A fire management plan for hummock grasslands and adaptive management approach to implementation. Ongoing application of mosaic burning trials, Walpole Wilderness Area. Establish 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 wih the development of fire management strategies to mitigate large and intense wildfires – tropical savanna, 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. Benchmark data on population and distribution of feral camels. 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 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 Weeds CRC to investigate effective control measures. Invetigate interactions between fire, weeds and fragmentation, seek opportunities for Adaptive Experimental Management programs for weed control and ecosystem rehabilitation. **Herbarium:** Corporate information systems and in particular the Regional Herbaria and adjunct Weed Information Network continue to assist in community based natural resource management planning processes, especially by providing technical data and advice. **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). Complete modelling contract of likely impacts of climate change on south-west biodiversity. Assist with the establishment of rangelands monitoring sites. Complete five year review of FORESTCHECK – publish findings. Ongoing establishment and assessment of

Key Result Area	Anticipated outcomes or achievements
	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. 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. Science Division staff to assist with compliance by providing technical advice. 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. Science Division staff to assist with soil protection requirements by providing technical advice. 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.
KRA 4. Recovery of threatened species and ecological communities and conservation and sustainable use of other significant species.	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

Key Result Area	Anticipated outcomes or achievements
	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. Ongoing collection, testing and storage of seed of threatened flora.
KRA 5. Providing for sustainable nature-based recreation and tourism and increased enjoyment and appreciation of protected areas	The Herbarium is expected to receive specimens collected under Scientific Licence Condition 7.1. This rarely happens and there are no funds to support processing. Appeals will continue to be made to review the Licence condition or provide support for processing specimens that add knowledge.
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. 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:	Community support for the Regional Herbaria Project is still very high. The Project was intended to be financially self -supporting after the initial grant expired however this was difficult to implement because of an expectation that the herbarium should provide an identification service to consultants etc. (it does to CALM staff). In 2003/2004 some well organized community groups have gained funds that will cover costs of specimen identification and processing.
Summary of any major staffing issues:	Key issue for the Science Division is ageing workforce. A Workforce Planning Strategy has been developed to address this. Implementation of this strategy will be a priority for the Division. Greater emphasis on networking and building partnerships.

Key Result Area	Anticipated outcomes or achievements
	The Division is also in the process of restructuring. Division will focus more attention on 'regionalizing research' through greater emphasis on consultation, advice, tech. transfer and participation in adaptive experimental management programs in collaboration with Regions. Funding is required for an additional taxonomist.
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 salary for Anne Cochrane. Increased difficulties accessing external funds. Accommodation and space issues – Perth Herbarium. Proposed new herbarium building will solve this problem. Placement of Perth Observatory. Funding is required for identification botanist - currently only 50% funded. Funding is required for Regional Herbaria co-ordinator and curator. Funding is required for Database Validator. Research Assistants are required for Taxonomist botanists (currently they do not have access to any research assistants unlike all other scientists in the Division). Curation FTE needs to be increased (currently only funded to 1.2 FTE). A thorough and comprehensive review of the Herbarium including management, planning, taxonomic output, staffing levels, funding, specimen preservation, health and safety issues and potential value of the Herbarium information systems to conservation is needed.

RESEARCH ACTIVITIES

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, mobilities, 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

- 150 botanical sites scored twice and 60 additional sites scored once.
- 80% of the 500 stygofauna sites have been sampled twice.
- First half of bat sampling completed at 12 campsites.
- First season of vertebrate sampling, including birds, completed at 151 sites.
- Two thirds (60) of aquatic invertebrate sites sampled, and sampling of invertebrates was completed at the first 150 terrestrial sites.
- Floristic sampling completed on 60 wetland flora sites.
- Numerous 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.
- ALTERM monitoring of region.

Future directions (next 12-18 months)

- Floristic sampling completed on 150 biodiversity and 60 additional sites.
- Second 150 terrestrial sites selected.
- Pilbara survey mammal results presentation at Australian Mammalogy Society meeting.
- Second 150 terrestrial sites installed.
- First 150 terrestrial sites fully sampled for all groups and second 150 terrestrial biodiversity sites sampled for vertebrates once.
- Second 150 biodiversity sites sampled once for flora.
- All wetland sites completed.
- Completed stygofauna fieldwork, sorting commenced.
- Second 150 biodiversity quadrats sampled twice for flora and vertebrates.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Biological Survey of the Agricultural Zone (SAP Survey).

SPP# 98/0020

Team members
G Keighery (0.50), S Halse (0.20), N McKenzie (0.20), M Harvey (0.20), (External); Total CALM (0.90).

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, mobilities, 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.

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.
- ALTERM monitoring of region.

Future directions (next 12-18 months)
The following milestones apply, now that the SAP survey volume has been published:

- A CD that communicates survey results now available.
- Companion booklet to the SAP survey volume completed.
- Buntine/Marchagee monitoring completed.
- Nominate Yallabatharra natural diversity recovery catchment.
- 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 (0.10), A Burbidge (0.10), J May (0.50); Total CALM 0.70.

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.
- Updated Australian mammal audit matrix and begin analysis of regional data.
- analysis of mammal status matrix completed and results displayed as Tables and Figs
- 14 mammal species accounts drafted for ‘Mammals of Australia’.

Management implications

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

Future directions (next 12-18 months)

- Mammal audit paper draft finalized.
- Provided completed drafts and updated distribution maps of 15 species accounts for the revised edition of 'Mammals of Australia'.
- Final fossil identifications from M McDowell and A Baynes.
- Present Audit mammal analysis results at Australian Mammalogy Society meeting.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

National Reserve System working group

Core Function - Policy

Team members
N McKenzie (0.10); 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.
- IBRA version 6 released.

Management implications

- Reserve system development, management and standards.

Future directions (next 12-18 months)

- NRS Directions Statement released by Commonwealth Government, and commence implementation of its directions in WA by CALM.

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.
- Flight performance data compiled for 5 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)

- *Tadarida australis* migration paper published.
- Flight performance data collected and compiled for remaining Pilbara bats.
- Identified echolocation calls from 12 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.

Management implications
- Scientific basis of effective nature conservation.

Future directions (next 12-18 months)
- Prepare discussion paper on status of Greenough Flats Threatened Ecological Community.
- Submit paper on floras of 34 island nature reserves of Shark Bay.
- 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 (0.80), N McKenzie (0.10); Total CALM 0.90, plus AA Burbidge (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.

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 (0.10), G Keighery (0.10); Total CALM 0.20.

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 six papers published on taxonomic outcomes of surveys.
- Numerous presentations.
- Conservation Commission advice on significant forest flora, Whicher 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).

Management implications

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

Future directions (next 12-18 months)

- Swan Coastal Plain flora checklist published.
- Floristic Reference sites established in PMA.
- Complete archiving SCP etc data sheets.
- Prepare taxonomic papers.
- Prepare reserve flora checklist papers for Ridge Hill Shelf.

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 (0.05); Total CALM 0.05.

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 bamded 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.
- CALM Executive Director has approved funding for urgent survey of ranges prospective for iron ore mining.

- Advice to managers.
- Advice to WA Threatened Species and Communities Unit (CALM).
- Advice to CALM's Environmental Protection branch on impacts of proposed developments.
- Prepared budget and proposal for SIAC.
- Interviews completed for 4 new survey positions.

Management implications

- Will give 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)

- Assemble survey team (4 people) and equipment.
- Produce survey report – Year 1 survey.
- Produce survey reports – Year 2.

CALM Regions
Goldfields, Midwest.

IBRA Regions
Coolgardie, Yalgoo.

NRM Region
Rangelands.

Floristic survey of the Darling Scarp

SPP# 2000/0007

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

Context
To assess the conservation significance of the plant communities along the Darling Scarp. This represents the first quantitative survey of this area which has recently been shown to be a regional hotspot for endemic taxa. Project to deliver data to Swan Region NRM and Local Government to assist in land use planning.

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

Aim
Provide a regional classification of the remnant vegetation of the Darling Scarp on public lands between Walyunga and the South Dandalup River. A second related aim is to provide an assessment of the conservation status of the plant species and communities of this area.

Summary of progress and main findings

- Advice to managers.
- Advice to WA Threatened Species and Communities Unit (CALM).

Management implications

- Will provide a regional context for the assessment of the impacts of proposed developments on conservation values on flora and vegetation of the scarp.

Future directions (next 12-18 months)

- Submit paper.

CALM Regions
Swan, Northern Forests, Central Forests, Southern Forests.

IBRA Region
Jarrah Forest.

NRM Regions
South West, Swan.

Biological survey of the Barlee Range Nature Reserve

SPP# 93/0030

Team members
S van Leeuwen (0.05); Total CALM 0.05.

Context
The first detailed quantitative survey of biodiversity assets in the Gascoyne bioregion. Interim management guidelines including a wildfire threat analysis and long-term monitoring quadrats required for Barlee Range Nature Reserve management. Flora, birds, ants, fish, land snails, bats, mammals and reptiles sampled to represent biodiversity (see Pilbara SPP context). Biogeographic link between Carnarvon and Pilbara region surveys. Geomorphic and geographical coverage of reserve using 12 quadrats; six seasons over 5 yrs.

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

Aim
To undertake a biological survey of the Barlee Range Nature Reserve to facilitate an assessment of its conservation values and how these should be managed. This will be achieved by comprehensively documenting the flora, fauna and biotic assemblages present within the reserve and assessing their representativeness on a regional basis.

Summary of progress and main findings

- Landscope Expedition completed.
- Plant specimens identified.
- Advice to other CALM Divisions.
- Advice to external government and non-government agencies.

Management implications

- Knowledge of the biota of the reserve for its management.

Future directions (next 12-18 months)

- Report submitted for publication in Conservation Science or WAM Records.

CALM Region
Pilbara.

IBRA Region
Gascoyne.

NRM Region
Rangelands.

Botanical survey of the Hamersley Range uplands

SPP# 93/0031

Team members
S van Leeuwen (0.05); Total CALM 0.05.

Context
Relevant to Pilbara Biological Survey, wildfire threat analysis for management, and assessment of Threatened Ecological Communities, substantiation of mulga lands conservation reserve proposal and input into priority and declared rare flora listings. Eighty permanent 50 x 50m quadrats throughout the Hamersley Range, sampled during 2 seasons.

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

Aim
To comprehensively document the flora of upland sites within the Hamersley Range. This will facilitate an evaluation of the distribution of rare, geographically restricted and endangered plant species and assist with the identification of areas of high floristic richness for management purposes.

Summary of progress and main findings

- All voucher specimens lodged in Herbarium.
- Taxonomic paper accepted in Nuytsia.
- Advice to other CALM divisions.
- Advice to external government and non-government agencies.
- Deliver seminars to interested community groups.

Management implications

- Knowledge of the floristic values of the Hamersley Range uplands for management and conservation decisions.

Future directions (next 12-18 months)

- 2 scientific papers (community patterns and nestedness) submitted for publication.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Botanical survey of the Pilbara tussock grasslands

SPP# 99/0002

Team members
S van Leeuwen (0.05); Total CALM 0.05.

Context
Relevant to Pilbara Biological Survey, wildfire threat analysis for management, and assessment of Threatened Ecological Communities, substantiation of mulga lands conservation reserve proposal and input into priority and declared rare flora listings. Twenty-four nested 100X100m quadrats in central Hamersley Range sampled in at least 2 seasons. Sites now incorporated in Flora component of Pilbara Biological Survey.

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

Aim
To determine if the tussock grasslands within the Central Hamersley Range are adequately represented in the project area's only conservation reserve, Karijini National Park. Fulfilment of this

aim will be achieved by assessing the botanical conservation significance of the tussock grassland communities in the project area.

Summary of progress and main findings

- Plant specimens identified.
- Advice to external government and non-government agencies.
- Benchmark quadrats for central Hamersley Range.

Management implications

- Knowledge of a significant component of the biota for management planning.

Future directions (next 12-18 months)

- Scientific paper (floristics) submitted for publication.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Biological survey of the south-western Little Sandy Desert, KRA 1.1. 1.2, 6.6
SPP# 99/0003

Team member
S van Leeuwen (0.05); Total CALM 0.05.

Context
The first detailed quantitative survey of biodiversity in Little Sandy Desert bioregion. Long-term monitoring quadrats required for reserve system design and management. Flora, birds, ants, bats, mammals and reptiles sampled to represent biodiversity (see Pilbara SPP context). Geomorphic and geographical coverage of western side of bioregion using 45 biodiversity and 30 flora-only quadrats; sampled in 3 seasons in 3 different years.

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

Aim
To comprehensively document, through systematic and random surveys, the flora and fauna of the southern portion of the Little Sandy Desert. This survey would facilitate the formulation of proposals for the creation of a conservation reserve in this portion of the bioregion. The project aims to document the plants and animals of this poorly known and inadequately reserved region and identify those species and communities which are of conservation significance so they may be adequately protected through land reservation.

Summary of progress and main findings

- Plant specimens identified.
- Advice to external government and non-government agencies.
- Implementation of reserve recommendations.

Management implications

- Data for assessing conservation needs and values in the region.

Future directions (next 12-18 months)

- Report submitted for publication in CALMScience or WAM Records manuscripts.

CALM Region
Pilbara.

IBRA Region
Little Sandy Desert.

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), but seconded for first 6 months, and on leave for last 5 months of year.

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.

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 (1.0), J Angus (1.0), M Onus (1.0), N Hamilton (1.0); Total (4.0).

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.

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 scientific validation of the Track Density Index (TDI) as a reliable estimate 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 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.

- 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 has recently commenced.

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.

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

- All contemporary and historical records of Ground parrots and bristlebirds brought into a digital environment, and accuracy validated, for use in a GIS, to facilitate modelling of habitat use and planning of specific management actions.
- In collaboration with regional staff, discussion paper concerning fire management at Waychinicup–Manypeaks presented at workshops on the South Coast.
- Obtained significant NHT funding.
- Monitored translocated population of Bristlebirds in Walpole–Nornalup NP and re-assessed options for further translocations.
- In collaboration with regional staff, developed an integrated recovery plan for South Coast Threatened Bird Species.
- Written protocol developed for Ground parrot translocations.
- Major systematic survey for Ground parrots conducted in Fitzgerald River National Park. Results made accessible to all park managers and are being used for planning of fire protection and targeted predator control.
- Preliminary nest searching achieved the first photograph of a two-week post-fledging juvenile Ground parrot. This provided a more accurate calculation of timing of breeding while also leading to more positive publicity.
- A conference trip to Queensland indicated a large knowledge gap since the ground breaking work in the 1980s. Consequently the Western Ground Parrot Recovery Project is the only

dedicated research body collecting new information on this species. Very little of the knowledge from the east is applicable to the WA population due to the highly divergent habitat requirements of the eastern and western sub-species.

- Systematic survey for Ground parrots commenced in Cape Arid National Park and reserves to the west including Cape Le Grand NP.
- Monitoring surveys for Ground parrots carried out in Waychinicup; results confirm that population numbers have dropped catastrophically in this area, 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 including Noongar Troops from a pilot program in Albany (Noonac Nidjo Nuntch 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 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 (0.5); M Hayward (former PhD student, now Post Doctoral researcher).

Context
An increased awareness of the presence of the Quokka on the mainland has resulted in numerous records of occurrence since 1992, has confirmed the existence of several populations at the northern extent of the Quokka's known geographic range and indicated the current distribution is similar to that in 1992. Further survey (Liddelow, pers. comm.) has confirmed Quokka presence at additional sites within the northern Jarrah forest. Survey and censuses at six of these mainland locations from the northern Jarrah forest indicated low abundance (Hayward *et al.*, 2003). Population estimates have been derived for only one other site on the mainland (Gervasse, near Collie) (de Tores *et al.*, in review). Only one population is thought to have persisted on the Swan Coastal Plain (from Muddy Lakes, near Bunbury) and this is yet to be confirmed, as is the presence of an unconfirmed report of Quokka presence from a Water Corporation Reserve west of Dunsborough (Jim Lane, pers. comm.). Reasons for the Quokka's decline and its threatened species status

include predation by the introduced Fox, *Vulpes vulpes*, habitat loss, habitat alteration as a result of disturbance from Pigs and habitat alteration from dieback.

In conjunction with the demographic study, surveys were conducted for Quokka presence at 66 sites supporting *Agonis linearifolia* (ti-tree) swamp shrublands within the northern Jarrah forest. Quokka presence/absence at all sites was modelled. The model selection process found Quokka presence/absence was best described by the model which showed Quokka presence required an *Agonis linearifolia* mosaic comprised of areas burnt within the past 10 years, long unburnt areas. The model also showed Quokkas avoided areas with a high proportion of Jarrah - Marri open forest and 15 - 19 year post-fire *Agonis* swamp. The preferred mosaic is therefore specific and complex and presents a challenge for conservation managers and management of the use of fire in particular.

Management actions have been recommended and advocate adopting an active adaptive management approach for the northern Jarrah forest populations. Research and monitoring of these Quokka populations should focus on examining the response to a variety of management practices including habitat manipulation through the use of fire, Fox baiting and Pig control.

The specific issues arising from the northern Jarrah forest research and from the review of distribution and causes for decline are:

- 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 *Agonis* 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.

Even if it is possible to create the preferred mosaic at a local scale (i.e. at individual swamps), it will require some degree of mathematical modelling to determine the optimal management strategy at a landscape scale (i.e. the northern Jarrah forest). This presents a challenge to researchers and CALM's fire management operational staff.

High priority is recommended to examine existing, historic and potential Quokka sites in the northern Jarrah forest, with the objective to stratify the existing *Agonis* mosaic and determine whether any of these swamps can be better managed through the use of fire to create the preferred mosaic. In the absence of an agreed experimental approach (i.e. agreed to by all stakeholders) whereby a set of models and management actions have been formulated and appropriate monitoring protocols have been established, burning of these swamps would constitute a program more akin to the trial and error approach than an adaptive management program.

The structural damage caused by Pigs has not been assessed. The role of Pigs in spreading dieback has not been assessed in terms of its importance to management of Quokka habitat. Similarly, the importance of historic exposure to dieback has not been assessed – the northern Jarrah forest Quokka populations may be existing in *Agonis* swamps which are remnants of a more diverse floristic assemblage and structural mosaic.

It is assumed all northern Jarrah forest sites currently known to support Quokka populations are below carrying capacity and if carrying capacity is reached, dispersal will occur. Consistent with this scenario, it is hypothesised the northern Jarrah forest formerly supported a metapopulation(s) and this metapopulation is currently in a state of terminal collapse (Hayward *et al.*, 2003). However, results from the study on the genetic structure of these same populations (Alacs, 2001) suggests the northern Jarrah forest populations may never have constituted a functional metapopulation(s). There is a need to determine whether Quokkas historically constituted a metapopulation(s) in the northern Jarrah forest as this will influence the management strategies adopted.

The mechanisms for dispersal and colonisation are not known. Do Quokkas disperse from sites at carrying capacity to establish new populations in areas of suitable habitat, and if so, over what distances will dispersal occur? There is a need to determine these dispersal and recolonization patterns.

There is a need to determine the importance of individual Quokka populations/subpopulations over the species entire range. This importance should be assessed in terms of the population's strategic value locally, regionally and globally as determined by its geographic location, demographics, genetic structure and importance as a source population for re-stocking other populations/subpopulations. This would enable land use planners, in particular planners of harvesting and burning operations, to assess the potential impact of these operations on Quokka populations and to adopt a more rigorous and strategic approach to assessment of the potential effects from and operational activities generally (de Tores *et al.*, in review).

Aims

- To undertake a review of the distribution and conservation status of the Quokka, *Setonix brachyurus*.
- To quantify population size and habitat requirements of the Quokka at the sites within the northern Jarrah forest.
- To examine the genetics of populations at the demographic study sites in the Northern Jarrah forest.
- To propose management strategies for conservation of the Quokka at mainland sites.

Summary of progress and main findings

- The major findings have been previously reported and are now also reported in the following publications:

Alacs, E., Aplers, D., de Tores, P. J., Dillon, M. J., and Spencer, P. B. S. (2003). Identifying the presence of Quokkas (*Setonix brachyurus*) and other macropods using cytochrome *b* analyses from faeces. *Wildlife Research*, 30 (1): 41-47.

de Tores, P. J., Hayward, M. W., Dillon, M. J., and Brazell, R. (in review). Review of the distribution, causes for the decline and recommendations for management of the Quokka, *Setonix brachyurus* (Macropodidae: Marsupialia), an endemic macropod marsupial from south-west Western Australia. *Manuscript submitted to Conservation Science Western Australia*.

de Tores, P. J., Hayward, M. W., and Rosier, S. M. (2004). The western ringtail possum, *Pseudocheirus occidentalis*, and the Quokka, *Setonix brachyurus*. Case studies: *Western Shield* Review - February 2003. *Conservation Science Western Australia*, 5 (2): 235-257.

Hayward, M. W., de Tores, P. J., Augee, M. L., Fox, B. J., and Banks, P. B. (2004). Home range and movements of the Quokka *Setonix brachyurus* (Macropodidae: Marsupialia), and its impact on the viability of the metapopulation on the Australian mainland. *Journal of Zoology*, 263: 219-228.

Hayward, M. W., de Tores, P. J., and Banks, P. A. (2005). Habitat use of the Quokka, *Setonix brachyurus*, (Macropodidae: Marsupialia), in the northern Jarrah forest of Australia. *Journal of Mammalogy*, 86 (4): in press.

Hayward, M. W., de Tores, P. J., Dillon, M. J., and Fox, B. J. (2003). Local population structure of a naturally occurring metapopulation of the Quokka (*Setonix brachyurus* Macropodidae: Marsupialia). *Biological Conservation*, 110: 343-355.

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)

- Future directions for which recommendations have been made are:
- Survey to determine presence at Muddy Lake, south of Bunbury and to confirm

presence/absence at other reported locations form the Swan Coastal Plain.

- assess the genetics of south coast, southern forest, Muddy Lake (if confirmed) and Stirling Range populations to determine the levels of genetic variability within each population and for the southern forest and south coast populations, determine the extent of genetic differentiation of populations within the same, nearby and geographically distant catchments.
- Survey and estimate population size at a suite of sites within the same and different catchments within the southern forest and south coast regions and in conjunction with the genetic analyses, undertake spatial analyses of populations to:
- Determine dispersal and recolonization patterns.
- Examine the extent of movement within and between populations in these catchments.
- Future directions for which recommendations have been made and funding requested are focused on implementing the Active Adaptive Management (AAM) program for Quokka conservation in the northern Jarrah forest. The long-term outcomes are to implement an AAM program within the northern Jarrah forest, and through the use of fire, manipulate the vegetation structure of *Agonis* dominated creek lines and create the Quokkas preferred structural habitat mosaic. This mosaic will be more precisely defined – the spatial configuration of the seral stages will be determined (i.e. the proportion of each seral stage required at each *Agonis* creekline will be determined and the component of the mosaic at the upper limit of 'time since last fire' will be determined). Modelling (e.g. Stochastic Dynamic Programming) will determine the extent and annual requirement for burning to maintain the preferred mosaic.
- Monitoring at selected sites will determine whether Quokka numbers increase and will also determine whether Quokkas disperse from known sites and establish new, self sustaining populations. Specific measurable long-term conservation outcomes include determining:
- The number of known extant Quokka sites where the preferred structural mosaic has been established through the use of fire.
- The number of new sites where the preferred structural mosaic has been created through the use of fire.
- The number of sites where Quokka populations remain stable or show an increase in abundance (as measured through survival analyses and population estimates, respectively).
- The number of sites currently thought to be supporting potentially suitable habitat, where Quokka presence has not been detected/confirmed, and where, post habitat manipulation, Quokka presence is confirmed and a population established.
- The number of sites where population mixing has been confirmed (i.e. sites where animals have been known to disperse to and where the source site is still viable).

CALM Regions
Swan, South West.
The findings from the research on the distribution and conservation status encompassed CALM's Midwest, Swan, South West, Warren and South Coast regions.

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

NRM Regions
South West, Swan.

Conservation management of the Western ringtail possum, *Pseudocheirus occidentalis*

SPP # 1993/0142

Team members
P de Tores (0.4), J Jackson (0.4), I Bertram (MSc student, Glasgow University, Scotland); Total (1.0).

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 localized 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 localized 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

- Results from monitoring releases in the period January 2004 to June 2005 at Leschenault and an unbaited site at Yalgorup National Park (Martin's Tank) have confounded interpretation of the program's outcomes. At the baited site (Leschenault), there have been 22 predation events from a sample size of 29 radio collared Western ringtail possums. Ten of these predation events were unequivocally attributable to predation by pythons, nine were attributed to predation by Cats, two attributed to Cat/Fox predation (it was unclear which predator was responsible) and only one predation event was attributed to Fox predation. At the unbaited site there have been six predation events from 24 radio collared Western ringtail possums. Of these, three were attributed to Fox predation, one to Cat predation, one to raptor predation and one was unable to be attributed to a specific predator. There is a clear pattern of an increase in the number of Cat predation events in the presence of Fox control. This is consistent with the principle of mesopredator release (an increase in the abundance of one predator as a result of the removal or reduction in abundance of another, dominant predator). The same may also apply to the pattern of predation by pythons. However, both patterns may simply reflect site specific differences.
- A proposal has been submitted as part of a larger proposal to expand Western Shield and address the issues of mesopredator release at the landscape and local scale.

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 research to date has been funded almost entirely from funds received from proponents of development projects which result in loss and/or destruction of Western ringtail possum habitat and fragmentation of Western ringtail possum populations. This funding source is unreliable, unpredictable and has dictated the research be carried in a stop/start manner. The lack of continuity of the research has confounded interpretation of the results. There are currently no funds beyond 30 June 2005 and, in the absence of 'new' funding, the research will cease at 30 June 2005. An Australian Research Council (ARC) Linkage application has been submitted in collaboration with researchers from Murdoch University. However, that proposal is contingent upon a CALM in-kind contribution and cash contribution. The CALM in-kind contribution and cash contribution was to be sourced from developers. In the absence of reliability of the funds from developers CALM will be unable to honour its in-kind and cash contribution to the ARC Linkage application, and if awarded, the grant will need to be relinquished. Importantly, the ARC Linkage grant, even with CALM's in-kind and cash contribution, is insufficient to examine the suite of issues which need to be addressed to determine whether translocation is a viable management option for displaced and rehabilitated Western ringtail possums.
- In recognition of the above, and the need to determine the importance of these issues to CALM's Western Shield translocations in general, a proposal has been submitted to determine whether translocation can be adopted as a viable management tool for displaced and rehabilitated Western ringtail possums. Specifically, the program will assess the importance of climatic and habitat variables, predator control, predator/predator interactions, predator/prey interactions, survivorship, habitat use, anthropogenic disturbance factors (fire and fire management practices), population demographics and the extent of competition between the Western ringtail possum and the Common brushtail possum, *Trichosurus vulpecula*.
- The research is proposed to be carried out in conjunction with, and will complement the research proposed through, the ARC Linkage application. The ARC Linkage application has sought funding to examine survivorship, habitat use, population demographics, wildlife health/disease issues and the extent of competition between the Western ringtail possum and the Common brushtail possum for *in situ* populations at sites where the two species are sympatric. It will also determine the importance of wildlife health/disease issues to translocation success. CALM's in-kind and cash commitment to the ARC Linkage application is now proposed to be met by funds sought through this application. This will negate the need for dependence on funds from developers and ensure continuity of the research.
- The project outcomes include determining whether translocation is a viable option for displaced and rehabilitated Western ringtail possums, and if so, determining the conditions under which translocation success can be achieved. Irrespective of the viability of translocation as a management tool for the Western ringtail possum (i.e. translocation success or failure), CALM will be better placed to provide advice to land use planners on the ramifications of developments which advocate translocation as a means to ameliorate the effect of habitat loss and population fragmentation.

CALM Regions
Swan, South West.

IBRA Region
Swan Coastal Plain.

NRM Region
South West.

Mesopredator Release and CALM's involvement in the Australasian Invasive Animals Co-operative Research Centre (AIA CRC)
Concept Plan to be prepared

Team members
P de Tores, N Marlow and D Algar; FTE commitment in 2004 /2005 P de Tores (0.1).

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 Australasian Invasive Animals CRC (AIA 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 AIA CRC application was successful and the new centre will commence operation on 1 July 2005. It will become the largest 'organisation' undertaking research into the management of invasive vertebrate species in Australia.

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 (including availability of invertebrates).
- Anthropogenic and other disturbance factors (e.g. Pig damage).
- The role of fire as a disturbance factor and as a management tool.
- Climatic variables, in particular the effect of drought.
- The role of disease.

Summary of progress and main findings

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

Management implications

- The proposal is based largely on findings from CALM's *Operation Foxglove* (northern Jarrah forest) and results from Dryandra. *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 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. The data suggest a reduction in the number of predation events attributed to Foxes was compensated for by an increase in the number of predation events attributed to Cats. This pattern is consistent with the principle of mesopredator release. Similar conclusions were drawn from survivorship data for Woylies translocated from Western Australia and South Australia to Yathong Nature Reserve, western NSW. The translocation was deemed to have failed as a result of predation by Cats. Foxes were considered to no longer be a threat to wildlife at Yathong, however, in the presence of Fox control, 74% of the known predation events were attributed to predation by Cats. Results from Woylie translocations elsewhere have rarely been able to demonstrate translocation success. Of approximately 34 translocations, only four (to Yendicup forest (Perup), Batalling forest, Boyagin Nature Reserve and Karakamia Sanctuary) have unequivocally demonstrated translocation success. Of these, Batalling is a known anomaly as it supports a suite of rare fauna with populations established as a result of translocation. Boyagin Nature Reserve is within 50km of Dryandra (the source of the translocated Woylies) and it is hypothesized that translocation success is a function of the presence of critical habitat attributes and effective Fox control. Karakamia Sanctuary is enclosed within a predator proof (Fox and Cat proof) fence and provides no opportunity for re-invasion by Cats. The combined results suggest that in some sites, Fox control alone is insufficient to result in translocation success for the Woylie and successful translocations are dependent on Cat exclusion and/or the presence of specific habitat attributes.

- Foxglove data further demonstrated that re-invasion of Foxes occurred within two weeks of an aerial baiting event and Fox density was higher in forest areas closer to the interface with agricultural land than in core areas of the forest. The number/proportion of Foxes surviving a 1080 baiting event in the northern Jarrah forest was unknown, as was the extent to which Foxes may be bait shy or bait wary.
- The interactions between the two introduced predator species (Fox and feral Cat) and the resident native predator species from the northern Jarrah forest, the Chuditch, *Dasyurus geoffroii*, are also poorly understood. In the absence of a target specific Cat bait, CALM's ability to control Cats will be limited (i.e. the south-west forests). Where Cats and Chuditch are sympatric, the issue of mesopredator release will need to be addressed before adopting large scale Fox control programs.

Future directions (next 12-18 months)
If the research is supported it will provide managers with a better understanding of the implications of controlling and not controlling one or more predators, the importance and value of integrated control and the relative importance of predator control and habitat management. It will provide managers with a greater understanding of the need, and will provide the wherewithal, to incorporate temporal and spatial aspects of habitat management with feral predator control. Specifically, the outcomes 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 and if so, will determine if Cat control is required in all cases where Fox control is implemented.

CALM Regions
Swan, South West, Wheatbelt, Midwest.

IBRA Regions
Jarrah Forest, Swan Coastal Plain, Avon Wheatbelt, Yalgoo.

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

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 submitted.
- Western Australian insect databases searched for Amycterine specimens.
- Management implications.
- New project.

Future directions (next 12-18 months)

- Database the Western Australian Museum Amycterine Collection.
- Visit the Australian National Insect Collection and Macleay Insect Collection to record Western Australian Amycterine specimens.

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 program

SPP # 1993/0145

Team members
T Friend (0.15), N Thomas (0.5); Total (0.65).

Context
The Numbat is Western Australia's State mammal emblem and is ranked Vulnerable. 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.

It aligns with Corporate Priorities 5, 8 and 12, KRA 4, KRA 6 and sub-outputs NC 4A and NC 4C for 2005/06.

Aims

- To measure the success of establishment of Numbat populations through re-introduction.
- 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

- As only a small number of Numbats were bred at Perth Zoo in 2004, only 4 animals were available in December 2004 so they were released at the Stirling Range National Park (SRNP) rather than going to a new site. Four young born at SRNP were collared and their dispersal and survival are being followed.
- Mortality of Numbats released in the SRNP is principally due to predation by raptors.
- A 5 yr study of the value of predator avoidance training has shown that trained young captive-bred Numbats have a higher survival rate in the 5 months after release.
- Dryandra Woodland was the only Numbat site where driven survey was only carried out this year, in November 2004. Sighting rates remain low, and the regular April survey was cancelled due to lack of funds.
- Two-day diggings surveys were carried out at Boyagin and Batalling. Digging frequencies are relatively high at Boyagin and while the Batalling population is persisting in wandoo areas it has contracted from surrounding recently logged Jarrah forest to the west. The area to the north is an unbaited research site and the survey revealed no signs of Numbats there.
- The Numbat Recovery Plan is being revised and will be submitted in July 2005.
- 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.
- 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 March 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 next year, with recovery team input into the location.
- A survey for Numbats and feral Cats at Dragon Rocks will be carried out with Katanning District involvement in 2005/06. A survey for Numbats will also be carried out at Karroun Hill NR.
- A review of Numbat translocations will be completed by the end of 2005. The revised recovery plan will be submitted for adoption by the State and Commonwealth in July 2005.

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 members
T Friend (0.05), N Thomas (0.05); Total (0.1).

Context
The Red-tailed phascogale is ranked Endangered on State, Commonwealth and IUCN threatened species lists. 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 is currently being prepared.
- 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 scant 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 2005. 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 2005/06. The plan recommends the continuation of this study.

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 (0.5); Total (0.6).

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 and 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

- In 2004 the first mainland reintroduction, at Peniup, was shown to have been successful, with the capture of 52 individuals during the spring monitoring session. Three monitoring sessions carried out with local community members were carried out this year, in September, January and April. Dibblers were first released at the site in October 2001, and until September 2004, although females have been found with attached young, and independent site-bred progeny have been captured, numbers remained low. The third release of captive-bred Dibblers (43 individuals) at Peniup was carried out in Oct 2003.
- A translocation proposal to commence a new reintroduction, to the Stirling Range NP was approved in October 2004, and later that month the 50 Dibblers were released in long-unburnt mallee-heath vegetation in the national park. Several of the released Dibblers have been re-trapped in the release area and monitoring grids have been established. Another release will be carried out at the site in October 2005.
- Monitoring of the 2 Western Shield transects in the Fitzgerald River NP (FRNP) showed that numbers were high in 2004/05. The opportunity was taken to take six wild Dibblers into captivity to maintain genetic variability within the captive breeding colony at Perth Zoo.
- 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.
- Student projects continue to be supported on the Jurien Bay islands. A Stewart is writing up her PhD study on Dibbler-mouse-Dunnart interactions on the Jurien Bay islands (Boullanger, Whitlock and Escape). This work has shown that house mice live longer on Whitlock Island, where nutrient levels are higher, than on the other 2 islands. This follows up the finding by H Mills and K Wolfe that male Dibblers exhibit die-off after mating on Boullanger but not Whitlock Islands and K Wolfe's conclusion that this correlates with nutrient status (Boullanger low: Whitlock high).
- Dibbler surveys commenced in spring 2004 east of the FRNP, near Kundip and Jerdacuttup, where several Dibblers were recorded between 1970 and 1985. Hair tubing is now being used to reduce cost and increase coverage of surveys. Analysis of hair-tube samples collected in Jan-July 2004 from FRNP, Torndirrup NP, Waychinicup NP, near the mouth of the Pallinup and near the Beaufort Inlet revealed no Dibbler hairs. Future surveys will be carried out in spring to maximize the chance of encounters with Dibblers. A new Dibbler site was discovered near East Mount Barren (FRNP) by ranger S Mills in May 2005.

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 continue eastwards in 2004/05, especially between Hopetoun and Esperance.
- A study of Dibbler habitat preferences based on the distribution of captures on trapping grids will commence in 2005/06.

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), S Hands (0.5); Total (2.25).

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 was funded in 2004/05 by NHT through SCRIPT under the South Coast Threatened Species Project and involves collaborative connections with Perth Zoo, universities 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 2005/06.

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

- A temporary translocation of 2 wild potoroos to Bald Island was carried out in February-March 2005. The animals settled into the same area after 2 weeks and both regained weight lost after release. This was a very important finding as the release was carried out at the time of year when the underground fungi that they eat are least abundant. Habitat preferences and dietary information was gained from this study.
- A large furred female pouch young was taken from her mother in the wild and successfully 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 new collaborative health study of wild and captive Potoroos with Murdoch Veterinary Masters student Rebecca Vaughan commenced in 2005. This study will focus on several previously identified disease agents and overall health status assessed through haematology, blood biochemistry and bacteriology.
- Field work for a Landscope Visa card grant project that extends the investigation of oxalosis to the wild population has been completed. Urine samples were collected from 17 wild Potoroos and 14 have been analysed so far, with the result that only one showed the high glycolate and oxalate levels indicating predisposition to this fatal disorder.

- Supported Murdoch Honours student J Meinema's study of the blood parasite Trypanosoma in Gilbert's potoroos in 2004 by provision of blood samples and other field support.
- Continued support of Gilbert's Potoroo Action Group's educational and fundraising activities.

Management implications

- Bald Island provides a very real possibility as a translocation site for Gilbert's potoroo. 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. Recent fire on Mount Manypeaks has reduced translocation site options there. 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)

- Complete analysis of Bald Island trial results and complete report.
- Prepare full translocation proposal, to carry out a translocation of 3-4 animals to Bald Island. These animals will be closely monitored and if they regain release weight and establish home ranges, they could remain on the island as founders, should approval be given. More animals would need to be added in subsequent years.
- 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.
- Establish a long-nosed potoroo colony near Albany and commence new cross-fostering trial.
- 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.
- Support Perth Zoo efforts to develop artificial insemination techniques in Long-nosed potoroos and transfer these techniques to Gilbert's potoroos.

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), N Thomas (0.05); Total (0.10).

Context
Bernier and Dorre Islands are of extremely high conservation value because they have retained populations of several mammals 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 Ph.D. students working on the Western barred bandicoot wart-like virus disease on an ARC Linkage Grant.
- PhD student Steve 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 Steve 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)

- Further tissue from island animals will be collected during a field trip and sent to Steve Smith in 2005.
- The results of the cross-breeding experiment conducted at Kanyana Wildlife Rehabilitation Centre commencing in 1994 will be written up in 2005.
- 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 2005.

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 WA, 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 the only threatened rodent species in WA without either a draft or completed recovery plan.

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

- Second population of Heath mice found in the western part of FRNP, but none trapped at Cape Arid NP.
- Ongoing ecological studies at Lake Magenta NR identify low population turnover (low recruitment), some diurnal movements, and patterns of burrow use.
- Ongoing collaborations with industry (BHP Billiton), Murdoch University and Deakin University (Victorian Heath mouse studies).
- Bibliography updated.

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)

- Ongoing ecological studies at Lake Magenta NR and Fitzgerald River NP: mark-recapture trapping, radiotelemetry, refuge sites, habitat requirements.
- Re-survey of Fitzgerald River National Park sites.
- Investigate population dynamics.
- Develop predictive modelling of occurrence.
- Survey of predicted sites of occurrence.

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

- Approximately 1300 sites across the southern forest have been surveyed, with more than 50% of these inhabited by Quokkas.
- The survey revealed that feral Pig activity and inappropriate fire regimes are adversely impacting on Quokka habitat.
- Early indications are that southern forest Quokkas are responding favourably to Western Shield Fox control.
- Further survey and mapping of sites is in progress.
- Data analysis and publication of findings is progressing.
- Interim guidelines for fire management to protect Quokka habitat have been distributed for implementation.

Management implications

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

Future directions (next 12-18 months)

- Complete analysis of southern forests survey.
- Extend survey to the 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 are stable, with normal distribution curves for ages.
- Capture rate for Woylies remains high at c. 72%, with little variation between fire treatments and through time. This contrasts with Dryandra forest where the Woylie population has decreased substantially in recent time.
- Other vertebrates have to compete with the Woylies for the traps and even though their capture rates are low they are consistent with other areas of similar faunal suites.
- The density of feral predators (Fox, Cat) is consistently low.

Management implications

- Effectiveness of feral predator control (Fox and Cat) over time to assess the effectiveness of Western Shield baiting in the PNR.

Future directions (next 12-18 months)

- Continue monitoring in the PNR twice/year using the CALM Bushrangers as a reward and as a teaching exercise in fauna handling and trapping techniques.
- Prepare 5-yearly 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 underway.

Management implications

- If Wambengers are found to ingest sufficient Probaits, operational baiting with Probaits may need to be restricted to areas from which Wambengers are absent.

Future directions (next 12-18 months)

- Complete field trials investigating the impact of toxic Probaits on a population of Phascogales.
- Analyse data.
- Write final report including management protocols.
- 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.

Management implications

- If the uptake of Probaits by Foxes can be increased to equal that of the dried meat bait, Probaits can be used operationally in all Western Shield sites and thus significant savings can

be made by the Department.

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.

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 a listed threatened species at both State and Commonwealth levels, and a recovery plan was prepared in 1994.

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 conserve the status of the Chuditch. This needs to be reviewed and a revised recovery plan prepared if necessary.

Summary of progress and main findings

- Ongoing Western Shield monitoring at key recovery / translocation sites completed.
- 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 commenced.
- Mukinbudin area surveyed for Chuditch after a roadkill and sightings were reported.

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 IUCN status.
- Recall recovery team.

- Revise Recovery Plan.

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 to be prepared.

Team members
K Morris 0.10, 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 (eg 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, 4.7mg and 9.6mg.
- 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
- Successful ARC linkage grant application with Uni of NSW.
- Vegetation assessment inside and outside exclosures on North Island continued.
- Spotlighting transects completed and suggest that tammar wallaby population is 100-150.
- First field trip to implant deslorin planned for May/June 2005.

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

Future direction (next 12-18 months)
- Twice yearly field trips to North Island until all females are implanted with deslorin, and ongoing monitoring of tammar wallaby population.

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 - G Kregor plus AA Burbidge (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

- Boodie Island reintroduced population of Boodies monitored in November 2004. Boodies are now more abundant on Boodie Island than before rat control was undertaken in 1985.
- Middle Island golden bandicoots monitored in November 2004. Abundance appears to have increased since black rats were eradicated in 1992.
- Boodie and Middle Islands monitored for black rats – none detected.
- Rock-wallaby population assessed on Barrow Island – estimated to be 50-60 individuals, less than previous estimates.
- Report on rock-wallaby survey prepared and distributed to CALM and Chevron Texaco Jan 2005.
- Ongoing input into the development of the Gorgon EIS / ERMP.
- Ongoing supervision of a PhD project examining the social structure and genetics of Boodies on Barrow Island (and other sites).

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 Texaco staff to determine future directions of monitoring program.
- Winter survey of rock-wallabies planned for August 2005.
- More detailed analysis and publication of mammal trapping and spotlighting data.

- Hand over of monitoring responsibilities to Chevron Texaco.

CALM Region
Pilbara.

IBRA Region
Pilbara.

NRM Region
Rangelands.

Ecology and conservation of threatened pythons in WA

SPP # Concept Plan to be submitted (supercedes 1993/0159 and 1998/0005)

Team members
D Pearson (0.15); regional staff at Denham - K Himbeck, M True; Total (0.15).

Context
Several of WAs pythons are threatened.

This project aligns with Nature Conservation output NC 4C, conservation of threatened species. This project also has a significant community involvement component and aligns with NC KRA 6.

Aims

- To investigate the distribution and status of threatened WA pythons by collating Museum and historical records and collecting observations from CALM staff and the general public, including Aboriginal ethno-zoological information.
- The continuation of an ecological study of the threatened Woma python *Aspidites ramsayi*, at Shark Bay (in association with Denham staff) and in the Northern Wheatbelt, focusing on habitat usage, diet, reproduction and field thermoregulation, and investigate the likely threats to its conservation.
- To complete an ecological study of the Pilbara olive python *Liasis olivaceus barroni* on the Burrup Peninsula and publish results for this site and other sites in the Pilbara. Final report of TSN project on Pilbara olive pythons sent to DEH.
- To make recommendations on the conservation status of WA pythons.
- To continue long-term mark-recapture study of Garden Island carpet pythons to aid understanding of the importance of prey assemblages in the reproduction and recruitment of Python populations.
- To commence a radio-telemetry study of the rough-scaled Python (*Morelia carinata*) in conjunction with the Australian Reptile Park if funding from BHP Billiton is forthcoming.
- To prepare educational material to encourage appreciation of the pythons, and involve local communities in their conservation.
- To publish papers on spatial ecology of Carpet pythons and Carnac Island tiger snakes, and a Landscope article on Mondrain Island.

Management implications

- Pythons are top level predators and their ongoing conservation is important as part of sustainable fauna reconstruction. In some areas pythons are becoming significant predators of reintroduced threatened fauna and this interaction needs to be better understood.

Future directions (next 12-18 months)

- Publish paper on distribution and conservation status of Carpet Pythons.
- Publish paper on distribution and conservation status of Pilbara Olive Pythons.
- Complete radio-telemetry project on Burrup Peninsula.
- Complete data entry for Pilbara Olive Python study sites and analyse data.

- Prepare presentations on island populations of Carpet Pythons and Pilbara Olive Python project.
- Ongoing Woma python telemetry (2-3 yrs) at Peron Peninsula and subsequent write-ups.
- In conjunction with CALM Midwest staff, undertake further searches to locate an extant population of Woma pythons in the northern Wheatbelt.
- Continue mark-recapture studies on Garden, West Wallabi and Mondrain Islands.

CALM Regions
Swan, Midwest, Pilbara.

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

NRM Regions
South West, Rangelands, Northern Agricultural.

Protocols for monitoring Rock-wallaby abundance and preparation of a recovery plan for WA Rock-wallabies

SPP # Concept Plan to be submitted (supercedes 1995/0016 and 1995/0005)

Team members
D Pearson (0.05); Regional staff Goldfields, Pilbara, Ngaanyatjarra and Western Desert Land Councils; Total (0.05).

Context
Several of the rock-wallabies that occur in WA are threatened, and occur at low densities, often in remote locations. This project will provide protocols that effectively allow the monitoring of rock-wallabies in these situations, and prepare a recovery plan for these taxa.

It aligns with Nature Conservation Output KRA 4, specifically NC 4C.

Aims
- To compare and assess different techniques for monitoring the distribution and abundance of rock-wallabies; including, but not restricted to, observation and spotlight transects and faecal pellet surveys.
- To develop a range of suitable monitoring protocols for CALM, conservation groups and Aboriginal communities to monitor the distribution and abundance of rock-wallaby populations, often in remote locations.
- To prepare a Recovery Plan for the rock-wallabies that occur in WA- a contract received from DEH, to be completed by November 2005.

Management implications
- Fox baiting in the Townsend Ridges has ensured the continued survival and recovery of this genetically unique population.
- Rock-wallaby populations in the Townsend Ridges and on Mondrain Island successfully survived large fire events and may not be as sensitive to pyric disturbances as might be expected.

Future directions (next 12-18 months)
- Revision of project to focus on investigating appropriate monitoring strategies and protocols for different populations that can be conducted by management staff, Aboriginal contractors and other community members.
- Revision of the draft rock-wallaby recovery plan (1991).
- Establishment of rock-wallaby recovery team covering all taxa in WA to provide a forum for improvement in management operations and to encourage focused relevant research by CALM and tertiary institutions.

- Continued scientific support (rock-wallaby trapping/monitoring and genetic sampling) for management of populations in the Calvert Range, Townsend Ridges, Barrow Island, Recherche Archipelago, Cape Range and desert locations.
- Development of a collaborative rock-wallaby survey/monitoring project with CALM Exmouth and the Cape conservation Group, and the completion of the first round of surveys.

CALM Regions
Goldfields, Pilbara, South Coast, Midwest.

IBRA Regions
Murchison, Central Ranges, Esperance, Little Sandy Desert, Carnarvon.

NRM Regions
Rangelands, South Coast.

Fire effects on desert vertebrates

SPP # 1993/0092

Team member
D Pearson (0.1) Total (0.1).

Context
This project aligns with Nature Conservation Output KRA 3 – conservation of landscape scale ecological systems.

Aim
To research the impacts of spring 'patchy' (= potential prescribed) fires and summer wildfires on the small terrestrial vertebrates, invertebrates and flora of hummock grassland in the Great Victoria Desert and make recommendations for management.

Summary of progress and main findings

- The Queen Victoria Spring study site is one of the few long-term fire monitoring sites in arid Australia (commenced 1986). A fire in Jan or Feb 2003 burnt the entire area, leading to the termination of the field component of the study in March 2003 with the removal of most traps. Spider samples were identified by P Langlands, an Honours student at Curtin University and form the basis of his thesis.

Management implications

- The season and intensity of fires have profound effects on the terrestrial vertebrates in spinifex grasslands. Patchy spring fires enhance local diversity but create opportunities for open areas specialists. Extensive summer fires remove several mammal and reptile species. Patchy spring fires are the preferred fire management strategy to conserve biodiversity in these grasslands.

Future directions (next 12-18 months)

- Recover remaining equipment from the Queen Victoria Spring site.
- Write up spider data for publication with P Langlands and K Brennan.
- Analyse vertebrate trapping data and publish papers on fire impacts on dragon lizards, dasyurids and rodents.
- Lodge collections of flora with WA Herbarium and vertebrates with WA Museum.

CALM Region
Goldfields.

IBRA Regions
Great Victoria Desert, Coolgardie.

NRM Region
Rangelands.

Implementation of the Lancelin Island skink recovery plan

SPP # 1999/0011

Team member
D Pearson (0.1), Perth Zoo - captive breeding; Total (0.1).

Context
The Lancelin Island skink is found only on Lancelin Island and has recently been translocated to another island, Favorite, as part of the recovery plan for this threatened species.

This project aligns with Nature Conservation output KRA 4, specifically NC 4C.

Aims

- To ensure the survival of the Lancelin Island Skink through strategic research and monitoring of the species as recommended in the Recovery Plan, particularly population and habitat monitoring and monitoring the success of a translocation to Favorite Island.
- To update the current Recovery Plan and manage the Recovery Team in role as Chair.
- To train regional CALM staff to take over monitoring role for the Lancelin and Favorite Island populations.
- To continue liaison with Perth Zoo over their small captive population.
- To complete publication of information on the success of captive breeding of Lancelin Island Skink and the impact of herbicide on individuals.

Summary of progress and main findings

- Monitoring of translocated population on Favorite Island in March and November 2004 with CALM Midwest staff. Translocation of captive stock to Favourite Island (total 130 Skinks) appears to have been successful with recaptures of released animals and the capture of a neonate indicating breeding.
- Write up annual report and organize recovery team meeting. Reports on progress of Lancelin Island Skink Recovery Team to Corporate Executive.

Management implications

- The establishment of a second wild population of the skink will greatly improve its conservation status.
- Captive breeding research indicates that the species is long lived and can be bred easily in captivity.

Future directions (next 12-18 months)

- Monitoring of Favourite Island translocated population and Lancelin Island population in Nov and Dec 2005. No further releases of captive-bred skinks contemplated but a direct transfer of individuals from Lancelin Island may be undertaken in the future to provide more genetic diversity in the translocated population.
- Publication of results of captive breeding and translocation to Favourite Island.

CALM Region
Midwest.

IBRA Region
Geraldton Sandplains.

NRM Region
Northern Agricultural.

Population dynamics of rare arid zone dasyurids; improving knowledge for monitoring and management

SPP # 2001/0002

Team member
D Pearson (0.3); Total (0.3).

Context
This project aligns with Nature Conservation Output KRA 4, specifically NC 4C.

Aim
To examine the population fluctuations of 3 dasyurid species which occur on mineral leases in the north-eastern Goldfields and to determine the relative influence of seasonal conditions (rainfall), vegetation change and predation on population structure, dispersal and core habitat usage.

Summary of progress and main findings

- Completion of fieldwork at Mt Keith and supervision of an Honours project examining mulgara diet. Input into preparation of a mulgara recovery plan.

Management implications

- Mulgaras show a strong negative response to low rainfall, but appear to have larger resident populations than sympatric rodents.

Future directions (next 12-18 months)

- Preparation of final report for WMC and publication of results.

CALM Region
Goldfields.

IBRA Region
Murchison.

NRM Region
Rangelands.

Conservation of marine turtles

SPP # 1993/0040

Team members
B Prince (0.75), K Morris (0.35), Total (1.10); 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.
- Ongoing study into monitoring of nesting beach temperature profiles.
- Commenced preparation of WA marine turtle management plan

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 Wildlife Branches.
- Continue involvement with the national recovery team.
- 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.
- Develop a research program for marine turtles in the MoU Box, including Browse Island.
- Continue a study into the temperature profiles of nesting beaches along the north west coast.

CALM Regions
Midwest, Pilbara, Kimberley.

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

NRM Region
Rangelands, Northern Agricultural, Swan, South West.

Return to Dryandra
SPP # 2003/0002

Team members
N Thomas (0.5), 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 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.
- Sightings and capture of wild born Dalgytes within Dryandra Woodland proper indicate that they have established well, albeit in low numbers.
- Boodie translocations carried out into Dryandra Woodland during autumn 2003 and spring 2004 failed predominately due to predation by native and exotic predators 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 WBB wart-like syndrome underway.

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.
- Development of improved trapping techniques and protocols required for monitoring Dalgytes outside RTD enclosures.
- During 2005/06 investigate whether Dalgytes are impacting on Marl recruitment within the enclosures by manipulating Dalgyte numbers through removal for reintroductions.
- Spring 2005 and/or autumn 2006 undertake a top-up release of Dalgytes into Dryandra Woodland; possible translocations to other conservation estate.
- Spring 2005 undertake a release of Boodies into Dryandra to investigate methods to ameliorate predation from Foxes and investigate methods to enhance burrow construction by release Boodies.
- Mala TP for Tutanning Nature Reserve to be completed and submitted by mid 2005.
- Mala translocation carried out into Tutanning Nature Reserve and radio-tracking/monitoring carried out by spring 2005 or autumn 2006.
- Source additional Mala from the Northern Territory for release into RTD enclosure and/or direct

reintroduction into the wild.

- Top up release of Mala to TNR by spring 2006, if practical and required.
- During 2005/06 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), plus AA Burbidge (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.
- 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.

CALM Region
Kimberley.

IBRA Regions
North Kimberley, Central Kimberley.

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 (1.0), C Ward (0.5), J Rooney (0.5) C Vellios (0.5); Total FTE: 2.5.

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 2 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

- To compare survey methods to identify the most effective means of detecting ngwayir and koomal.
- To describe the life histories of ngwayir and koomal within the Perup Jarrah forest (population demographics, fertility, etc).
- To examine the habitat selection and preferences of these possums within the Perup Jarrah forest.
- To investigate what factors explain the distribution and abundance of ngwayir and koomal in the Jarrah forest of the upper Warren region.

Summary of progress and main findings

- All fieldwork associated with all components of this research program have been completed.
- Comparative survey method trials: Data analysis has been completed and a manuscript describing this study has been submitted for publication in a scientific journal.
- Life history studies: Data analyses have been completed and 2 manuscripts, one for each species, have been submitted for publication in a scientific journal.
- Habitat selection: Data analysis for the selection of diurnal refuges for both species has been completed and a manuscript finished.
- Factors associated with the distribution and abundance possums in the Jarrah forests of the Upper Warren region: The data analysis and manuscript for the anthropogenic factors associated with the abundance of ngwayir has been completed and 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 (next 12-18 months)
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.

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

- Completed and distributed progress report on second year of fieldwork at remnant bushland sites on the Swan Coastal Plain (SCP), including initial data analysis of mark-recapture data and relationship between abundance and weather conditions.

- Completed 183 butterfly transect surveys at 21 metropolitan bushland sites comprising 25 fragments, and food- and nectar-plant surveys at each site. These included autumn surveys for the endangered graceful sun moth (*Synemon gratiosa*), and located 3 new sites for this species.
- Completed 3 abundance and habitat surveys of a proposed critically endangered butterfly (the Arid bronze azure, *Ogyris subterrestris petrina*) in Goldfields region.
- Obtained additional records of butterflies from the Kimberley region, expanding knowledge of butterfly distributions in WA.
- Deposited samples of the large bronze azure, satin azure and northern purple azure (*Ogyris idmo*, *O. amaryllis* and *O. zosine*) for DNA analysis with Griffith and Harvard Universities.
- Presented results of surveys at a meeting of the Friends of Trigg Bushland reserve.

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 and distribute report on third year of fieldwork.
- Prepare and publish paper on methods of surveying for butterflies and day-flying moths in Western Australia.
- Draft progress report and inform all stakeholders of results of metro region surveys.
- Conduct more surveys at additional sites in the fourth year of the study.
- 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

- Sampling initiated July 2004, with 5 days field sampling in reserves, National Parks and remnant bushlands on Coastal Plain south of Bunbury.
- 44 sites sampled for earthworms.
- At 13 sites no earthworms found.
- Limited sorting and identification done.

  Preliminary observations:

  - 2 of 2 sites on Quindalup units, no earthworms.
  - 5 of 5 sites on Spearwood units under Tuart, no earthworms.
  - 3 out of 4 sites in vicinity of creek lines with introduced *Aporrectodea* spp.

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 winter 2005 and 2006.
- Commence identification of specimens in January 2006.

CALM Regions
Swan, South West.

IBRA Region
Swan Coastal Plain.

NRM Region
Swan.

FLORA CONSERVATION

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.

Aim
To provide genetic information for the conservation and management of Western Australian flora, especially rare flora. Current work aims to resolve the possible hybrid status of *Grevillea phanerophleba*; to determine the genetic diversity between the 2 subspecies of *G. curviloba* to inform taxonomic status; to determine the diversity and clonality in *E. absita*, to determine taxonomic identity of populations in the *Synaphea stenoloba* complex, and to determine level of differentiation between populations of *Eremophila microtheca* and *E. rostrata* to inform taxonomic status.

Summary of progress and main findings

- *Grevillea phanerophleba* – analysis of genetic variation of plants of *G. phanerophleba* and the putative parents *G. amplexans* and *G. biternata* from 2 locations has been completed. Comparison of the genetic identity and taxonomic identity is consistent with the species being a hybrid but is not conclusive. Further evaluation with other genetic markers, cpDNA and rDNA was not informative.
- *Eucalyptus absita* – Survey of the area revealed 4 new populations plus one new hybrid population. Genetic analysis has shown that all populations except one are single clones. The number of known individuals is now 16 rather than hundreds as previously determined.
- *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* – Collections of material have been made from the known populations and DNA extracted for genetic analysis to investigate the level of differentiation between populations from different areas in each species as they are suspected to represent different subspecies.

Management implications

- Assessment of the hybrid status of *G. phanerophleba* will ensure that management of this Critically Endangered species is appropriate.
- Identification of clonality within clumps of *E. absita* means that there are only 16 individuals of this taxon known leading to a possible revision of its conservation status.
- 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.

Future directions (next 12-18 months)

- Work on *G. phanerophleba* will be completed to resolve its putative hybrid status.
- Work on *G. curviloba* will be completed to resolve the level of differentiation between the subspecies and the extent of clonality within the populations.
- Analysis of *E. bennettiae* as a hybrid between *E. sporadica* and *E. lehmannii* will be published.
- Taxonomic revision of the leafless *Tetratheca* species in the Koolyanobing area will be published.
- 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), 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

- Completion of microsatellite marker development for *C. quadrifidis* and gene flow studies completed for *C. quadrifidis* and of *E. wandoo*.
- Completion of seed set/reproductive output analysis for *C. quadrifidis* and *E. wandoo.*
- Completion of growth/fitness trial experiments for *C. quadrifidis, E. wandoo* and *E. pauciflora*.
- Mating system studies completed for *E. pauciflora, E. wandoo* and *C. quadrifidis*
- Final Milestone report for phase 1 of the project with CSIRO submitted to Land and Water Australia.
- Paper in press 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 *Molecular Ecology* on 'Isolation and characterization of microsatellites in the woody shrub, *Calothamnus quadrifidus* (Myrtaceae)'.
- Paper submitted to Biodiversity and Conservation. 'Bird pollination and mating system variation for the shrub in fragments of species rich kwongan in south-west Western Australia'.

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)

- Finalize funding with CSIRO for phase 2 three year program with Land and Water Australia.
- Based on above commence selection of additional species and site selection in Spring 2005.
- 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.

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 published in *Conservation Genetics* on 'Genetic divergence among and population genetic structure within 2 rare *Banksia* species and their common close relative in the *Banksia* subgenus *Isostylis* R.Br. (Proteaceae)'**.**
- Book Chapter 'Genetic variation in plant populations: assessing cause and pattern.' published in *Plant Diversity and evolution: Genotypic and Phenotypic Variation in Higher Plants.*
- Draft paper completed on 'REDUCED genetic diversity and increased inbreeding in the rare ghost wattle, *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.*

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)

- Submit paper to the international journal Conservation Genetics on 'Reduced genetic diversity and increased inbreeding in the rare ghost wattle, *Acacia sciophanes* compared with its sister species *Acacia anfractuosa*'.
- 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 data analysis of population genetic structure in the critically endangered *Verticordia*

staminosa.

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), D Coates (0.05); Total (2.05).

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 more than 158 rare, threatened and poorly known taxa were made (283 accessions). This included 109 DRF, 112 Priority and 62 general collections of taxa associated with threatened ecological communities.
- All data pertinent to the collection, testing, storage and monitoring of seed-based data has been entered into the WASEED database, which is presently undergoing some updates.
- TFSC staff attended a seedbanking workshop and delivered 3 talks at Mt Annan Botanic Gardens, Sydney (4-8 April, 2005).
- TFSC staff attended the *Eighth International Seed Workshop* (Brisbane 8-13 May 2005).
- In conjunction with the CALM Albany District Conservation Officer, a bushbook on Endemic Flora of the Stirling Ranges National Park is nearing completion.
- A poster paper was presented to the *Eighth International Seed Workshop* in Brisbane in May 2005, entitled ‘Salt tolerance in six conservation significant species from south-western Australia’ by A Cochrane and S Schreck.

- A poster paper was presented to the *Eighth International Seed Workshop* in Brisbane in May 2005, entitled 'Successful storage of seed from threatened West Australian plants' by A Crawford, A Cochrane, K Steadman, J Plummer and R Probert.
- Three articles were published in *Landscope*:
- Pearson, D, Hopper, S, Cochrane, A, Comer, S and Danks, A 2004 'Fire in the Arc' *Landscope* 20, 1: 10-17.
- Cochrane, A. 2005. 'Seed bank pays dividends' *Landscope* 20,2: 27-31.
- Cochrane, A Barrett, S and Gilfillan, S. 2005. 'The feather leafed banksias' *Landscope* 20, 3: 22-28.

Management implications

- Improved conservation of threatened 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.
- Ongoing research into the seed biology and seed storage behaviour of a number of critically endangered 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.
- Presentation of poster to Australian Mammal Society conference, Albany (4-8 July 2005) entitled 'Endozoochory and the Australian bluebell: seed consumption of *Sollya fusiformis* by mammals at Two Peoples Bay Nature Reserve, Western Australia: by A Cochrane, T Friend and S Hill.
- Draft paper prepared on 'The effects of temperature and dormancy breaking treatments on the germination of 5 endemic and geographically restricted herbaceous perennials from south west Western Australia'.
- Other articles for publication.

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 (0.3), 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.

Aims

- 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.
- To update Western Weeds field guide.

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.
- Complete major weeds review for State of Environment report.
- Publish second edition of Western Weeds.

CALM Regions
All.

IBRA Regions
All.

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 W.A. taxa of *Acacia* completed; new species, *A. splendens* (with C. Elliott), submitted for publication.
- Field 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 W.A. *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 through (1) publication of a book (field guide) and scientific papers; (2) conducting an Acacia Symposium in Dalwallinu, (3) developing an Acacia website (called WorldWideWattle) and (4) 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 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.

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).
- Effect appropriate 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

- 21 translocations planted in previous years were monitored.
- Assisted District CALM staff with planting and monitoring of new flora translocations for *Grevillea batrachioides* and *Verticordia albida*.
- Assisted community members from Cunderdin in planning, planting and monitoring of translocations of *Acacia volubilis* and *Daviesia cunderdin*.
- 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 4 workshops on Australian threatened flora translocations in Bendigo, Perth, Brisbane and Canberra. 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.

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 21 critically endangered plant species where further planting's are deemed necessary.
- Assist District and Regional staff in planning and planting at least 3 more translocations of Threatened plant species.
- Continued the monitoring of the 21 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.
- Assist in running at least 3 more interstate workshops on threatened flora translocations.

CALM Regions
Midwest, South Coast, South West, 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.) Approx. 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.
- 17 taxa have been targeted for survey, with an increase of 18 known populations.
- 12 taxa have been put forward for addition to the Priority list.

Management implications

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

Future directions (next 12-18 months)

- 1 taxon has been highlighted for recommendation for gazettal as rare after a small amount of further survey in the 2005 flowering season.
- Further survey is required on c. 120 taxa not yet targeted.
- The list of target taxa requires revision in relation to new taxa added in the most recent Priority List of February 2005.

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 102 taxa have been completed and information updates from Dept. files underway for all Priority 1 taxa.
- Mapping of populations for final report completed for all Priority 1 taxa.
- Two days fieldwork completed in the Region.

Management implications

- A first meeting has taken place for the Recovery team for the Goldfields Region.

Future directions (next 12-18 months)

- Add information to files and manuscript account for all new taxa added to Priority List as work continues.
- Write up accounts for 100 taxa remaining to be completed and other parts of the Management Plan.
- List all populations, with dates of inspections, number of plants, and condition of populations for all 44 Priority 2 taxa.
- Send Priority Two taxa information to the Goldfields Regional Ecologist for fieldwork during flowering season.
- Arrange fieldwork in the Region.

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.

Management implications

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

Future directions (next 12-18 months)

- Applied for NRM funds to determine plant species differences in phosphite effectiveness in order to build a database of species belonging to either phosphite effective or non-effective groups.
- 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.

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 105 taxa for susceptibility in 2005.
- To date 50+ taxa transferred to pots for testing in 2006.
- Database of 200 + taxa updated.
- Provisional susceptibility list distributed within CALM.

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 2005.
- Inoculate plants in 2006 and record mortality.
- Update database.
- Test survivors for root infection.
- Test *Lambertia* species for within species variation in susceptibility.

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 (0.15); Total (0.15).

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

- The project has been reviewed and it is now in the final analysis and write-up phase. It will be phased out in 2005-06 and 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).

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 17 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 drought deaths were recorded at both sites. There were minimal additional losses in 2002-05.

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

- Limited infill planting was done in 2004 and 1 new line was added; the total number of unrelated DRJ lines planted is now 29.
- DRJ clones are now in production at Alcoa's lab for final infill planting in July 2006, to reach the goal of 35 DRJ lines.
- First seed is expected to be produced within about 2 yrs, with the first crop of buds now developing.

Seedling inoculation trials (NHT Project 003072):

- A series of glasshouse inoculation trials was carried out in summer/autumn 2002-03, and monitoring carried on in 2003-04, using seedlings derived from surviving resistant lines in early field inoculation trials. These trials will give the first indication of the likely performance of the DRJ seed orchard progeny. Final assessments were done in 2004 and data analysis for 3 of the 4 trials is complete. Progeny have shown good levels of resistance in general.

Management implications

- Once seed production starts in the seed orchard (expected within 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)

- Complete analysis of data for the 2002-04 inoculation trials on seedling progeny of survivors in early field inoculation trials (NHT Project 003072), and prepare report. Transfer final selections to Alcoa lab for propagation.
- Prepare report on field survival and growth of DRJ for publication.
- Infill planting of DRJ Seed Orchard at Manjimup PPC in July 2006.
- 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 (0.3); Total (0.3).

Context
Operational Dieback Forest Rehabilitation (DFR) plantings will desirably include Dieback Resistant Jarrah (DRJ) – 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 survival assessments were completed on the 2 trials established in 2003 at Willowdale and Jarrahdale.
- Data were analysed and a progress report completed.
- Probing of soil prior to planting, to ensure adequate soil depth for root penetration, led to the highest levels of Jarrah seedling survival, and the application of mulch also enhanced survival. However, fertilizer (applied post-planting as 'tree pills'), did not enhance survival and indeed depressed it.
- A further trial was established in 2004 on a black gravel DFR site at Willowdale, and additional treatments (including a different slow-release fertilizer, and watering) applied. Preliminary observations indicate very good survival levels following this fertilizer application.

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.

Future directions (next 12-18 months)
- First-year assessment and Pc sampling of the 2004 trial, and second-year assessment of the 2003 trials, are due in 2005.
- Data to be analysed and a report written for publication.
- One further trial needs to be set up in 2006 to determine the combination of treatments for optimum Jarrah seedling survival in the Black Gravel sites, based on the results achieved 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 Yellow (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 30 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 (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

- Monitoring of MY in WA by CALM has continued, in collaboration with Dr D Hanold 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 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. [Researchers from Victoria visited WA in February 2005 and were shown a variety of MY sites by M Stukely.]
- Scientific paper submitted for publication.
- MY-affected trees have been recorded by me 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.
- Revisited MY sites in South Australia and met with University of Adelaide researchers (April 2005).
- 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.
- 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 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 (0.25), J Webster (0.6); J Ciampini (0.4); Total (1.25).

Context
Accurate knowledge of the Phytophthora 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 1133 samples were processed for *Phytophthora* between 1st May 2004 and 30th April 2005.
- 163 *Phytophthora* isolates (other than *P. cinnamomi*) were subcultured for identification to species.
- Unusual *Phytophthora* isolates were again sent to Murdoch University for DNA analysis. This *Phytophthora* has been found with unexpectedly high frequency in association with dying plants. While it is morphologically similar to *P. citricola*, its DNA sequence is quite distinct, and suggests a separate species.
- 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.
- 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.
- Further work will be done on the recently isolated *Phytophthora* sp. nov., with a view to publishing this.
- The *Phytophthora* Culture Collection will be maintained and expanded, and available to researchers.
- 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.*

- Published paper in Conservation Biology.
- Factors affecting seed germination and seedling establishment are more important than factors affecting seed production for the persistence of *V. fimbrilepis* in habitat fragments.
- Monitored 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.

Fire and the population dynamics of a critically endangered shrub *Cyphanthera odgersii* ssp. *Occidentalis.*

- Published paper in conference proceedings.
- Factors affecting seed germination and seedling establishment are more important than factors affecting seed production for the persistence of *C. odgersii* ssp*. occidentalis* in habitat

fragments.

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 *Cyphantehra odgersii* ssp. *occidentalis* and *V. fimbrilepis* spp. *fimbrilepis* in habitat fragments.

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* 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

- Measured population demography, pollination and reproductive for the 4 taxa.

Management implications

- The comparative investigations of the 4 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 4 species.
- Collect environmental data for modelling distribution of the 4 species.

CALM Region
Goldfields.

IBRA Region
Coolgardie.

NRM Region
Rangelands.

HERBARIUM

Program Leader: Dr Neville Marchant

Collections management

Core Function

Team members

K Knight (0.8), N Marchant (0.1), R Cranfield (0.4), C Parker (0.5), P Spencer (0.5), S Carroll (0.9), K Veryard (1.0), 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 7.4.

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

- 21 480 specimens were added to the collection, which now stands at 614 020.
- The major plant groups now in the collection are as follows:

Myxomycetes	377
Fungi	10 133
Algae	12 057
Mosses	6 193
Liverworts	1 738
Lichens	10 469
Ferns	3 289
Gymnosperms	1 828
Monocots	95 694
Dicots	472 062
Total	**614 020**

- Significant curatorial work accomplished in the family Poaceae and the genera Eucalyptus, Tetratheca, Hypocalymma, Acacia, Stylidium, Thryptomene, Micromyrtus and Senecio.
- Rare Flora taxa curated see under WACensus and WAHerb.
- Significant collections added to the Herbarium holdings were as follows:
    - SWALE 2 (Surveying Western Australia's Land Edge) Project
    - Forest Check
    - Banksia Book vouchers
    - Mount Bakewell Reserve Survey
    - Planetary Biodiversity Inventory
    - Salinity Action plan
    - Stirling Range Fire Research
    - UWA survey Recherche Archipelago
    - Wildflower Society Bushland Survey
    - Woodland Watch Project
    - Gnangara Mound Survey 2002
    - ITC Remnant Vegetation Survey
    - SEARCH
    - Upper Lefroy Valley Catchment
    - WA Lichen Study Curtin University
    - Swan River Trust

    - G Byrne Collection
    - G Sankowski Collection
    - Flora Conservation (S Patrick)
    - Managed and supported by the curatorial staff, volunteer participation again was significant, totaling 14 565 hours (equivalent to 8.1 FTE).
- Tasks carried out and/or assisted by volunteers were as follows:
    - Volunteer Newsletter.
    - Mounted 12 610 specimens.
    - Assisted in curation of specimens.
    - Assisted in the incorporation of 21 480 specimens that were added to the collection this year.
    - Delta scoring commenced for Petrophile and Isopogon.
    - Completed the DELTA scoring for Dryandra.
    - Validating plant chemistry vouchers.
    - Validated 1 097 doubtful location outliers.
    - Continuing the validation of the 6 000 specimens of the W E Blackall collection.
    - 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 to 38 genera and 115 species.
    - Validating collection information on 2 300 Max Koch collections.
    - Maintained and increased the number of taxa represented in the Reference Herbarium. The Reference Herbarium now has 13 530 specimens.
    - Over 1710 visitors have used this resource to identify their plant specimens.
    - The state-wide Regional Herbarium Network continued to be supplied with identification validation, vouchering and databasing. 1 985 specimens from the Regional herbaria were identified and added to the collection. Contribution from Regional Herbaria now total 23 915 specimens.
    - Mounted, repaired and sorted 1 500 marine algal and seagrass specimens for On-line Marine Plant Project (see below).

Future directions (next 12-18 months)

- To continue extending the collection and to provide information on the flora of Western Australia.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

WA Marine Plants Online Project

Team Members
C Parker (0.2), J Huisman (0.2), E McGough (0.6), M Baister (0.6). Total (1.6).

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 15 000 specimens (out of a total 25 000), 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

- Permission to use the WA files of the AMANI (Australian Marine Algal Name Index) database, thus ensuring c. 1000 marine algal names will be incorporated into the WA Census.
- Draft guidelines for collecting new marine plant collections available.
- Specimens received at the Herbarium for databasing from CSIRO, Murdoch and UWA amount to three quarters of total available for databasing.
- 5 volunteers work on the project carrying out repair work and mounting of specimens, so far 1 500 specimens processed.
- Identification of names totals 172.
- Specimens databased 2 409 bringing total collections for project to 5 500.

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)

- Complete databasing of remaining 15 000 specimens.
- Provide on-line information about them via FloraBase.
- Verify the identity of specimen images.
- Identify remaining unnamed specimens.
- Establish a collection techniques training program.

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

IBRA Regions
Central Kimberley (CK); Dampierland (DL), Northern Kimberley (NK), Victoria Bonaparte (VB), Geraldton Sandplains (GS), Swan Coastal Plain (SWA), Jarrah Forest (JF), Warren (WAR), Esperance Plains (ESP).

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

Perth Urban Bushland Fungi Project

Team members
N Boucher (1.0), R Hart (0.5); Total 1.5.

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 addresses the current low level of awareness and knowledge about fungi and their general exclusion from 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 37 workshops and forays in 18 urban bushlands.
- Details of 847 fungi recorded.
- 121 fungi specimens collected for WA Herbarium collection.
- First record of the Spotted Mycena in Western Australia -- found in Kings Park.
- Common Fungi of the Perth Region posters prepared and distributed.
- PUBF website created.

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 planned for the 2005 season, including GPS and digital camera workshops.
- Launch of PUBF website on 3 July 2005.
- Incorporation of ex CSIRO fungal specimen data and species images into WA Herbarium databases.
- 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 (0.2), K Knight (0.2), E McGough (0.6, contract), M Ware (0.5, contract), C Douropoulos (0.4, contract), J Dale (0.4, contract), M Humphreys (1.0, contract), M Baister (0.6, contract); Total 3.9.

Context
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 the necessary tasks of curating, identifying, databasing and validating the material to be incorporated into the main herbarium collection.
- Approximately 12 000 records will have been processed this financial year. This added to the 47 700 in previous financial years yields a total of c. 60 000 specimens processed as part of the AVH since project commencement in 2001.
- 2 230 AVH records were given an improved identification as a result of taxonomic validation in this period. In total, 9 100 specimens databased as part of the AVH backlog have been given an improved identification as a result of taxonomic validation.
- Having dealt with the more well-documented specimens in the AVH backlog, the remaining 30 000 specimens to be processed as part of the project will be found to be increasingly time-consuming to curate, identify and database. As outlined in the AVH Mid-term Review (June 2004), the PERTH component of the AVH project may discover a number of species not able to be incorporated into the herbarium collection.

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)

- Validation of geocode statement and identification will be continue to be prioritized to ensure a consistent quality across the national collection, projected to total 6 million specimens.
- The distributed web mapping application for AVH has been re-developed to ensure that the accumulating data is readily accessible through a reliable and intuitive interface, and is due to be tested and implemented during 2005-06.
- 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 staff for the Australian Plant Consensus Census project have been appointed.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Biosystematics of the WA flora

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), M Trudgen (0.4), J Wege (1.0), BS Mahon (0.4), B Richardson (0.6); R. Davis (0.2); Sue Carroll (0.1), M Trudgen (0.4, contract), J Wege (1.0, contract), P Wilson (0.2, contract); Total 8.3.

Aims

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

Taxonomic studies of Conservation Priority species

- Taxonomy of several groups clarified taxonomically, e.g. *Petrophile* (Proteaceae) and *Dicrastylis* (Lamiaceae) (B Rye).
- Taxonomy studied in *Tetratheca, Lomandra, Wurmbea* and other plant groups, especially in Warren Region (T Macfarlane).

Taxonomy of the family Poaceae

- *Amphipogon* revision published in Flora of Australia (T Macfarlane).
- Book chapter published on grass classification (T Macfarlane).
- *Austrodanthonia* revision in WA continued with fieldwork and identification of one presumed new species as a species already known in eastern Australia (T Macfarlane).
- Botanical support for Quarram grassland management team (T Macfarlane, R Cranfield).

Taxonomy of the family Epacridaceae

- Collaborative research into the relationships of WA *Monotoca* based on morphological and molecular evidence continued (A Chapman).
- Paper describing 1 new species in *Monotoca* finalized for publication (A Chapman).
- Collaborative research on generic concepts extended to include 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).
- Standard character list for comparative morphological data capture across the family prepared and circulated amongst participants (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).
- Paper describing 2 new species in *Brachyloma* accepted for publication in Nuytsia (R Cranfield).
- Progress with defining additional species in *Brachyloma* (R Cranfield).

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 (B Rye and M Trudgen).

- Papers in press for *Astus* and *Astartea* (M Trudgen and B Rye).
- Several papers submitted and many others in preparation (B Rye and M Trudgen).
- Paper on *Agonis* and relatives now in press (J Wheeler and N Marchant).
- Progress on manuscript preparation for revision of *Chamelaucium* (N Marchant).
- Continuing studies of *Darwinia*, including preparation of illustrations (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 *Erodophyllum*, and description of 2 new genera from the Pilbara region (N Lander).
- Completion of interactive key to WA genera of Asteraceae for use in FloraBase (N Lander).

Taxonomy of the family Proteaceae

- Paper in press 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*: literature review and significant field work towards a reassessment of the taxonomy of this group (A Spooner).
- Interactive Key to *Dryandra* completed, currently in test phase (N Lander, volunteer).
- Data scored for interactive key to *Petrophile* and *Isopogon* (N Lander, volunteer).

Taxonomy of the family Chenopodiaceae

- Supervision of PhD project on subfamily Salicornioideae (Samphires) completed with examination and passing of K Shepherd's thesis (T Macfarlane).
- Papers published on:
- Molecular analysis of phylogeny (K Shepherd, M Waycott, A Calladine).
- Fruit and seed structure (K Shepherd, T Macfarlane, T Colmer).
- Morphological analysis of variation and phylogeny (K Shepherd, T Macfarlane, M Waycott).

Taxonomy of lichens (R Cranfield)

- Census of lichens for WA published.
- Census of lichens for WA being maintained, and submitted for inclusion as a new section of FloraBase.
- WA Herbarium collections reviewed.
- Fieldwork with international lichen specialists.
- Collections from NSW and Canberra herbaria 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.
- Digital image project underway to illustrate lichens for FloraBase and field guides.

Taxonomy of the family Stylidiaceae (J Wege)

- Study and curation of the Stylidium collections at Perth.
- Taxonomic resolution of several species complexes, including the identification of 15 new taxa and the reinstatement of 2 species.

- Field research, including the collection of 150 herbarium vouchers.
- Additions to the conservation priority list, including a successful DRF nomination.
- Provision of photographs to Florabase.
- Papers accepted for publication:
- *Stylidium validum* (Stylidiaceae): a new trigger plant from southern Western Australia.
- *Stylidium diplotrichum* (Stylidiaceae): a new scale-leaved trigger plant from south-west Western Australia, with taxonomic and anatomical notes on allied species.
- Reinstatement of *Stylidium rigidulum* (Stylidiaceae), with notes on the morphologically allied *S. kalbarriense*.
- Taxonomic notes on the locket trigger plants from Stylidium subgenus Tolypangium section Repentes.
- Taxonomic observations on the *Stylidium leptocalyx* complex (Stylidiaceae).
- Taxonomic observations on *Stylidium spathulatum* (Stylidiaceae), with the description of 3 allied species from section Saxifragoidea.
- Description of *Stylidium hymenocraspedum* and the lectotypification of *S. maitlandianum* (Stylidiaceae).

Interactive Key to species of *Phytophthora* (N Lander)

- Revision of the interactive key to *Phytophthora* species created in 1998 has been commenced, adding 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).
- Weed species descriptive data for FloraBase, scoring continued with a focus on Kimberley species with funding from the Weed CRC (volunteers, A Spooner).
- Blackberry survey conducted in summer 2004/05 by CALM, Forest Products Commission, Agriculture and Landcare staff provided a contemporary view of distribution of the different species and led to focused control work, with identifications of specimens carried out with CSIRO (T Macfarlane), and field data gathering for biological control feasibility study (R Cranfield).
- Participation in Manjimup Weed Action Group (T Macfarlane, R Cranfield).

3. Managing the Herbarium's taxonomic journal Nuytsia

- Publication of 1 part, containing 18 papers and short communications, including the formal recognition of 29 new taxa in 9 plant families.
- Preparation of 3 parts for publication, containing approx. 40 papers and short communications.
- Publication of an online presence for the journal allowing greater access to contents, abstracts and the download of recent papers, as well as searching across all papers and short communications since 1970. A resource section for authors is also included.

4. Scientific names: participation in the Australian Plant Census (Consensus Census) project

- Participation by CALM in the project to prepare a single plant census for the whole of Australia involved attendance at a workshop in Canberra (T Macfarlane).
- The first stage concerns rare and threatened plants which is part of the project to align State and Commonwealth endangered lists.
- There will be some changes to the way the Herbarium, via the WA Census, handles two classes of informal plant names, Phrase names and Manuscript names.
- Several Departmental staff are contributing to this project.
- The Australian plant census, which will be a consensus on names of species and the classification used, will be an important framework for Australia's Virtual Herbarium (see below).

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)

- Review of taxonomic situation with Declared Rare and Priority flora with the intention of formalizing the taxonomy of as many presumed new species as possible.
- Progress on a census of fungi for WA, as a basis for fungal information in FloraBase.
- Progress with ongoing taxonomic studies of various plant groups to improve knowledge of the flora.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

5. Taxonomic Information Systems

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 new registration system integrated into a more general task across multiple projects - completed.
- Implementation of a revised image database to address issues helped along by an increasing number of donations of high-quality photographs, and requests for reuse of the photographs in other projects – ongoing.
- Implementation of a staged roll-out of features and improvements in subsequent versions – ongoing.
- Addition of interactive map for IBRA regions – progressing.
- Addition of maps and images for families and genera – completed.
- Addition of further maps and images – ongoing.

Botanical content aspects

- Maintenance of short descriptive data for all new species only (A Spooner, M Choo).
- Addition and maintenance of generic and family descriptions from the WAGenera project (T Macfarlane) –ongoing.
- Review and definition of taxonomic names component, with relation to the upgrading of the WACENSUS system project completed.

- Addition of an illustrated glossary – progressing.
- Maintenance of other descriptive datasets for Kimberley Weeds and the genus *Hakea* - ongoing.
- Addition of a phylogenetic tool for exploring higher-level systematics of WA Flora - progressing.
- Addition of interactive keys - commenced.
- Maintenance of other descriptive datasets for Weeds of WA and the genus *Hakea* –ongoing.
- Addition of a phylogenetic tool for exploring higher-level systematics of WA Flora – progressing.
- Addition of interactive keys – progressing.
- Upgrade content and delivery pages for the WWF Woodland Watch project - completed.

Technology transfer and promotion aspects.

- Publication of general articles and news items announcing the new version – ongoing.
- Training workshops to community conservation groups, CALM staff and the education sector – ongoing.

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 12 803 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 types of content to FloraBase, including interactive keys for identification of several plant groups.
- Expand the coverage of plant groups to include non-vascular plants, especially the algae, lichens and fungi of WA.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

WACensus
Core Function

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 205 new names were added to WACensus, with 138 being new manuscript or phrase names and 67 names published.
- A total of 137 edits were made to WACensus.
- WACensus updates are regularly distributed to over 272 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
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 21 480 records were added during the last financial year, including over 5 916 lower plants and fungi.
- Of these, about 14 000 were entered as part of the AVH project.
- Totals for conservation taxa are now: P1 – 3 213, P2 – 5609, P3 – 10 807, P4 – 7 793, R – 5 517.

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

Core function

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

- Ten monitoring sites were established in the eastern part of Wellington District (750 mm annual rainfall zone) in Godfrey, Trees, Stockyard and Bell blocks. Three sites in Bell block were burnt by wildfire in December 2004 after the spring sampling session had been completed. The fire will have affected results of autumn sampling for vertebrate and invertebrates, and early winter fungi surveys. Assessment of regeneration and nutrient status at the burnt sites has been postponed until 2006 to allow recovery.
- Stand structure (basal area and stocking of overstorey species) was measured at all sites, while regeneration stocking and soil/foliar nutrient concentrations were sampled at the 7 unburnt sites.
- Spring and autumn sampling have been completed, with fungi surveys scheduled for June 2005 according to seasonal conditions.
- Invertebrate samples have been sorted to morphospecies and the reference collection extended from that already established in 2001. Over 1100 morphospecies have now been collected.
- 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 2004-05 Annual Report at a project meeting in August 2005.
- Select and establish grids in Blackwood District for 2005-06 monitoring.
- Major analysis of data to be undertaken in 2006.

CALM Region
Warren, South West, Swan.

IBRA Regions
Jarrah Forest, Warren.

NRM Region
South West, Swan.

FORESTCHECK – soil assessment
Core function

Team member
K Whitford (0.3); Total (0.3).

Context
Monitoring the impact of timber harvesting activities on soil physical properties is important in understanding the long-term impacts of timber harvesting activities. Such knowledge contributes to the evolution of ecological sustainable forest management, and the sustainable use of forest resources, by informing the adaptive management process.

This study, which is in the fifth year of data collection, aligns with Corporate Priority 9 and KRA 3, and contributes to sub-outputs SFM 3N and SFM 3K.

Aims

- To record the extent of soil disturbance on FORESTCHECK monitoring sites where machine disturbance (snig tracks) can be readily identified.
- To monitor the intensity of changes to soil physical properties induced by logging.
- To monitor any change in these soil physical properties over time.

Summary of progress and main findings

- A fourth replicate of FORESTCHECK monitoring sites was established this year.
- Snig track and landings mapping provides a permanent record of the location of major soil disturbance on the FORESTCHECK sites, and enables determination of the proportional area of the faller's block disturbed by logging machinery, i.e. a measure of the extent of soil disturbance on the faller's blocks.
- 190 bulk density measurements were made on 2 new sites. These measurements provide information on the intensity of soil disturbance on these sites, and the size of the changes in bulk density caused by logging, relative to an undisturbed site.

Management implications

- Knowledge gained from FORESTCHECK soil disturbance monitoring was used to provide advice for the preparation of Forest Management Plan 2004-2013.
- Advice was also 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*.
- Field sampling techniques developed and tested as part of the FORESTCHECK soil disturbance monitoring were used in adaptive management trials that were set up by CALM and FPC to examine alternative approaches to managing soil disturbance to those proposed in the Forest Management Plan (2004-2013).

Future directions (next 12-18 months)

- FORESTCHECK is an ongoing monitoring program that records the impacts of logging operations at a range of sites throughout the Jarrah forest. The value of this data accrues as similar measurements are repeated on additional sites. No changes in the current measurements are proposed. Additional sites will be measured next year.

- Compile data and summaries for the 5 year report.
- Combine data from FORESTCHECK soil disturbance monitoring with data from the adaptive management trials of cording, and draft a manuscript for publication.

CALM Regions
South West, Swan, Warren.

IBRA Region
Jarrah Forest.

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 treatments (3 plots at Lindsay forest), were completed and an autumn burn treatment at McCorkhill block was attempted but failed to burn due to low fuels and high fuel moisture content. These burns will be carried over and added to next year's program.
- This research is yielding valuable information about the fire response strategies and life histories of a wide range of vascular plant species.
- No fire regime suits all species; species richness is optimised by intermediate regimes that are diverse in fire season and interval.
- Plant-form species diversity is reduced by long periods of fire exclusion. Sustained, very frequent (3-4 yr intervals) summer/autumn burning disadvantages some obligate seed species but advantages others including annuals herbs and some resprouters. There is uncertainty about the longevity of seed viability in the soil.

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.
- Re-measure trees and analyse tree growth in summer 2005/06.
- Sample and analyse soil nutrients across all treatments in summer 2005/06
- Re-measure floristics on all plots in spring 2006.

- Preliminary analysis of data in summer 2006/07 and review 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 the Kimberley savanna woodlands may be adversely impacting on the structure and recruitment of boabs, Kimberley icon species.

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

Aims
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)

- 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 2003, a follow-up operation over a considerably larger area was carried out in 2004, 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 80%. 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 is being 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)

- Formalize the establishment of the Lorna Glen project in an adaptive experimental management framework in partnership with Goldfields Region.
- Complete analysis and write-up of first stage of fire ecology (plants) study.
- Write-up and publish results of baiting trials at Lorna Glen.
- Carry out a second large-scale Western Shield baiting operation at Lorna Glen winter 2005.
- Monitor baiting impact and re-invasion by feral Cats, Foxes and wild Dogs/dingoes.
- Prepare a translocation plan, and if baiting is successful, implement the plan.
- Continue monitoring small mammal and reptile response to introduced predator baiting.
- Complete the development of a fire management plan.
- Continue assessment of vascular plants and invertebrates.
- Establish FIREWATCH grids to monitor impacts of fire on biodiversity.
- 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

- Biodiversity monitoring grids were established and assessed during spring 2004 and summer 2005 in readiness for patch-burning in March 2005. Weather conditions proved unfavourable and only a small proportion (<1%) of the intended treatment area was burnt.

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)

- Patch-burn in spring 2005 and consider patch-burning in autumn 2006.
- Satellite monitoring of burnt patches.
- Re-assess monitoring grids in spring/autumn 2006/07
- Preliminary analysis of data in summer 2007/08 and review study.

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 genetic entities in *Acacia microbotrya* and *A. saligna*; determine the genetic diversity captured in the DRJ clones of *Eucalyptus marginata* and the selections of *E. cladocalyx*; and investigate the mating system and diversity in sandalwood.

Summary of progress and main findings

- *Acacia microbotrya* – Several taxonomic and genetic entities have been identified within this taxon which will lead to taxonomic revision. Analysis of populations in the overlap zone between what is currently recognized as var. *microbotrya* and var. *borealis* shows they are

mixed populations with some hybridization occurring.

- *A. saligna* – Analysis with RFLP markers have identified 3 genetic clusters within this species complex which are divergent enough to warrant recognition at species rank in a taxonomic revision. Journal paper has been submitted for publication. Mating system and reproductive biology have been investigated and are currently being analysed
- *Eucalyptus cladocalyx* – The genetic identity of provenance variation has been determined and selections are being assayed to determine their provenance of origin.
- *E. marginata* – 100 DRJ clones have been assayed and analysis shows they are representative of the diversity present in the natural populations. Some evidence for somaclonal variation consistent with change in DNA methylation pattern was found. Report has been written. Phylogeographic analysis has shown historical separation of the Swan Coastal Plain and Darling Scarp populations indicating fragmentation due to the uplifting of the Darling Plateau along the Darling fault line around 2.8 million years ago. Journal paper has been submitted for publication
- *Santalum spicatum* – Mating system was investigated in a trial with 6 provenances and shows generally very high level of outcrossing except for two provenances where selfing occurred. Analysis indicated crossing was restricted to within-provenance in these trees and suggests asynchronous flowering between these provenances and the other provenances.
- Journal papers have been published for genetic diversity and taxonomic revision of the *Melaleuca uncinata* complex, taxonomic status of *Eucalyptus quaerenda*, phylogeographic patterns in *E. loxophleba*, and genetic diversity in *E. marginata*.

Management implications

- *Acacia* - Several genetic and evolutionary lineages have been identified in both *A. microbotrya* and *A. saligna*. The level of differentiation between the lineages will support and inform taxonomic revisions of these two complexes. Clarification of the taxa within these complexes will enable development for revegetation plantings to be carried out in a reliable manner without risk of genetic contamination and hybridization in natural populations.
- *E. marginata* - Knowledge of the diversity captured in the DRJ clones compared to natural variation will ensure appropriate deployment of the clones for forest rehabilitation.
- *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. spicatum*.

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 # to be allocated

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 frasiana*, *Bossiaea ornata* and *Kennedia coccinea*.
- *Bossiaea ornata* – Collections of leaf material of 14 populations throughout the forest have been made for genetic analysis.

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)

- Genetic analysis will be undertaken for *B. ornata*.
- Collections of leaf and seed will be made for the other 4 species.

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
Margaret Byrne (0.2), Lynley Stone (1.0), Warren Hudson-Taylor (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.

Aim.

- 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.
- 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 has been established, and AQIS status assessed.
- Draft Weed Risk Assessment framework developed and sent out to Salinity CRC and Australian Weed Management CRC participants for comment.
- Commenced study comparing weed risk assessment models currently used in Australia to determine the most suitable model for Southern Australia.
- Selected sites for gene flow analysis between planted *E. loxophleba* ssp *lissophloia* and natural *E. loxophleba* ssp. *supralaevis* and ssp. *loxophleba*, and trialled primers for genetic analysis.
- Germinated seedlings and extracted DNA from *E. absita* to determine extent of gene flow.
- Developed suitable DNA extraction protocol for *Atriplex*.

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.
- Develop weed risk assessment process and introduce it into the Salinity CRC through training workshops.
- Continue involvement in national discussions on approaches to post-border weed risk assessment.
- Genetic analysis to determine gene flow between *E. loxophleba* subspecies.
- Genetic analysis to determine gene flow between *E. absita* plants.
- 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.

Pest incursion of *Cardiaspina fiscella* in WA

SPP # to be allocated

Team member
J Farr (0.05); Total (0.05).

Context
The psyllid *Cardiaspina fiscella* naturally occurs in eastern Australia on *E. saligna* but in 2001 it was found in Western Australian at Albany on planted *E. robusta*. Natural hosts of *C. fiscella* are related to Karri, therefore there is a concern this insect (which is known to outbreak in eastern Australia) could use Karri as a food plant.

In line with Corporate Priority 5 and 12, and Corporate Strategy 1.5 (protect biodiversity from threatening processes).

Aim
To continue vigilance for introduction of potential new forest (tree) pests to WA.

Summary of progress and main findings

- Current distribution of *Cardiaspina fiscella* now confirmed as ranging from Perth to Albany Project cancelled.

Management implications

- To be aware of the potential of this insect to include Karri as a host tree.

Future directions (next 12-18 months)

- To be incorporated into the development of a Forest Health Surveillance program.

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

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

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

Distribution of gumleaf skeletonizer (GLS) in the central and southern forests of WA

SPP # 93/0104

Team member
J Farr (0.05); Total (0.05).

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.

Aims

- To map the distribution of GLS in relation to outbreak periods.
- To investigate possible cause of outbreak.

Summary of progress and main findings

- Paper published as Farr, J. D., Swain, D. and Metcalf, F. (2004). Spatial analysis of an outbreak of *Uraba lugens* Walker (Lepidoptera: Noctuidae) in the southwest of Western Australia: Does logging, vegetation type or fire influence outbreaks? *Australian Forestry*, 67 (2): 101-113.

Management implications

- Past forest management practices have not influenced GLS populations. This research shows that Jarrah grown in marginal areas (subject to drought and waterlogging) are more prone to severe defoliation and may act as the epicentre for GLS population outbreak expansion.

Future directions (next 12-18 months)

- Project completed.
- Implications of this project will be incorporated into the development of a forest health surveillance program.

CALM Regions
South West, Warren.

IBRA Regions
Jarrah Forest, Warren.

NRM Regions
South Coast, South West.

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 – 2004 monitoring completed; report on 1978-2000 depth and salinity data from 151 wetlands completed, compilation of draft 1981-2000 pH monitoring report well advanced, analysis of depth, salinity and pH data to 2004 well advanced.
- Wetland bathymetry – field surveys of lake bed, shoreline, inflow and outflow contours of Lakes Taarblin (north section), Ardath, Wallambin North, Campion, Mollerin and Cowcowing completed, and maps and depth-volume calculators prepared.
- 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 years 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.
- Reports 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.

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 # to be allocated

Team members
S Halse (0.05), B Smith (0.5), Total (0.55).

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 have been selected, groups that will be identified to species level have been determined, and a sampling protocol adopted (the AusRivAS box-sampling method).
- Prof Richard Norris visited WA to review the project and endorsed the proposed methodology.

Management implications

- None to date (sampling begins next year).

Future directions (next 12-18 months)

- Begin monitoring next year.

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 # to be 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 is an experiment that 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.

Summary of progress and main findings

- Created a GIS database of Jarrah forest harvest history, burn history, and dieback occurrence to assist in study site selection.
- Field assessment of 600 sites is underway with the aim of selecting 20 suitable study sites.

Management implications

- The results will enable an informed assessment of the adequacy of stream buffer zones in protecting streamzone biodiversity and 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)

- Form a technical reference group comprising CALM, FPC, Water and Rivers Commission, and Water Corporation.
- Liaise with FMB and FPC to include study sites in 2005/06 harvest plans.
- Commence pre-treatment monitoring of macroinvertebrates, stream water quality, and streamzone vegetation.

CALM Regions
Swan, South West.

IBRA Region
Jarrah Forest.

NRM Regions
South West, Swan.

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 2004.
- 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, 4 yrs after the harvesting and silvicultural treatments and 2 yrs after the silvicultural burn. Groundwater rose an average 0.64 m the hillslopes and 0.84 m in the valleys in the intensive-treatment

catchment and an average 0.41 m in the hillslopes and 0.12 m in the valleys 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

- The 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)

- Continue monitoring of groundwater levels, stream flow, stream salinity, stream turbidity and rainfall for at least another year and 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.
- Commence write-up following monitoring of 2005 wet season.

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 are being sorted in preparation for specialist taxonomic

identification.

- Botanical specimens are being 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 commenced.
- The Western Australian component of the national Directory will be updated in 2005 to include new sites and enhanced site descriptions.

Management implications

- Literature search, field survey results and interviews will lead 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)

- Identification of aquatic invertebrate and botanical specimens of remote wetlands will be completed, data analysed and information synthesized.
- Descriptions of proposed new sites for the Directory will be prepared, together with enhanced descriptions of existing sites.
- The Western Australian component of the Directory will be updated in 2005 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 two sets of floodgates. Careful management of flows and water levels is needed to prevent adverse impacts on fringing vegetation, waterbirds and adjoining properties. Following a mass fish kill in 1997, 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 2003/04 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.
- The sandbar was opened several weeks earlier than usual due to high concentrations of hydrogen sulphide from rotting seagrass in Wonnerup Inlet and the threat this posed to fish life.
- Monitoring of fish activity and water levels at the floodgates was undertaken by team members with CALM Blackwood District backup during 2004/05. The Vasse estuary floodgates 'fish gate' was opened for long periods in summer-autumn to maintain the target water level, allow fish to pass and, in December, kill a potentially toxic algal bloom. The Wonnerup estuary floodgates fish gate was opened for long periods 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 2004/05. 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 2005/06.
- 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 # 2004/004

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 of mature Karri and Red tingle continued to decline from 12 months to 36 months after fire.
- Seedling regeneration of Karri, red Tingle and Marri has been vigorous.
- 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 4 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. The Red-eared firetail finch became widespread in the third year after fire. The Red-eared firetail finch became widespread in the study area in the third year after fire. One new species recorded this year is the Fork-tailed Swift, a migratory species from northern Asian.
- 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

- Sites at Grey have been prepared for counts to be done in spring 05.
- This year's count at Grey will be 20 years since regeneration.
- Counts were carried out at the 16 Kingston Jarrah sites in spring 04.
- 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.
- Counts will be done this spring 05 in Kingston which will be 10 years since regeneration.

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 to be done in the Grey sites in spring 05 (20 yrs since regeneration).
- Counts to be done in the Kingston sites spring 05 (10 yrs since regeneration).
- Review and analyse both sites data at the end of this years counts.

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.

Aims

- To provide information about the effects on tree and stand growth of 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

- Growth was re-measured in the Warren thinning experiment during autumn 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 the 2000 the there has been only limited tree mortality, and many bole scars have occluded.

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.

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 to manage vegetation condition and fuel loads used in these reserves, and there is a need to better understand the 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 to 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

- Before-After monitoring sites (and Control-Impact sites where possible) were established and monitored for 12 months prior to the prescribed fuel reduction burn.
- The low intensity burn, undertaken in November 2003, achieved ca. 80 % coverage with 50 – 75 % of the litter fuel load consumed at the monitored sites. Many of the understorey shrubs were scorched and killed back to ground level.
- Despite low rainfall in the year after the burn (only 66 % of the long-term average), a substantial pulse of infiltration water was observed in Jewel Cave in September 2004.
- Dripwater chemistry showed a significant decrease in Mg ion concentration after the burn, consistent with the response predicted from increased groundwater recharge based on the studies of Treble (2004) who measured an increase in the Mg signal preserved in speleotherms related to declining rainfall trends in the southwest.
- Monitoring of soil water content and movement showed no discernible difference between control and impact sites, probably because of very mild fire conditions.
- Leaf area did not show a consistent difference between the control and impact sites, or before cf. after at the fire treatment sites. This was attributed to the sparse and heterogenous structure of the scrub layer, and limitations in the light gap analysis software which captured leaf area predominantly in the overstorey, but not in the scrub layer.
- The overall multi-year declining trend in cave groundwater levels continued.
- The low intensity of the fire treatment, combined with exceptionally low rainfall in the year following the fire, would have reduced the effective groundwater recharge. Despite these constraints, enhancement of groundwater recharge was suggested by the pulse in dripwater infiltration and the dripwater chemistry.

Management implications

- Fire will influence groundwater recharge in karst aquifers and cave systems. Prescribed burning can be expected to have the effect of increasing groundwater recharge. The effectiveness of fire-induced recharge will be dependent on fire intensity and subsequent rainfall patterns. Fire management planning should consider the effect of fire on groundwater recharge, especially in karstic limestone areas. Prescribed burning could be used as a management tool to *temporarily* enhance recharge in karst aquifers and cave systems where groundwater biodiversity (stygofauna, TECs) may be threatened by declining groundwater levels. However, use of fire for this purpose should not be prescribed without site-specific knowledge of the groundwater hydrology, and careful consideration of other impacts and conservation considerations.

Future directions (next 12-18 months)

- Further monitoring of selected variables over a second rainfall year post-burn is recommended to better quantify the effect of the fire treatment. Monitoring of daily rainfall, dripwater chemistry (Mg and Cl), infiltration rate and cave water levels will continue as previously. Fuel accumulation will be measured annually, while soil water content and movement will be monitored at reduced intensity which can be increased if winter rainfall is high.

CALM Region
South West.

IBRA Region
Warren.

NRM Region
South West.

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). Total (3.3).

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).
- The fire history is in the process of being characterized for a study site identified in southern Jarrah forest and associated vegetation complexes north of Walpole.
- No biological surveys have been carried out as the project is still in the planning / experimental design phase.

Management implications
- Provision of scientifically-based guidelines for the optimum 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 the experimental design by characterizing fire histories.
- Field validation of replicate sites for fire histories and vegetation complexes.
- Establish monitoring plots.
- Conduct floristic and fungi surveys in spring 2005 and spring 2006.
- Liaise with specialist scientists in the Department to determine the surveying methodology of vertebrate and invertebrate taxa.

CALM Region
Warren.

IBRA Region
Warren.

NRM Regions
South Coast, 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.
- The book 'Life along land's edge' Wildlife along the shores of Roebuck Bay was released on April 21 2004 in Perth and on April 28 in Broome.
- 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.

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 August 2004.
- Funding was obtained from CALM's Wetland Project proposals. Initiated analysis of data collected from the Eighty-mile Beach monitoring ('Monanna') Project.
- Continued 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 a 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

- Completion of a food-web study of the Bay incorporating use of stable isotopes, by RNIOZ, University of Western Australia and CALM.
- Monitoring of the benthos at 4 sites in Roebuck Bay continues through collaboration with Broome Bird Observatory.
- Potential for sea grass studies at Roebuck Bay through collaboration with scientists from The Netherlands.
- 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

- A program is being considered that might result in community monitoring of the crab fauna of parts of the 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 (0.13), R Smith (0.05); Total (0.18).

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

- Liaison with FPC on operational methods of control.
- Poster prepared (Robinson, R.M., Seymour, A. and Rayner, M.E. Stump pulling to control Armillaria root disease following the first thinning of karri regrowth. CALM, FPC.)
- Scientific paper in press Robinson, R.M. 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).
- A field tour to Warren block to view stump-pulling operations was incorporated into RWG 7 (Forest Health) meeting 3, October 2004.
- Results from the Warren thinning experiment show that 15 years after thinning plots to 200 sph, up to 50% of the gain in mean total volume was lost due to Armillaria-caused defect and mortality.

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)

- Involvement with Sustainable Forest Management Division and FPC in developing and monitoring operational control methods for ARD during first thinning operations.
- Set up 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 (0.33); R Smith (0.1), K Pearce (0.17); Total (0.51).

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

- The results show that a distinct and recognizable fungal flora fruits on recently burnt sites. A number of fungi appear to be stimulated to fruit by fire or take advantage of the post-fire conditions. As time progresses those fungi that are adapted to post-fire conditions are replaced by species more commonly found in unburnt forest.
- Field work completed (5 yrs of results).
- Annual report completed.
- Book chapter published (Robinson, RM and Bougher, NL 2003. The response of macro-fungi to fire in Jarrah (*Eucalyptus marginata*) and Karri (*Eucalyptus diversicolor*) forests. *In* Abbott, I and Burrows, N (Eds.). Fire in Ecosystems of south-west Western Australian: Impacts and Management, pp. 269-289).
- Scientific paper in preparation (Robinson, RM, Mellican, A and Smith, RH. The succession of macrofungi following a wildfire in Karri regrowth forests in Western Australia.)

Management implications

- Results contribute to information on the management of fire for maximizing biodiversity in Karri forest.

Future directions (next 12-18 months)

- The next monitoring will be undertaken in 2008 (coinciding with 10 yrs post fire). Laboratory work will continue to catalogue and identify voucher specimens collected throughout the project.
- Results for the first 5 yrs to be published in a scientific paper.
- Collaborate with colleagues from other agencies with identification of voucher specimens.

CALM Region
Warren.

IBRA Region
Warren.

NRM Region
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 inventory 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
- Quarterly trapping programs for medium-sized mammals were completed.
- Manuscript submitted for publication on the factors affecting the detection of possums by spotlighting.
- Spotlight monitoring on the 3 standardized transects was restructured to 6 repeat surveys per transect per year, incorporating the findings submitted for publication (point above).
- Data management and processing is underway in preparation for analysis and 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); Total (0.2).

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 develop a method of describing the dimensions of hollows used by fauna.
- 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 modelling 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 and one book chapter have been published from this research.
- *Landscope* article published.
- Hollows and ground logs measured on plots at two sites in virgin 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 virgin 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 (0.2); Total (0.2).

Context
Timber harvesting and forest management activities impact on soil physical and chemical properties. This study evaluated indicators of soil physical and chemical status, and 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 sensitivity of soil organic matter as an indicator of ecologically sustainable forest management in Western Australian Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) forests.
- To examine the impact of fire on organic carbon and clarify the effect of fire on N and organic carbon in the forests of south-western Australia.
- To establish some base data on the intensity and extent of soil disturbance in the Jarrah logging coupes using a nationally agreed survey protocol for estimating soil disturbance.

- To development and refine the survey techniques proposed in the nationally agreed survey protocol for estimating soil disturbance.
- To compare survey techniques for determining snig track area.
- To examine the commonly expressed assumption that only minor soil compaction and disturbance occur in Jarrah logging coupes.
- To examine techniques for measuring bulk density in gravelly forest soils and identify appropriate measurement technique for these soils.
- To examine the effects of corer size on the measured fine earth and total bulk density, and determine if this is affected by soil gravel content.
- To examine the relationship between soil disturbance class, bulk density and soil shear strength.
- To report and compare the extent of disturbance on faller's blocks in the Jarrah forest of south-west WA.
- To investigate the impact of snig track compaction on tree and stand growth in the Karri forest.
- To determine the size of any growth reduction occurring on snig tracks and the size of any compensating growth increase adjacent to snig tracks.
- To examine the bulk density of the soil on and about the snig tracks to identify the threshold value at which soil compaction causes a reduction in tree growth.

Summary of progress and main findings

- The field work and data analysis is complete and the final report to the funding body has been submitted, reviewed and accepted.
- The final report was revised this year and has been published on the Forest and Wood Products Research and Development Corporation's website.
- Three manuscripts from this work have been submitted for internal review and require further revision.

Management implications

- Advice was provided during the preparation of Forest Management Plan 2004 - 2013.
- Advice was provided to the Conservation Commission regarding the setting of soil moisture and soil disturbance limits for logging activities.
- Advice was also 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 implementation of Appendix 6 of FMP 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)

- Revise and submit three 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 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 (0.3); Total (0.3).

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

- Field work completed.
- Laboratory work completed – seed counting, drying and weighing of seed fall collections from 1996.
- Data analysis completed.
- Final SPP report written and in internal review.
- Manuscript for external publication written and in internal review.

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)

- This SPP is no longer active and no future work is currently planned in this area.
- 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), T Burbidge (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 ants, beetles and spiders to morphospecies level completed and data entered into database.

Management implications

- Not yet apparent as analysis of data not completed.

Future directions (next 12-18 months)

- Complete sorting of other orders to morphospecies level.
- Assemble database and analyse.
- Write up and publish in refereed journal.

CALM Region
Swan.

IBRA Region
Jarrah Forest.

NRM Region
Swan.

Monitoring northern extent of Jarrah leafminer outbreak

SPP # to be allocated

Team members
A Wills (0.02), T Burbidge (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

- Roadside survey of Jarrah understorey completed in October 2004. Report of findings prepared December 2004, distributed to relevant SFM and other personnel and lodged in the CALM library.
- Presence and absence of leafminer mines and larval cutouts was mapped at a scale of 1:700,000 and a boundary between locations where cutouts were detected and not detected was interpolated.
- Initial monitoring was completed annually for the years 1987 to 1992 when rapid encroachment of the JLM outbreak into the northern Jarrah forest from the central forest around Collie appeared to be imminent.

- Encroachment of JLM into the northern Jarrah forest has been slow and the status of infestation was subsequently monitored at longer intervals in the years 1996, 1999 and 2004.

There has been no apparent progress northwards of JLM populations since the last survey in 1999. There appears to be slight contractions southwards in the area containing populations of JLM.

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.

CALM Region
Swan.

IBRA Region
Jarrah Forest.

NRM Region
Swan.

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.

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 (0.2); Total CALM (0.2). S Hopper (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

- High level results of species richness and endemism published in *Annual Review of Evolution, Ecology and Systematics* (December, 2004).

Management implications

- Species richness and endemism maps are currently being trialled in two NRM regions, Recovery catchments from Salinity Action Plan.

Future directions (next 12-18 months)

- Submit technical paper by December 2005.
- Contribute to a book on endemism in 2006.

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 (0.25), M Choo (0.35); Total (0.6).

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

- Visited other conservation agencies in Australia in March 2005 to study their management of biodiversity information. A draft report has been prepared and is currently being considered by Directors.

Management implications

- A number of recommendations were made affecting how information is managed within CALM, including new policies, a review of the role of EIMC and a range of protocols and standards for collecting and managing biodiversity data, particularly spatial information, and a number of strategic high-priority projects.

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.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Provision of authoritative names of WA plant taxa

Core function

Team member
P Gioia (0.1); Total (0.1).

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, a major upgrade of the Herbarium's plant name information system, was delivered into production in November, 2004.

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 (0.25); Total (0.25).

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

- Software is currently in development.

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)

- NatureMap is currently implemented in old technology. While the current progress to production is scheduled for November, 2005, a more corporate implementation is required based on the same development environment as EcoBase.

CALM Regions
All.

IBRA Regions
All.

NRM Regions
All.

Species database management software (Max)
Core function

Team member
P Gioia (0.1); Total (0.1).

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.

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.
- Provide support for entering fauna data.

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.
- 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.

Implementation of climate change activities in CALM
Core Function

Team members
R McKellar (0.80), A Hopkins (0.10); Total (0.90).

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.

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.
- Co-ordinate or liaise with KP Article 3.4 research (revegetation, rangeland regeneration, etc).
- Test the updated BioClim modelling framework; 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.

CALM Regions
Potentially all.

Management of terrestrial bioprospecting in CALM
Core Function

Team members
R McKellar (0.20), N Marchant (0.05); Total Science Division (0.25). K Atkins, G Wyre (Nature Conservation Division).

Context
Bioprospecting is a means of gaining financial returns from knowledge gained about Western Australia's biota where that knowledge can be 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.

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.

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 - Effect of fire on forest fungi report completed (with R Robinson).
- Paper on Wandoo decline drafted (with J Mercer and J McGrath).
- Karri site type 10 paper accepted for publication (with G Wardell-Johnson).
- Statistical advice provided to Projects EDEN and WESTERN SHIELD.
- FORESTCHECK progress report.
- Impact of feral honeybees paper accepted for publication (with D Paini).

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 and Stirling Range datasets.
- Upgrade Science Project Plan and Manuscript databases.

- 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
- Upgraded CONSLib search facility (11/2004).
- Added BugBase to Science Internet site (mid 2004).
- Revised structure of Intranet site (12/2004).
- Added Pilbara Bibliographic Database to Science Internet site (08/2003).
- Reworked access to Fire and FORESTCHECK sections of Science Internet site (08/2004).
- Added Nuytsia journal pages to Science Internet site, including database searches (02/2005).
- Reworked web site access to databases for cleaner delivery of data to site features such as CONSLib and Biblio (02/2005).
- Added new content and maintenance of current content on all Science Division sites.
- Liaised with, tutored and mentored Beng Siew Mahon, Bronwyn Mathiesen and Lisa Wright, who now manage the Intranet site directly.
- Managed and corrected Biome web server failures (05/2005, 06/2005).

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.

Future direction
- Be involved in planned NatureBase/CALMweb upgrade to a Content Management System (CMS).

PERTH OBSERVATORY

Program Leader: Dr James Biggs

Astronomical Outreach and Education

Core Function

Team members

J Biggs (0.2), P Birch (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.

It aligns with KRA 5 and 6.

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

Key activities in this core function include:

- 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.
- Development and marketing astronomy education resources.

Most of the milestones for these activities involved the maintenance of the level of activity and user participation. However, attendance fell back to normal levels this year owing to the lack of an interesting and widely publicized celestial event that serves to prompt the public to visit.

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 successfully installed and tested by the Observatory technical staff and became operational well ahead of the time anticipated by our collaborators.

The Observatory was entered on the State Heritage Register, not only in recognition of its rarity and historical importance, but also because of its ongoing educational, scientific and social values.

Activity Measures

Activity	2004/2005*	2003/2004	2002/2003	2001/2002
Star Viewing Sessions	151	212	178	185
Night Visitors	4633	7246	5653	6107
Daytime guided tours	48	80	146	122
Day visitors	1289	2504	4119	3607
Astronomy Field Nights	19	18	23	27
Field Night attendance	2265	1524	2496	2833
Lectures and Talks	20	49	82	89
Talk attendance	1532	1283	1990	2899
Student consultations	15	17	86	57
Customer satisfaction (star viewing and guided tours)	-	98%	94%	94%
Astronomy awareness raised	-	98%	95%	95%
Educational quality	-	98%	98%	96%

*(*for 1 July 2004 to 3 May 2005)*

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. Furthermore, activities conducted in this project are reasonably well aligned with CALMs KRA 5 and 6.

Future directions (next 12-18 months)

- 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), P Birch (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.

It aligns with KRA 5 and 6.

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. However, the number of enquiries fell back to normal levels this year owing to the lack of an interesting and widely publicized celestial event that serves to prompt the public to seek further information. During the course of the year the Observatory produced twelve minor publications of an information/education nature.

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. This telescope was successfully installed and tested by the Observatory technical staff and became operational well ahead of the time anticipated by our collaborators. A sponsorship was obtained from Telstra BigPond for a satellite Internet link to communicate with the Internet telescope and this afforded a significant upgrade to the Observatory's information infrastructure.

Activity 5 has involved the creation and display of two posters that highlight the Observatory activities.
Furthermore, a new brochure that details Observatory educational resources was produced. This publication is directed mainly at teachers and highlights how the Observatory can assist with the new Curriculum Framework Science Learning Outcomes.

Activity Measures

Activity	**2004/2005 ***	**2003/2004**	**2002/2003**	**2001/2002**
Telephone enquiries	11,516	19,095	9,872	11,138
Information line	1996	3416	1,462	1,001
Email enquiries	543	519	562	535
No. talks, lectures etc	20	49	82	89
Talk attendance	1532	1283	1,990	2,899
Consultations	20	20	86	57
Newspaper, radio and TV	105	147	136	149
www page hits	709,572	2,200,704	1,116,079	875,783
Positive responses to 'quality' question in customer surveys	-	98%	98%	98%
Satisfaction of information requests as they occur	-	92%	98%	99%

*(*for 1 July 2003 to 3 May 2004).*

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. Furthermore, activities conducted in this project are reasonably well aligned with CALMs KRA 6.
- Promotion and training students in the use, of the Internet telescope will consume a significant amount of Observatory resources.

Future directions (next 12-18 months)

- The activities and milestones remain essentially the same for 2004/05. 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. Observatory promotion and information provision will be further enhanced by a substantial upgrade of Observatory website.

Astronomical research

Core function

Team members
(details are provided under each SPP, below).

Context
This core function involves the utilization of research facilities and capitalizes 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:

- To monitor brightness changes in stars, comets, gravitational lensing events and other celestial bodies, and participate in their further study.
- To determine positions of minor bodies (asteroids and comets) and targets of opportunity and forwarding these to the International Astronomical Union for publication and dissemination.
- To search for extra-galactic supernovae in low-redshift spiral galaxies.
- To test 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 3 papers in refereed international journals and another 4 in minor publications (poster papers, abstracts etc). 100% of referred papers submitted were published (100% in 03/04).

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), P Birch (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

- No observations were made in 2004/2005, as there were no suitable targets bright enough for our instruments.
- One refereed paper was published in April 2005 concerning the roAp star HR 1217.

Future directions (next 12-18 months)

- 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'. No target stars have been announced for 2005/2006.

Imaging and spectrophotometry of comets

SPP # 98/0010

Team members
J Biggs (0.01), P Birch (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 collaboration with US astronomers in the study of comets.

It aligns with Corporate Priority 12.

Aim

- 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

- Cometary observations were made on 6 nights in November and December 2004 on 49P/Comet Arend- Rigaux as part of nucleus rotation studies.
- An astronomer from Lowell Observatory worked with Perth Observatory staff in February 2005 processing data taken over the previous 30 yrs as part of an ongoing collaboration between the two institutions.
- Observations made in May 2005 with the Perth / Lowell 61cm reflector of 9P/Comet Tempel1 were used to fine tune the settings for observations being made with the Deep Impact mission.

Future directions (next 12-18 months)

- Further observations will be made of Comet 9P (Tempel1) during 2005 in the lead up to the Deep Impact Mission culmination in mid 2005.
- Commissioning of an automated focuser for the PLAT in 2005 should facilitate an increased number of observations.

Imaging and CCD photometry of transient and variable sources

SPP # 98/0011

Team members
J Biggs (0.04), P Birch (0.01), 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, and increase knowledge of the structure and processes within stars.

Summary of progress and main findings

- To monitor possible transient changes to the star SS2883 in a student project.

Future directions (next 12-18 months)

- Suitable targets will be observed as time and resources permit. Future observations will be conducted using the 35-cm Real Astronomy Experience (RAE) telescope. The University of California (Berkeley) and the Lawrence Hall of Science loaned the telescope, its ancillary equipment and software.

Astrometry of minor planets, comets and targets of opportunity
SPP # 98/ 0012

Team members
J Biggs (0.20), P Birch (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 2004/2005*, a total of 57 (43 asteroid and 14 comet) minor body positions were published - a system upgrade curtailed activity in this project.
- This project was transferred to the 35-cm Real Astronomy Experience (RAE) telescope. The University of California (Berkeley) and the Lawrence Hall of Science loaned the telescope, its ancillary equipment and software.
- The RAE telescope is a fully operational Internet telescope and can be operated from around the world. Though this telescope will be shared with others, observing will be more efficient and fainter objects can be imaged.

Future directions (next 12-18 months)

- Monitoring of NEOs will continue with the milestone an increased number of published

positions. Further integration of telescope and camera control onto 1 PC will be progressed. Also, the search of the Earth's Lagrangian points for asteroids will be continued.

*As at 3 May 2005.

Monitoring gravitational microlenses

SPP # 98/0013

Team members

J Biggs (0.01), P Birch (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

- 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.
- Two refereed papers and one other were published.

Future directions (next 12-18 months)

- The June-August 2004 bulge season included many prime events, papers on some have already been published and some are in preparation. The 2005 bulge season has already seen a couple of outstanding events, and a paper on one is currently in preparation already. A commercial automated focuser for the PLAT has been purchased, and is awaiting some 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), P Birch (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

- Three new supernovae were discovered during the 2004/2005-year, and another 2 new supernovae were detected, but just after discovery by other astronomers.
- Three minor publications were produced.
- Mathematical modelling of SN 2004S is complete and a paper is in preparation.
- A good set of VRI light curves for SN 2005AE.

Future directions (next 12-18 months)

- Paper concerning SN 2004S will be submitted for publication and assessment of the datum for SN 2005AE will be made. 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), P Birch (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

To test appropriate Western Australian sites regarding their suitability for astronomical observations, in order to provide information necessary for the planning of future facilities.

Summary of progress and main findings

- An observation run over several nights was undertaken on the summit of Mt Singleton.
- These data have been analysed in a manner consistent with earlier data.

Future directions (next 12-18 months)

- This site evaluation project will result in a paper detailing the preliminary results of conditions for optical astronomy observing in WA. 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 ((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 project (i) has been completed and a report on the butterfly faunas of the over 40 sites included in project (iii) is in preparation.

During this year (fiscal 2004/05) the study was expanded from 21 to 42 sites of remnant bushland on the Swan Coastal Plain. More than 30 species of day-flying Lepidoptera have been recorded in the surveys, including the threatened graceful sun moth (*Synemon gratiosa*), which has now been recorded at 5 sites, 3 of which are new records.

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. Franklin. The rapid southward spread of this wildfire was eventually controlled along the northern boundary of London forest block, which had been prescribed burnt in the previous spring of 2002. The contrasting intensities at which these adjoining two forest blocks were burnt has provided an opportunity to compare the fire impact on the biodiversity of their invertebrate communities. Beetles 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 again in January, February, and April 2005. The first 'small grain' mosaic fire was lit by helicopter in mid April, but went out after burning about 5% of the forest block, due to high litter moister. This treatment has been re-scheduled to spring 2005, when drier weather should allow the burnt patches to be enlarged.

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: R Butcher

Project title
Systematics of the south-western Australian endemic genus *Synaphea* R.Br. (Proteaceae: Conospermineae)

Progress report
Synaphea R.Br. is endemic to the South-West Botanical Province of WA and the genus comprises small shrubs characterized by tough, usually divided leaves and small, yellow, tubular flowers held in a spike. The differentiation of species is notoriously difficult as the taxa are distinguished by subtle size, curvature and pubescence characters. The number of named species in *Synaphea* has recently been increased, but the taxonomy is far from resolved. Taxonomic resolution of the genus is required for conservation and management, as many species are recorded as having highly restricted geographic ranges and a high proportion of the described species are currently listed as either Priority or Rare.

Morphological and molecular characters have been used in cladistic analyses to test the infrageneric classification of *Synaphea* proposed by AS George in which the genus was divided into 4 sections. These analyses indicate that *S. pinnata* is highly distinctive in the genus and may warrant recognition at sub-generic level, but that there is no support for recognizing the other sections proposed. These analyses also indicated that DNA sequence data from the Internal Transcribed Spacer region (nrDNA) and the *trn*L-*trn*F region (cpDNA), which are commonly used in molecular systematics, are not informative to differentiate between many morphologically divergent taxa in *Synaphea*. Morphometric investigation of species boundaries and infraspecific variation in 2 problematic species complexes with high conservation priority are ongoing.

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.

The results of the study indicate that 37 terminal taxa (25 species) can be identified in the series using seedling and adult morphological characteristics. Some of the taxa described recently (Johnson & Hill, 1999) cannot be identified and are considered synonymous with existing taxa, while other previously unrecognized taxa are also identified and described. Both morphological and molecular results indicate that cross-taxon gene flow has been an ongoing and important cause of the current biogeographical patterns seen in *E.* ser. Subulatae.

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*.

The suprageneric phylogeny of the sedges of the region was explored using DNA sequences of the chloroplast gene *rbcL* as well as morphological and pollen characters. The intraspecific phylogeny of *Reedia spathacea* was also examined using analysis of variation in the chloroplast genome to gain insight into the historical biogeography of this genus. The resulting phylogenetic analysis supported *Reedia* as a Tertiary relictual genus and a basal member of the Cyperaceae of the region. Moreover it also highlighted inconsistencies in the current circumscription of several other local sedge genera. A suite of morphological characters indicated that (unlike most other local sedges) *Reedia* was poorly adapted to fire. However the RFLP markers did not distinguish significant genetic differences between the extant populations of *Reedia*, suggesting that these populations have not been reproductively isolated from each other for a lengthy period. Therefore it appears unlikely that the wetlands currently inhabited by *Reedia* were refugia for humid climate taxa throughout the arid Pleistocene era.

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: **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 planting's. 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.

A total of 410 *Austrodanthonia caespitosa* plants have been collected from 23 sites though out 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. This represents half the total material to be collected. Some seed has been collected from this material and further collections will be made in spring. Analysis of soil samples collected with each plant is ongoing.

The literature review was submitted to the Charles Sturt University in February 2004.

Scientist: **D Coates**
Student: C Gage

Project title
Genetic and ecological viability of fragmented populations of the long lived woody shrub *Eremaea pauciflora*

Progress report
The aim of this research is to identify and quantify genetic and demographic processes that determine the viability of populations of the common myrtaceous shrub *Eremaea pauciflora* which occurs in the heavily fragmented landscape of the WA wheatbelt. This research will employ a range of techniques including the use of molecular genetic markers (isozymes and microsatellites), demographic monitoring and growth experiments to examine aspects of the genetics and ecology of remnant populations of *E. pauciflora*. This work will extend previous genetic and ecological research

on factors affecting the viability of rare plant populations within remnant vegetation. Combined with studies on other common species, this is an important step in developing guidelines for the appropriate management of viable vegetation remnants in degraded and fragmented landscapes to ensure the long-term persistence of native flora in areas such as the wheatbelt.

19 populations of *E. pauciflora* have been chosen for sampling. Viable seed production was investigated and population genetic diversity studies were completed. Currently, viable seed production for 2003 is under investigation and microsatellite markers to assess gene flow are being developed.

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 to 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. Twenty 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 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, Tuart 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. 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.

Experimental fires were conducted at two 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 1970's 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.

An abstract describing the project has been submitted to the Tall Timbers Fire Ecology Conference to be held in Florida, USA.

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.
