RESEARCH ACTIVITY REPORT

July 2001 – June 2002

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 Science Division for the fiscal year 2001 / 2002.

Progress achieved in the performance of core functions is also documented.

Worth noting is the breadth of activity. Research was conducted in all regions of the State, and covered a wide range of taxa (vascular and cryptogamic flora; terrestrial, benthic and aquatic invertebrates; water moulds and fungi; and vertebrates). Numerous ecological processes were investigated, including fire, extinction, predation, salinization and tree growth.

A diverse array of approaches were used, including the development of comprehensive databases, syntheses of historical information, survey and inventory, monitoring, molecular (DNA), single species and communities. Most studies were short-term.

I believe that the mix of descriptive and experimental studies is appropriate.

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

Users of this document are requested to contact me on neilb@calm.wa.gov.au if they have any suggestions for improved presentation in subsequent reports.

Dr Neil Burrows
Director, Science Division

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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

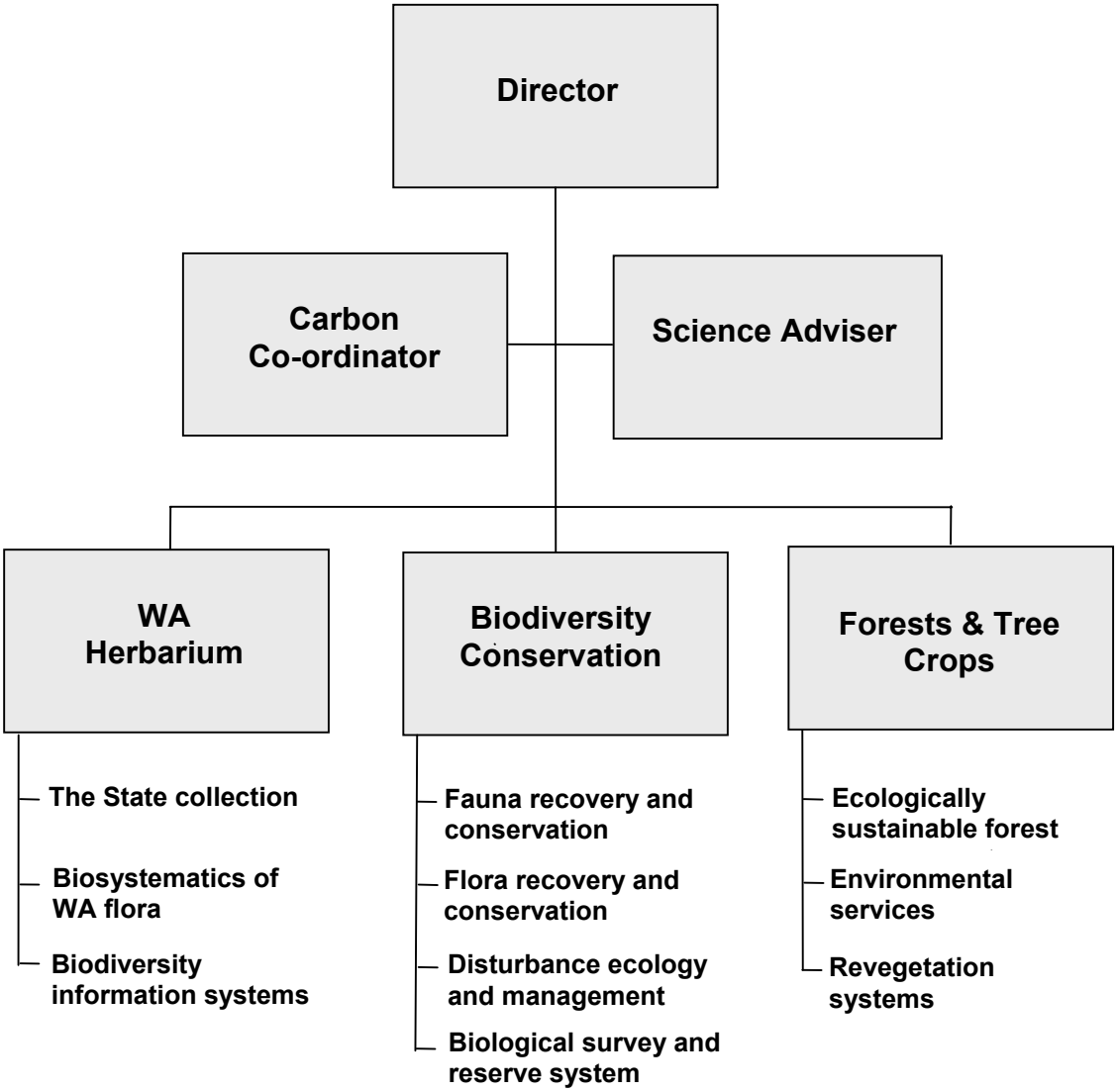
Provision of up-to-date and scientifically sound information to uphold effective conservation of biodiversity and sustainable natural resource management in Western Australia.

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 DCLM, and carrying out DCLM 's other legislative responsibilities.
- To ensure that Science Division is responsive to the needs of policy makers and output purchasers in DCLM and FPC by bringing science to bear on the solution of the State's most pressing problems relating to conservation and land management.
- To advise DCLM 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 DCLM 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 DCLM, to meeting the need for knowledge on conservation and land management matters by the public of Western Australia.

SERVICE DELIVERY STRUCTURE



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CURRENT COLLABORATION WITH ACADEMIA

Scientist	Name of student	Project	Level	University
Abbott, Ian	Tim Simmons	How birds may be used as a bio-indicator of ecosystem health in jarrah forest at various stages/disturbance states.	PhD	Curtin University
Abbott, Ian	Dean Paini	The impact of the European honey bee on Australian native bees	PhD	University of Western Australia
Abbott, Ian	Matt Williams	Conservation and ecology of threatened butterflies	PhD	Curtin University
Angus, John	Not yet finalized	The project is collaboration between DCLM, Murdoch University and the City of Armadale. Basic aim is to investigate any benefits arising from the exclusion of domestic cats through local government by-laws. The project will investigate the activity and abundance of feral/stray cats within the suburb and adjacent bush, and the abundance and diversity of birds and small ground-dwelling vertebrates. This will be compared to those which inhabit other subdivisions in which domestic cats are kept. Diet and activity of domestic cats at this site will also be studied, both directly and through questionnaires.	PhD	Murdoch University
Bartle, John	Robyn Bell	Germination physiology of three oil mallee species *Eucalyptus horistes* L Johnson & K. Hill, *E. loxophleba* spp. lissophloia L. Johnson & K. Hill and *E. polybractea* R. T. Baker	Masters	Notre Dame University
Biggs, James	Shane Walsh	Search for earth Trojan asteroids. Asteroids have also been detected in stable orbits at the Lagrangian points (L4 and L5) of Jupiter. That is, their orbit is the same as Jupiter's, but 1/6 of an orbit ahead and behind it. These are called Trojan asteroids. Recently, Trojans have also been found for Mars (Weigert et al, 2000). So far no Earth Trojan Asteroids (ETAs) have been found in the limited searches conducted (Weigert et al, 2000). Further knowledge about asteroids and their origin could be derived by discovery of ETAs. They possibly have a different evolutionary history being relatively close to the Sun.	3rd Yr research project, Dept of Applied Physics	Curtin University
Biggs, James	Margaret Peters	An upper limit to the number of Kuiper Belt objects (KBOs). KBOs are quite distant members of the Solar System. As such, they are quite faint and only detectable using very large telescopes. This project adopts a different strategy to search for these objects. Multi-epoch photometric star catalogues will be given a statistical analysis in order to search for anomalously low readings. These readings may indicate occultations of stars by KBOs. A useful upper limit to the number of objects in the Kuiper Belt will be calculated from this analysis.	3rd Yr research project, Dept of Applied Physics	Curtin University
Biggs, James	Anthony O'Brien	16" Telescope Automation. There are three objectives in this project: To use currently available software to successfully control the 16" telescope; use this software to simultaneously control a CCD camera attached to the 16" telescope; and acquire scientifically useful data	3rd Yr research project, Dept of Applied Physics	Curtin University
Biggs, James	Owen Giersch	A study of the effects of binary motion on the detection of radio pulsars. The objective is to determine the effect of binary motion	Honours, Dept of Applied Physics	Curtin University

		on the detectability of radio pulsars. A pulsar signal will be simulated for a wide variety of orbital configurations. These signals will be Fourier transformed to examine the signal structure in the power spectrum, and thus determine their detectability in terms of the standard detection techniques		
Biggs, James	Magnus Troebaeck	Construction, testing and utilisation of a wide-angle 'night sky camera'	Final year project, Dept of Space Science	Umea, Sweden
Biggs, James	Daniel Schott	Construction, testing and utilisation of a wide-angle 'night sky camera'	Final year project, Dept of Space Science	Umea, Sweden
Burrows, Neil	Rachel Haton	Fire ecology of *Metacrinia nichollsii*	Honours	University of Western Australia
Burrows, Neil	Peter Adams	Exchange of parasites and diseases between native mammals and feral cats	PhD	Murdoch University
Burrows, Neil	Olivier Chavand	The origin and phylogeographic structure of the feral cat population in Western Australia	PhD	Murdoch University
Burrows, Neil	Adrian Wayne	Ecology and habitat requirements of the western ringtail possum	PhD	Australian National University
Byrne, Margaret	Margaret Wheeler	Reproductive biology and genetics of Jarrah. The pollination and reproductive biology of jarrah is being investigated particularly in relation to development of cross pollination techniques. The genetic diversity and structure of Jarrah and 2 other subspecies is being analysed.	PhD	Murdoch University
Byrne, Margaret	Nic George	Development of *Acacia saligna* for revegetation. Genetic analysis of the forms of *A. saligna* is being carried out in conjunction with a taxonomic revision to resolve the ambiguities in the complex. After forms or taxa are identified their fodder value and reproductive biology will be investigated.	PhD	University of Western Australia
Byrne, Margaret	Dean Nicolle	Taxonomic revision of *Eucalyptus* series *Subulatae*. The morphological variation within and between subseries is being assessed to form the basis of a taxonomic revision of the series *Subulatae*. Genetic assessment is being carried out for specific taxa and groups where there are specific questions about relationships.	PhD	Flinders University
Byrne, Margaret	Ryonen Butcher	Taxonomy and systematics of the genus *Synaphea*. This genus is very complex and *Synaphea* species are being assessed for morphological and genetic variation to allow a treatment of the genus and an infrageneric classification to be developed.	PhD	University of Western Australia
Byrne, Margaret	Cate Tauss	Phylogeny, phylogeography and conservation of *Reedia spathacea*. The position of this monotypic genus within the Cyperaceae phylogeny will be determined using molecular and morphological data. The phylogeography of the species will be investigated to provide information for the conservation of the species and also provide insights into the role of wetlands as refugial areas.	MSc	University of Western Australia
Byrne, Margaret	Lynley Stone	Development of *Conospermum* for the cut-flower industry. The reproductive biology of *Conospermum* is being investigated. Genetic analysis is being used to investigate some problems in the cross pollination of plants in one species.	PhD	Murdoch University

Byrne, Margaret	Esther Walker	Investigating the possible hybrid status of 2 Declared Rare Flora in the Albany region, *Eucalyptus bennettiae* and *Adenanthos cunninghamii.* Genetic analysis of the taxa and the 2 suspected parent taxa was carried out with samples from 2 locations for each species.	Honours	Murdoch University
Coates, Dave	Christopher Gage	Genetic diversity, demography and viability of fragmented populations of *Eremaea pauciflora*.	Honours 2002 / PhD 2003	Murdoch University
De Tores, Paul	Matt Hayward	The project examined the ecology of the quokka, *Setonix brachyurus*, in the northern Jarrah forest of south-west Western Australia. Emphasis was on population structure, survivorship at low density sites, home range, habitat use and modelling to predict quokka occurrence. The northern Jarrah forest populations were found to be at critically low density and represent the terminal remnants of a collapsing metapopulation. Habitat analysis confirmed the requirement for a mosaic of vegetation structure and recommended use of fire to manipulate habitat to provide the required structural mosaic.	PhD	University of New South Wales
De Tores, Paul	Erika Alacs	The project investigated genetic variation in the quokka, *Setonix brachyurus*, using microsatellites and amplified fragment length polymorphism (AFLP). Quokka populations were examined from Rottnest Island and from mainland locations from the northern Jarrah forest. The Rottnest Island population was found to be highly genetically differentiated form mainland populations. The mainland populations were also highly differentiated indicating these populations have been historically separated. A high risk of extinction was identified for the northern Jarrah forest populations.	Honours	Murdoch University
Friend, Tony	Tim Button	Corridor use and home range of the quenda (*Isoodon obesulus fusciventer*). This project was carried out during 2002. It commenced as a study of the use of vegetated corridors in farmland on the outskirts of Mount Barker, the site of quenda translocations out and in (associated with roadworks) in the early 1990s. The current study design employed hair-arches to determine quenda presence/absence in corridors and surrounding farmland. The low number of quendas following the fires two years ago resulted in few results and a study of home range was added to the thesis work at a late stage.	BSc	University of Western Australia
Gibson, Neil	Gary Odgen	Wetland tree recruitment in inland wetlands of south-west Western Australia. The objective of the project is to understand the process of recruitment in the dominant wetland tree species found in inland wetlands throughout the south-west of WA. Specifically this involves assessment of key biotic and abiotic paramenter; examination of age structure; examination of the reproductive phenology of representative tree species; determine role of drought, flooding and salinity of seedling establishment; produce model of wetland tree recruitment.	PhD	Edith Cowan University
Halse, Stuart	Winston Kay	Examining population dynamics, genetics and movements of crocodiles in the Kimberley. Co-supervise.	PhD	University of Queensland
Halse, Stuart	Karen Sutcliffe	Examining distribution and conservation status of aquatic insect groups (odonates, trichopterans, plectopterans) in the south-west using the Monitoring River Health Initiative (AusRivAS) samples collected by DCLM and universities between 1994-1999.	PhD	Murdoch University

Halse, Stuart	Erin Lowe	Examining tolerance of diatoms and macroinvertebrates to salinity and acidity, mostly on Swan Coastal Plain.	PhD	Curtin University
Halse, Stuart	Annette Mackintosh	Examining the ecology of stygofaunal ostracods in the Pilbara, including life history information, factors affecting distribution and the usefulness of isotopic composition of ostracod shells to show the extent of annual fluctuations in groundwater conditions (temperature, oxygen, salinity) over the past few years.	PhD	Australian National University
Harper, Richard	Peter Ritson	Carbon sequestration in *Pinus pinaster* in relation to soils and climate	PhD	University of Melbourne
Macfarlane, Terry	Kelly Shepherd	The project is a taxonomic and evolutionary study of the samphires (Chenopodiaceae subfamily Salicornioideae). They are also considered to be taxonomically difficult, with identification being problematic and the basis of variation patterns poorly understood. The project involves morphological, anatomical, molecular and cytological information, and is investigating the question of whether the Australian species represent a monophyletic group within the world Salicornioideae, is examining the monophyly of the Australian genera, and is looking at evolutionary mechanisms in the Australian taxa.	PhD	University of Western Australia
Marlow, Nicky	Rachel Dawson	Examining the timing of reinvasion of baited areas by foxes and fox cat interactions in Dryandra.	Honours	University of Western Australia
Marlow, Nicky	Not finalized	Examining the effect of dieback on invertebrate communities. Co-supervising with Mark Garkakalis from Murdoch University.	Honours	Murdoch University
McGrath, John	Not finalized	Tuart project		Murdoch University
McGrath, John	Not finalized	Wandoo ARC project		University of Western Australia
Morris, Keith	Stephanie Hill	The short-term impacts of fire on small terrestrial vertebrates of Francois Peron National Park, Shark Bay	Honours	Murdoch University
Morris, Keith	Damien Cancillo	Ecology of the heath mouse *Pseudomys shortridgei*	PhD	Murdoch University
Morris, Keith	Not finalized	Social structure of burrowing bettongs	PhD	Murdoch University
Pearson, Grant	Tanya Compton	A study focusing on the phenotypic response of the local Tellinidae to their environment. Phenotypic plasticity studies will primarily concern feeding physiology and behaviour, shell morphology and anti-predation strategies. The study aims to identify some of the adaptations that enable optimal life strategies for these animals in Roebuck Bay (Town Beach and Dampier Flats)	PhD	Royal Netherlands Institute for Sea Research
Robinson, Richard	Peter Scott	Identification of the causal organism associated with stem canker disease in the rare and endangered meelup mallee (*Eucalyptus phylacis*)	Honours	Murdoch University
Shearer, Bryan	A. Koning	Processes in lateritic soil in Western Australia	PhD	University of Western Australia
Shearer, Bryan	R. Pilbeam	Phosphonate distribution in *Eucalyptus marginata* Donn ex Sm. forest and colonization by *Phytophthora cinnamomi* Rands	PhD	Murdoch University
Shearer, Bryan	B. Komorek	Mode of action of phosphonate in native hosts to *Phytophthora cinnamomi*	PhD	University of Western Australia
Shearer, Bryan	S. Collins	Survival of *Phytophthora cinnamomi* in rehabilitated bauxite mining areas	PhD	Murdoch University

Start, Tony	Thalie Partridge	Just enrolled and in the process of planning her study. It will involve fire, small mammals and cats in Purnululu National Park	PhD	Macquarie University
Start, Tony	Carol Palmer	It will involve four CWR mammals, their habitat requirements and the effect of fire on those requirements. Species will be Northern Phascogale, Northern Quoll, Golden Bandicoot and Golden-backed Tree-rat	PhD	James Cook University
Stukely, Mike	Margaret Wheeler	Reproductive biology and genetics of Jarrah. The pollination and reproductive biology of Jarrah is being investigated particularly in relation to development of cross pollination techniques. The genetic diversity and structure of Jarrah and 2 other subspecies is being analysed.	PhD	Murdoch University
Wayne, Adrian	Kristy Chapman	Differential decay rates of Common Brushtail Possum (*Trichosurus vulpecula)* and Western Ringtail Possum (*Pseudocheirus occidentalis*). Examination of the differential decay rates of possum scats as a complementary study to DCLM Science Division Research examining the suitability of scat surveys as an efficient and reliable method of estimating possum abundances in Jarrah forest	Honours	University of Western Australia
Yates, Colin	Marcelle Buist	Comparative ecological characteristics of the rare and threatened *Acacia lobulata* and *Acacia* sciophanes and their common congeners *Acacia verricula* and *Acacia anfractuosa*	PhD	University of Western Australia
Yates, Colin	Andrew Franks	ARC Linkage Project, Landscape fragmentation and rare plant species: can we develop a general framework of population responses?	PhD	Murdoch University

RESEARCH ACTIVITY

WESTERN AUSTRALIAN HERBARIUM

Group Manager: Dr Neville Marchant

Herbarium curation

Core function

Team Leader: Chang Sha Fang

Aims

Documentation of the WA flora to adequately represent species distribution and variation, based on authenticated specimens held at the Western Australian Herbarium; maintenance of currency of corporate databases relating to species names and distribution.

Summary of progress

The Herbarium storage facility was recognized as inadequate and unsafe by the DCLM Corporate Executive, which met at the Herbarium on May 20, 2002. The construction of a new herbarium building is DCLM's highest departmental priority.

Concerted effort continues to be directed towards protection of the collections from insect attack. Monitors are checked regularly and insect levels scrutinized. The collection was fumigated in the last financial year and it is planned to re-fumigate the collection areas in April 2003.

The collection at June 30, 2002 totalled 528 972.
24 453 specimen sheets were added to the collection in the current year.
Of the new accessions 1327 were priority Conservation taxa and 279 were Declared Rare and Endangered Flora specimens.

Herbarium specimen loans is an active program where specimens are sent to specialists in tertiary institutions or other Herbaria for taxonomic research or for specialist identification. This way the herbarium is able to maintain currency of names. During the year to June 30, 2002, 8976 incoming and outgoing loans were processed: -

Loans In	3971
Loan Out	2751
Exchange In	810
Exchange Out	1444
Total	8976

Curation staff and volunteers maintain the public access Reference Herbarium. The total number of specimens is now 11000 and the facility is used by an average of 6 botanists per day. It is the focus of biological surveys undertaken by the WA Wildflower Society and private consultants.

Future directions

The Herbarium collections will continue to expand by the addition of more material. As the Regional Herbaria Project is the main source of new material it is expected that fewer additions will be made to the collection in 2002-03.

Regional herbaria project

Core Function

Team Leader: Chang Sha Fang

Aims

Operation of a Regional Information Network of trained parataxonomists whose activities are focused on local herbaria in collaboration with Landcare and kindred groups.

Summary of progress

The Regional Herbarium Project is a key WA Herbarium function based on collaborative partnerships between the WA Herbarium and regional community groups. One of the main benefits of the program has been to extend the specimen collection at PERTH. The Regional Herbaria Project is now the largest supplier of herbarium material to PERTH and the prime means by which the collections are extended, thus allowing us to meet the requirements of the Conservation and Land Management Act 1984 33.

The Regional Herbaria Project serves an estimated 700 regional volunteers and others. It trains community groups to collect two sets of each specimen. One of these is sent to Perth for identification and databasing, while the other remains in the local herbarium collection. Experienced staff and volunteers carefully identify the Perth specimen. It is databased, barcoded and incorporated into the State collection, where it can be compared with other specimens and studied by taxonomists. Each regional herbarium receives, by mail or Internet, an initial identification and then a barcode number for each specimen. Later, where identification is corrected or names altered the label on the Regional Herbarium specimen is updated so that it is in accordance with its duplicate in the Perth herbarium. With a reliable and current name a regional conservation group can then access other available information on biodiversity through FloraBase on the Internet.

External funding (NHT) for the project continued until January 2002. A supplementary grant from the Executive Director enabled the project to service identification until 15 March 2002. Since that date the service has continued by means of Herbarium volunteers.

- 2 859 Regional herbaria specimens were added to the WA Herbarium. Of these 87 were Priority taxa and 20 were Declared Rare and Endangered flora.
- The Reference Herbarium, an identification tool housed in a public access area adjacent to the Research Herbarium, has 12 869 specimens and recorded 1 517 visits by botanists.

The Survey of Western Australia's land edge (SWALE) Project received funding from Coastcare Australia. The project aims to train regional herbaria groups to survey and document coastal ecosystems. Permanent transects have been established and herbarium specimens gathered. The collections have added substantially to knowledge of coastal flora. The results of the SWALE Project are to be presented at a seminar co-hosted by the Herbarium and the Coastwest program and the State Planning Commission.

The Collections Volunteer program continued to provide excellent contribution and assistance to the work at the Herbarium. During the year to June 30, 2002, 85 volunteers were on our roster with 65 giving at least 50 hours. The total number of volunteer hours was 17 942, an increase from last year.

Future directions

- The project is the prime source of new material coming to the collection.
- It supplies well-annotated specimens that fill gaps in knowledge so the project will continue as funding becomes available.

Weed Information Network

Core Function

Team Leader: Chang Sha Fang

Aims

To document fully the alien flora of WA, based on reliably identified voucher specimens, and to provide an electronic means of weed identification through FloraBase

Summary of progress

- This project, to form an effective Network to document the weeds of WA, is a basic need for the development of National, State and local weed strategies. The ongoing documentation of the current impacts of weeds in local areas and the subsequent development of management strategies are of the highest priority in conserving Western Australia's high biodiversity.
- There is no reliable list of the naturalized weeds of WA. There are numerous publications, including a published book facilitating weed identification. However, there is still no definitive list of weeds of the State, indicating which species are naturalized and where they occur, nor is it possible to easily identify many weeds. An important impediment is the lack of voucher specimens in the State plant collection, the DCLM Herbarium. There are currently 1150 weed names and 20 631 specimens in the State Collection with very little data on their biology and no information to determine if they are naturalized or not. It is likely that the true number of naturalized weeds in WA is between 700 and 800 species.
- As a result of lack of sound information, Landcare and similar groups cannot access reliable information on the potential aggressiveness, geographic spread, biological data and control or management information. Weed information is generally only reliable if the current scientific name of the weed is accurately known. The name needs to be based on pressed, dried, labelled herbarium specimens, which "voucher" a species, an occurrence, a biological characteristic or a management practice.
- Because there has not been a concerted effort to document the weeds of WA, botanists, ecologists and Landcare and related community groups cannot answer the following questions: -

  What particular weed species are naturalized in WA or in their district?
  In which precise locations have they been recorded and what are their habitat preferences?
  What is their potential spread?
  What are the biological attributes that may be critical to successful control or management?

- The WIN Project seeks to gather answers to these questions by developing partnerships between the DCLM Herbarium and collaborating local community groups. The data gathered will be made available to all stakeholders through Internet and other means.
- Two strategies are being implemented. The first is to capitalize on the existing Regional Herbarium Network of highly trained and motivated volunteers in regions. There are 74 functioning Regional Herbaria in WA, most being in the native plant species-rich agricultural areas. Training programs will focus on the most efficient way to gather weed information from the field and voucher this information by specimen collections and documentation. Training will be extended to Agriculture WA staff, Local Government environmental officers and, include Landcare, Bushcare and other key regional personnel already involved in the Regional Herbaria Project. A part of this strategy is herbarium-based where botanists will confirm the identification of WA's weeds by collaboration with taxonomists in other herbaria, especially those in eastern Australia, New Zealand, Europe and South Africa.
- The second strategy involves the gathering and processing of information to enhance the DCLM corporate plant information system FloraBase. Comprehensive user-friendly descriptions of weed species are currently being captured in the Descriptive Language for Taxonomy (DELTA) protocol. The outcome will be a user-friendly identification facility and a weed information system that will

provide a framework for weed management data. These data will be readily available and updated to remain current.

- An outcome of the training and information gathering strategies will be a capacity to provide a comprehensive surveillance system for existing and new weed incursions in WA.
- The WIN Project is being developed in collaboration with Agriculture WA, particularly the Weed Action Groups and the Environmental Weed Action Network (EWAN).
- Funding for the WIN Project ceased in January 2002. Since that date input has been by volunteer effort and staff guidance.

  1 640 specimens were added to the herbarium collection.
  393 species covering the alien species of 13 families have been fully described and details captured in DELTA.

Future directions

The project is a vital one and its aim to establish a surveillance network will be pursued as funding allows.

Bioprospecting

Core Function

Team Leader: Chang Sha Fang

Aims

Collection, processing and vouchering of bioprospecting samples of the WA vascular flora and management of the plant extract library to support the departmental bioprospecting agreement with BioProspect Ltd.

Summary of progress

- The herbarium's bioprospecting activity is a statutory requirement covered by the Conservation and Land Management Act 1984, Section 33 (1) (ca)
- To promote and encourage the use of flora for therapeutic, scientific or horticultural purposes for the good of people in this State or elsewhere, and to undertake any project or operation relating to the use of flora for such a purpose.
- 2 560 specimens were added to the herbarium collection

Future directions

Collections will continue as long as the agreement between BioProspect Ltd and the Department is maintained.

Biosystematics of Declared Rare Flora (DRF) and priority taxa

Core Function

Team leader: Terry Macfarlane

Aims

- Provision of reliable taxonomy to underpin effective conservation management.
- Maintenance of an up-to-date census of the WA flora.
- Improving scientific knowledge of biodiversity of the WA flora.

Summary of progress

- 59 genera with DRF and Priority species were studied.
- A total of 96 species were reviewed and details corrected or confirmed in the WACensus database.
- The manuscript for the 2-volume handbook the Flora of the South West ((Bunbury, Augusta, Denmark) was completed. Publication is expected to be in September 2002. The Flora covers 2 060 native and alien vascular plants. Apart from the publication itself, the flora-writing project has made significant contributions to curation and to electronic information systems.
- A project was commenced to provide easy to use identification keys in FloraBase by illustrating the technical characters.

Conservation status of native taxa

Core Function

Team leader: Terry Macfarlane

Aims

Provision of up-to-date names and data on all aspects of native and alien flora including systematic, biological, ecological, conservation status and economic attributes.

Summary of progress

- Studies on Declared Rare Flora (DRF) and Priority taxa are carried out in conjunction with taxonomy of non-conservation taxa.
- Apart from the 59 genera referred to under Biosystematics of DRF and Priority Taxa, a further 16 genera and over 300 species have been reviewed.
- Taxonomic research on Agonis, Astartea, Asteraceae, Baeckea, Darwinia, Chamelaucium, Hibbertia, Leucopogon, Poaceae, Proteaceae and Lichens continued, with information disseminated via the information systems and directly by reports and notifications to Departmental officers.
- Detailed field work was carried out in conjunction with Central Forest Region as part of a two year program to revisit populations, seek new ones, and review the taxonomy and conservation status of priority taxa, and a report completed. The program contributed botanical expertise and knowledge transfer to accompanying regional staff.

Future directions

The project will continue to efficiently deal with taxonomic problems as they arise.

Weed taxonomy, biosecurity, incursion monitoring

Core Function

Team leader: Terry Macfarlane

Aims

Provision of up-to-date names and data on all aspects of alien flora to support agencies concerned with management and control.

Summary of progress

- Weed taxonomy is carried out largely by collaboration with taxonomists in overseas institutions. The aim of the Biosystematics program is to ensure that a current name is used for alien taxa recorded as naturalized in WA. As reported under Weed Information Network, the capture of descriptive data for 393 species covering the alien species of 13 families has been completed and details captured in DELTA.
- The renewed focus on weed taxonomy has led to an increased acquisition of specimens for documenting the geographical occurrence of the weeds. A closer collaboration has been formed with the Department of Agriculture to formalize the Program's role in weed incursion notification. This involvement is working successfully as shown by some publicized cases of new weed discoveries, early and accurate identification of which can have very large economic benefits to WA.

Future directions

- Determination of names of alien taxa will continue.
- Funding will be sought for the continuation of the project.

Nuytsia

Core Function

Team leader: Barbara Rye

Aims

The Herbarium's taxonomic journal *Nuytsia* facilitates the formal publication of names of WA plant species and information for identifying and characterizing them.

Summary of progress

During the year three parts of Volume 14 of the WA Herbarium publication *Nuytsia* were published. A total of 18 taxonomic papers totaling 457 pages were published as follows: -

Parts 1 & 2	September 2001	2 paper	318 pp.
Part 3	January 2002	16 papers	139 pp.

Parts 1 and 2 were published together for a special orchid issue because the second of the two papers was exceptionally large. Two versions of this issue were printed, one with the usual cover and the other with an illustration of orchids for release at the Perth International Orchid conference in September 2001.

Future directions

- Changes will be made to the Editorial management.
- The editor Dr Barbara Rye will continue as editor until Alex Chapman assumes that role late in 2002.
- The publishing process is regularly reviewed in terms of changing technology and in order to minimize costs while fulfilling the formal requirements of nomenclature.

FloraBase

Core Function

Team Leader: Nicholas Lander

Aims

Provision of easily-accessed computer-based botanic information systems to efficiently manage biological inventory.

Summary of progress

- FloraBase is the WA Herbarium's information delivery system that accesses data from the WA plant names database (WACENSUS), the herbarium specimen database (WAHERB), the electronic flora of WA, the WA plant Genera database (WAGENERA), spatial data, plant imaging, weed studies and taxonomic literature database.

New FloraBase registrations		
Level 2	145	
Level 3	35	
Level 4	19	
Level 5	13	
Total FloraBase registrations	976	
Average successful requests per day	3 064	
Average data transferred per day	26	megabytes

- *WACENSUS*

This activity entails the design, development and maintenance of the database and related procedures to enable the management of taxonomic and nomenclatural changes to WA plant names. It is also the basic component for a number of related datasets within DCLM such as the Wildlife Branch DRF database and the Science Divisions WAHERB specimen database.

The WA Herbarium plant census is the authoritative list of WA plant taxa. It is kept up to date and entries are verifiable through specimens or authoritatively published articles. Changes to names are made only after critical assessment.

WACENSUS Insertions	Manuscript names	62
	Phrase names	67
	Published names	157
	Current names	282
	Non current names	4
	Total	572
WACENSUS Edits	Taxonomic synonyms	44
	Nomenclatural synonyms	70
	Misapplied names	18
	Excluded	20
	Error	5
	Total	157

- *WAHERB*

Total insertions 26 756 specimens
Number of edits made to database 54 102, including 13 277 name changes on specimens (representing 3% of the entire collection)

WAHERB database totals at June 30, 2002

	Total Nos.	% increase over year
Algae	5586	2.6
Mosses	4942	7.8
Liverworts	1295	19.6
Fungi	6987	1.7
Lichens	5876	17.1
Ferns	2902	4.5
Gymnosperms	1649	5.2
Monocots	83689	5.0
Dicots	416046	4.7

Total	528972

- *Electronic Flora of WA*

The WA Herbarium has adopted a strategy aiming at leveraging staff effort to best effect in the public interest. The publication of the Flora of the South West in August 2002 will mark the end of the regional flora writing program to deliver handbooks to floras of WA regions. Apart from the formal publication of taxonomic research in Nuytsia, the WA Herbarium's taxonomic effort is now directed to electronic capture of descriptive information that will be delivered in an interactive way through FloraBase. Species descriptions and a species identification system based on data captured in DELTA and delivered by FloraBase is the adopted strategy for taxonomic output of the Herbarium.

The adoption of DELTA methodology by the WA Herbarium has required the development of a "database engine", which integrates taxonomic descriptive data coded in DELTA from studies in Biosystematics of DRF and Priority Taxa.

The database engine named DELIA, is complementary to DELTA and makes DELTA files available to corporate information systems such as those delivered by FloraBase. During the year DELIA was launched at an international conference in Sydney and it has been extensively utilized in Weed Information network and other data transfers in the Herbarium.

- *WAGENERA*

This project is to produce an identification tool for all of WA's vascular plant genera. The data for over 90% of WA genera has been captured electronically. In conjunction with this data set, illustrations of core characters are being prepared. Development work on a new version of FloraBase has commenced and will include components of the WAGENERA database, notably full familial and generic descriptions for the WA flora in the first instance, followed later by online identification tools for these taxa. FloraBase version 2 is due to be released in mid 2003.

- *Spatial Data*

Maps showing distribution of all WA Taxa are updated regularly, reflecting Herbarium curation advances so that FloraBase delivers up-to-date geographical information

- *Plant Imaging*

A team of highly-trained volunteers carry out image capture editing and management. The total number of taxa illustrated in FloraBase at June 30, 2002 was 3 700.

- *Weed Species*

Funding for the Weed Information Network (WIN) ceased in January 2002. Since that date trained volunteers under staff supervision have carried out data capture. Morphological details of 13 families and a total of 390 species, representing over one third of WA's weed flora have been entered into the database.

- *Taxonomic Literature Database*

The State Botanical Library is an integral part of the Herbarium's information systems. Its holdings relevant to the names and other data of the flora of Western Australia is databased and made available through FloraBase.

At June 30, 2002 the Library housed 21 000 records.

Future directions

- Databases will be expanded and maintained.
- FloraBase version 2 is to be launched in mid 2003.

NatureBank

Core Function

Team Leader: Paul Gioia

Aims

To provide warehousing of a range of datasets in a single GIS environment that will lead to a land and biota management resource tool.

Summary of progress

- The data is being organized to facilitate their extraction for use within specialized collaborative projects such as Fire Decision Support Systems or Disease Management Systems. The system will also display a range of themes based on the outcomes of associated projects and deliver these outputs through GIS applications which will be visible on the intranet and, possibly, the internet.
- The project (previously named WABIOTA) is now closely integrated with the divisional information system NatureBank.
- Development work to add simple online species mapping facility has continued.

Future directions

- Funding has been acquired to develop NatureBank.

MAX field information capture system

Core Function

Team Leader: Paul Gioia

Aims

To provide a species editing program and collecting tool that will enable capture of field data and facilitate its transfer to WAHERB.

Summary of progress

MAX is a stand-alone species-editing program that is based on the herbarium's information systems. MAX provides users with an electronic field-collecting book compatible with WAHERB and with up-to-date species names. MAX allows Herbarium collaborators to enter specimen details, print labels and upload data directly to WAHERB. MAX is a basic tool of the regional Herbaria Project. MAX has been updated during the year and work has progressed on a new version, Max 2.1.0 (build 118) to be available in December 2002. This build addresses a number of issues, and now allows the user to specify and display user-defined fields in a collecting book.

269 records inserted using MAX or HERBIE software
298 Total MAX users

Future directions

- A new version will be produced by December 2002 and work will proceed on further development.
- Training session for departmental officers will be held during 2003.

Divisional LAN (Local area network)

Core Function

Team Leader: Mike Choo

Aims

To provide the necessary LAN infrastructure to support the communication objectives of the Science Division.

Summary of progress

The Herbarium is responsible for the ongoing development and maintenance of a network for electronic communication within DCLM's Science Division. This involves the overseeing of the Divisional LAN and allocation of funds to upgrade services based on an assessment of priorities. The physical maintenance is performed by Information Management Branch through a service agreement.

Australia's Virtual Herbaria project

Core Function

Team Leader: Alex Chapman

Aims

- To develop systems compatibility between information systems of Australian Herbaria.
- To oversee the databasing of PERTH's backlog.
- To implement geocode and taxonomic validation programs.

Summary of progress

- All Australian State herbaria have received funding from Environment Australia to database Herbarium collections. Funding was matched dollar for dollar by the States. As PERTH was almost entirely databased we were able to negotiate funds to deal with the backlog of some 90 000 specimens awaiting processing and housed in the Herbarium. In addition identifications and geocodes of the curated specimens is being undertaken.
- During the year to June 30, 2002, 13 116 specimens were databased and have been added to the collection.

Future directions

- The backlog will be further reduced.
- Planning for the recital of the voucher specimens from the Salinity Action survey of the wheatbelt is expected to proceed.

BIODIVERSITY CONSERVATION GROUP

Group Manager: Mr Keith Morris

The Dalgyte *Macrotis lagotis* in south-west Western Australia: Original range limits, subsequent decline, and presumed regional extinction

Ian Abbott

Aims

To determine the distribution of this species at the time of European settlement (1826) and the reasons for its subsequent contraction in range.

Summary of progress

Project completed and published at: Abbott, I. The Bilby *Macrotis lagotis* (Marsupialia: Peramelidae) in south-western Australia: Original range limits, subsequent decline, and presumed regional extinction. Records of the Western Australian Museum 20: 271-305.

Knowledge of the original southwestern geographic range limits of the Dalgyte *Macrotis lagotis* in Western Australia, before its regional decline and apparent extinction, is currently underpinned by only 6 museum records, including 3 from near Bridgetown. The collector of one of the latter specimens in 1933 was interviewed, clarifying the source localities of these specimens. A further 155 residents, mostly aged 70 yrs or more, were interviewed, resulting in additional localities based on observations. A search of published and unpublished historical sources also revealed several acceptable records. This information was then coupled with detailed 1: 250 000 vegetation complex maps prepared in 1998 for the Regional Forest Agreement to produce a map of the inferred original distribution of the Dalgyte in southwestern Australia. Dalgytes appear to have occurred in suitable areas of open forest and woodland in the northern and eastern Jarrah forests, west to about Chittering, Chidlow, Marradong, Bowelling, Boyup Brook and Bridgetown. The main southern limit appears to have been Warren River at Quillben forest block (along valleys containing sandy soils), Perup River near Deeside, Hay River near Forest Hill, and north of Porongurup Range. Bilbies also occurred, apparently sporadically, farther southwest at Margaret River, along the Blackwood River between Darradup and Alexandra Bridge, near Lake Jasper, near Dombakup, and between Kent River and Denmark.

Factors possibly implicated in the local extinction of the Dalgyte in southwestern Australia are reviewed. Although drought, disease, trapping, and distribution of poison baits for rabbit control reduced population numbers of the Dalgyte, the coup de grâce was delivered by the arrival of the Fox in the late 1920s/early 1930s. The last specimens were collected in 1935, though a few populations might have persisted very locally until the 1970s or even 1980s.

Current proposals to re-introduce the Dalgyte to public land in its inferred former range will serve to test the hypothetical original distribution of the Dalgyte, prior to the arrival and establishment of the Fox.

Origin and spread of the Cat, *Felis catus*, on mainland Australia, and its early impact on native fauna

Ian Abbott

Aims

To establish whether the cat was introduced to Australia by Indonesians, from Dutch shipwrecks or with British settlement. To evaluate the evidence that the cat impacted detrimentally on various species of native fauna before other anthropogenic factors began to operate.

Summary of progress

A comprehensive search of historical sources found no evidence that the cat *Felis catus* was present on mainland Australia prior to settlement by Europeans. Nor were records of cats found in journals of expeditions of exploration beyond settled areas, undertaken in the period 1788-1883. Cats did not occupy Australia from the earliest point of entry (Sydney, 1788), but instead diffused and were spread from multiple coastal introductions in the period 1824-1886. By 1890 almost the entire continent had been colonized. This new chronology for the feline colonization of Australia necessitates a re-appraisal of the early impact of the cat on native mammal and bird species. The evidence for early impacts of cats causing major and widespread declines in native fauna is considered tenuous and unconvincing.

Aboriginal fire regimes in south-west Western Australia: evidence from historical documents

Ian Abbott

Aims

To review all historical documents for the period 1696-1888 likely to provide firsthand information about Aboriginal usage of fire.

Summary of progress

Project completed and submitted for publication.

Empirical data were extracted and classified according to their relevance to season, frequency, scale, and intensity of Aboriginal burning. In coastal and forested parts of the south-west of Western Australia, most fires were set by Aborigines in summer (December-March). On suitable days many ignitions could occur and fires could be large, resulting in burnt patches in the order of tens and hundreds of hectares. Trees could be scorched to c. 15 m. In the drier inland, most fires were recorded in October and November. Coastal plain woodlands and grassy woodlands inland had fire return intervals of 2-4 yrs. Fire in Karri forest and kwongan appears to have been less frequent and more localized, so that much of those landscapes remained unburned for longer than 4 yrs. These conclusions accord with those from experimental studies of fire behaviour and ecological research.

Several misconceptions in the literature about fire regimes, based mainly on inferences from information about vegetation, are clarified. Knowledge about Aboriginal burning derived from early visitors and colonial records can inform current fire management so as to maximize the conservation of biodiversity.

Fire and terrestrial invertebrates in south-west Western Australia

Team Leader: Ian Abbott

Aims

To review all 31 fire impact studies (1955-2000) on terrestrial invertebrates in south-west WA.

Summary of progress

Project completed and a paper by Van Heurck, P. & Abbott, I. has been submitted for publication.

At landscape scales, invertebrate biodiversity is greatest where habitat heterogeneity (represented by a wide range of post-fire successional stages in the vegetation) is maximized. No single habitat type in a particular landscape will include every invertebrate species in the landscape, as some species are rare without frequent fire and others are rare if fire is frequent. Following fire, α diversity (local species richness) declines in the acute phase but β diversity (landscape species richness) is increased. Recent studies of single fires and long-term fire regimes in south-eastern Australia reveal similar trends.

With a great diversity of invertebrate species and only rudimentary knowledge of their taxonomy and ecology, a combined precautionary and adaptive approach to fire management across the landscapes of the southwest of Western Australia seems appropriate. Elements of this should include strategic planning at regional and landscape scales, greater variety in season of burning, size and frequency of planned fires, and more effective long-term monitoring of indicator and fire sensitive taxa. The impact of unplanned fires (wildfires) on invertebrate assemblages in particular merits further study. Additional surveys are needed to map and determine the bio-indicator potential of post-fire invertebrate species assemblages for monitoring more efficiently forest ecosystem health and the restoration of threatened plant communities across the full continuum of disturbance.

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

SPP #96/14

Team Leader: David Algar

Aims

The feral cat is recognized as a significant threat to fauna conservation in Western Australia, particularly in arid and semi arid regions. Not only do feral cats prey on native fauna and have the potential to spread diseases, but also they have proven to be an obstacle to fauna re-introduction programs. The principle objective of the feral cat control research program is to design and develop an operationally feasible bait and baiting regimes to provide effective and cost-efficient broad-scale control of feral cats. Essentially, 3 strategies are being employed to achieve this.

Firstly, a series of trials were conducted, which were completed in 1999, to develop a bait medium that was attractive to feral cats. The bait also had to have operational utility including a capacity to carry a toxin, be relatively simple and inexpensive to manufacture, be easily and safely handled and transported and could be deployed aerially over large areas. Secondly, field-based research and operational trials focused on the field testing and further development of effective broad-scale aerial baiting strategies for feral cats. This initially involved examination of bait uptake in relation to the time of year (season) to enable baiting programs to be conducted when bait uptake is at its peak and therefore maximize efficiency. A key factor affecting bait uptake is the availability of live prey, the nature and abundance of which varies geographically and seasonally. While a number of trials have been undertaken in a range of ecosystems, current and future investigations aim to examine the effects of season, baiting intensity (number of baits laid km^{-2}) and baiting frequency (interval between baiting operations) needed to optimize sustained control. Finally, it will be essential that a comprehensive risk assessment of the potential impact of feral cat baiting programs on populations of non-target species be undertaken, and where necessary, methods devised to reduce this risk. This risk assessment is in part required to gain National Registration Authority registration of the new bait as well as assuring the protection of native fauna. While techniques have been developed to assess the relative abundance of feral cats, it is also necessary to further develop and validate these techniques to efficiently and reliably census feral cat populations.

Summary of progress

The cat bait has achieved patent status this year. Research into the relationships between season, live prey abundance and bait uptake are well advanced in a number of bioregions. Results show temporal (seasonal) variability in live prey abundance and bait consumption. In areas that experience a Mediterranean-type climate and particularly where rabbits are abundant, the optimum baiting period occurs in the drier autumn/early winter months when young, predator-vulnerable prey are not present but before the onset of winter rains. Research in the interior arid zone has suggested that the optimum time to conduct baiting programs and maximize their effectiveness is under cool dry conditions in winter. At this time, the abundance and activity of all prey types, in particular small mammals, reptiles and birds, is at its lowest and bait degradation due to ants and to hot, dry weather, is significantly reduced. The current series of trials are designed to investigate baiting efficacy at differing baiting intensities. To date, this series has demonstrated that a baiting density at least half that used in island eradications is equally

efficacious in the control of feral cats in the arid interior. This evidence has been supported by a highly effective toxic baiting of feral cats on the Gibson Desert Nature Reserve and Peron Peninsula this year. The high level of bio-marking and good control of feral cats during these exercises suggests that further reductions in bait distribution may not reduce baiting efficacy.

Future directions

Future research will focus on refinements to the bait medium, the development of a felid specific toxin, refinements to bait production and handling and designing bioregionally appropriate baiting regimes with respect to season, intensity and frequency of baiting. Further research on non-target issues is a high priority.

Biological survey of Yanchep National Park

SPP #93/33

Team Leader: Allan Burbidge

Aims

Specific aims were to determine patterns of community composition in the Yanchep National Park and the adjacent Ridges area and to establish a series of permanent 'benchmark' quadrats for future monitoring of community change. A further aim was to gather data in a form that would allow objective comparisons with data from other surveys in the region, so as to enable the conservation value of the area to be placed in a regional context, thus providing a more objective assessment of its value to conservation. The project has contributed data relevant to management planning in the area.

Summary of progress

None in 2001/02; data collected and field work completed previously.

Future directions

Complete draft MS as time permits.

Biological survey of Cape Arid National Park

SPP #93/34

Team Leader: Allan Burbidge

Aims

The aim was to determine patterns of community composition in Cape Arid National Park and to establish a series of permanent 'benchmark' quadrats for possible future monitoring of community change. A further aim was to gather data in a form that would allow objective comparisons with data from other surveys in the region, so as to enable the reserve to be placed in a regional context, thus providing a more objective assessment of its value to conservation. The project has contributed data relevant to management planning in the area.

Summary of progress

None in 2001/02; data collected and field work completed previously.

Future directions

- Integrate vertebrate data sets.
- Write up as opportunity permits.
- Contribute to management plan for Esperance coastal reserves.

Carnarvon Basin survey

SPP #93/35

Team Leader: Allan Burbidge

Aims

To assess the adequacy of the current regional reserve system in the southern Carnarvon and northern Geraldton Sandplains biogeographic districts on the basis of patterns of distribution of plants and animals, and to design an optimal regional reserve system which would fill major gaps identified by the above process.

Summary of progress

- Project essentially complete – 600 page scientific volume (31 authors, 19 chapters, externally refereed) – published in early 2001; subsequently launched by the Hon Minister in the current reporting period.
- 'Companion' volume published and distributed to all pastoralists in the study region, plus relevant Commonwealth, State and Local government agencies, libraries, Conservation Commission, etc.; work is underway to distribute to selected schools with appropriate resource notes for teachers. This volume is a distillation of the scientific data, written for land managers and the interested layperson, and includes suggestions for actions that can be taken up by individuals or community groups.
- "Carnarvon Basin survey – implications for monitoring biodiversity" – invited presentation for the workshop "Monitoring biodiversity in the rangelands – moving towards sustainability", Perth, 8 February, 2002. The intent of this presentation was to provide the scientific background concerning conservation values in the Carnarvon Basin area and a consideration of issues relevant to practical and meaningful monitoring of these values.

Published

- Burbidge, A.H. (Compiler) (2001) Companion to Biodiversity of the southern Carnarvon Basin. DCLM.
- Burbidge, A.H. (2002) Biodiversity of the Carnarvon Basin. Western Wildlife 6(3): 14-15.

Future directions

Complete distribution of 'Companion' volume to schools.

Conservation of the Western bristlebird

SPP #93/65

Team Leader: Allan Burbidge

Aims

The overall aim of this project is to document response to both moderate and intense fire, identify habitat preferences, determine adequate census protocols and develop translocation techniques in order to enable informed management such that the species can eventually be removed from the list of threatened fauna.

Summary of progress

- Monitoring of translocated population at Nuyts Wilderness, Walpole-Nornalup NP (after major fire in March 2001), located and mapped at least 7 of the 15 birds translocated in 1999 and 2000). Post-fire monitoring in Fitzgerald River NP – this is assisting the development of our understanding of habitat needs for this species in the park and will help in the formulation of future management actions.

- Completed first comprehensive census of bristlebirds in the Two Peoples Bay – Manypeaks area (with regional staff and consultants) – this has provided previously unavailable systematic base line census data for bristlebirds and whipbirds in this area, and can be related to future monitoring of fire effects or management actions.
- Provided input to review of fire management at Waychinicup-Manypeaks (in progress)
- Contributed to review of effects of fire on birds.

Published

- McKenna, S. and Burbidge, A.H. (2001) Rare birds survive Nuyts fire. Landscope 17(2): 7.
- Burbidge, A.H. (2001) Rare birds survive wilderness wildfire. Conservation News November 2001: 2.
- Burbidge, A.H. (2002) Walpole bristlebirds doing well – despite the fire! South Coast Threatened Birds News 6: 4.

Talk to BAWA Oct 22, 2001 (with Sarah Comer): "Bristlebird censusing and monitoring 2001".

- The translocation project has had a high degree of success due to the positive collaborative efforts of DCLM regional staff (Sarah Comer, Albany and various staff at the DCLM Frankland office) and the volunteers that they have brought to the project.

Future directions

- Monitoring of response to fire at Nuyts Wilderness and FRNP; possible translocation of more birds to Nuyts.
- Continue input to review of fire management at Waychinicup-Manypeaks.

Ground parrot recovery

SPP #2000/02

Team Leader: Allan Burbidge

Aims

The Western Ground Parrot is Critically Endangered. The aim of this project is to document response to fire and determine habitat preferences to enable management actions to reverse the overall decline in population numbers.

Summary of progress

- Some progress on writing up of census data.
- Provided input to review of fire management at Waychinicup-Manypeaks (in progress).
- Contributed to review of effects of fire on birds.

Future directions

- Complete collation of vegetation structural data
- Analyse and write up census data (Matt Williams is assisting with analysis)
- Analyse and write up vegetation / fire response data
- Continue to provide input to review of fire management at Waychinicup-Manypeaks
- Draft recovery plan
- Obtain external funding to facilitate research and management action for this declining Critically Endangered species.

Project Desert Dreaming

RPP #60/90

Team Leader: Neil Burrows

Aims

To test the hypothesis that changed fire regimes and introduced predators caused the demise of medium size mammals in the arid zone.

Summary of progress

Experimental re-introductions using 2 medium-sized mammal species were carried out in 1992 with the demise of the animals due to predation by feral cats. The project demonstrated that while habitat was suitable for medium size mammals, the feral cat posed a serious threat to mammal re-introductions in this environment. It also demonstrated that for these species at least, fire succession was not a critical factor affecting their survival. The results of the experimental re-introduction have been published. Since 1992 the project has focused on developing cost-effective measures to control introduced predators, especially feral cats. Significant progress has been made using innovative feral cat bait developed by DCLM scientist Dr David Algar. Outstanding results have been achieved when the bait is delivered at high density and under cool dry winter conditions. A paper on the results of this work has been submitted to the Journal of Arid Environments.

Future directions

- Rate of re-invasion by feral cats following successful baiting in June 2002 is being monitored to determine baiting frequency needed for sustained control. The successful baiting operations carried out in 2002 will be replicated in 2003 to further prove the technique.
- New studies are underway in the Gibson Desert to investigate fire effects on vascular plants and invertebrates. Large wildfires have burned out more than 80% of the Gibson Desert Nature Reserve during the last 3-4 yrs.

Using prescribed fire to rehabilitate landscapes disturbed by mining exploration in the arid zone

SPP #93/160

Team Leader: Neil Burrows

Aims

To investigate the effectiveness and efficiency of using moderate intensity prescribed fires to facilitate regeneration of perennial vegetation on seismic/cut lines used for mineral exploration in the Rudall River National Park. The hypothesis is that fire will cue seeds to germinate and, with wind, will facilitate the mobilization of soil and seed banks.

Summary of progress

Mark 2 fire behaviour prediction model has been prepared and distributed to operations staff. This technique proved to be very successful as a tool for regenerating perennial vegetation under certain conditions. Clay content of the soil, level of compaction and antecedent rainfall were important factors affecting revegetation success following moderate intensity fire.

Future directions

- Fieldwork completed.
- Data analysis and write-up for submission to Journal of Arid Environments.

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

SPP #2000/04

Team Leader: Neil Burrows

Aims

To investigate the relationship between age/size class structure of boab stands and fire history. The hypothesis is that frequent, intense late dry season fires and grazing by cattle is preventing recruitment of boabs.

Summary of progress

Field surveys were completed in 2001. Data are being analysed. Early indications are that boabs are quite resistant to fire, although some stands that have a history of frequent fire and grazing show lower recruitment levels.

Future directions

- No further fieldwork.
- Anticipate submitting paper in July 2003.

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

SPP #98/03

Team Leader: Margaret Byrne

Aims

This project provides genetic information for the conservation and management of Western Australian flora, particularly rare flora. Current work aims to resolve the possible hybrid status of *Eucalyptus bennettiae*, *Adenanthos cunninghamii* and *Grevillea phanerophleba*; determine the phylogenetic relationships between geographically diverse populations of *Grevillea althoferofum*, *Adenanthos pungens* and *Dryandra ionthocarpa*; resolve the taxonomic status of *Tetratheca* species and the systematic position of *Eucalyptus delicata*.

Summary of progress

- *E. bennettiae* – analysis with microsatellite loci has confirmed the status of the type population as a hybrid between *E. sporadica* and *E. lehmannii*. Analysis of a second population is underway.
- *A. cunninghamii* – analysis with AFLP markers is being carried out for plants from 2 locations. Preliminary analysis at one population is consistent with *A. cuninghamii* being a hybrid between *A. cuneatus* and *A. sericeu*s.
- *G. phanerophleba* – collections of leaf material have been made from *G. phanerophleba* individuals from 2 locations and populations of the putative parents *G. amplexans* and *G. biternata*. DNA has been extracted and AFLP analysis has commenced.
- *G. althoferorum* – Genetic analysis has confirmed the clonal nature of the Eneabba population and suggests that clonality is also present at the Bullsbrook population. The 2 populations are distinct but taxonomic determination is unresolved and requires further analysis.

- *A. pungens* – The 2 subspecies are differentiated by habit and 1 is critically endangered. Sequencing analysis has identified that the 2 subspecies are not genetically distinct and that they should be combined into a single species.
- *D. ionthocarpa* – The relationship between the newly found populations at Brookton and the ones at Kambellup has not been resolved. Sequencing the ITS locus has been problematic as multiple loci were detected therefore clean sequence data could not be obtained. This species will need to be investigated using a different approach.
- *Tetratheca* – The taxonomic relationships of the *T. aphylla* group have been investigated by morphology and by sequencing a nuclear and chloroplast gene. The analysis has confirmed the species as genetically distinct including the endangered *T. paynterae* at Windarling Rock. The plants found at the Die Hardy Range are genetically and morphologically distinct and should be recognized as a new species.
- *E. delicata* – The relationships between *E. delicata*, *E. salmonophloia* and *E. longicornis* are being investigated to clarify which series *E. delicata* belongs to. Populations have been assayed with RFLP loci and data analysis is currently being conducted.

Future directions

- Work on *G. phanerophleba*, *E. bennettiae* and *A. cunninghamii* will be completed to resolve their putative hybrid status.
- Analysis of *E. delicata* will be completed.
- The phylogenetic relationships between populations of *D. ionthocarpa* and *G. althoferofum* will be investigated using different approaches.

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

SPP #2001/01

Team Leader: David Coates

Aims

In this project the significance of the level of genetic variation, its maintenance and the effects of changes in outcrossing (inbreeding) will be assessed in relation to rarity, population size and information gathered from the ecological studies. These investigations will provide baseline information for ongoing in situ management of rare species, particularly in relation to the importance and maintenance of population size. Outcomes will relate directly to the recovery, translocation, ex situ germ plasm collection and ongoing management of threatened flora and other high priority flora. Specific aims are to assess:

1. The relationship between effective population size and levels of genetic diversity, and the minimum effective population size for maintaining genetic diversity
2. The effects of population size and habitat degradation on mating system parameters that indicate inbreeding or the potential for inbreeding.
3. Whether reduction in population size, increased inbreeding and reduced genetic variation are associated with any reduction in fitness determined from ecological studies
4. 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

- Completed allozyme and mating data analysis for 5 *Banksia cuneata* populations.

- Completed mating system analysis of *Verticordia fimbrilepis* ssp. *fimbrilepis* populations.
- Draft paper prepared on patterns of genetic variation in *Banksia cuneata* and *B. oligantha.*
- Completed analysis of population genetic structure in 6 populations of *Verticordia fimbrilepis* subsp. *fimbrilepis* and *Verticordia fimbrilepeis* subsp.

Future directions

- Finalize population genetic structure and mating system studies on *Verticordia fimbrilepis.*
- Prepare paper on mating system variation and population genetic structure in *Verticordia fimbrilepis*.
- Finalize paper on population genetic structure and the mating system of the rare ghost wattle, *Acacia sciophanes* and its common congener *Acacia anfractuosa.*
- Complete temporal mating system studies on *B. cuneata.*
- Submit for publication paper on "Evolutionary patterns and genetic structure in rare and widespread species in a triggerplant (*Stylidium caricifolium*: Stylidiaceae) species complex".

Genetic and ecological viability of plant populations in remnant vegetation

SPP #2002/01

Team Leader: David Coates

Aims

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 will quantify the genetic and ecological factors that influence the viability of plant populations in fragmented landscapes and explore how these are affected by remnant characteristics such as size, disturbance and landscape position. Target species with a wide range of life histories will be used to allow results to be extrapolated broadly. Based on this, thresholds of population size and landscape context required for genetic and ecological viability of life history classes such as trees, shrubs and herbs will be identified. The project is unique in combining molecular genetic and demographic approaches to identify key biological processes affecting population performance and determining under what remnant vegetation conditions they limit viability and remnant conservation

Specific aims:

1. Examine and model the relationships between key genetic and demographic factors affecting viability and remnant vegetation characteristics such as size, disturbance and landscape position
2. Compare results among 3 target taxa with varied ecologies to assess how life history affects the impact of remnant characteristics on population viability.
3. 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

- Three target taxa (*Calothamnus quadrifidis*, *Eremaea pauciflora*, *Eucalyptus wandoo*) selected for first phase of study.
- 20 sites per taxon selected in Dongolocking area and mapped for demographic, ecological and genetic studies.
- 20 plants per populations (*C. quadrifidus*, *E. wandoo* and *E. pauciflora*) tagged and sampled for genetic and demographic studies.

- Year 1 assessment of seed production in *E. pauciflora* completed and analysed.
- Genetic diversity studies on *E. pauciflora* completed and analysed.
- Year 1 sampling for seed production and flowering phenology in *C. quadrifidus* and *E. wandoo* completed.
- Genetic diversity studies commenced on *C. quadrifidus* and *E. wandoo.*
- Milestone 3 Report for project completed and submitted to Land and Water Australia.

Future directions

The project has minimum 3 yr duration with all Land and Water Australia year 1 milestone requirements met and most exceeded. 2002/03 Milestones are as follows:

- Completion of analysis of site / population characteristics – disturbance, connectivity, density.
- Completion of genetic variation studies covering all populations of *C. quadrifidis* and *E. wandoo.*
- Development of microsatellite markers for *E. pauciflora* and *C. quadrifidis* for gene flow studies.
- Commencement of mating system studies on *E. pauciflora* and *C. quadrifidis.*
- Completion of seed set / reproductive output analysis for year 1 for *C. quadrifidis* and *E. wandoo.*
- Commencement of growth/fitness trial experiments for all 3 species.
- Preparation of publication on genetic variation and reproductive output in fragmented populations of *Eremaea pauciflora.*
- Milestone report to Land and Water Australia.

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

SPP #99/10

Team Leader: Anne Cochrane

Aims

The establishment of a long-term storage facility for seed of rare and threatened taxa affords a cost effective and efficient interim solution to loss of floral genetic diversity and has provided a focus for flora recovery in Western Australia. The project provides information on the seed biology of rare and threatened species and propagules for future translocation programs. The provision of relevant information on seed availability, seed biology, storage requirements and viability of seed of rare and threatened taxa has assisted in the development of management prescriptions and preparation of Interim Recovery Plans and Translocation Plans.

The project aims to:

1. Collect and store genetically representative collections of seed of rare and threatened Western Australian native plant species.
2. Determine the germination and storage requirements of seed.
3. Monitor the viability of stored seed over the long term.
4. Increase knowledge of seed biology using both field and laboratory based studies.
5. Describe and categorize seed and gather phenological data.
6. Incorporate all information into a corporate database (WASEED).

Summary of progress

Substantial funding was received from the Millennium Seed Bank Project, Royal Botanic Gardens Kew, UK to support the existing works program. Under this funding a Technical Officer was contracted for a 3 yr period. Between mid 2001 and mid 2002 seed collections from more than 170 rare, threatened and poorly known species were accessed. All data pertinent to the collection, testing, storage and monitoring of seed-based data has been kept up-to-date in the WASEED database. A project to investigate factors affecting germination of Melaleuca species was conducted for the Department's Farm Forestry Unit. A project to investigate seedbank dynamics and response to disturbance of the critically endangered *Grevillea maxwellii* was initiated with Bankwest Landscope Visa Conservation Card funds. Seed Notes were produced and several articles were published.

Future directions

- Ongoing collection of seed for incorporation into the genebank, including 50 DRF and 100 priority taxa.
- Ongoing research into the seed biology and seed storage behaviour of several critically endangered plant taxa.
- Germination testing, storage and monitoring of existing accessions.
- Reporting requirements to NHT, MSBKew and Bankwest Landscope Visa Conservation Card Trust Fund. Articles for publications to be written.

Conservation management of the Quokka, *Setonix brachyurus*, within the northern Jarrah forest Western Australia

SPP #93/54

Team Leader: Paul de Tores

Aims

- Estimate population size at representative sites within the northern Jarrah forest.
- Determine habitat requirements of the Quokka within the northern Jarrah forest.
- Provide advice to managers for effective conservation of the Quokka within the northern Jarrah forest.

Summary of progress

- Completed all fieldwork, commenced write-up of papers.
- Co-supervised honours student (Erika Alacs) on Quokka genetics.
- Submitted paper on identifying Quokka presence from DNA extracted from scats.
- Submitted paper on population structure within the northern Jarrah forest.
- Initial data analyses from demographic work (Matt Hayward's PhD) indicated northern Jarrah forest populations are the terminal remnants of a collapsing metapopulation.

Future directions

- Maintain custodianship of Quokka distributional database and, in collaboration with IMB, enable access by operational staff.
- Complete additional papers and provide managers with specific directions for better conservation management of the Quokka over its range.
- Identify priorities for Quokka management and research and seek active role in adaptive management approach.

Translocation of the Western ringtail possum, *Pseudocheirus occidentalis*

SPP #93/142

Team Leader: Paul de Tores

Aims

Determine whether translocation is an effective and/or appropriate management strategy for the Western ringtail possum.

Summary of progress

- Completed field work (December 2002) from funds available for existing work.
- Had demonstrated translocation success at Leschenault, however, changes to baiting regime and failure of operational staff to bait are possible causes for the recently detected collapse of the translocated population. Other possible causes for the collapse are competition with Brushtail possums, increased predation by cats, foxes or pythons, prey switching (rabbit numbers have been significantly reduced and may no longer be as prevalent in the diet of introduced and native predators), effects from drought, presence of disease (toxoplasmosis has been confirmed in the ringtail population at Yalgorup) or unsuitable habitat.
- Yalgorup translocation has met the following criteria for success – has demonstrated survivorship of released animals, breeding success of released animals, survival of young to sexual maturity and subsequent breeding success.
- Completely revamped, updated and restructured the distribution database and all records are attributed and validated. Database now conforms to database normalization principles. The process of revamping and restructuring has resulted in a manuscript on Western ringtail possum distribution, a review of the conservation status and management (manuscript completed and to be circulated for internal review).

Future directions

- Maintain custodianship of Western ringtail possum distributional database and, in collaboration with IMB, enable access by operational staff.
- Subject to funding and support of the Western ringtail possum recover team investigate the causes of the collapse of the Leschenault Peninsula population and continue monitoring to assess longer term fate of the Yalgorup translocation.
- Seek resolution to the conflict between conservation management and visitor use.
- Establish student run project(s) (PhD level) to assess the relative importance of changes to baiting regimes, competition with brushtail possums, predation by cats, foxes or pythons, prey switching and habitat variables.

Operation Foxglove: Large scale fox control in the northern Jarrah forest of southwest Western Australia – native fauna response to 1080 baiting over large areas

SPP #93/157

Team Leader: Paul de Tores

Aims

The major research objectives are:

- to determine efficient and cost effective 1080 baiting regimes for fox control over large tracts of conservation estate and multiple use forest;
- to determine the level of fox density reduction required to allow native fauna populations to increase and be sustained; and
- to determine whether fox predation is a major limiting factor to native fauna abundance.

Summary of progress

Findings from Foxglove have been:

- Conveyed in person to Nature Conservation Division's Senior Environmental Officer.
- Presented at least 3 times prior to June 2002 (as part of the CAFE committee reporting process) to the former Regional Manager and/or former acting Regional Manager for Swan Region. The Swan Region Nature Conservation Program Leader was also present at one of these presentations.

The results have also been presented at a workshop (Perup, May 2001) where regional managers from all the forest regions were present.

Future directions

- Rework Woylie survivorship analysis using program MARK.
- Complete analysis of trapping data (Item Response Theory).
- Finalize recommendations to managers.
- Complete the following manuscripts (some already in draft):
- Large Scale fox control in the northern Jarrah forest of southwest Western Australia. 1. Survivorship of translocated populations of the Woylie, *Bettongia penicillata*, and implications for operational 1080 baiting programs.
- Large Scale fox control in the northern Jarrah forest of southwest Western Australia. 2. Native fauna response to different levels of fox density reduction.
- Use and validation of sandplotting to derive an index to fox density.
- The use of satellite telemetry to monitor movements of the Red fox, *Vulpes vulpes*. A pilot study.
- Survivorship and habitat use of the Common brushtail possum, *Trichosurus vulpecula*, in 1080 baited and unbaited sites in the northern Jarrah forest of south west Western Australia.
- Use of den trees by the Common brushtail possum, *Trichosurus vulpecula*, in the northern Jarrah forest of south west Western Australia

Factors affecting establishment in the Numbat re-introduction program

SPP #93/145

Team Leader: Tony Friend

Aims

Re-introduction to areas under fox control comprises the major strategy of the Numbat Recovery Plan. Success of establishment varies between sites. This project aims to identify the causes of this variation:

1. To measure the success of establishment of numbat populations through re-introduction.
2. To attribute mortality to specific causes.
3. If population growth is zero or negative, remove one of the factors causing mortality. Assess the effect of removing the cause of mortality on the growth of the population.

Summary of progress

Stirling Range NP 2001 release.

- 14 captive-bred Numbats were released in the Stirling Range NP in December 2001. Seven were "predator-trained" with respect to raptors and 7 were untrained. Five months later 6 in each group were relocated. Three in the trained group were alive but only one in the untrained group was still alive. This supports last year's findings when at the corresponding time 5 of 7 trained animals were still alive compared with only one of 5 untrained animals. Raptor predation was the predominant cause of death amongst both groups.
- Breeding and survival of young at Stirling Range indicate that this population is well on the way to establishment.

Diggings surveys at Karroun Hill NR

- Diggings surveys were carried out at Karroun Hill NR in October 2001 and January 2002. Although widespread 1-2 yr old signs were found, no fresh diggings were found and it seems that the population has crashed there recently. The monitoring program is well beyond the radio-tracking phase so there has been no way of determining the cause of the crash. Western Shield management has decided to terminate the baiting program, in place since 1988, on the basis of these surveys.

Driven surveys at Dryandra, Boyagin and Tutanning

- Driven surveys were carried out in November 2001 and April 2002 at Dryandra, in November 2001 at Boyagin and in March 2002 at Tutanning. At Boyagin, numbers are up in the west block and down in the east block compared with 2000. At Dryandra, there were slightly fewer sightings in November 2001 than in November 2000, and slightly fewer in April 2002 than in April 2001. The overall trend at Dryandra is a decrease in numbers. An intensive investigation into population dynamics at Dryandra is proposed for commencement in 2002, with the endorsement of the recovery team.

Diggings survey at Batalling

- A diggings survey was carried out at Batalling in March 2002 over tracks surveyed in 1997 and 2000. Fresh Numbat signs were found in 5 locations in the survey area, indicating the persistence of a Numbat population there. No Numbats have been released at Batalling since 1995.

Milestones

- Review paper on Numbat translocations completed and submitted for internal review.
- Landscope article on Numbat recovery published.
- Dryandra Woodland Ecology Course, an avenue for public education on the Numbat, held in November 2001.

Future directions

- Release of ~16 zoo-bred Numbats at Stirling Range NP.
- Continue monitoring radio-collared animals at SRNP.
- Continue monitoring by carrying out driven surveys at Dryandra (November and April) and Boyagin (October).
- Continue monitoring by carrying out diggings surveys at Hills Forest, Karroun Hill and Dragon Rocks.
- Intensive monitoring of adults and young at Dryandra to assist understanding of population dynamics: radio-collar at least 5 litters in October 2002 and subsequently follow their progress and fate, to enable construction of a population model using program MARK.
- Revise Dryandra Woodland Ecology Course in conjunction with Narrogin District personnel.

An assessment of the effect of fox control on Red-tailed phascogale populations

SPP #93/149

Team Leader: Tony Friend

Aims

- The Red-tailed phascogale *Phascogale calura* occurred patchily across much of arid and semi-arid Australia, but is now restricted to the southern half of the wheatbelt, where most of its populations occur in small remnants of native vegetation.
- The aim of the project is to assess the effect of fox control on populations of the Red-tailed phascogale. This will be achieved by monitoring population numbers on 9 reserves, including unbaited, long-baited and newly baited sites and comparing rates of change of populations under the 3 baiting regimes.

Summary of progress

- In May 2001, trapping was carried out at 3 of the 9 reserves monitored under the Feral Pests Program grant (1993-1996). Results were not consistent with the short-term conclusions of the original study, which predict that RTP numbers will be lower on unbaited reserves.
- It is proposed to run a round of trapping on each reserve in April 2003, to provided a census 9 yrs after baiting commenced. Narrogin District will cease baiting on 2 of the baited reserves, so this will be the last opportunity to carry out this census.

Future directions

- Three-day trapping session for Red-tailed phascogales will be carried out on each of 9 reserves (2 unbaited) in Narrogin and Katanning Districts.

Genetics and ecology of the Western barred bandicoot

SPP #93/163

Team Leader: Tony Friend

Aims

The Western barred bandicoot *Perameles bougainville* is an endangered species that survived only on Bernier and Dorre Island, Shark Bay. The objective of this project is to collect background information relevant to the recovery of the species through re-introduction to the mainland.

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

Summary of progress

- Two disease conditions have been found in captive and wild populations of the Western barred bandicoot. One or both conditions have serious implications for translocation plans for this and other species.
- A workshop will be convened in July 2002 to produce a strategy for management of the disease conditions and the translocation program.

Future directions

- Workshop to be held.

Dibbler recovery plan

SPP #95/11

Team Leader: Tony Friend

Aims

- To ascertain the distribution and conservation status of the Dibbler in Western Australia.
- Through the use of BIOCLIM and GIS use existing information in a predictive manner to locate new populations and examine other habitats.
- To examine the species population dynamics and habitat relationships (initially on the known island populations) through regular monitoring using traps and radio-tracking.
- To document the species ecology in relation to potential threats, particularly fire and plant pathogens.
- To assemble this information and prepare a draft recovery plan for *P. apicalis*, and prepare scientific publications detailing the conservation status and ecology of the species.

Summary of progress

- Re-introduction to Peniup carried out on October 2001. 41 Dibblers released, of which 23 were radio-collared. There was high mortality amongst the collared Dibblers and some indication that the collars were detrimental to some of the Dibblers, particularly the smaller individuals. Monitoring by trapping has shown that a small colony has become established. The latest monitoring trip, in May 2002, resulted in the capture of one female Dibbler with 8 pouch young. The population is just hanging on. The condition of the animals indicates that the habitat near the release site is suitable. Smaller radio-collars will be used in the proposed release in October 2002 and fewer animals will be collared.
- Survey at Torndirrup NP by trapping commenced. Dibblers were found here in 1987 but have not been recorded since. Fox control ceased in TNP in 2001 and there is an urgent need to complete the survey to establish whether Dibblers persist here. No captures yet and a block containing the oldest vegetation in the Park was burnt in early 2002. As Dibblers have very distinctive hairs in cross-section, hair-tubing methods for Dibblers are being developed for use in 2002 here and in surveys at Cape Arid and other sites.
- The results of round-the-clock radio-tracking of Dibblers at Fitzgerald River NP in 1999 and 2001 have been analysed. Dibblers are crepuscular in activity and their morning activity period extends until 7.30 am in summer. Traps are now checked later in the morning so that dibblers cannot spend more than 18 hours in a trap.
- Population monitoring in FRNP shows low numbers at present as in other small mammal populations currently.
- Support provided to the following activities:
- Dibbler monitoring trips to Boullanger and Whitlock Islands,
- Monitoring trips to Escape Island to monitor introduced Dibbler population
- Research on Dibbler biology in captivity and Jurien Bay Islands
- Draft Recovery Plan produced in June 2002. Submission for adoption by the Commonwealth scheduled for end September 2002.

Future directions

- Continue to support student projects on Boullanger and Whitlock Islands. UWA students will take over monitoring Escape Island once a year.
- Second release of Dibblers at Peniup NR. Monitoring of radio-collared animals, followed by trapping monitoring every 3 months.
- Develop hair-tubing methods at Fitzgerald River NP.
- Complete survey for Dibblers at Torndirrup NP by trapping and hair-tubing.
- Commence survey at Cape Arid NP by hair-tubing following up successful recoveries with trapping.
- Opportunistic survey using hair-tubing to follow up sighting reports from the public.

Gilbert's potoroo recovery plan

SPP #96/08

Team Leader: Tony Friend

Aims

- Gilbert's potoroo is Australia's rarest mammal, known to exist only as a single population of less than 40 individuals, at Two Peoples Bay near Albany.
- This project aims to achieve the research requirements of the Gilbert's potoroo recovery plan, including investigations of:
- Population dynamics
- Reproductive biology
- Ecology, including habitat usage, social organization, predation and diet
- Captive management, including artificial diet, breeding management and assisted breeding
- Occurrence of further populations
- Disease occurrence in wild and captive populations.

Summary of progress

Breeding colony:

- A female born in February 2001 was the last young produced in captivity. Current captive population is 7 animals. New developments in captive management have been 1) the development of sources of truffles to feed to the captive animals in supplementation of the artificial diet, 2) the reduction in the amount of oxalate-rich sweet potato by replacement with cereal-based food.

Truffle analysis:

- The captive diet developed in 1994/5 when animals were first taken into captivity was based on diets fed to Long-nosed potoroos modified by palatability. As GPs are highly fungivorous and eat virtually only hypogeal fungi (truffles), collection of several species of these fungi is under way, for nutrient analysis to assist in designing a more appropriate artificial diet. A large quantity (about 50 g dry weight of each species) is required in order to carry out assays for basic components and some important vitamins and other nutrients. Sufficient of 3 species has been collected so far, and enough of 2 others to carry out basic analyses.

Support research into artificial insemination

- The GP Recovery Team agreed that a pair of GPs should be transferred to Perth Zoo so that the feasibility of artificial insemination in this species could be assessed. A male and a female were transferred from the captive colony at TPB in November 2001. Oestrus monitoring showed that the female was cycling and that the male was producing sperm, albeit in low quantity. Before electro-ejaculation trials could be carried out, however, the male died, in May 2002. The Recovery Team will decide on the next step.

Support research into cross-fostering

- In 2000, a SPIRT grant application by Dr Dave Taggart of Adelaide University and Adelaide Zoo in collaboration with DCLM for a 3 yr project to assess cross-fostering in potoroos for possible application to GP was successful. Since then Dr Taggart and his team have been transferring small pouch young between Long-nosed potoroos, Boodies and Woylies to assess which would be the best foster species to receive young from other potoroids. So far their best success has been with the Long-nosed potoroo. This work continues.

Monitoring in TPBNR

- Regular monitoring of the wild GP population at TPBNR is carried out by trapping on established traplines every 4 mths. Currently 7 areas are monitored and the number known to be alive at the last 2 sessions is 13 potoroos. This is probably over half of the wild population. Of these 13 animals, 7 are females and one may not be reproductive. One aim of monitoring is to work out the rate of production of young in order to assess the effect of removing young to cross-fostering.

Radio-tracking

- In February 2002, 6 GPs in Firebreak Valley, the prime GP site, were fitted with tail transmitters and radio-tracked for 2 weeks from fixed stations by project staff assisted by 24 volunteers. This is the third year this exercise has been carried out. Preliminary results of this study have shown that GP meta-populations are stable, in numbers, individuals and in spatial organization. The size and arrangement of the home ranges in the valley over 3 yrs shows that the maximum population of the site is about 8 individuals.

Survey in TPBNR

- Survey by trapping within TPBNR during 2001/2002 has resulted in the discovery of another GP site in the next valley to Firebreak Valley. Since that discovery, the colony of 3 animals that resided there has gone and those individuals have not been relocated.

Survey outside TPBNR

- Two surveys were carried out outside TPBNR, in the Green Range and near Cheyne Beach, prior to April 2002. No evidence of potoroos was found. Additional Projects funding has allowed the employment of Jen Trouchet for 4 months to carry out a thorough search of the area between Gull Rock NP and Cheyne Beach using the hair arch method. Hair identification is being carried out by Barbara Triggs but no determinations have yet been returned.

Cat survey

- In November 2001 a cat was trapped in a remote part of TPBNR. Faecal and gut contents included remains of Quenda and Noisy scrub-bird.
- Dr Dave Algar carried out a cat survey of TPBNR in April 2002. Bad weather hampered this work but signs of cat presence were detected. Dave will be producing a report.
- It is likely that cat trapping will become part of the regular management of TPBNR.

Future directions

- Rewrite GP recovery plan, with Dr Jackie Courtenay
- Complete truffle analysis

- Redesign captive diet
- Monitoring in TPBNR; targeted trapping to determine young production/mortality
- Radio-tracking in 2003, with particular emphasis on young-at-heel, to determine survivorship in that age-group
- Survey in TPBNR: hair-arch survey of Bishops Gully area
- Survey outside TPBNR: Complete survey of Green Range. Assist in DEC survey west of Albany. Check sighting reports from the public etc.
- Fox/Cat video surveillance system for trapping tracks at TPBNR
- Support research into artificial insemination
- Support research into cross-fostering.

Return to Dryandra

Team Leader: Tony Friend

Aims

To re-introduce at least 5 medium-sized mammal species, which are now extinct in the Wheatbelt, to Dryandra Woodland and to compare the success of 2 or 3 re-introduction methodologies for each species. These are 1) release of wild-caught translocated individuals, 2) release of site-bred individuals and 3) - release of intensively captive-bred stock (if available). The breeding program aims to eventually provide stock for the re-introduction to other Western Shield fauna reconstruction sites.

Summary of progress

- Populations of 5 species established within Dryandra enclosure.
- Regular monitoring of 4 species populations within the enclosure at 3-monthly intervals and extra monitoring for Mala carried out. Merrnine monitoring methods using battue developed. Viable populations of Mala, Bilbies, Marl and Boodies established. Merrnine are established and breeding but has been reduced to small numbers through predation by Wedge-tailed eagles.
- Bilbies have been reintroduced into Dryandra Woodland proper and monitoring is continuing. Food availability appears to be adequate and Bilbies have bred since release. Within the Woodland, Bilbies have been prey to Carpet pythons and large raptors (Masked owl?). Bilbies that have left the Woodland after release have been taken by foxes and feral cats.
- A proposed release of marl in 2000 was postponed pending investigations of disease conditions found in captive and island populations. This investigation is continuing.
- The Boodie and Bilby populations inside the enclosure are breeding strongly.
- Construction of Barnia Mia, a 4ha predator-proof interpretive centre completed October 2002. Trapping of suitable RTD species for release into Barnia Mia carried out.
- Report to WS committee August 2001 and July 2002.
- Western barred bandicoot disease workshop organized for July 2002.
- Draft SPP written.
- Friend, T; Anthony, C and Thomas, N (2001). Return to Dryandra: marsupials hop away from extinction. Landscope 16 (4): 10-16.

Future directions

- Undertake survey within Dryandra Woodland for surviving colonies of Bilbies. Top up release of Bilbies into Dryandra Woodland by autumn 2003, monitored using tail transmitters.
- Boodie TP to be completed and submitted by early 2003. Boodie translocation carried out into Dryandra Woodland proper in spring 2003 and radio-tracking/monitoring carried out. Top up releases of Boodies into Dryandra Woodland, if required, by spring 2004.
- Development of trapping techniques and protocols for monitoring Bilbies and Boodies outside RTD enclosure.
- During 2003, source additional Marl, Mala and Merrnine for top up release into RTD enclosure. Radio-tracking of Marl, Mala and Merrnine in enclosure to establish cause of mortality. Develop research program on the specific requirements for breeding sufficient numbers for release.
- Marl translocation carried out into Dryandra Woodland proper and radio-tracking/monitoring carried out by spring 2004. Development of trapping techniques and protocols for monitoring Marl outside RTD enclosure.
- Mala TP for Dryandra Woodland to be completed and submitted by end 2003. Mala translocation carried out into Dryandra Woodland proper and radio-tracking/monitoring carried out by spring 2004. Development of trapping techniques and protocols for monitoring Mala outside RTD enclosure. Top up release of Mala by spring 2005 if required.
- Merrnine TP for Dryandra Woodland to be completed and submitted by end 2004. Merrnine translocation carried out into Dryandra Woodland proper by spring 2005. Development of trapping techniques and protocols for monitoring merrnine outside RTD enclosure.
- During 2004 determine feasibility and carry out a trip to Dorre Island to capture Boodies and Merrnine to augment numbers in the RTD enclosure.
- Report to WSSWMC to be completed and submitted annually.

Floristic survey of the coastal communities of the Warren botanical subdistrict

SPP #93/37

Team Leader: Neil Gibson

Aims

This project will allow a detailed assessment of the conservation status of plant species and plant communities in the Warren bioregion and will also develop an understanding of some the major threatening processes affecting these areas and develop management strategies to deal with these problems.

Summary of progress

A further paper published - Gibson, N, Keighery, GJ, Lyons, MN (2001) Vascular flora of Scott National Park, Camping Reserve 12951 and Gingilup Swamps Nature Reserve, Western Australia. CALMScience 3: 411-432.

Future directions

Write up of several more papers.

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

SPP #93/38

Team Leader: Neil Gibson

Aims

This project will allow a detailed assessment of the conservation status of plant species, plant communities in remnant bushland and regional parks of the Swan Coastal Plain and will also develop an understanding of some the major threatening processes affecting these areas and develop management strategies to deal with these problems.

Summary of progress

- Tuart proceeding published June 2002. Several publications (see GJ Keighery summary) to assist management planning.

Future directions

- Write up several further papers.

Floristic survey of the Goldfields Ranges

SPP #93/166

Team Leader: Neil Gibson

Aims

This project will allow a detailed assessment of the conservation status of plant species and plant communities on a series of greenstone and banded ironstone ranges in the eastern goldfields region. It will also provide baseline data against which proposed mining actives can be assessed.

Summary of progress

Publications

Gibson, N. & Lyons, M.N. (2001) Flora and vegetation of the Eastern Goldfields Ranges: Part 4. Highclere Hills. Journal of the Royal Society of Western Australia 84:71-81.

Gibson, N. & Lyons, M.N. (2001) Flora and vegetation of the Eastern Goldfields Ranges: Part 5. Hunt Range, Yendilberin and Watt Hills. Journal of the Royal Society of Western Australia. 84:129-142.)

Future directions

- Formal write up of a further 2 ranges and synthesis paper.

Re-survey and analyses of F. Podger's dieback sites at 30 yr interval

SPP #96/09

Team Leader: Neil Gibson

Aims

This project aims at examining change in vegetation communities 30 yrs after the deliberate introduction of dieback into forest and woodland communities in the Jarrah and Swan Coastal Plain bioregions.

Summary of progress

No activity.

Future directions

- Analysis.
- Write up.

SAP – Monitoring salinity and its effects on the biota of wetlands in the agriculture zone of south-western Australia. (Wetland vegetation component)

SPP #98/18

Team Leader: Neil Gibson

Aims

This project is designed to provide ongoing monitoring of the biological resources in wetlands of the agricultural zone of south-west Western Australia. Maintenance of wetland biological diversity in the agricultural zone is one of the major objectives of the Salinity Action Plan. This project specifically monitors floristic composition and tree health in 25 wetlands across the agricultural zone to measure any changes in flora occurring in, and around the wetlands.

Summary of progress

- Run by consultancy.
- The 2001/02 monitoring completed.
- Electronic and hard copy of data and final report received.

Future directions

- Ongoing DCLM priority.
- The 2002/03 monitoring program will be undertaken by M N Lyons.

Floristic survey of the Darling Scarp

SPP #2000/07

Team Leader: Neil Gibson

Aims

This project will allow a detailed assessment of the conservation status of plant species, plant communities in remnant bushland and regional parks along the Darling Scarp and will also develop an understanding of some the major threatening processes affecting these areas and develop management strategies to deal with these problems.

Summary of progress

No activity.

Future directions

Write up.

Salinity Action Plan - Monitoring salinity and its effects on the biota of wetlands in the agricultural zone of south-western Australia (Aquatic ecosystems component)

SPP #98/18

Team Leader: Stuart Halse

Aims

In this project trends in biodiversity in wheatbelt wetlands are being compared to changes in salinity and land use in surrounding areas. Project outcomes relate directly to State Salinity Strategy.

Specific aims are:

- To monitor long-term changes in inundation and salinity patterns in wetlands in south-west Western Australia (principally the wheatbelt).
- To monitor changes in groundwater levels under wetlands and the salinity of that groundwater.
- To document changes in waterbird and aquatic invertebrate use of, and plant composition and vigour around, wetlands.
- To relate changes in biodiversity value to changes in hydrology and salinity and to changed land management practices.
- To identify environmental thresholds that trigger substantial decline in wetland biodiversity and to examine whether wetland remediation work leads to an improvement in biodiversity.

Summary of progress

- Monitored salinity, depth, pH, total N and total P at 100 wetlands in September and October, monitored groundwater at 25 wetlands in October and March, monitored waterbirds and invertebrates at 13 wetlands and vegetation condition at 8 wetlands.
- Errors in historical salinity and depth database corrected, preliminary analysis of trends at selected wetlands.
- Report on 2001/02 vegetation sampling completed and lodged in library, report prepared on waterbird and invertebrate sampling and groundwater monitoring for the period 1997/2000.
- Paper published on invertebrate monitoring methodology (Halse SA, Cale DJ, Jasinska EJ & Shiel RJ 2002 Monitoring change in aquatic invertebrate biodiversity: sample size, faunal elements and analytical methods. Aquatic Ecology 36: 395-410).

Future directions

- Continue annual monitoring (this is the major thrust of the project).
- Analyse trends in depth and salinity at wetlands with long-term records.
- Analyse trends in vegetation health 1997/2002 and prepare paper for publication in 2003/04.
- Film Postcards WA segment on wetland monitoring and salinization to publicize the project.

Weeds: Advice and liaison

SPP #97/10

Team Leader: Greg Keighery

Aims

Advice on weed issues ranging from targets for biological control, potential weeds for environmental protection, provenance of plantings and proposed rehabilitation subjects for regional parks.

Summary of progress

- *Verbesina* survey and status on the Abrolhos Islands.
- Comments for DCLM on *Pisonia* as a weed, Biological control of *Asphodelus*.
- 200+ herbarium collections of new weed records and populations.
- Blackwood Environmental Group Bridal Creeper Seminar at Bridgetown.
- Weeds of National Significance (WONS) steering group on Bridal Creeper.

- Environmental Weeds Action Network AGM lecture (Environmental Weeds Action Network) AGM Address on “Salinity and Weed Potential”. Prepared dot points for EWAN Newsletter (Environmental Weeds Action Network). EWAN Annual general meeting address (Salinity and Weeds).
- Blackwood Environment Group (Bridal Creeper Workshop; Bridal Creeper in Western Australia, distribution and effects).
- 13th Australian Weeds Conference.
- CRC for Weed Management Systems; New directions for CRC in biological control.
- ANZEEC Group for weeds of conservation concern rehabilitation plans.

Publications

- Keighery, G. and Sercombe, N. (2001). *Verbesina encelioides* (golden crown beard) on the Abrolhos Islands. Department of Conservation and Land Management, Western Australia, report to Abrolhos Management Group.
- Keighery, B. and Keighery, G. (2001). Biology and weed risk of *Euphorbia terracina* in Western Australia. In *Euphorbia terracina* (Geraldton Carnation Weed or Spurge): a Guide to its Biology and Control and Associated Safety Issues: Proceedings of a Workshop Conducted by Environmental Weeds Action Network, 7 October 2000 Environmental Weeds Action Network, Perth. 4-7
- Keighery, G. and Wilson, P. (2001). New weeds: *Dietes grandiflora*. Environmental Weeds Action Network Info Notes 5(2), 9-10
- Keighery, G.J. (2002). Biology, distribution and effects of bridal creeper in Western Australia. In Conference Proceedings: Managing Bridal Creeper: a Community Workshop for the South West, May 17th 2002, Bridgetown (ed. G. Hales). Blackwood Valley Landcare Zone, Bridgetown. 1-8.
- Keighery, G.J. (2002) The Enemy Within: Native Environmental Weeds of Western Australia. Proc, 13 th Australian Weeds Conference, Eds: Spafford-Jacob, H., Dodd, J. and Moore, J.H. pp. 93-95.

Much of the weed results are within flora publications (e.g.: Tuart Communities flora, flora of Drummond Nature Reserve) and reports rather than stand alone reports as may be the case for feral animals.

Salinity Action Plan

SPP #98/20

Team Leader: Greg Keighery

Aims

- To provide an overview of biogeographic patterns in the wheatbelt in relation to salinity, and to identify areas of greatest conservation significance.

Summary of progress

- Field survey concluded.
- Data has been compiled in standard formats
- Extensive liaison with Districts where work has been undertaken: Moora, Geraldton, Narrogin, Katanning, Merredin.
- Involvement in Salinity R/D Technical Group
- Involvement in Ministerial taskforce on Engineering Solutions to Salinity
- Involvement in CRC for Plant Based Solutions to Salinity

- Involvement in Treasury Taskforce submission to Commonwealth Grants Commission
- Involvement in Salinity Management tour with Acting Executive Director, DCLM.
- Involvement in selection of new recovery catchments

Publications

- Keighery, G.J., Keighery, B.J., Gibson, N. and Gunness, A. (2001). Vegetation and Flora of "Quairading Nature Reserve", Shire of Quairading. Western Australian Wildflower Society, Nedlands.
- Keighery, G.J. (2001). State Salinity Strategy: DCLM Biological survey of the agricultural zone. In Salinity Seminar: Presented by the Midwest Oil Mallee Association, 21st August, 2001, Morawa Shire Hall Midwest Oil Mallee Association, Morawa. 1-10.
- Keighery, G. and Lyons, M. (2001). Existing and potential natural diversity recovery catchments indicative list. Department of Conservation and Land Management, Western Australia, 1-4.
- Keighery, G., Halse, S. and McKenzie, N. (2001). Why wheatbelt valleys are valuable and vulnerable: the ecology of wheatbelt valleys and threats to their survival. In Conference Papers: Dealing With Salinity in Wheatbelt Valleys: Processes, Prospects and Practical Options, Merredin, 30 July-1 August 2001 State Salinity Council, Perth. 55-65.
- Keighery, G.J. (2002). Taxonomic notes on the genus *Stenopetalum* (Brassicaceae). Nuytsia 14, 393-403. Why wheatbelt valleys are valuable and vulnerable: the ecology of wheatbelt valleys and threats to their survival. In Conference Papers: Dealing With Salinity in Wheatbelt Valleys: Processes, Prospects and Practical Options, Merredin, 30 July-1 August 2001.
- DCLM biological survey of the agricultural zone. Salinity Seminar: Presented by the Midwest Oil Mallee Association, 21st August, 2001, Morawa Shire Hall Midwest Oil Mallee Association.

Future directions

- Write up all components of SAP biological survey
- Complete write up of SAP biological survey
- Prepare for publication of SAP biological survey
- Productive Use and Rehabilitation of Saline Lands (PURSL) Conference
- Biodiversity in Salinizing Landscapes International Conference
- Monocotyledons Conference

Monitoring of Carnac & Penguin Island Silver gull populations

SPP #99/12

Team Leader: Jim Lane

Aims

In April 1993, the Department of Conservation & Land Management published, following consultation with local government authorities and researchers at Murdoch University, an Action Plan for Silver gulls in the greater Perth metropolitan area. A principal aim of the plan is to reduce metropolitan area gull numbers by reducing their access to artificial food sources such as poorly managed rubbish disposal sites, lidless rubbish bins, littering and hand feeding of gulls. Following adoption of the plan, a monitoring program was initiated to detect changes in numbers of breeding pairs on Carnac and Penguin Islands, 2 main nesting sites of gulls in the metropolitan area. The aim of the monitoring program is to provide data that will assist in determining the effectiveness of gull number reduction measures.

Monitoring began in 1994. Carnac and Penguin Islands are photographed (35 mm diapositive film; overlapping oblique photos) by one or 2 photographers (usually J. Lane and Senior Wildlife Officer Doug Coughran) from a light aircraft with door removed at low level on or about 18 May each year, between 0815 and 0900 hrs. The developed photographs are subsequently projected onto paper and the gulls marked and counted. The time of year and day for the aerial census was selected on the basis of advice that breeding was usually at or near a peak at this time of the year and gull numbers were usually most "stable" (one adult per nest) at or near this time of day.

Summary of progress

Aerial photographic monitoring was undertaken in May 2002.

Future directions

- During 2002-03, gulls will be counted from aerial photographs take in 2000, 2001 and 2002, and trends since 1994 will be analysed.
- A report on the results of this work will be prepared in 2002-03.

Directory of important wetlands in Australia

SPP #99/14

Team Leader: Jim Lane

Aims

The first edition of A Directory of Important Wetlands in Australia (ANPWS 1993) was prepared by the CONCOM Wetlands Working Group, published by the Australian Nature Conservation Agency and released to coincide with the 1993 Conference of Contracting Parties to the "Ramsar" Convention on Wetlands. The WA Chapter to the first edition was prepared by Roger Jaensch and Jim Lane. This chapter included detailed descriptions of 88 Western Australian wetlands and wetland systems. Second (ANCA 1996) and third (EA 2001) editions have since been published, incorporating additional wetlands and updated information. There are 120 nationally important Western Australian wetlands and wetland systems in the third edition. Detailed descriptions are each are available at the Environment Australia website. Updating of the Directory database is an ongoing project.

The current aim of this project is to prepare further editions of the WA Chapter of A Directory of Important Wetlands in Australia, incorporating additional wetlands and updated information. Work for the 4th Edition will focus on identifying and gathering information on candidate wetlands in those regions (IBRA) either not represented or clearly under-represented in previous editions. The project is funded by the Commonwealth Government.

Summary of progress

- During 2001/2002 a field survey of an outstanding candidate site in the Nullarbor, an IBRA bioregion currently unrepresented in the Directory, was undertaken.
- Waterbird populations were surveyed and water depths were measured and samples taken for analysis.
- Macroinvertebrate communities were also sampled.

Future directions

- The outstanding Nullarbor site will be revisited during 2002/03 to collect additional data. Further trips will be made until the lake dries. This lake fills (to a depth of more than 20 metres) only after exceptional rains such as occurred in 1995 and can take a decade or so to dry out.
- Information will be collected on other candidate sites, and existing sites, for the 4th edition of the Directory.

Monitoring of impacts of Dawesville Channel on waterbird usage

SPP #99/16

Team Leader: Jim Lane

Aims

- Surveys in the 1970s and 1980s showed that Peel-Harvey Estuary supported larger numbers of waterbirds than any other estuary in south-west Western Australia. On this basis, the estuary was listed in 1990, together with Lakes McLarty and Mealup and the Yalgorup Lakes, as a Wetland of International Importance under the Ramsar Convention.
- Opening of the Dawesville Channel in April 1994 had the potential to impact on waterbirds and other values of Peel-Harvey. Following decisions by Government, a number of monitoring programs were initiated. The aim of the waterbird monitoring program is to assess waterbird use of the estuary following completion of the Channel and to recommend any impact mitigation measures that might be needed.
- Surveys of waterbird use (all species) were conducted in October, December and February of 1996-97 and 1998-99. Aerial censuses of Black Swan and Australian Pelican numbers and distribution were undertaken over a more extended period. Pelican breeding activity and success were also monitored. Salinity profiling of the lower Harvey River and southern Harvey Estuary were also undertaken. This field work has been concluded. Data analysis and report preparation are now well advanced.

Summary of progress

- Report prepared on results of 1996-97 surveys of waterbird use of Peel-Harvey Estuary.
- Report prepared on 1998-99 Peel-Harvey waterbird survey results.
- Draft report prepared on 1976-77 and earlier waterbird survey results.

Future directions

- A report will be prepared during 2003 comparing results of pre-Dawesville Channel (1970s) and post-Dawesville Channel (1996-97 & 1998-99) surveys of waterbird use of Peel-Harvey Estuary.
- A report will be prepared during 2003 on changes in Black Swan numbers and distribution on Peel-Harvey from the 1970s to the 1990s, relating these to changes in macrophyte abundance and distribution and other factors, including those external to Peel-Harvey.
- A report will also be prepared on Pelican breeding activity and success and changes in numbers and distribution on Peel-Harvey from the 1970s to the 1990s, relating these to various factors operating in Peel-Harvey and externally.
- A report will be prepared on changes in the salinity profile of the lower Harvey River and southern Harvey Estuary following opening of the Dawesville Channel, and implications for wildlife values.

Assessment of impacts of management actions on nature conservation values of the Vasse-Wonnerup Ramsar wetlands

SPP #99/17

Team Leader: Jim Lane

Aims

Surveys in the mid 1980s showed that Vasse-Wonnerup supported more than 30 000 waterbirds each year. On this basis, the site was listed in June 1990 as a “Ramsar” Wetland Of International Importance. Prior to 1988 Vasse-Wonnerup was predominantly fresh-brackish, due to installation of floodgates in 1908 to prevent entry of seawater. From 1988 to 1997, increasing volumes of seawater were allowed into Vasse estuary during summer-autumn in attempts to prevent sudden, mass fish deaths. The high levels of saline water retained caused death of fringing vegetation, damage to pastures and unknown impacts on use of the estuary by waterbirds. A technical working group established to investigate these issues recommended (Lane *et al* 1997) that a monitoring program be established to properly assess recent changes and future trends in health of fringing plant communities, and that surveys be conducted to assess current use of Vasse estuary by waterbirds. The TWG also recommended strategic openings of the entrance sand bar and floodgates, monitoring of water quality and fish behaviour, and several other measures aimed at reducing mortalities.

Since 1987, a monitoring program to record trends in health of plant communities fringing the Vasse estuary, and groundwater levels and salinities beneath plant communities, has been initiated. Waterbird surveys have been conducted each between 1998 and 2001. Estuary and Inlet water levels; fish behaviour; the state of the sand bar, and flow directions and rates at the floodgates and Inlet mouth have been recorded from late December to mid April each year. These data have been used to guide strategic openings of the sand bar and floodgates.

Summary of progress

- 2001/02 monitoring successfully completed.
- Strategic openings of sand bar and floodgates conducted.
- No mass fish deaths in Vasse Estuary, Wonnerup Estuary or Wonnerup Inlet.
- Vasse Estuary and Wonnerup estuary target water levels achieved.
- Incorporation of remote operation, remote monitoring and fish release technologies into designs for proposed Vasse and Wonnerup replacement floodgates.

Future directions

- Continuation of vegetation, waterbirds, water levels, salinities and fish monitoring programs.
- Ongoing scientific input into the management of the Vasse-Wonnerup Ramsar Site.
- Preparation of reports presenting results of monitoring programs.
- Scientific input during preparation of the proposed Vasse-Wonnerup management plan.

Probait trials Phase II

SPP #00/14

Team Leader: Nicky Marlow

Aims

DCLM is developing a new fox bait, ‘Probait’. The field efficacy, non-target risk and longevity of these baits need to be determined before the baits can be used operationally. The aims of the project are:

1. To determine that ‘Probaits’ are as efficacious in poisoning foxes as the currently used dried meat bait.
2. To determine that ‘Probaits’ are no more of a hazard to non-target species than the currently used dried meat bait
3. To determine that ‘Probaits’ remains as toxic to foxes for the same duration as the currently used dried meat baits under field conditions.

Summary of progress

- The ingestion of Probaits by captive non-target species has been investigated and a manuscript 'The acceptability of 3 types of predator baits to non-target fauna' by G. R. Martin, L. E. Twigg, N. J. Marlow, W. E. Kirkpatrick, D.R. King, and G. Gaikhorst' has been accepted for publication by Wildlife Research.
- A report was written for the National Registration Authority and accompanied the application for registration of Probaits.
- Initial field trials revealed that in their current form Probaits are 11% less likely to be ingested by foxes than the currently used dried meat bait. Changes to the formulation of Probaits have been proposed so that a harder bait which has an insect repellent included has been designed.

Future directions

- The reformulated Probaits are to be tested for their field longevity at 3 sites. At the conclusion of these trials a determination will be made as to whether these baits last as long in the field and therefore are available to foxes for as long as dried meat baits. If so trails investigating the relative uptake of Probaits and dried meat baits by foxes will be repeated. In these trials 2 areas will be baited with both bait types each of which is labelled with a different biomarker. Foxes in both areas will be recovered using cyanide baiting and the relative proportion that has ingested each bait type will be quantified. This will reveal whether Probaits will be as effective as dried meat baits in controlling foxes. The relative merits of undertaking a baiting trial to determine the effectiveness of Probaits in protecting vulnerable fauna will need to be considered.

Assessing the distribution and status of the Wambenger

Team Leader: Nicky Marlow

Aims

Recent genetic work has indicated that the Brush-tailed phascogale in WA is a new species and is therefore endemic. There is some anecdotal evidence that *Phascogale* populations have declined as a result of fox baiting and possibly logging. This study will investigate the distribution and density of Wambengers especially in relation to these threats. The IUCN status of this species may be reclassified based on the results of this investigation.

Future directions

- The past and current distributions of Brush-tailed phascogales in south-west Western Australia are being compiled. These will be analysed using GIS techniques and will be compared to areas which are logged and/ or baited. The impact of baiting and/ or logging (if any) on the status of the Brush-tailed phascogale will be determined.
- If serious threats to *Phascogale* populations are identified preliminary field work will be undertaken (i.e. setting up of nest boxes which require several months of 'settling in' before they are used by phascogales) so that comprehensive field trials investigating the status of the Wambenger can be undertaken in 2003-2004.

WATTLE: an electronic information system for Australian species of *Acacia*

SPP #99/05

Team Leader: Bruce Maslin

Aims

The aim of this project is to produce an electronic key to the identification of Australian species of *Acacia* and for each taxon to deliver a distribution map and line drawing, photographs and descriptive information. By quickly and efficiently providing accurate names for *Acacia* species, and then delivering information concerning them, the WATTLE database is a useful tool for a wide range of users who are involved in the study, management and conservation of this large group of plants. The project will proceed in 2 phases: Phase 1 is the production of the key to species and provision of essentially the same information that appeared in the Flora of Australia (*Acacia*) volumes; phase 2 will refine the key (by adding more taxa) and deliver a richer cluster of textual information (relating primarily to biology, ecology and utilization) and photographs of the species.

Summary of progress

The WATTLE CD has been published (2001) and formed part of a entry in the 2002 Eureka Prize (Biodiversity Research category: achieved finalist status but not first prize). Two papers concerning retypification of *Acacia* submitted for publication (desired outcome: retention of the generic name *Acacia* for the Australian Wattles).

Future directions

Because I have not been able to secure dedicated funding for WATTLE phase 2 this project will be progressed as an adjunct to other research activities (e.g. the Pilbara project for which an SPP is yet to be prepared). If retypification proposal is unsuccessful then adopt an alternative strategy for a new generic name (other than Racosperma) for the Australian Acacias.

Wattles of the Dalwallinu Shire

SPP #00/13

Team Leader: Bruce Maslin

Aims

The aim of this project is to research and promote the *Acacia* flora of the Dalwallinu Shire through (1) publication of a book (field guide) and scientific papers on the Wattles of the region, (2) conducting an *Acacia* Symposium in Dalwallinu, (3) developing an *Acacia* website (called WorldWideWattle) for the dissemination of information on Australian Acacias and (4) participating in the creation of an Environmental Interpretive Centre in Dalwallinu.

Summary of progress

- Field guide: Much of the base information has been gathered but some field studies still needed; scientific paper describing new species drafted.
- *Acacia* Symposium: Symposium The Conservation and Utilization Potential of Australian Dryland Acacias conducted (July 2001); proceedings currently being edited for publication in Conservation Science Western Australia (I am author/co-author on 3 of the papers).
- World Wide Wattle: Planning meetings involving primary stakeholders undertaken (involving DCLM, Dalwallinu Shire and CSIRO Forestry and Forest Products); domain name purchased; a preliminary outline of the site has been constructed (http://www.worldwidewattle.com).
- Dalwallinu Environmental Interpretive Centre: attended planning meetings hosted by the Shire.

Future directions

- Complete field guide 'Wattles of the Dalwallinu Shire' and assist the Dalwallinu Tourism Group to acquire funds for publication.
- Continue development of the World Wide Wattle web site.
- Assist in the development of the Dalwallinu Environmental Interpretive Centre.

Acacia biology, conservation and utilization

Team Leader: Bruce Maslin

Aims

A multi-faceted project that aims to provide a sound systematic basis for effective conservation and utilization of Acacia. Taxa currently targeted include *A. microbotrya* and *A. saligna*, both of which have relevance to nature conservation and have potential for use in farm forestry. An assessment of the agroforestry potential of the southern Australian *Acacia* flora (for use in wide-scale commercial plantings for land amelioration projects, especially salinity control) is also being undertaken. A comprehensive re-assessment of conservation status of the Western Australian *Acacia* flora is planned to commence in 2003.

Summary of progress

- *Acacia microbotrya*: field study and morphometric analyses completed; 4 taxa provisionally recognized.
- *Acacia saligna*: field study to collect material for genetic and fodder analysis undertaken; indications are that the species comprises 4 distinct variants.
- Agroforesty potential of *Acacia*: informal report on W.A. species submitted to Farm Forestry Unit; report (intended for publication) on southern Australian species in progress.

Future directions

- *Acacia microbotrya*: taxonomic findings to be correlated with genetic results and scientific publication plus report (to FCP) prepared; it is not expected that this sub-project will continue beyond June 2003.
- *Acacia saligna*: detailed analysis of herbarium collections to be undertaken followed by field study next Spring (2003); taxonomic revision to follow.
- Agroforesty potential of *Acacia*: progress report on assessment of southern Australian species to publication; it is not expected that this sub-project will continue beyond June 2003.
- Conservation status of W.A. *Acacia* flora: the design and scope of this sub-project will be undertaken early in 2003; it is expected that the sub-project will commence with a review of herbarium collection records.

Eastern Goldfields and Goongarrie survey

SPP #93/25

Team Leader: Norm McKenzie

Aims

Continue vertebrate database.

Summary of progress

- No vertebrate databasing.
- The plant databasing completed.

Rainforest Monitoring (Tropical Savannas CRC)

SPP #93/26

Team Leader: Norm McKenzie

Aims

- Oscar-Napier: Sort and identify land snails. Tim Willing to supply plant identification and do birds at one quadrat.
- Do Nimbing analysis.

Summary of progress

- All limestone reef soil data compiled.
- Nimbing data compiled for analysis.
- 1 Napier Range bird quadrat to do.

Ecomorphology and community structure and Lyssavirus

SPP #93/28

Team Leader: Norm McKenzie

Aims

Re-focus work to East Kimberley and Pilbara.

Summary of progress

- Coolgardie bat paper published.
- *Nyctophilus* ultrasound paper accepted.
- Bat wing-beat paper accepted
- Bat lyssavirus found in Kimberley, Pilbara and Goldfields.

Salinity Action Plan (Terrestrial zoological component)

SPP #98/20

Team Leader: Norm McKenzie

Summary of progress

- Collaborated with AH Burbidge to complete specimen identifications and data entry.
- Carried out preliminary analyses on vertebrate data.
- Removed some drift fences and carried out patch-up sampling.
- Commenced drafting of paper on vertebrate data set.

Future directions

- Presented paper with AH Burbidge and J Rolfe at 'Biodiversity and Salinity' conference in Albany, October 2002.
- Complete MS on vertebrate biogeographic patterns in relation to salinity.

Biodiversity Audit

Team Leader: Norm McKenzie

Aims

- NLWRA website pages
- Second pass on subregional database
- Transfer results into regional operations
- Commission sub-fossil work to fill in gaps
- Write mammal status paper

Summary of progress

- All 5 components completed over period of 9 months.
- Case studies
- Case Study summaries and pie charts
- Sub-regional Synopses
- Regional summaries
- Mammal audit

National Reserve System & IBRA development

Team Leader: Norm McKenzie

Aims

Incorporate comments and produce final report

Summary of progress

Report on NRS selection criteria completed by working group and sent via Ministerial Council for public comment.

Pilbara survey

Team Leader: Norm McKenzie

Aims

- Select terrestrial quadrats
- Liaise with collaborators and industry

- Seek external funds
- S Halse to complete year one of stygofauna component

Summary of progress

- Prepared logistic plans.
- Milestones and costings.
- Made presentations to potential funding sources.

Experimental translocation of critically endangered plants

SPP #01/04

Team Leader: Leonie Monks

Aims

The project involves the monitoring and collection of translocation technique information and demographic data from 16 experimental translocations of critically endangered flora established over the past 4 yrs. Analysis of these data will provide a comprehensive overview of translocation methodologies for threatened flora in WA and the first set of guidelines that could be used for assessing translocation success. As such the project has 3 main aims. These are:

1. Develop appropriate translocation techniques for a range of critically endangered flora.

2. Develop detailed protocols for assessing and predicting translocation success.

3. Establish a translocation database for all threatened plant translocations in Western Australia.

Summary of progress

- Set up new translocations for *Eremophila scaberula* and *E. nivea* where the experimental focus was on trialing direct seeding techniques.
- New translocations were set up for *Brachysema papilio*, *Darwinia* sp. Williamson and *Petrophile latericola* in winter 2001, with a follow up translocation of *Brachysema papilio* in winter 2002. The initial translocation looked at different site preparations prior to planting. The follow up translocation of *B. papilio* focused on ideal seeding age at planting.
- Further planting of *Grevillea calliantha* was undertaken at the original translocation site.
- Translocations planted in previous years were monitored. Monitoring included counting survival, measuring growth and trialing a new monitoring method. The new method involved assessing flower to fruit ratio of translocated plants compared to natural plants.
- Development of flora translocation database commenced.
- Commenced mating systems study on *Lambertia orbifolia* translocation.
- Submitted 2 papers for publication and presented a poster at the *Acacia* symposium.

Future directions

- Continued planting of experimental translocations of 16 critically endangered plant species where further plantings are deemed necessary.
- Continued monitoring of the 16 current translocations and analyses of population biology data.

- Publication of translocation methodology data and *Lambertia orbifolia* mating systems study.
- Finalize development of rare flora translocation database.
- Translocations for 3 new species developed and translocation proposals written and approved.
- Assist Corrigin LCDC with the design and implementation of translocations of 2 Critically Endangered plant species (*Daviesia cunderdin* and *Acacia volubilis*).

Monitoring of mammal populations on Barrow Island

SPP #00/12

Team Leader: Keith Morris

Aims

- To regularly monitor the native mammal populations on Barrow Island nature reserve through grid trapping and spotlighting transects.
- To routinely search for introduced mammals, particularly rats and mice.
- To provide information relevant to the management of Barrow Island for nature conservation e.g. Gorgon development.

Summary of progress

- Annual monitoring undertaken in October 2001, database updated.
- Rock wallabies included in monitoring for first time.
- Mammal populations lower than previous years.
- Record low rainfall.
- Annual report prepared, copied to ChevronTexaco, and incorporated into environment management plan.
- Recommendation to reduce speed limits on some roads implemented.
- Landscope article published.

Future directions

- Continue annual monitoring.
- Undertake more detailed analysis of grid trapping and spotlighting data.
- Ensure ongoing ChevronTexaco support for travel, vehicles and accommodation.
- Ongoing collaborations with Pilbara Region staff.

The impact of indigenous take on the conservation of marine turtles

Team Leader: Keith Morris

Aims

- To quantify the extent of traditional harvest of marine turtles in the Broome / Dampier Peninsula are of the west Kimberley.

- To use the information in modelling population trends in the north west shelf green turtle stock.

Summary of progress

- Data collection completed in October 2002.
- Final report prepared for NHT.
- Over 200 Green turtles, mainly females taken per year by the 4 communities surveyed.
- Developed data collection methods and datasheet
- Data collection commenced
- Preliminary analyses undertaken: Most turtles taken are Green females, approx 500 per year harvested by 4 communities, harvested stock include all of the NW Shelf stock
- Excel spreadsheet updated.
- Progress and Final Reports prepared for EA. Project updates in "Marine Matters" newsletter (MCB)
- NHT application successful 01/02
- Presentation to "Celebrate the Bay" – Broome June 2002

Future directions

Future Collaborations with Aboriginal communities, Kimberley Environs, Broome District staff

Population surveys, conservation status and area based wildlife management programs for rare and threatened flora

SPP #93/45

Team Leader: Sue Patrick

Aims

Develop protocols required for the conservation of threatened and poorly known flora in Western Australia by publication of area based wildlife management programs for declared rare and poorly known flora.

The project aims to:

- publish Wildlife Management Programs, providing a summary of our present knowledge of the rare, threatened and priority flora taxa for W.A. with identification information..
- undertake population survey and census required to determine the conservation status of priority flora.
- provides a preliminary assessment of the impact of processes which may affect threatened flora and suggests strategies which eliminate or minimize the threat.
- as a result of fieldwork, it will continually update the declared rare and priority flora lists by provision of rare flora report forms to Wildlife division.

Summary of progress

Publication of Plans for 2 Districts:

- Patrick, S.J. & Brown, A. (2001). Declared Rare and Poorly Known Flora in the Moora District. Wildlife Management Program No 28. Department of Conservation and Land Management
- Patrick, S.J. (July 2001). Declared Rare and Poorly Known Flora in the Geraldton District. Wildlife Management Program No 26. Department of Conservation and Land Management

- Change in Priority status recommended for 121 taxa in Moora District and 110 in Geraldton District
- Goldfields Plan- Species treatments for 181 taxa set up and commenced
- Assessment of conservation status of all priority 1 & priority 2 species in Goldfields Region commenced for completion August 2002 for Regional staff fieldwork program.

Future directions

- Continue write up of Plan, comprising accounts of 181 taxa, introductory chapters and the plan for management.
- Complete some fieldwork, funding permitting.
- Seek further funding.

Confirmation of the conservation status of rare and poorly known flora thought to be Endangered or Critically Endangered

SPP #99/20

Team Leader: Sue Patrick

Aims

The project addresses the Departmental Priority Flora list of over 1000 taxa listed in Western Australia as poorly known, but considered to be rare and likely to be threatened. Many are known from only one or 2 sites, may be represented by only a single collection in the Western Australian Herbarium and have not been sighted for the last 10 to 20 yrs. Based on current estimates, it is thought that as many as 10% are likely to be Critically Endangered.

The project aims to:

- Select c. 200 taxa from the Western Australian flora listed as poorly known but considered to be rare, which are highest priority for confirmation of their conservation status and are likely to be Critically Endangered.
- Accurately determine the conservation status of these taxa in the field, by survey and assessment of threats.
- Recommend additions to the State and ANZEC threatened flora lists and where necessary indicate possible IUCN ranking as critically endangered.
- Recommend remedial actions for taxa ranked as Critically Endangered in order to prevent extinction.
- Allocate lower priority for conservation action to those taxa assessed by the project to be under less threat than previously thought.

Summary of progress

- 4 taxa approved for DRF status
- 6 taxa written up for submission to Threatened Species Scientific Committee
- 17 taxa targeted as requiring further survey Spring 2002 before submission to TSSC
- List of c. 200 taxa drawn up as most in need of survey from Priority Flora list.
- Fieldwork undertaken to survey c. 60 taxa with an increase of c. 55 populations.
- Information resulting from fieldwork sent to Wildlife Branch and relevant Districts. i.e. 130 Rare Flora Report Forms and survey reports.

- 7 taxa put forward for addition to Priority list.
- 11 taxa recommended for downgrade on Priority List.

Future directions

- Complete reports, process specimens for field work spring 2002.
- Complete field trips spring 2002
- Complete write up of all taxa required for submission to TSSC for 2002.
- Continue field survey where required on taxa not yet fully surveyed, as funding permits.
- Final report to NHT Endangered Species Program, Feb. 2003.

Fire effect on desert vertebrates

SPP #93/92

Team Leader: David Pearson

Aims

- To study the impacts of spring "patchy" (= potential prescribed) fires and summer wildfires on the small terrestrial vertebrates of hummock grassland in the Great Victoria Desert and make recommendations for management.
- The Queen Victoria Spring study site is one of the few long-term fire monitoring sites in arid Australia (and the only one in the WA section of the Great Victoria Desert). Its purpose is to investigate the impact of spring and summer fires on terrestrial vertebrate fauna. The study commenced in 1986 and fires were applied to plots in September 1988, January 1989, October 1990 and November 1992 and pitfall trapping used to assess impacts. Vegetation cover, plant species diversity and terrestrial invertebrate populations are also monitored to assist with the explanation of the responses seen in vertebrates.

Summary of progress

Sorting of invertebrate samples has been ongoing throughout the year. Most invertebrates are being sampled to order, while others are sorted to finer categories. Andy Williams was trained in ant identification techniques at Murdoch University and is currently preparing a reference collection in conjunction with Dr Bryan Heterick.

Future directions

- Ongoing invertebrate sorting.
- A monitoring trip to the site is proposed for March 2003 and will involve the replacement of fencing (to be conducted with the Goldfields Region as a training/orientation exercise for some of their staff).
- Preparation of manuscript on the impact of fire on Dragon lizards and ningaui.

Ecology and conservation of Carpet and Woma pythons

SPP #93/159

Team Leader: David Pearson

Aims

- To determine the ecology and threats to the conservation of 2 species of threatened pythons.

- Project commenced in 1995 and featured detailed radio-telemetry work of 2 Carpet python populations on Garden Island and at Dryandra State Forest. In addition, data on morphometrics, diet and reproduction collected for these populations and those on West Wallabi, Mondrain and St Francis (S.A.) Islands.
- Over 1000 pythons captured, measured, marked and 90 of these fitted with transmitters and detailed data on home ranges, movement, diet, mating strategy and thermal behaviour collected. Research on captive breeding of Woma pythons.

Summary of progress

- Detailed radio-telemetry and mark-recapture study of Carpet pythons completed in March 2002. PhD thesis completed. Two papers published from this work, 2 accepted and 2 more in prep. Ongoing mark-recapture study of pythons to look at long term trends in growth rates and recruitment is being carried out on Garden Island in own time and at my own expense.
- Woma python radio-telemetry commenced on Peron Peninsula in 1999, but only 2 pythons have been telemetered to date. Woma pythons are very difficult to locate and fieldwork has been sporadic (typically during annual Landscope Expedition). Some searching/community liaison work in the Northern Wheatbelt was conducted in March 2002 (during translocation work for Lancelin Island Skink SPP 99/11) where the most recent sightings have occurred.

Future directions

- Ongoing mark-recapture of Carpet pythons on Garden Island (own resources and time).
- Capture of more Woma pythons at Peron and Watheroo area for radio-telemetry.
- Preparation of papers on reproduction and status/ conservation of Carpet pythons.

Experimental management and monitoring of Western Desert rock-wallaby populations

SPP #95/16

Team Leader: David Pearson

Aims

- To undertake research and management actions in association with Goldfields staff and Ngaanyatjarra people to preserve a genetically unique rock-wallaby population in the Townsend Ridges.
- Survey work for rock-wallabies in the Central Ranges of W.A. (Pearson 1992) located few widely separated populations. Subsequent karotyping indicated that the Townsend Ridges population was unique amongst rock-wallaby populations in the region by possessing 21 chromosomes. Since this population had been reduced to around 6 individuals, a project was formulated to commence fox/dog baiting to reduce predation pressure. Baiting has been conducted by local Ngaanyatjarra people on a contract basis. Research has focused on assessing the effectiveness of the baiting in terms of the number of rock-wallabies trapped and the distribution of fresh faecal material along the cliff-line.

Summary of progress

- Trapping/ monitoring trip in May 2002 indicated an expanding population.
- Severe fire in September 2002 led to inspection and baiting in October 2002.

Future directions

- Ongoing liaison with Goldfields staff and Ngaanyatjarra staff about baiting.

- Monitoring of response (survival?) of rock-wallabies following fire.

Status, ecology and conservation of Pilbara Olive python

SPP #98/05

Team Leader: David Pearson

Aims

- To determine the distribution, status, habitat requirements, diet, activity patterns and reproductive behaviour of the threatened Pilbara Olive python.
- This project commenced in 1996 and has slowly gathered data over the ensuing period as it largely relies on volunteers to collect radio-telemetry data. Olive pythons on the Robe River (Pannawonica), Millstream, Tom Price and the Burrup Peninsula were implanted with radio-transmitters and volunteers and rangers have followed their movements to collect basic information on their ecology. A project with volunteers in Tom Price has attempted to breed the species in captivity for the first time.

Summary of progress

- Ongoing telemetry work on the Burrup Peninsula and at Millstream by volunteers. Support provided to replace transmitters and find lost pythons. Completion of a report for Environment Australia on the Burrup work (TSN grant to the Nickol Bay Naturalists).

Future directions

- Completion of Millstream telemetry by the end of 2003.
- Write-ups of Pannawonica and Tom Price telemetry in next 6 months and final report on Burrup work in December 2002.

Recovery plan implementation for the Lancelin Island skink

SPP #99/11

Team Leader: David Pearson

Aims

- To aid the survival of the Lancelin Island skink through strategic research.
- Monitoring of the species as recommended in the Recovery Plan (Pearson and Jones 1997), particularly population and habitat monitoring on Lancelin Island and translocation of skinks to another island.
- The Lancelin Island skink is only known from Lancelin Island (7.6 ha) and a single location on the adjacent mainland. Further surveys have failed to find any other individuals on the mainland. Detailed ecological research was undertaken on Lancelin Island by Jones, the effect of the herbicide Fusilade by King and Pearson and captive breeding was carried out successfully by Perth Zoo. Many islands along the mid west coast were inspected for their potential as translocation sites for skinks and Favorite Island off Jurien Bay was selected as the best available.

Summary of progress

- Translocation of 41 captive-bred skinks from Perth Zoo to Favorite Island carried out in March 2002.
- Ongoing breeding research with Perth Zoo to provide further stock for translocations.

Future directions

- Monitoring of translocated Favorite Island and Lancelin Island populations in December 2002 and March 2003.
- Further release of captive-bred skinks and direct transfer of Lancelin Island wild stock proposed for December 2003.

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

SPP #01/02

Team Leader: David Pearson

Aims

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

Summary of progress

- Monitoring trips in March, June, July and August 2002.
- Trapping success very poor due to very dry conditions.

Future directions

- Ongoing monitoring of Mulgara populations at Mt Keith.
- Survey of other possible study sites at Leinster. Radio-telemetry of Mt Keith Mulgaras.
- Trialling of automated system to examine burrow use.

Identification and monitoring of benthic invertebrate communities of tropical intertidal mudflats

SPP #99/15

Team Leader: Grant Pearson

Aims

- Roebuck Bay and Eighty Mile Beach are among the most important feeding grounds and roosts along the Australasian East Asian Flyway and are listed as Wetlands of International Importance under the Ramsar Convention.
- A survey of the benthos of Roebuck Bay in 1997and Eighty Mile Beach in 1999 revealed an unusually rich diversity of marine intertidal mudflat infauna. Prior to the 97/99 surveys very little information had been available on the nature and distribution of the benthic fauna for either site.
- Community understanding and interaction in research on the intertidal mudflats has improved significantly since surveys began. Local schools and tertiary institutions and other organizations are now actively engaged in studies of some form of benthic science.

Summary of progress

- Completed to review stage the report “The Long Mud” - Benthos and Shorebirds of the Foreshore of Eighty Mile Beach, Western Australia (Pearson, Piersma, Hickey, Lavaleye)
- Preliminary report “Southern Roebuck Bay Invertebrate and Bird Mapping 2002”. (Piersma, Pearson, Hickey, Lavaleye, Rogers)

- Interim report on the community based monitoring of Roebuck Bay (De Goeij and Lavaleye).
- Report on 3-week study of the management of intertidal mudflats - Maps and Mud- What spatial skills are required to support a major ecologic research project (Hickey, Pearson, Piersma)
- Survey - Landscope Expedition “Life on Lands Edge –Birds of Roebuck Bay, Broome”.
- Collaborated with RNIOZ (Piersma) and Groningen University (Wulf) to establish a postgraduate student at Broome Bird Observatory. (Tropical bivalve diversity in Roebuck Bay; life history adaptations and the role of shorebird macrobenthic predators)
- Collaborated with Broome Bird Observatory, West Kimberley District, Rubibi Aboriginal Council to construct a boardwalk at Roebuck Bay.
- Collaborated with local community groups to progress ongoing monitoring of Eighty Mile Beach and Roebuck Bay
- Developed the concept for a book that will promote the conservation values of Roebuck Bay through the use of high quality colour photographs by Jan van de Kam and text by the collaborators in Sroebim –to be published by DCLM
- Initiated and developed a section 16a reserve for the dunes east of the HWM at Eighty-mile Beach in collaboration with WKD and EPB
- Postcards WA segment on “The use of volunteers in nature conservation – benthos of Roebuck Bay”

Future directions

- The report on Eighty Mile Beach will be published in 2003. (A broken arm has prevented Lavaleye from completing the identification of samples and reporting.)
- Provide on-going support to post graduate student and community groups during 2003.
- Provide input into the preparation of the book on the ecology of Roebuck Bay
- A report on the results of the Sroebim survey will be prepared for publication in 2004.

Taxonomy and zoogeography of aquatic Oligochaetes of Western Australia

SPP #98/08

Team Leader: Adrian Pinder

Aims

This project aims to document the extent and distribution of aquatic oligochaete diversity in Australia, with a particular emphasis on Western Australia. These worms are found in almost all aquatic habitats and play a particularly important role in wetland sediment ecology. I am currently the only researcher in Australia able to identify most of these worms and to describe new species. Thus, this project contributes to more complete species level identification of aquatic invertebrates for several other DCLM projects, including; the Salinity Action Plan, aquatic threatened community work by WATSCU (e.g. cave and spring faunas) and the Pilbara stygofauna survey. Numerous new species will be collected during the latter and these will be described.

Specific aims are

- To describe new taxa where necessary
- To assess the distribution, endemicity and conservation status of aquatic Oligochaetes in Western Australia.
- Establish a database of distribution records for Australian aquatic Oligochaetes and create a Delta database of taxonomic information suitable for the production of interactive keys.

- To investigate the environmental factors controlling the occurrence of the worms, where adequate environmental data is available.

Summary of progress

- During the past year I have identified Oligochaetes from the Salinity Action Plan, 2 of WATSCU's threatened communities and begun to examine groundwater worms from the Pilbara. I have also identified worms for other organizations including the NSW Department of Land and Water Conservation and several Victorian consultancies. The latter help to give a broader biogeographic setting for the Western Australian fauna and fees charged for this work offset the minor costs associated with this project.
- This year I have published descriptions of 2 new species of Tubificidae from the wheatbelt (1) and a paper on the diversity and distribution of Australian Naididae and Phreodrilidae (2). I have submitted 3 further papers, including descriptions of new species from granite outcrops and Pilbara groundwater-fed springs (3) and records of eastern Australian worms (4,5).
- During 2002 I have been responsible for entering worm systematic, nomenclatural and distributional data onto Environment Australia's 'Australian Biological Information Facility (ABIF)' web-based catalogue, in collaboration with Prof. Emer. Barrie Jamieson (Uni. Qld) and Dr Tim Kingston (NSW Dept. Agriculture).
- Chapters on worms for 2 books [on 'Malaysian Freshwater Fauna' (6) and the New Zealand 'Species 2000' project (7)] have also been completed and accepted.

Unfortunately, the small time allocation for this project and the rate at which new undescribed species continue to be uncovered limit the extent to which I have been able to work on other aspects of this SPP, such as the interactive identification guide. It should be noted that aspects of the project involving non-Western Australian oligochaetes and publications have been completed in my own time.

References

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- Pinder, A. M. (2001). "Notes on the diversity and distribution of Australian Naididae and Phreodrilidae (*Oligochaeta*: *Annelida*)." Hydrobiologia 463: 49-64.
- Pinder, A. M. (in press). "New species and records of Phreodrilidae (*Annelida*: *Clitellata*) from Western Australia." Records of the Western Australian Museum.
- Pinder, A. M. and P. K. McEvoy (in press). "*Embolocephalus yamaguchii* (Brinkhurst, 1971) (*Clitellata*: *Tubificidae*) from South Australian streams." Records of the South Australian Museum.
- Pinder, A. M. (submitted). "First Australian records of 3 species and two genera of aquatic oligochaetes (*Clitellata*: *Annelida*)." Proceedings of the Linnean Society of New South Wales.
- Pinder, A.M. and Ohtaka, A. (in press). Oligochaeta and Aphanoneura. In, Freshwater Invertebrates of Malaysia and Singapore, Yule, C. and Hoi-Sen, Y. (eds) Academy of Sciences Malaysia, Kuala Lumpur.
- Glasby, C.J., Read, G.B., Lee, K.E., Blakemore, R.J., Fraser, P.M., Pinder, A.M., Erséus, C., Moser, W.E., Burreson, E.M., Govedich, F.R., Davies, R.W. and Dawson, E.W. (in prep.). *Phylum Annelida*: Bristle-worms, Earthworms, Leeches. In, The New Zealand Inventory of Biodiversity: A Species 2000 Symposium Review, Gordon, D.P. (ed.) Canterbury University Press, Christchurch, New Zealand.

Future directions

I currently have about 50 undescribed species in my collection and will give priority to describing those worms from Western Australian (and particularly DCLM) projects. I expect to write at least one paper describing new Western Australian worms. With regards to new material, priority will be given to the

worms that will arise from the Pilbara stygofauna and surface water projects. If time is available I will also prepare a paper on groundwater worms in Australia for the 9th International Symposium on Aquatic Oligochaetes in the Netherlands in 2003. I will also continue to be involved in the ABIF project.

Conservation of marine turtles

SPP #93/40

Team Leader: Bob Prince

Aims

- Design and develop functional turtle database.
- Analyse turtle data collected to date.

Summary of progress

- Functional database.
- Completed demographic study for turtles.

Future directions

Report on turtle demographics.

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

SPP #93/68

Team Leader: Bryan Shearer

Aims

- *Phytophthora cinnamomi* infection is a major threatening process affecting the viability and genetic diversity of populations of rare and endangered flora of south-western Australia. The fungicide phosphite is proving to be an effective control strategy for the protection of threatened plant communities from *P. cinnamomi* infection. As part of an integrated conservation strategy, the Department of Conservation and Land Management has developed techniques for spraying the fungicide by aircraft onto critically endangered communities.
- While initial applications of the fungicide have halted progress of disease, information on the longevity of the fungicide in various plant species and communities is required to develop optimal spray regimes that will effectively control *P. cinnamomi* infection over time.
- The project aims to determine the longevity of effectiveness of phosphite against *P. cinnamomi* infection in field and glasshouse trials in order to optimize application of the fungicide for long-term control of the pathogen.

Summary of progress

- Obtained funding from NHT.
- Demonstrated that plant species has a greater influence on phosphite efficacy than environment or site.
- Phosphite levels in the plant do not appear to be related to efficay of the fungicide.
- Presentations of the work given to IUFRO conference and to Woodvale and Como Research Centres, Albany and Bussleton Districts. Fifth presentation scheduled for the Herbarium.

Future directions

- Continue determining longevity of action.
- Test site differences under controlled conditions.
- Further test species differences.
- Test application technique.

Susceptibility of rare and endangered flora to *Phytophthora*

SPP #99/19

Team Leader: Bryan Shearer

Aims

Phytophthora cinnamomi infection is a major threatening process affecting the viability and genetic diversity of populations of rare and endangered flora of south-western Australia. As part of an integrated conservation strategy, the Threatened Flora Seed Centre (TFSC) was established in 1992 by the Department of Conservation and Land Management for the gene banking of threatened and rare flora.

While considerable progress has been made in the collecting and storage of seed of rare flora, little is known of the susceptibility of the stored taxa to *Phytophthora* infection. Current estimates of the susceptibility of rare and threatened flora to *P. cinnamomi* infection are mainly determined from empirical observation or "educated guesses" based on family susceptibility. However species within susceptible families, such as the Proteaceae, *Papilionaceae* and *Myrtaceae*, vary greatly in their susceptibility to P. cinnamomi infection (Shearer and Dillon 1995, 1996). There is a need to systematically test taxa in the TFSC collection to prioritize endangered species according to need for protection from *P. cinnamomi* infection. Seeds in the TFSC collection are routinely tested for germination and are available for testing for *P. cinnamomi* susceptibility.

The project aims to test the available seedlings of endangered flora in the Threatened Flora Seed Centre (TFSC) collection to *P. cinnamomi* infection to:

- rank taxa in the TFSC according to susceptibility to *P. cinnamomi* ;
- identify variation within species in susceptibility to *P. cinnamomi* ;
- determine variation in susceptibility to *P. cinnamomi* between and within families.

Summary of progress

- 120 taxa tested in summer 2001/02.
- Database updated, now 241 species.
- Provisional susceptibility list released to WATSCU.
- Presentations of the work given to IUFRO conference and to Woodvale and Como Research Centres, Albany and Busselton Districts. Fifth presentation scheduled for the Herbarium.

Future directions

- Plant up germinating seed as received from Threatened Species Seed Unit 2001/02.
- Inoculate plants in summer 2003.
- Update database.
- Test survivors for root infection.

Integrated overview of values, uses and modifying processes in the Ord River riparian zone

SPP #2000/01

Team Leader: Tony Start

Aims

Integrated overview of values, uses and modifying processes in the Ord River's riparian zone. The study incorporates hydro-geomorphological and biological aspects.

Summary of progress

- Field work complete. Identification and processing of specimens well advanced. Databasing of results well advanced. Regional Herbarium established. Historical photo collection post 1950 is substantial (several hundred) and digitized. Photo acquisition now focused on pre-1950s material. Monitoring program for lower Ord established (for WRC) and inputs made to the WRC environmental water requirement studies and water allocation plan for Lower Ord. Input also to Kimberley inter-agency riparian and weeds management groups and regional management.
- Floristic, site and bird data are held in purpose built Access databases. Flora specimens are entered onto Max, vouchers lodged in the Kimberley Regional Herbarium. Duplicates in PERTH with digital MAX files. Some additional duplicates in DNA (=Darwin) and various other Australian Herbaria.

Publications

- Start AN and Handasyde T. 2002. Using photographs to document environmental change: The effects of dams on the riparian environment of the lower Ord River Australian Journal of Botany 50: 465-480.
- Start AN and Handasyde T. 2002. The value of old photographs. Western Wildlife 6(3): 8-9 & 20.
- Start AN and Handasyde T. (In press). The Ord: what have we done ~ what can we do?. In: Grazing in Wetlands. Proceedings of a conference held in Darwin, 2001

Presentations

- The Ord: what have we done ~ what can we do? "Grazing in wetlands" conference; Darwin 2001
- Up-date on our riparian work. Presentation to SEEKS, Kununurra May 2002.
- Patterns of riparian habitat change in an impounded river. Paper to Conference on Environmental Disturbance in Tropical Savannas. Darwin June 2002
- Fire management in riparian corridors paper presented to 6th North Australian Fire Management Workshop, Timber Creek, NT. June 2002.
- Collaboration: Dr Karl-Heinz Wyrwoll (and students) Geography Department, University of Western Australia.

Future directions

Ord riparian papers will include the following topics ; weeds, birds, floristic dynamics in relation to hydrology and dams. I hope to complete data analysis and write 3 papers by June 2003

Mistletoes and their fire ecology

SPP #00/08

Team Leader: Tony Start

Aims

A project to collect data on Mistletoes (throughout the State) for use in taxonomic, biogeographical and ecological (particularly fire) studies. The project is ongoing and opportunistic. I collect data incidentally during other project work and in my own time. Most data are processed in my own time.

Summary of progress

I have several hundred herbarium sheets to be deposited in PERTH and my card-vouchered collection with host and geographical data now exceeds 2000. All records are on an Access database. Mistletoes are useful indicators of fire regimes. They are also fire vulnerable. There are several undescribed species in *Amyema* and *Lysiana*. They need to be described and the latter needs revision.

Collaborations

Ainsley Calladine at JCU (Townsville)

Future directions

I shall continue collecting data opportunistically but writing up is of lower priority than my core projects. Nevertheless information has been incorporated into popular articles, 'Savanna burning' and to various fire fora. I will be retiring in 2-3 yrs and plan to: (A) re-determine the PERTH collection (I am aware of many mis-identifications) (B) incorporate my collection into PERTH and (C) write fire ecology, biogeographic and taxonomic papers then.

Biological survey of the Barlee Range Nature Reserve

SPP #93/30

Team Leader: Stephen Van Leeuwen

Aims

To undertake a biological survey of the Barlee Range Nature Reserve to facilitate an assessment of its biological and nature conservation values. This will be achieved by comprehensively documenting the flora and fauna of the Nature Reserve using systematic and repetitive sampling regimes. The ensuing delineation of communities into which this biota is partitioned will be investigated using multivariate techniques. Subsequent analyses will quantify the influence of environmental variables on observed community patterns. Assessments will also be undertaken on the taxonomic, biological and conservation status of taxa and communities encountered thereby permitting a regional appraisal of the biological and nature conservation values of the Nature Reserve.

Summary of progress

All fieldwork associated with this project has been completed. Over the past 12 months a Landscope Expedition to the Nature Reserve was undertaken which resulted in the identification of several new plant species previously not recorded. New flora and fauna populations were also documented for several taxa of biological or conservation significance.

Approximately 6 weeks of work is required to finalize this project and present the final report. Chapters addressing Regional Setting, Epigeic Ants and Birds are complete. The Flora chapter needs review and augmentation in light of recent specimen discoveries and re-determinations. Similarly, the Fauna chapter requires alteration in light of recent taxonomic changes and confirmation of identifications for specimens lodged in the Western Australian Museum. Some work is outstanding on the introductory and concluding chapters and an Executive Summary needs to be compiled. It is envisaged that the report will be prepared to a standard suitable for publication and some chapters will be submitted to peer reviewed journals.

Future directions

Completion of this project and the subsequent publication of the final report or constituent chapters is obligatory. To achieve this outcome work is required on several chapters (Introduction, Flora, Terrestrial Fauna, Conclusion) and on the compilation of the final product. It is envisaged that this outcome will be achieved by August 2003.

Botanical survey of Hamersley Range Uplands

SPP #93/31

Team Leader: Stephen Van Leeuwen

Aims

- The aims of this survey were to comprehensively and quantitatively document the flora of upland habitats throughout the Hamersley Range, investigate the arrangement of this flora into communities, identify the environmental correlates influencing the distribution of taxa and circumscription of communities and assess the biological and conservation status of such entities.
- The fundamental deliverables were a botanical (species and communities) and environmental correlates inventory for upland habitats within the Hamersley Range. These inventories were employed to evaluate the presence and distribution of plants of biologically and conservation significance and the floristic communities into which they are partitioned. The botanical inventory was also used to verify the comprehensiveness, adequacy and representativeness of the existing conservation reserve system (Karijini National Park) with respect to the flora and floristic communities of upland habitats.

Summary of progress

- Substantial progress was made on this project during the last 12 months. The final report to the funding agency was submitted and the preparation of manuscripts for publication in peer reviewed journals is well underway.
- A total of 80 uplands encompassing the altitudinal, climatic and selective gradients present across the geographical extent of the Hamersley Range were systematically sampled during the survey. A total flora of 378 vascular plant taxa were recorded from these uplands. This flora includes many species of taxonomic, biological and conservation interest, in particular 11 taxa that may represent new species, 57 taxa at the geographical limits of their distributional ranges, 27 taxa which are disjunct outliers and 15 taxa of conservation significance. This upland flora was quantitatively partitioned into 5 ecologically identifiable and justifiable floristic communities, which were influenced in distribution by geographical position, altitudinal, climate and geological/edaphic considerations. Fortuitously, the existing Hamersley Range conservation reserve system, namely the Karijini National Park, adequately represents most taxa and floristic assemblages. No significant threats were identified to this upland flora although the potential for degradation of biological and conservation values was noted as a consequence of tourist developments, inappropriate fire management practices and future iron ore mine developments. Several recommendations were tendered in respect to the outcomes of this survey. Five of these recommendations related specifically to the flora and floristic assemblages while 2 recommendations petitioned for consistency in the delimitation of sub-regional biogeographical boundaries in the Pilbara.

Future directions

Over the next 12 months work will primarily focus on the preparation and finalization of manuscripts for publication. These manuscripts will provide an inventory of the flora of upland habitats within the Hamersley Range, define the floristic communities into which this flora is organized and identify the environmental forces influencing this partitioning and finally, address issues of floristic nestedness, insularity and reservation of species and their communities.

Fire-Mulga study

SPP #93/141

Team Leader: Stephen Van Leeuwen

Aims

This project aims to investigate the effects of fire on Mulga communities in the Hamersley Range. This project was designed to test a number of hypotheses presented in relation to the importance and persistence of Mulga woodlands. These hypotheses are:

- Mulga dominates a variety of distinct and definable plant and animal assemblages each of which occupies distinct positions along the catenary sequence with characteristic edaphic and geomorphic features;
- Some species represented in the Mulga-dominated assemblages are endemic;
- Species composition and vegetation structure of some or all Mulga-dominated assemblages and the ecotones between these assemblages and hummock grasslands are dynamic and shifting;
- Fire is an important cause of Mulga-dominated assemblages varying in their vulnerability and resilience to this perturbation; and
- Modification of Mulga-dominated assemblages by fire is reducing biological diversity in the Hamersley Range.

Summary of progress

- No progress has been made on this project over the past 12 months.
- Previously 70 km of belt transects were established in the central Hamersley Range along which the occurrence of Mulga was documented and the floristic assemblages quantitatively defined. Subsequently, repeated systematic sampling of the flora, vertebrate fauna and epigeic ants at replicated sites in 4 characteristic Mulga woodland assemblages has been undertaken. Quantification of vegetation structure and characterization of topographic and edaphic variables has also been undertaken for these woodland assemblages. The experimental treatment of some replicated woodland sites, through burning has also been undertaken although this treatment has been confounded in recent years by extensive wildfires which have burnt several control woodland sites.

Future directions

- A review of progress to determine the future direction for this project will be undertaken over the next 12 months. A considerable volume of data has already been collected and requires analysis and publication. Paramount in this regard is the preparation of a manuscript defining the 4 Mulga woodland assemblages identified in the Hamersley Range and describing their floristic composition, topographic setting and edaphic attributes. It is also envisaged that within the next 12 months it would be opportune to resample the 70 km of belt transects and document changes which have occurred in the spatial distribution of the 4 Mulga woodland assemblages as a consequence of fire.
- The continued progression of this project for another decade has been facilitated through generous support received from Robe River Iron Associates. This support is manifested in the form of funding to the value of $180 000 which was forthcoming from the West Angelas Coondewanna West Environmental Offset sponsorship initiative.

Biological survey of the Burrup Peninsula

SPP #99/01

Team Leader: Stephen Van Leeuwen

Aims

The aim of this project was to conduct a comprehensive biological survey of the Burrup Peninsula to facilitate an accurate evaluation of the nature conservation and natural environment heritage values of the locality.

This project was originally conceived to document the conservation and natural environment heritage values of the Burrup Peninsula and has attempted to achieve this outcome despite limited funding. The project aimed to provide land management and development agencies with important information on the biological attributes of the Peninsula. It was envisaged that the primary output from the project would be a report detailing the biota of the Peninsula and identifying the communities into which this biota was partitioned. This report would highlight and delimit taxa and communities that were of conservation significance thereby facilitating an assessment of the nature conservation and heritage values of the Peninsula.

Summary of progress

- Fieldwork associated with this project has been completed. All botanical identifications have been completed while some work is outstanding in respect to fauna determinations. Over the past 12 months the GIS atlas for the project has been completed. The primary task outstanding on this project is the preparation of manuscripts and the compilation of the final report.
- Over the past 12 months the majority of activity associated with this project has been directed towards the supervision of a detailed botanical survey on the Peninsula funded by the Office of Major Projects (formerly Department of Resource Development). This botanical survey was considerably more detailed and intensive than that undertaken during the Departmental biological survey and was supported by substantially more funding. Considerable research effort has also been directed towards the appraisal of development projects proposed for the Peninsula. This process has involved significant liaison with government regulatory agencies, development proponents and environmental consultants culminating in the critical review of numerous environmental impact statements and management plans.

Future directions

- Completion of this project through compilation and submission of the final report is outstanding. Achievement of this output is some distance off and will not be achieved in 2003. Considerable effort is required in respect to the analysis of data and the preparation of various chapters detailing the sampled biota. The GIS atlas developed for the project also requires revision and augmentation given increased knowledge of geological considerations and proposed changes in land tenure.
- Liaison with regulatory agencies and development proponents in respect to the environment and the impacts of development will be ongoing.

Botanical survey of Central Hamersley Range tussock grasslands

SPP #99/02

Team Leader: Stephen Van Leeuwen

Aims

- The aim of this project was to undertake a botanical survey of tussock grassland communities found on valley floors within the central Hamersley Range. This survey will enable an assessment of the nature conservation values of such grasslands and their constituent species and facilitate the quantitative assessment of their representativeness and the adequacy of the existing conservation reserve network in the Pilbara region.
- The conservation significance of the tussock grassland communities in the central Hamersley Range, is undetermined in terms of species richness and the presence of rare, geographically restricted and poorly known taxa, preliminary investigations indicate that it may be high. The level of similarity between grassland communities and thus the representativeness of any one ‘island’ is also undetermined. Many of these grasslands are not represented in the Karijini National Park, the only conservation reserve in the region, and most are currently impacted by pastoral grazing and other rangeland management practices such as frequent burning. This project will document the flora of

these grasslands, determine the distributional status of constituent taxa, define their conservation value and highlight any deficiencies in the existing reserve system.

Summary of progress

- All fieldwork associated with this project has been completed. Over the past 12 months considerable effort has been directed towards the identification of specimens and the development of the taxon by site data matrix. The GIS atlas developed for the project has undergone further augmentation with the release of additional geological data and the refinement of bioclimatic and fire history information.
- The final report for this project is well advanced however, recent problems associated with the identification of specimens have hindered progress. These identification problems are principally associated with several grass taxa, which are integral constituents of the floras of the Central Hamersley Range Tussock Grasslands. The problems revolve around the incorrect identification of several taxa which has profound implications for the taxon by site matrix and the subsequent floristic analyses which have been performed. Basically, a taxon identified as a single entity from almost all sites has been identified as 3 distinct taxa by specialist graminoid taxonomists and hence the taxon by site matrix needs to be reconstructed.

Future directions

- Completion of this project and submission of the final report will be achieved before the end of 2003. Achievement of this output requires the reconstruction of the taxon by site matrix and the subsequent re-analysis of floristic patterns and delineation of assemblages. Some minor refinements to the environment variables dataset are also likely given the availability of additional information which may assist in the interpretation of detected floristic patterns which had proved problematic in exploratory analyses. It is envisaged that a manuscript detailing the floristics of tussock grasslands in the Hamersley Range will be submitted for publication in a peer reviewed journal.
- The extension of this project to investigate the floristics and conservation significance of similar tussock grassland habitats throughout the Pilbara will occur over the next 4 yrs as a consequence of support received from Robe River Iron Associates. This support is manifested in the form of funding to the value of $80 000 which was forthcoming from the West Angelas Coondewanna West Environmental Offset sponsorship initiative. This extension of the project will be undertaken as part of the Pilbara Biological Survey.

Biological survey of the south-western Little Sandy Desert

SPP #99/03

Team Leader: Stephen Van Leeuwen

Aims

- The principal aim of this biological survey was to comprehensively, systematically and quantitatively document the flora and fauna of the south-western Little Sandy Desert. Other objectives were to investigate the community arrangement of biota, identify how these communities were partitioned across the landscape and assess the biological and conservation significance of the species and communities encountered. The survey design involved a rigorous and comprehensive field program supported by herbarium, museum and laboratory analyses.
- The fundamental deliverables were inventories on the flora and fauna of the south-western Little Sandy Desert. Commensurate with this output were contributions to inventories for the biogeographical region and an assessment of the distributional, biological and conservation significance of plants and animals within the Desert. It was anticipated that these inventories would also be used to substantiate recommendations on the conservation status of species and provide the foundation for assessment of the comprehensiveness, adequacy and representativeness of the existing conservation reserve system in the Little Sandy Desert. Outputs from the survey were also

used to justify recommendations for augmentation of the Little Sandy Desert conservation reserve network.

Summary of progress

- Substantial progress was made on this project during the last 12 months. The final report to the funding agency was submitted and the preparation of publication quality manuscripts for several biotic groups is well underway.
- A total of 522 vascular plants, 87 herpetofauna, 116 birds and 28 extant indigenous mammals were recorded during the survey. Many taxa were of biological and conservation significance and several, mostly plants, were not previously recorded in the scientific literature. Many taxa were at the limits of their distributional range and are disjunct outliers of otherwise mostly northern or southern ranges. In broad terms the biota is dominated by central arid zone elements although southern and tropical arid zone groups were present. Floristic and avifaunal communities were readily distinguishable and their arrangement across the landscape appears to be controlled by topographic and edaphic considerations. The location of the study area in a transitional zone between major phytogeographic elements in the Australian flora together with heterogeneity in land surface types and soils was advanced as justification for the biological diversity recorded. This diversity appeared to differ notably from other areas in the biogeographical region. In order to address deficiencies in the comprehensiveness, adequacy and representativeness of the conservation reserve network in the biogeographical region, a proposal was tendered for the creation of the Giles Nature Reserve. This proposed nature reserve exemplifies the physiogeographical character of Little Sandy Desert and is intrinsically representative of the biota in the region.

Future directions

Over the next 12 months work will primarily focus on the preparation and finalization of manuscripts for publication. In addition to those chapters already presented in the final report, manuscripts addressing the epigean ant fauna, scorpion fauna and overall patterns of community composition within the study area will be prepared. It is anticipated that the survey will be published as a supplementary volume to the Records of the Western Australian Museum.

Effects of spring and autumn burns on vertebrates in (Batalling) Jarrah forest

SPP #93/75

Team Leader: Adrian Wayne

Aims

To investigate the effect of spring and autumn burning on populations of small mammals, reptiles and amphibians inhabiting Batalling Jarrah forest.

Summary of progress

- Data validation and preliminary population analysis of the Common brushtail possum completed.
- Results for the Common brushtail possum included in review paper for the DCLM Fire Symposium, April 2002; ‘Relationships between mammals and fire in south-western Australian ecosystems: what we know and what we need to know.’ G. Friend and A. Wayne.
- Data validation process for other medium sized mammals progressed towards completion.

Future directions

- Analysis of population responses of Quenda, Chuditch and Woylies to prescribed bun treatments during 2002/03.

- Commence data validation for frog and reptile data during 2002/03.
- Preparation of report and publication for medium-sized mammals.

Conservation biology of vulnerable frogs

SPP #93/93

Team Leader: Adrian Wayne

Aims

Geocrinea lutea population monitoring in response to burning in Swarbrick Block, Walpole.

Summary of progress

Regular annual surveys accomplished in October and November 2001.

Future directions

- Ongoing monitoring.
- Geocrinea Recovery Team to determine the term of the project.
- Consider whether Ian Wheeler should replace Adrian Wayne as supervising officer responsible for this project. Adrian Wayne to remain in a support role.

Conservation and ecology of threatened Western Australian butterflies

Team Leader: Matthew Williams

Aims

- Determine the relative importance of contemporary ecological processes in limiting butterfly population survival and growth (What are the effects of fire and other disturbances on butterfly populations and their host plants?);
- Determine any ecological differences between threatened and common congeners that explain why rare taxa are threatened (What factors limit the distribution and population size of some rare taxa?);

Summary of progress

- Undertook fieldwork at Koondoola Regional Bushland Reserve (KRBR), Oct 2001-Mar 2002: mark-recapture study of western jewels and blue iris-skippers; 37 surveys of butterflies and day-flying moths completed.
- Completed progress report on the above.
- Completed initial data analysis of mark-recapture and survey data.
- Surveyed foodplants and nectar sources at KRBR, July 2002.
- Obtained fire history of KRBR and weather data, and analysed in relation to butterfly abundance.
- Added 2 sites (Warwick Open Space, Cottonwood Crescent) to the study.

Future directions

- March 2003 - further surveys.
- Sept-Dec 2003 – 2-wkly surveys at all sites.

The population ecology of Critically Endangered flora

SPP #00/15

Team Leader: Colin Yates

Aims

- This project aims to rank the ecological constraints to population growth in Declared Rare (Threatened) Flora and provide management guidelines for use in recovery plans.
- whether there are differences in reproductive and ecological attributes between rare and common congeners which explain why rare taxa are restricted in distribution and threatened.
- provide general models of extinction vulnerability for plant functional groups (based on floral architecture, pollinator interactions and fire response).

Summary of progress

- Assessing limitations on population growth in the Critically Endangered *Acacia aprica* and *Acacia cochlocarpa*.
- Flowering phenology, soil seedbank and the impact of fire, weeds and grazing were investigated in 2 rare Acacia taxa restricted to the agricultural district north of Perth. Research was undertaken over 3 yrs.
- Size class structure, levels of canopy death and an absence of juveniles indicated that all populations are in decline. Flowering intensity and success varied between populations and years in *A. aprica* and between years in *A. cochlocarpa* ssp. *cochlocarpa*. Seed bank analysis indicated that seeds were patchily distributed while experimental fires demonstrated that such events could break seed dormancy and promote germination. Both taxa have similar germination physiologies and showed increased germination after seeds were exposed to heat. Following emergence, however, competition with annual weeds had a negative impact on seedling growth and survival in both taxa. While vertebrate grazing had some influence, weeds were the major inhibitory influence on recruitment.
- Seed production is unlikely to be responsible for population decline in both taxa. Reduced fire frequencies since fragmentation may be responsible for population decline in both taxa but other site-specific factors such as weeds and grazing may affect the establishment of seedlings following fire.
- The reproductive and ecological attributes of the rare *Acacia lobulata* and *Acacia sciophanes* and their common relatives *A. verricula* and *A. sciophanes*.
- Marcelle Buist has finished collecting and analyzing data comparing the reproductive and ecological characteristics of the Critically Endangered *A. lobulata* and *A. sciophanes* and their common closest relatives. The research is currently being written up by Marcelle for her PhD dissertation.
- The comparative population structure and reproductive biology of the Critically Endangered shrub *Grevillea althoferorum* and 2 closely related more common congeners *G. rudis* and *G. synapheae* ssp. *pachyphylla.*
- *Grevillea althoferorum* is a critically endangered, sprouting shrub known from 2 disjunct populations within the South-West Botanical Province of Western Australia. This study compares the conservation biology of *G. althoferorum* and 2 closely related but more common congeners, the non-sprouter *G. rudis* and the sprouter *G. synapheae* subsp. *pachyphylla* in order to determine whether there are differences in reproductive and ecological attributes that might explain why *G. althoferorum* is rare.
- In contrast to the more common species, neither population of *G. althoferorum* exhibited evidence of seedling recruitment. However, the northern population was confirmed to be clonal and was actively recruiting from root suckers. Both populations of *G. althoferorum* were found to have reduced amount of viable pollen on stigmas in comparison with the other species. The fruit set at the southern

population of *G. althoferorum* was considerably lower than that found for the common species, with only 0.15% of flowers setting fruit and no fruit was produced in the northern population.

- In addition no evidence of a soil seed bank was found for either population of *G. althoferorum*, but *G. rudis* and *G. synapheae* subsp. *pachyphylla* both had soil stored seed which germinated following treatment with aqueous smoke solution. Sexual recruitment at both populations of *G. althoferorum* was absent, and reproduction appears to be predominantly clonal. Management strategies for *G. althoferorum* should therefore focus on the protection of adult plants from accidental destruction.
- Pollination, demography and extinction vulnerability in a rare Critically Endangered granite endemic shrub *Verticordia staminosa* ssp. s*taminosa.*
- Key considerations in assessing extinction vulnerability for rare plant species in fragmented landscapes are the reproductive dependence on a pollinator, breeding system, importance of seeds in demography and regeneration niche.
- This study aimed to determine the extent to which the above factors constrain population growth in *V. staminosa* ssp. *staminosa* and influence the taxon's extinction vulnerability. Measurements across 9 sub-populations on the breeding system, pollinator activity, rates of flowering, pollination and seed production, seedling demography, mature plant mortality and size class structure were undertaken over 3 consecutive years.
- *V. staminosa* has a mixed mating system with similar rates of pollen tube development and fertilization being observed in self, crossed and open pollinated flowers. Floral morphology, orientation and nectar production, suggest some degree of specialization associated with pollination by birds which were occasionally seen visiting flowers. However, feral honeybees were the most commonly observed flower visitor and seem to have replaced honeyeaters as the primary pollinator.
- Honeybee abundance was influenced by sub-population size but rates of pollination and the subsequent proportion of flowers that produced viable seeds was independent of sub-population size suggesting that self-compatible species are more resilient to Allee effects.
- Germination and emergence of seedlings occurred on mineral soil and in moss mats in each winter but the highest numbers were recorded in the wettest winter and recruitment was heavily biased towards individuals growing in or over cracks/fissures in the rock. Over the 3 yr study period recruitment exceeded mortality.
- A relatively unspecialized flower and mixed mating system have buffered the taxon against the effects of pollinator disruption. Seed production does not constrain population growth. Extinction vulnerability is more likely to be influenced by factors that affect the regeneration niche. Predicted increasingly dry winters and springs in south-western Australia and competition with annual weeds in the rock crevices may be important for the survival of the species in the future.
- Pollination, demography and extinction vulnerability in a rare Critically Endangered shrub *Verticordia fimbrilepis* ssp. *fimbrilepis.*
- Fieldwork and data collection for a 3 yr study investigating the effect of population size and landscape context on rates of pollinator diversity, rates of pollination and seed production have been completed. Field studies investigating, seed bank dynamics, germination physiology, demography and impact of fire on the foregoing processes have been completed.
- The fire ecology of the Eastern Stirling Range Montane Heath and Thicket community – A Critically Endangered Ecological Community. Continued description of fire response of the community, monitoring of fire related demography of critically endangered flora and monitoring of impact of 2 different fire intervals on species richness and abundance.
- Landscape Fragmentation and Rare Plant Species: Can We Develop a General Framework of Population Responses? ARC Linkage project with Murdoch University.

- This project aims to categorize threatened plant taxa on the basis of functional attributes (floral architecture and level of pollinator specialization, fire response). Detailed ecological studies of a limited number of taxa within each group will be undertaken. Models will be developed for each functional group of how rates of pollination, seed production and seed fitness and demography are affected by population size and landscape context. Information from models for each functional group will be extrapolated to other taxa in that group to provide guidelines for flora conservation.
- Andrew Franks has begun research on this project for his PhD. Definition of floral architecture functional groups, measurement of floral characteristics and allocation of Declared Rare Flora (Threatened) taxa has begun.
- The relationship between fire and rarity in south-west Western Australia.
- Co-authored a review of the relationship between fire and rarity in south-west Western Australia.

Future directions

- Continue to supervise Marcelle Buist's PhD write up of research on the reproductive and ecological attributes of the rare *Acacia lobulata* and *Acacia sciophanes* and their common relatives *A. verricula* and *A. sciophanes*.
- Complete analysis of *V. staminosa* ssp. *staminosa* and *V. fimbrilepis* ssp. *fimbrilepis* research and write up.
- Continue to monitor the Fire Ecology of the Eastern Stirling Range Montane Heath and Thicket Community.
- Continue to co-supervise Andrew Franks and Landscape Fragmentation and Rare Plant Species: Can we develop a general framework of population responses?
- Complete field work on the ecological factors constraining population growth in the Critically Endangered *Calytrix breviseta* ssp. *breviseta*.

FORESTS AND TREE CROPS GROUP

Group Manager: Dr John McGrath

The impact of repeated defoliation on the wood growth of Jarrah saplings

RPP #24/86

Team Leader: Ian Abbott

Aims

To document stem growth and survival of annually 100%-defoliated versus undefoliated Jarrah ground coppice in a regenerating Jarrah coupe.

Summary of progress

Tasks Completed

- Fifteenth year of measurement completed.
- Treatment plants were defoliated and measurements were entered into database. This study is a scaled-down continuation of a study that commenced in 1987 and was published in 1993 by Abbott, I., Van Heurck, P. & Burbidge, T. 1993. Impact of frequency and intensity of defoliation on growth of Jarrah (*Eucalyptus marginata*): an experimental study with saplings. Forest Ecology and Management 56: 175-183.
- As expected, the repeatedly defoliated plants have virtually ceased growing; most plants remain alive and thus illustrate the resilience of Jarrah to extreme disturbance.

Invertebrate conservation in an urbanized landscape: The native earthworm fauna of the metropolitan sector of the Swan Coastal Plain and its representation in the conservation estate

SPP #93/21

Team Leader: Ian Abbott

Aims

To sample the earthworm fauna of the Perth metropolitan Swan Coastal Plain (SCP) to examine whether vegetation-based criteria are sufficient for identifying a conservation estate for native earthworms.

Summary of progress

Outcomes:

- Project completed and results reported in Wills, A. & Abbott, I. (in press) Distribution of the native earthworm fauna of the Perth metropolitan sector of the Swan Coastal Plain. Pacific Conservation Biology.
- Twenty one native species were collected from 136 sample localities. All 5 previously described native species from the region and 3 native species previously collected but not formally described were again collected, while 13 previously uncollected species were found. Species abundances of native earthworms were uneven, in common with species-abundance relationships for many other invertebrate assemblages, with 10 singleton occurrences of species and few common species. Species diversity increased away from the coast across the sandy geomorphic units Quindalup, Spearwood and Bassendean. Our study did not resolve whether differences in earthworm faunas

reflect the gradient in soil qualities across these units, gradients in species-area effects, habitat diversity effects or a combination of these.

- Blocks of remnant vegetation identified in the Western Australian Government's Bush Forever plan as containing natural areas of regional conservation value are also likely to support at least one native earthworm species. However, many of the blocks of remnant vegetation so identified are not within the formal conservation estate. Two species identified in this survey fortuitously persist only in remnant vegetation patches not considered regionally significant. Actual regional diversity was estimated to be 38 native species, indicating many uncollected relatively rare species. Although earthworms are a low diversity group compared with other invertebrates, the localized distributions of most species indicate that the formal conservation estate does not provide adequate protection. Ongoing degradation of unprotected remnant vegetation will result in extinctions of localized invertebrate species.

Control of Jarrah leafminer: Selective retention of JLM resistant trees and ground coppice in a demonstration forest plot

SPP #93/97

Team Leader: Ian Abbott

Aims

To provide a visual demonstration of improvement in stand health and productivity by management practices.

Summary of progress

- Tasks completed: A repeat of coppice removal on about a quarter of the original coupe area was carried out during spring 2001.
- Anticipated outcome: Demonstration that selective retention of Jarrah Leafminer resistant trees is not a practical silvicultural tool for stand improvement as there is little establishment of regenerating seedlings to provide recruitment of resistant regeneration. Leafminer populations 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 the population size of the insect.

Short-term logging and burning impacts on species richness, abundance and community structure of birds in open eucalypt forest in Western Australia

SPP #93/155

Team Leader: Ian Abbott

Aims

To examine the impact of these disturbances on the avifauna by monitoring species richness and abundance of birds one yr before logging, one yr before burning, and for 5 yrs after burning.

Summary of progress

- Project completed and results reported in Abbott. I., Mellican, A., Craig, M.D., Williams, M., Liddelow, G. & Wheeler, I. Short-term logging and burning impacts on species richness, abundance and community structure of bird species in open eucalypt forest in Western Australia (submitted to journal).

- In 1985 new silvicultural prescriptions for managing Jarrah (*Eucalyptus marginata*) forest in south-west Western Australia came into operation. The most extreme logging treatment (Gap release) involved removal of most of the overstorey from 10 ha patches, followed by a regeneration fire. Although 68 bird species were recorded during the 7 yrs of the study, 29 of these were detected fewer than 15 times. Of the other 39 bird species recorded, only 2 species (*Gerygone fusca* and *Acanthiza apicalis*) showed a statistically significant treatment effect over time on their abundance. The abundance of *G. fusca* initially declined in the disturbed treatments and by year 7 of the study (5 yrs post-fire) in the Gap release treatment had not recovered its original abundance. *A. apicalis* increased its abundance in both Shelterwood and Gap release treatments. By year 7 both species had similar abundances in all treatments. Total abundance of all species varied little across treatments. Species richness was greatest by year 7 in the Shelterwood and least in the Gap release treatment. Community structure varied between years more on the External reference sites (not recently logged or burnt) than on the Gap release sites, perhaps suggestive of the overriding importance of climatic variation relative to the logging and burning treatments applied.

Effects of timber harvesting on invertebrates in Jarrah forest (Kingston invertebrates study extended data collection)

SPP #94/07

Team Leader: Ian Abbott

Aims

This study, part of a broader integrated research program, examined the impact of these disturbances on more than 400 species of leaf litter arthropods captured in pitfall traps one yr before logging, one yr before burning, and 4 yrs after burning.

Summary of progress

- Outcomes: Project completed and extended results reported in Abbott, I., Burbidge, T., Strehlow, K., Mellican, A. & Wills, A. (in press). Impact of logging and burning on species richness and abundance of grasshoppers, cockroaches and spiders in Jarrah forest in Western Australia. Forest Ecology and Management.
- Most species of cockroaches (Blattodea), crickets and grasshoppers (Orthoptera), and spiders (Araneae) were resilient to logging and burning, and immediate decreases in species richness or total abundance were rapidly reversed. Changes in community structure caused by the imposed disturbances were also minimal or short-term. Community structure in both the treatment and control sites at the end of the study was different from that at the beginning of the study, perhaps indicative of the overriding importance of climatic variation.
- The results of this study have broader relevance to understanding the long-term resilience of forest ecosystems in south-west Western Australia. Because of the role of the taxa studied in mediating decomposition, herbivory and predation, these ecosystem processes appear to be robust to the logging and burning prescriptions applied.

Landscape and fire management interactions and their effects on distribution of invertebrate biodiversity

SPP #01/03

Team Leader: Ian Abbott

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 for invertebrates in the northern Jarrah forest.

Summary of progress

Tasks completed:

- Suitable sites in Helena vegetation units in the Helena and Serpentine River valleys were identified in Spring 2001.
- Pitfall traps were installed and opened for 10 days in November 2001.
- Trap contents were sorted to ordinal level during 2002.

BUGBASE, the DCLM database of its conservation terrestrial invertebrate collection

Core Function

Team Leader: Ian Abbott

Aims

To facilitate DCLM and public access to information held in the DCLM terrestrial invertebrate collection, managed by Science Division.

Summary of progress

Funding from the Gordon Reid Foundation for Conservation (administered by the Lotteries Commission of WA) has enabled electronic conversion of all records to proceed smoothly, with some 15 000 records databased.

Monitoring biodiversity in jarrah forest in south-west Western Australia: The FORESTCHECK initiative

Core Function

Team Leader: Ian Abbott

Aims

To explain the policy background, purpose, sampling design, methodology, and outcomes of a new integrated monitoring program.

Summary of progress

A paper by Abbott, I. & Burrows, N. has been submitted for publication in a book on forest fauna being edited by D. Lunney.

Precautionary forest management: a case study from Western Australian legislation, policies, management plans, codes of practice, and manuals from the period 1919-1999

Team Leader: Ian Abbott

Aims

To document the extent of precautionary forest management inherent in departmental documents, by locating and compiling definitive statements on 14 topics concerning the protection of forest values or precautionary forest practices.

Summary of progress

All available official policy documents (190) were examined. Statements from the 1920s onwards show a protective and prudential approach to conservation values within forest management. Strategic planning in forest management in WA has a strong precautionary foundation, well in advance of the formulation of the precautionary principle. A paper by Lee, K. & Abbott, I. has been submitted to a journal for publication.

Conservation of vertebrate fauna using hollows in forests of south-west Western Australia: strategic risk assessment in relation to ecology, policy, planning, and operations management

Team Leader: Ian Abbott

Aims

For the 42 vertebrate species use hollows in live standing trees in the forests of south-west Western Australia, to determine the reliance of each species on hollows in standing trees, assess the relative frequency of occurrence of suitable hollows (based on the size of hollow and hollow entry), and categorize each species by the size of their home range and their current dependence on publicly-owned forest.

Summary of progress

- Project completed and published: Abbott, I. & Whitford, K. 2002 Conservation of vertebrate fauna using hollows in forests of south-west Western Australia: strategic risk assessment in relation to ecology, policy, planning, and operations management. Pacific Conservation Biology 7: 240-255.
- No species was identified as being at high or immediate risk of decline. Eight species (6 bird, 2 mammal) were identified as excellent candidates for monitoring, with one species (*Trichosurus vulpecula*) most likely to provide the earliest indication of any critical reduction in the long-term supply of large hollows at small spatial scales.
- Past impacts of Aborigines and Europeans on populations of the larger species are likely to have been substantial, as these were hunted for food and trapped for fur. Hollow-using species are considered at present to be adequately safeguarded by: extensive areas of forest reserved from logging; science-based prescriptions mandating the retention of trees in Jarrah *Eucalyptus marginata* forest available for timber harvesting; a forest-wide baiting program to reduce predation by the introduced Red fox *Vulpes vulpes*; and a 70 yr tradition of adaptive forest management. The recovery of populations of medium-sized mammal species following control of foxes will provide an opportunity to re-assess the adequacy of current hollow-management strategies. Future research should include modelling of stand structure, determining the home range of priority species, and assessing the extent of overlap of home ranges. Monitoring of indicator hollow-using species should take place at landscape scales.

Karrak-watch: A summary of information about the Forest red-tailed black cockatoo of south-west Western Australia

Team Leader: Ian Abbott

Aims

To provide a home-page/website for an iconic forest-dependent species, based on a synthesis of all available, relevant information.

Summary of progress

Project completed and updated as new information becomes available. URL is http://www.naturebase.net/science/science.html

Biodiversity of canopy arthropods in Jarrah forest of south-west Western Australia: Review of ecological theory and conservation management

Team Leader: Ian Abbott

Aims

To contribute to the development of better theoretical understanding of the determinants of biodiversity of canopy arthropods in Jarrah forest.

Summary of Progress

- Project completed and published: Abbott, I. & Wills, A. Biodiversity of canopy arthropods in Jarrah forest of south-west Western Australia: Review of ecological theory and conservation management. Pacific Conservation Biology 7: 101-117.
- A theory proposed in 1996 by Recher, Majer &Ganesh linking biodiversity of forest canopy arthropods to site productivity was analysed. Available evidence from Jarrah *Eucalyptus marginata* forest is inconsistent with this model. We instead propose that increased habitat variety and temperature and rainfall clines are the major environmental factors that determine canopy arthropod species richness. Biodiversity gradients for mammal, landbird and reptile species across south-west Western Australia appear to provide an appropriate model for forest insect faunas. These gradients predict that the most diverse canopy fauna should occur in the eastern Jarrah and Wandoo forests.
- Precautionary forest management policies and procedures currently in place to conserve the poorly collected and inadequately known arthropod fauna of tree crowns in Jarrah forest are summarized and discussed. In essence, these maximize habitat diversity at landscape scales. Major conservation threats are considered to be factors that reduce leaf area at large spatial (*Phytophthora* infection) and temporal scales (summer wildfire and defoliating insect outbreaks). Logging is not considered significant because it is constrained to small spatial scales (10 ha for the most extreme treatment) and long return times (2-3 decades).

Subprogram 4 (woody germplasm) of the CRC for Plant-based Management of Dryland Salinity

Team Leader: John Bartle

Aims

To select and develop woody perennial germplasm for large scale, commercially viable industries within southern Australian land use systems.

Summary of progress

- The salinity CRC has just completed its first year of operation.
- Progress in capturing a return for the commitment of DCLM resources has so far been poor. This appears to be due to the fact that DCLM is so well advanced in woody germplasm development that the dominant consideration across the CRC as a whole has been to lift the involvement of other states in this area. Hence the current approved SP4 projects (Florasearch, salt tolerant germplasm, species testing) have only a minor role for DCLM in terms of funds flowing in. On the other hand DCLM has made a major contribution to identification of woody crop R&D targets nationwide. For example, mallee production system design and performance has attracted considerable R&D funds in other Subprogram areas. This contribution is well recognized by CRC management as is the present poor return to DCLM.

Future directions

- The main aim for DCLM within SP4 is to capture a significant role in the research and development that will flow from Search and Florasearch.
- The conclusion of the Search Project over the next several months should provide significant new priority R&D targets. DCLM has the option to consider withdrawal from the CRC. This may be satisfying but it would sacrifice an opportunity to continue to influence the agricultural research agenda in an area of vital importance to DCLM.

Mallee Genetic Improvement Program

Team Leader: John Bartle

Aims

To provide the oil mallee industry with genetically improved planting material.

Summary of progress

Approx 20 000 native trees of 4 taxa tested for oil content, currently 36 progeny trials of 4 taxa across 7 locations containing a breeding population of some 100 000 individuals, with 20% converted to seed orchards. Seed sales revenue ~ $50 000/yr.

Relevant publications

- Byrne, M (1999). High genetic identities between three oil mallee taxa, *E. kochii* ssp *kochii*, ssp *plenissima* and *E. horistes*, based on nuclear RFLP analysis Heredity 82, 205- 211.
- Hines, B. and Byrne, M (2001). Genetic differentiation between mallee and tree forms in the *Eucalyptus loxophleba* complex. Heredity 87, 566- 572.
- Bartle, J., Edgecombe, W. and Brennan, G., 1999. Western Australian program for the selection and development of new tree crops. In National Low Rainfall Tree Improvement Workshop Proceedings, Conference held at Woodhouse Rymill Conference Centre, Adelaide 3-5 November 1998, RIRDC Joint Venture Agroforestry Program, pp 34-39.

Summary of progress:

- Breeding and seed production programs have been established for 4 taxa:
    - The oleosa group i.e. *E. horistes*, *E. kochii* ssp *kochii* and *E. kochii* ss. *plenissima* widely distributed in the central and northern Wheatbelt and adjacent pastoral areas.
    - *E. angustissima*, south coastal region from Ravensthorpe to Israelite Bay.
    - The York gum group i.e. *E. loxophleba* ssp *lissophloia* and *E. loxophleba* ssp *gratiae* from the central and southern Wheatbelt and adjacent pastoral regions.

- *E. polybractea*, Blue-leaved mallee currently native to and commercially used in NSW and Victoria.

- Extensive collection of germplasm from across the full range of each taxon is ongoing, currently have database of c 20 000 native trees of 4 taxa (location, oil content). These trees provide seed for operational planting plus elite family collections for progeny testing. Multiple progeny trials have been established throughout the wheatbelt to test the performance of elite families. The program commenced in 1993 and each year since new progeny trials incorporating the best families available have been established. There are currently 36 trials of the 4 taxa across 7 locations containing a breeding population of some 100 000 individuals.
- Progeny assessments commenced in 1998, with leaf oil content (in particular cineole) and vigour assessed. Breeding values are calculated for individual trees and families, and culling plans produced. All progeny trials established between 1993 and 1995, and some established in 1996 and 1998, have been culled to become open pollinated seed orchards. Seed orchard seed is now available and it will constitute some 50% of seed sold in 2002.

Future directions

- The mallee breeding program has some key decisions to make in the next 2 years:
    - Completion of performance testing and culling for the remaining 70% of the progeny trials will be an investment of about $1 million. There will be no need to do this unless the industry 'takes-off' commercially and we can see substantial seed demand emerging.
    - If the industry does 'take-off' it will be able to invest in the next stage of intensification of breeding, i.e. clonal seed orchards and development of a second generation breeding population. DCLM should be able to attract industry investment to help undertake this work.
- The Oil Mallee Association has been an active collaborator in development of the mallee breeding program and DCLM must make the move to formally recognize this shared interest.

Selection and development of multiple purpose species for large-scale revegetation ('Seed Project'). Natural Heritage Trust Project No 973849

Team Leader: John Bartle

Aims

- Search: develop a search procedure that systematically analyses plant and product attributes and objectively identifies best prospects for development.
- Pre-feasibility investigation: assemble technical, economic, biodiversity and other information to select and rank a shortlist of the 12 most prospective species for development.
- Industry exploration:
    - establish a preliminary selection of best bets as demonstration trials.
    - plan and commence building industries, in particular, build a viable resource utilizing best practice and planting design for prospects identified in 1 and 2.

Summary of progress

- To be completed in 2002/2003. Now recognized as an important direction for R&D and promoted nationally by the CRC for Plant-based Management of Salinity and the Rural Industries R&D Corporation. Relevant publications are:
    - Bartle, J.R. (2001). New perennial crops: mallee eucalypts, a model large-scale perennial crop for the wheatbelt. In Managing Agricultural Resources 3 Proceedings pp. 117–128. Outlook Conference, 27 Feb -1 March 2001, National Convention Centre, ABARE Canberra.

- Bartle, J.R., Cooper, D., Olsen, G. and Carslake, J. (in press). Acacia species as large-scale crop plants in the Western Australian Wheatbelt. Conservation Science WA.

- The project consists of 2 main sections. Objectives 1 and 2 have completed analysis of the native flora of the southwest to identify initial best prospects for commercial development. The best prospects are now being subject to laboratory analysis of wood and other attributes to more sharply specify commercial potential.
- Objective 3 consists of extensive species/provenance performance testing and sponsors large scale planting of prospective commercial species by farmers with a view to exploring performance on the farm. Some 60 field trials have been established in 2001 and 2002, and 2 million Melaleuca planted on farms during 2002.

Future directions

- The project will conclude in the current financial year with final analysis and reporting on product potential, the completion of several new performance testing trials and the planting of 3.5 million seedlings of some 20 of the 'best bet' species with commercial development potential.
- Although this project terminates next year it has stimulated an array of projects within the CRC and RIRDC. CRC Subprogram 4 has commenced a national scale search project called Florasearch and a national species testing project. These new projects have been designed to continue the work commenced by the Search Project.
- Search aims to generate opportunities for development of new commercial tree crops for agriculture. A major future direction is to develop state and national plans for new industry development with a view to coordinating the difficult pre-commercial stage of new industries, when capital is scarce, cohesive proposals for funds are essential and duplication/competition mitigates against success.

Mallee Industry Development

Team Leader: John Bartle

Aims

To foster mallee industry development.

Summary of progress

- Over a period of more than a decade DCLM has invested some $6 million in development of the mallee industry. In the past few years DCLM has reduced its involvement as the Oil Mallee Association and the Oil Mallee Company took the reins of industry development. DCLM's contribution is now almost entirely confined to providing leadership in R&D. DCLM runs the breeding and seed production program (see separate Project statement) and leads most other aspects of mallee crop production R&D.

Recent publications

- Bartle, J.R. and Shea S.R. (2002). Development of mallee as a large-scale crop for the wheatbelt of WA. Proceedings Australian Forest Growers 2002 National Conference. Private Forestry – Sustainable, Accountable and Profitable. 13 to 16 October 2002 Albany WA pp 243 – 250.
- Enecon (2001). Integrated Tree Processing of Mallee Eucalypts. A report for the Joint Venture Agroforestry Program. Publication number 01/160, Project OIL-3A. Rural Industries Research and Development Corporation, Canberra.
- Wildy, D.T. and Pate, J.S., 2002. Quantifying above and below ground growth responses to the Western Australian oil mallee, *Eucalyptus kochii* subsp. *plenissima*, to contrasting decapitation regimes. Annals of Botany 90: 185-197.

- Farmers have been actively planting mallee since 1994 and there are now more than 23 million seedlings (8750 ha) planted. This long period of exploration of the mallee prospect has attracted some 1000 growers and a committed, farmer-controlled business structure. This body of knowledge and resource was sufficient to attract investment from Western Power Corporation and RIRDC to do a full feasibility investigation. DCLM, OMC and Enecon proposed and conducted this investigation in 1999/2000. The outcome showed that an 'integrated mallee processing' (IMP) plant, based on paying a competitive price for the mallee feedstock, and concurrently producing activated carbon, electricity and eucalyptus oil, could be commercially viable.
- The outcome of this investigation is that Western Power has commenced construction of a demonstration scale plant costing $6 million at Narrogin. This will show on an operational scale whether the commercial performance predicted in the feasibility study can be achieved.
- The mallee development involves all new enterprise from production, processing to marketing. It has been extremely difficult to raise sufficient funds to invest at the desirable level in all areas. The current major deficiencies are harvest technology, products and marketing and mallee growth modeling. DCLM has a priority position as the R&D service provider to the industry.
- The OMC has just announced that it has attracted a Japanese power company to invest in mallee as a carbon sink. Their start-up project is 1000 ha of mallee planting. This project adds to the commercial momentum of mallee.

Future directions

If the demonstration IMP plant shows that the process is operationally feasible then there is scope for construction of some 9 full scale IMP plants at a cost of more than $400 million, including the 10 000 ha mallee resource base required for each plant. Also the initial carbon sink project could burgeon into very large scale planting if Australia decides to ratify the Kyoto Protocol.

The IMP development alone should be enough to stimulate a major escalation in mallee and other tree crop R&D. DCLM is well placed to become a major R&D services supplier to mallee industry and other emerging tree crop industries.

Field ecology of the Western Australian Sandalwood (*Santalum spicatum*) and the impact of land management activities on sandalwood regeneration

SPP #96/06

Team Leader: John Brand

Aims

To examine factors affecting sandalwood recruitment and determine the influence of landforms on sandalwood density.

Summary of progress

(1) In October 2001, sandalwood recruitment trials were measured on Ninghan, Burnerbinmah and Thundelarra stations.

- The data from these trials has been entered onto spreadsheets with some initial analysis of growth data.
- During Nov 2001 – May 2002, 8 new recruitment plots were established on Gindalbie station, near Kalgoorlie.
- A report was also written on regeneration trials at Shark Bay:
- Ryan, P,C. and Brand, J.E. (2002). Sandalwood (*Santalum spicatum*) coppice regeneration and seedling survival near Shark Bay, Western Australia. Sandalwood Research Newsletter 15: 4-7.

(2) Work completed on analysis of sandalwood density and age/size structure on 4 stations in the north-eastern goldfields.

- Brand, J. E. and Jones, P.J. (2002). The influence of landforms on sandalwood (*Santalum spicatum*) size structure and density in the north-eastern Goldfields, Western Australia. The Rangeland Journal 24: (in press).
- At present, natural recruitment of *S. spicatum* is generally low in the semi-arid regions (mean annual rainfall < 250 mm) of Western Australia. In 1996-97, a detailed assessment *S. spicatum* near Paynes Find showed that less than 2 % of the *S. spicatum* surveyed had stem diameters less than 60 mm. In these semi-arid regions, *S. spicatum* stem diameters increase only 1-2 mm yr $^{-1}$. Therefore, there has been very little successful recruitment in this region for 30-60 yrs. Recruitment levels were higher near Menzies, with 26-34 % of *S. spicatum* with stem diameters less than 60 mm.
- During 1996-97, a series of recruitment trials were established on Ninghan, Burnerbinmah and Thundelarra near Paynes Find, and on Goongarrie and Jeedamya near Menzies. These trials are examining factors affecting sandalwood recruitment: grazing, seed dispersal, harvesting, host species and landform. These trials have shown that poor seed dispersal and heavy grazing appear to be the 2 most important factors preventing *S. spicatum* recruitment. Planting seeds near suitable host species and excluding grazing has resulted in greater seed germination and survival.
- In 2001-2002, 8 new recruitment trial plots were established on Gindalbie station, near Kalgoorlie.

Future directions

- In 2002-2003 a new set of recruitment plots will be established on a station near Mt Magnet. These trials will be a duplication of those established on Gindalbie in 2001/2002.
- Existing trials will be monitored.

Establishment and growth of sandalwood (*Santalum spicatum*) in south-western Australia

SPP #98/02

Team Leader: John Brand

Aims

- To examine the influence of host species and parasite-to-host ratios on *S. spicatum* performance.
- To identify superior provenances of Acacia acuminata that improve *S. spicatum* performance.
- To identify *S. spicatum* provenances with desirable plantation characteristics, such as fast growth and high oil content.

Summary of progress

- In May 2002, *S. spicatum* seeds were planted near A. acuminata provenance trials at 2 separate sites – Dowerin and Morawa. Trials at 10 separate sites in the Wheatbelt were measured during May-August 2002. A conference paper was presented at the Dalwallinu Acacia Symposium in July 2001.
- A paper has also been submitted in the proceedings:
  - Brand, J.E. (2002). Review of the influence of Acacia species on sandalwood (*Santalum spicatum*) establishment in Western Australia. Proceedings of the Dalwallinu Acacia Symposium, 13-14 July 2001, Dalwallinu, Western Australia (in press).
- A new *A. acuminata* / *A. saligna* trial was established at Quairading and Beverley in 2002.

- A chapter has also been written on sandalwood research in the 'Wildlife Management Plan – *Santalum spicatum*, Department of Conservation and Land Management, 2002/3.
- Direct seeding *S. spicatum* near 1-2 yr-old Acacia acuminata seedlings has proven to be a successful establishment technique. Mean *S. spicatum* stem diameters are increasing at up to 10 mm yr^{-1} (at 150 mm) near *A. acuminata* in plantations. Current trials are examining methods to further improve *S. spicatum* performance by examining the effects of different host species, parasite-to-host ratios and provenances.
- Since 1993, *S. spicatum* has been planted near a range of different potential host species, including *Acacia acuminata*, *A. saligna*, *A. microbotrya*, *A. aneura*, *A. hemiteles*, *A. pruinocarpa*, *A. resinomarginea* and *Allocasuarina huegeliana*. Fastest *S. spicatum* growth has occurred near *A. saligna* and *A. acuminata*. In a trial at Dandaragan, the mean stem diameter of *S. spicatum* near *A. saligna* was 59 mm at age only 3 yrs.
- Provenance trials have also been established to look at variation within *S. spicatum* and one of the preferred hosts – *A. acuminata*. *S. spicatum* seeds from different locations in the state have been planted together in trials to identify superior forms. The *A. acuminata* group consists of 7 different types and these have also been planted together at 2 separate locations to determine whether *A. acuminata* type affects *S. spicatum* performance.

Future directions

- Another *A. acuminata* / *A. saligna* host combination trial will be established at Beverley in July 2003.
- In Nov 2002, *S. spicatum* germination near *A. acuminata* provenances will be assessed at Morawa and Dowerin.
- In January/February 2003, *S. spicatum* seeds will be collected from 40-50 parent trees and 7 provenances in the Wheatbelt. These seeds will be planted at provenance trials at Quairading and Dowerin in April 2003.
- New trial plots will be established with FPC Sharefarms in 2003. Existing trials will be monitored.

Short-term effects of fire and logging on floristic composition and structure of Jarrah forest vegetation

SPP #93/98

Team Leader: Bruce Ward

Aims

To investigate the impacts of gap and shelterwood silvicultural systems on the floristic composition and structure of Jarrah forest understorey.

Summary of progress

- Project completed in 2001 and results published in Australian Forestry.
- Key findings were that in the short-term, logging does not cause any loss of plant species at the coupe scale, but results in a reduction in the abundance of native plants, especially geophytes.
- Management recommendations have been incorporated into new silvicultural guidelines.
- Study sites now form part of the FORESTCHECK monitoring program.

Future directions

- Fieldwork completed.
- Further analysis and write-up of structural changes in vegetation.

Fire regime effects on the structure and floristics of Jarrah forests

SPP #93/99

Team Leader: Bruce Ward

Aims

To investigate and monitor the long-term impacts of 4 fire regimes on the floristic composition and structure of upland Jarrah forest understorey vegetation.

Summary of progress

This is a long-term investigation, which commenced at Boundary Rd, Lindsay forest (near Manjimup) in 1970. Other sites were established in McCorkill forest (near Nannup) and Yendicup forest (Perup) in 1985. Treatments are maintained and plots assessed about every 3 yrs. Detailed information about regeneration response and juvenile period has been gathered. In addition, the long-term effects of various regimes on floristic composition and abundance has been analysed but is yet to be fully reported. A progress report was presented at the Fire Symposium held in Perth, April 2002. A paper will be published in a book that, in part, summarizes knowledge of fire and vegetation in south-west Australian ecosystems. Findings have been incorporated into operational forest fire management planning to devise fire regimes for biodiversity conservation.

Future directions

Project is ongoing. Further analysis and write-up of findings over the next 2 yrs. Fire treatments will be maintained at all sites with assessment every 3 yrs.

Genetics and molecular biology of tree species

SPP #98/07

Team Leader: Margaret Byrne

Aims

To provide genetic information for the conservation and utilization of tree species. Current work aims to identify the genetic entities in *Melaleuca uncinata*, *Acacia microbotrya* and *A. saligna*; determine the genetic diversity and structuring in *Santalum spicatum*, *E. occidentalis* and *E. cladocalyx*; determine the degree of genetic differentiation between species in the *E. angustissima* complex; determine the level of diversity captured in trials of *Pinus brutia*; and develop microsatellite markers in *P. pinaster*.

Summary of progress

- *M. uncinata* – Taxonomic assessment of the complex has identified 11 taxa which will be described as species. Data analysis of genetic assays of populations from 7 of these taxa showed that they were genetically differentiated from each other.
- *E. angustisima* – Analysis of the taxa in the complex with RFLP loci has confirmed their genetic distinctness. The 2 subspecies of *E. angustissima* were the most divergent of the taxa reflecting species rather than subspecies status. Contrary to morphological similarities *E. angustissima* spp. *angustissima* and *E. misella* were the most genetically similar taxa.
- *S. spicatum* – Sandalwood has moderate levels of genetic diversity with a significant level of differentiation between the populations. The wheatbelt and rangelands regions did not show differentiation but there is evidence of different genetic processes occurring between the regions. The rangelands populations have higher level of diversity and higher levels of geneflow than the wheatbelt populations and showed an equilibrium between gene flow and drift.

- *A. microbotrya* – Leaf material was collected from 25 populations and DNA extracted. Genetic analysis of the populations is being carried out with RFLP markers.
- *E. occidentalis* – Genetic analysis showed that the level of diversity in *E. occidentalis* was moderate compared to other Western Australian eucalypts. The level of diversity was not significantly different between populations although there was a trend towards lower diversity and higher differentiation in populations in the eastern end of the range. There was no evidence of historical inbreeding in the populations even though they are small.
- *E. cladocalyx* – Seed for 7 populations was obtained and grown. Leaf material has been collected from the seedlings and DNA extractions have been carried out. The populations will be assayed for differentiation with microsatellite loci.
- *P. brutia* – Genetic diversity of trees from plantings in WA and SA are being assayed using AFLP markers.
- *P. pinaster* – An international consortium has been established and a genomic library enriched for microsatellite sequences has been made.

Future directions

- Reports and journal papers will be written for *M. uncinata*, *E. angustissima*, *S. spicatum* and *E. occidentalis*. Laboratory work and analysis on *A. microborya*, *E. cladocalyx*, and *P. brutia* will be completed. Sequencing of P. pinaster clones will be carried out.
- *A. saligna* – The level of diversity and pattern of genetic structuring will be assessed in conjunction with taxonomic assessment. RFLP markers will be assayed in 30 populations from throughout the range of the complex.

Early rotation nutrition of *E. globulus* in the south-west of WA

SPP #93/128

Team Leader: Ian Dumbrell

Aims

To determine responses in tree growth and nutrient status to different rates of pre-plant trace element fertilizer applications. Compare differences between surface application and soil incorporated applications of blended fertilizers.

Summary of progress

- One experiment that is examining growth responses to trace element applications on newly cleared land has been in place for 2 yrs. Height measurements and foliage samples have been collected quarterly and will continue for at least another year. Preliminary data analysis has been done for the first 2 yrs height growth. Foliar analysis data are incomplete at this stage.
- Second experiment examining the efficacy of a range of slow release fertilizers on survival and growth of second rotation trees was initiated in August this year. Survival will be determined after 3 and 6 months and heights measured annually for 2 yrs.
- Experiment 1 - Some significant differences are beginning to appear between trace element fertilizer rate treatments in respect to tree height but too early to draw any conclusions. There appears to be no difference between surface application and soil incorporated fertilizer treatments at the same site.
- No results are available yet from the second experiment.

Future directions

- Experiment 1 - Continue quarterly measurements and foliar sampling. This experiment is essential to gain further knowledge on the trace element nutrition requirements of *E. globulus*. The response to varying rates of trace elements and modes of application on newly cleared acid peat soil will provide valuable information for prescribing fertilizer requirements in the future.
- Experiment 2 – Assess survival and growth over the first year. The best performing slow release fertilizer will then be used in a new experiment to compare various forms of fertilizer applications on second rotation *E. globulus* sites.

Mid rotation thinning and fertilization in pines

SPP #93/140

Team Leader: Ian Dumbrell

Aims

This project encompasses a range of experiments directed towards understanding and optimising mid-rotation nutrition, water-use and growth of pines within the high rainfall zone (>600 mm).

Objectives:

- Determine the response of *P. radiata* and *P. pinaster* to thinning and fertilization separately and in combination and thus describe the interactions involved.
- Determine seasonal patterns of growth and water use of these species.
- Determine if these responses vary between sites in south-west Western Australia.
- Determine responses to varying rates of nitrogen and phosphorus separately and in combination for both *P. radiata* and *P. pinaster*.
- Determine effects of nutrient supply and growth rate on wood quality in both *P. radiata* and *P. pinaster*.

Summary of progress

- There are currently 2 experiments being actively managed and 4 with an observational status.
- Active experiments - A post first thinning rates of N and application timing experiment in *P. radiata* was concluded with a final measurement and comprehensive stem analysis and biomass study. These results are currently being analysed prior to publication. The site received a second thinning and the experiment was remodelled to take it through to the end of rotation.
- Annual measurements of a post first thinning NxP interaction experiment in *P. pinaster* on the Swan Coastal Plain will continue for at least one more year. Inputs to this experiment are minimal.
- Some preliminary results from the biomass study of the rates of N experiment show a strong relationship between volume and above ground biomass with no differences between treatments. Neither were there noticeable differences between treatments when regressing canopy biomass (fresh or dry) as a percentage of the total above ground biomass against of total above ground biomass. Taper within different sections of the sampled trees appeared to be affected by size of the tree, again treatment differences were not noticeable.
- This plantation (including half of the trial plots) has just received its second thinning. In the modified experiment half of the plots have been thinned to 250 sph and half remaining unthinned (450 sph). Reapplication of the N rates was done in September 2002. This modification will investigate whether significant gains from fertilization can be made late in the rotation and whether greater timber volume can be produced by maintaining higher stocking rates late in the rotation.

- The *P. pinaster* NxP interaction experiment is showing some interesting preliminary results. From other experiments in early rotation nutrition of *P. pinaster* phosphorus is the key element to (height) growth while nitrogen appears to have little to no influence at all. In this mid-rotation trial, neither nitrogen nor phosphorus appeared to influence height growth, however there is now a significant influence of nitrogen on diameter, and subsequently, basal area growth.

Future directions

- Continue annual measurements and sampling in the NxP interaction trial.
- Analyse data from biomass study.
- Complete nutrient analysis of biomass samples.
- Complete carbon analysis of biomass samples.
- Relate Above and below ground biomass partitioning to carbon sequestered (with P Ritson).
- Continue annual measurements at Vasse 9 nitrogen trial.
- Report to Greenhouse CRC on the effects of nitrogen applications in *P. radiata* plantations on tree growth, biomass partitioning and carbon sequestration.

Early rotation silviculture for second rotation pines on the Swan Coastal Plain

SPP #97/04

Team Leader: Ian Dumbrell

Aims

To determine the effect of total weed control and broadscale fertilization on tree growth and survival compared to standard strip weed control and spot fertilization during the first years of the second rotation. The experiment also aimed to determine any differences in tree growth and survival between *P. radiata* and *P. pinaster* on similar sites with the same treatments.

Summary of progress

This experiment has now concluded. Results were presented at the '13th Australian Weeds Conference' in Perth, Sept 2002, and published in the conference proceedings.

Initial broadscale herbicide applications and subsequent spot applications were effective in maintaining the weed control plots weed-free for the duration of the experiment. Survival was reduced in both the *P. radiata* and *P. pinaster* when only partial (strip) weed control was used. After 4 yrs mean survival in the total weed control treatment was 95% for *P. radiata* and 92% for *P. pinaster*, while in the strip weed control treatment it was 43% and 75% respectively. The broadscale application of fertilizer had no effect on survival for either species. Height growth was reduced in the absence of complete weed control for both *P. radiata* and *P. pinaster*. The broadscale application of fertilizer had no effect on height growth for either species. The significant decreases in both survival and height growth in the absence of complete weed control and the lack of response to fertilizer for both species indicated that competition from weeds early in the second rotation was mainly for water.

Growth, nutrition and water use of mid-rotation *Pinus pinaster* in the medium rainfall zone

SPP #2000/16

Team Leader: Ian Dumbrell

Aims

To manipulate existing mid-rotation stands of *P. pinaster* through thinning and fertilization and gauge growth responses, water-use and soil water depletion/recharge characteristics both annually and seasonally over a number of years.

Summary of progress

- This experiment was established in 1997 and replicated on 3 sites within the 400 – 600 mm rainfall zone of WA. These sites were on Wood's property at Dandaragan (30.33° S, 115.8°3 E), Murray's property at Wickepin (32.78° S, 117.50° E) and Howard's property at South Stirlings (34.40° S, 118.10 °E).
- Intensive monthly measurements completed in August 2002.
- Final leaf area data to be collected.
- Preliminary data analysis has been completed. Further data analysis and publishing of results to be commenced in the coming year.
- A fourth site at Wickepin planted to *P. radiata* was thinned and fertilized and has been monitored since 1999. Monthly pre-dawn needle water potential, soil moisture and diameter growth measurements will be continued for at least another year.
- Plantation productivity is strongly linked to water availability.
- Both average annual rainfall and Climate Wetness Index are good predictors of plantation productivity. In the medium rainfall zone (400 – 600 mm) average annual rainfall is the most important variable.
- *Pinus pinaster* is effective in controlling soil water recharge, depleting stored soil water and lowering water tables even at 250 sph.
- *Pinus pinaster* is effective in extracting water from both sand and clay soil profiles in duplex soils.
- First rotation growth is being supplemented by stored soil water. The consequences are lowered productivity on the same site in subsequent rotations.
- Fertilizer responses have been small due to overall limitation on growth by water availability.
- To date there has been no response to fertilizer applications however there has been a positive response to thinning. With the 2001 and 2002 winters being dry, the plantation, particularly the 500 stems ha^{-1}, has become drought stressed with some deaths noted. Tree canopies are sparse and pale in colour. Water availability is the limiting factor here and stand survival is of concern.

Comparative use of mineral fertilizers and biosolids on the growth and nutrition of pines on the coastal sand plain

SPP #2000/17

Team Leader: Ian Dumbrell

Aims

The objectives of the experiment are to:

1. Determine the growth response of *P. pinaster* to biosolids
2. Assess the value of biosolids as a fertilizer replacement in plantations
3. Assess the potential for movement of nutrients and heavy metals from the applied biosolids into the soil and groundwater compared to background levels and current fertilizer practice

4. Determine the operational constraints and economic feasibility of biosolids application to plantations on the Swan Coastal Plain.

Summary of progress

- Joint trial with the Water Corporation of WA (which ran for 3 yrs) was completed in August 2001. Annual growth measurements, foliage and water sampling will continue until growth increments are not significantly different to the control (DCLM/FPC project).
- Results from the 3 yr trial were delivered to the "Biosolids Specialty Conference" Sydney June 2002 and will be presented at the Ozwater 2003 conference in Perth. Papers (refereed) prepared for publication in both conference proceedings.
- Currently preparing a final report for the Water Corporation to be presented to the Water and Rivers Commission and the Department of Environmental Protection.
- Results to date suggest that biosolids can deliver significant growth increases above that of mineral fertilizers through continual mineralization of essential elements. The longevity of the increased growth is yet to be determined.
- Environmentally the results are promising. Contamination of the groundwater has not occurred, there appears to be no movement of nutrients or heavy metals through the soil profile and there has been no trace of pesticides.
- The 3 major constraints of cost, storage, and time need to be addressed to improve biosolids as an operationally viable alternative to mineral fertilizer. Water Corporation have indicated they will meet all the costs involved in supplying, carting and spreading, for the foreseeable future.

Future directions

- The results of this trial will be used to demonstrate the suitability of biosolids application to plantations and that in so doing does not pose a threat to the environment. The end result is to refine biosolids application guidelines in plantations and facilitate future application approvals.
- A second trial in the same area using *P. radiata* is planned for 2003. It is intended to link this future trial with the current 'National Biosolids Research Program'.

Early rotation nutrition and silviculture of *Pinus pinaster* on ex-farmland

SPP #2000/18

Team Leader: Ian Dumbrell

Aims

This project is comprised of 7 experiments with their own specific aims. The overall aim however, is to be able to optimise early growth of *P. pinaster* by quantifying critical foliar and soil nutrient concentrations, diagnosis and correction of nutrient deficiencies, and determining the causes and correction of poor stem form.

Summary of progress

- All experiments are currently being monitored, 2 on a monthly basis and the remaining 5 on an annual basis. The first of these experiments established was and NPK interaction experiment replicated on 3 different sites. The experiment initially ran for 3 yrs and results from this phase have been submitted to Australian Forestry for publication. One of the sites (Talwyn – ex-bush) has been modified to look at the effects of nitrogen re-application.
- Dumbrell, I.C. and McGrath, J.F. "Growth and nutrient relationships of juvenile *Pinus pinaster* grown on ex-farmland in Western Australia". Submitted to Australian Forestry. Results from both rates of P experiments will be written up together at the completion of the second experiment. Phosphorus is

known to be the critical element required by *P. pinaster* for early growth. The adequate foliar concentration of phosphorus was defined as 0.07%. No response (or in some cases a negative response) to applications of N or K early in the rotation have been shown for *P. pinaster*. The lack of consistent response to P rates may be due to the existing concentrations of available P in the soil. The mean initial concentration of available P at this site was only 1.45 mg kg^{-1} which, at the inception of the experiment, was considered deficient and likely to elicit a response to applied P. Subsequent results from the NPK interaction experiment north of Perth, showed that concentrations as low as 0.75 mg kg^{-1} available P was all that was needed for adequate early growth of *P. pinaster*.

- Foliar applications of Mn have increased both foliar concentrations of Mn and increased height growth. This data has not yet been analysed to determine the significance of the increases.
- Fertilizer prescriptions for establishment and early rotation *P. pinaster* on farmland have been developed for inclusion in the FPC field manual. Results from a Spot vs Broadcast fertilizer experiment; have shown no difference in height growth between any of the treatments after 3 yrs. The best performing treatments are the 60g spot application (10.5 g P/tree) and the 600 kg ha^{-1} broadcast application (70 g P/tree), which are the 2 extreme fertilizer applications.
- At the spacing trials; very early stages of the experiment. No significant differences in height or survival to date. Too early to assess form.

Quantitative population monitoring of Gumleaf skeletonizer (GLS, *Uraba lugens*)

SPP #93/103

Team Leader: Janet Farr

Aims

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

Summary of progress

- Field work completed.
- The biology of GLS has now been published: Farr, JD. (2002). Biology of the Gumleaf Skeletonizer (*Uraba lugens* Walker: Lepidoptera, Noctuidae) in the southern Jarrah forest of Western Australia. Aust. J. Entomology 41: 60-69. Data on population levels (using a cherry picker) yet to be incorporated into a publication.
- The biology of *Uraba lugens* (Gumleaf skeletonizer, GLS) in the southern Jarrah forest of Western Australia is examined with respect to (1) distribution of egg rafts in the host canopy; (2) survival on different food plants; (3) phenology; (4) mortality and (5) fecundity. No preference for height was found for oviposition within the Jarrah (*Eucalyptus marginata* Donn ex Smith) canopy. Both Jarrah and Marri (*Corymbia calophylla* (Lindl.) K.D. Hill and L.A.S. Johnson) were intermediate to poor hosts within the host range for GLS compared with more preferred hosts from eastern Australia. A simulation model, used to determine phenology, showed GLS to be bivoltine in Perth and univoltine in the southern Jarrah forest near Manjimup, with capacity for the univoltine form to change to a bivoltine cycle following 2 consecutive warm winters. Six parasitoids were isolated from southwest Western Australian populations. The eupholid *Euplectrus* sp. and an unknown mortality agent were the predominant causes of population decline in 1988 following the 1982-88 outbreak. Fecundities were significantly different between the outbreak and non-outbreak periods. Furthermore, fecundity for the southern Jarrah forest population was significantly higher than measured fecundities of the bivoltine South Australian population.

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

SPP #93/104

Team Leader: Janet Farr

Aims

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

Summary of progress

- Fieldwork completed, manuscript near completion subject to finalization of fire distribution maps. Manuscript title: Spatial analysis of a *Uraba lugens* Walker (Lepidoptera: Noctuidae) outbreak in the southwest of Western Australia: Does logging, vegetation type or fire influence outbreaks? Manuscript will be completed by Dec 2002. Anticipate publication in 2003.
- Gum leaf skeletonizer (GLS, *Uraba lugens* Walker) went into outbreak in the southern Jarrah forest in 1982-1988. Aerial and observational survey data were used to incorporate a Geographic Information System (GIS) analysis on the possible impact of forest management practices on this insect. In addition, this allowed investigation into the influence of vegetation type on GLS distribution. A total area of 6.7 million ha was interrogated, including 89,900 ha of land infested with GLS. Results showed that neither logging nor prescribed burning induced increases in GLS populations. However a decrease in area infested with GLS was indicated for prescribed burning up to 3 yrs prior to the outbreak. Interrogation of vegetation complexes indicated that the GLS outbreak was initiated on marginal Jarrah on poorly drained sites which are prone to inundation in winter and drought in summer. In addition, 2-generation per year GLS populations were discovered on the fringes of the southern Jarrah forest during the observational surveys. This supports the hypothesis that 2-generation per year GLS were more prevalent in the southern Jarrah forest during the outbreak as opposed to single generation GLS during non-outbreak periods.

Biology of the new psyllid *Cardiaspina jerramungae* in the lower great southern of WA on Flat-topped yate

Team Leader: Janet Farr

Aims

To understand the biology and population dynamics of this new outbreaking psyllid.

Summary of progress

- Field work completed.
- Data validated and analysed.
- Life tables for 1989-1993 incorporating 14 generations, completed.
- Manuscript in preparation.

Pest incursion of *Cardiaspina fiscella* in WA

Team Leader: Janet Farr

Aims

Continued vigilance for introduction of potential new forest (tree) pests to WA.

Summary of progress

- The psyllid *Cardiaspina fiscella* was first discovered in Albany, in a *Eucalyptus robusta* plantation on Hanrahan Rd. CSIRO Canberra confirmed the psyllid's identity on 6 Nov 2001. Subsequently, populations have been found in Yarloop on *E. botryoides* (an amenity tree in a park at the south end of the old Yarloop work shops) on 7 Nov 2001, and on amenity trees (*E. botryoides*) at the University of Western Australia research station at Floreat on 11 Nov 2001. All populations were at high levels. Prior to Nov 2001 there was no record of *C. fiscella* in Agriculture WA, Department of Conservation and Land Management, Western Australian Museum and ANIC collections (all collections consulted).
- *A. fiscella* is endemic to Queensland NSW and Victoria and is known as an outbreaking species. Its hosts include *E. botryoides*, *E. grandis*, *E. robusta*, and *E. saligna*. To date the psyllid has not been found on endemic WA eucalypts. However, considering this insect's host preferences, *E. diversicolor* and *E. rudis* are potential hosts.
- At a Forest Health Advisory Committee (FHAC) meeting on 12 Nov 2001 it was decided the psyllid is well distributed throughout the south west of Western Australia and an eradication programme was therefore not warranted. No current work is being done on the psyllid in WA.

Essigella californica (a new pest in pine) population monitoring

Team Leader: Janet Farr

Aim

This insect was first found in WA July 2000. Monitoring of population levels and defoliation impact was designed in line with Australian National considerations for the Forest Products Commission in WA.

Summary of progress

Monitoring was conducted from 2000-June 2002. The original project suggested monitoring should continue to 2003, however monitoring has now ceased due to low aphid numbers and other work commitments for FPC. A draft report is near completion.

- *E. californica* populations peaked in summer and autumn. The initial population increase was therefore later than expected (i.e. spring and autumn). However it will be dependant on weather, and an early spring will mean greater opportunity for populations to increase.
- *E. californica* populations did not persist on *P. pinaster*, and defoliation levels on this pine species were below 25%.
- The influence of site quality was not tested, since no poor quality sites were included in the monitoring programme.
- Although *Cyclaneusma* was present, it was mainly found on older foliage and is unlikely to be associated with E. californica directly.

In addition we found a reasonable level of potential predators in the pine foliage. However, although these predators are capable of feeding on aphids, their capacity to maintain aphid populations below outbreak levels is limited. During warm periods this aphid has a 2-week generation and is therefore capable of rapid population increase. Also it needs to be pointed out that this study was done on very young pines, whereas the aphid prefers more mature trees. This may explain the moderate, but not excessive, population levels encountered. Nevertheless, older plantations were in close proximity to some monitoring sites and monitoring personnel were able to visually assess any evidence of severe aphid populations on mature trees. Despite this, there were no reports of severe defoliation of mature trees.

FORESTCHECK: Invertebrate monitoring

Team Leader: Janet Farr

Aims

To monitor invertebrate biodiversity in the WA Jarrah forest in relation to silvicultural practices.

Summary of progress

The first years (2001) spring and autumn sampling is complete and has been databased. Samples were sorted to morphospecies and a reference collection established. Indicator species have been nominated. Over 500 morphospecies were collected for the 2001 spring/autumn seasons. A progress report has been prepared and collection methods for the project have been finalized. The 2002 spring/autumn sampling will commence in October/November 2002.

Putting trees in their place

Team Leader: Richard Harper

Aims

Determine the most appropriate planting strategy for dryland afforestation to tackle salinity.

Summary of progress

- Funding obtained from the Natural Heritage Trust Farm Forestry Program. Catchment scale experiments established at Wickepin and Moora, to determine if partial revegetation will stabilize/reverse salinity. Investigations were made under 5-11 yr old mallee strips to determine the depth and lateral extent of rooting. Salt accumulation determined under 25 yr old discharge plantings. Gamma radiometrics evaluated as quick method of land evaluation. Soil water modeling used to determine if soil information can be used to identify “leaky” parts of farms. Completion of external project funding 2002. Project in conjunction with A/Prof Keith Smettem (UWA) and CSIRO Land and Water.
- Catchment scale experiments were planted and instrumented in 2000 and 2001. Funding for ongoing monitoring and measurement has been sought, as responses are not expected to occur for 10-15 yrs. Investigation of water depletion under mallees has produced indications that this species can root to depths of in excess of 10 m within 7 yrs of establishment on a range of soils. Similarly, investigation of discharge plantings has shown the accumulation of salt in the root zone and relatively low rates of growth (1-2 m^3/ha/yr).
- Soil survey offers promise as a way of making predictions of leakage of water in agricultural landscapes; cheaper ways of undertaking surveys are required and gamma radiometrics may be a useful tool.

Several outputs have been produced in the past year:

- Archibald, R., Harper, R. J., and Fox, J. E. D. (2002). Growth, survival and salt accumulation in 3 multi-species tree plantations in the 400 – 600 mm rainfall zone of Western Australia. In Proceedings ‘Productive Use and Rehabilitation of Saline Lands. Saltland Opportunities: Profit for our Communities and the Environment,’ Fremantle, Western Australia, 16-20 September, 2002. Promaco Conventions. pp 317-28.
- Archibald, R., Harper, R. J., and Fox, J. E. D. (in review). Tree performance and rootzone salt accumulation in plantations near saline discharge sites in the 400 – 600 mm rainfall zone of south-western Australia. Agroforestry Systems.

- Harper, R. J., Mauger, G., Robinson, N., McGrath, J. F., Smettem, K. R. J., Bartle, J. R., and George, R. J. (2001). Manipulating catchment water balance using plantation and farm forestry: case studies from south-western Australia. In 'Plantations, Farm Forestry and Water.' (E. K. S. Nambier and A.G. Brown Eds.) Proceedings of a national workshop, 20-21 July 2000, Melbourne. Water and Salinity Issues in Agroforestry Nº 7. RIRDC Publication Nº 1/20. pp 44-50. www.rirdc.gov.au/reports/AFT/01-20.pdf
- McGrath, J. F., Harper, R. J., Dumbrell, I. C., and Robinson, N. (2002). Limitations to plantation and farm forestry productivity in Mediterranean environments. In "Australian Forest Growers Conference", Albany, Western Australia. October 13-16, 2002.
- McGrath, J.F., Harper, R.J., Dumbrell, I.C. and Robinson, N. (2002). Developing sustainable tree cropping systems for water limited environments. In Proceedings 'Future soils: Managing soil resources to ensure access to markets for future generations,' Perth, Western Australia, 2-6 December, 2002.
- Robinson, N., Harper, R. J., Smettem, K. R. J., Archibald, R., Stilwell, A. T., and Oliver, Y. (2002). Recharge reduction on degraded agricultural soils with agroforestry systems. Paper 1770 in Symposium 39, "Amelioration of degraded soils through afforestation". '17th World Congress of Soil Science,' Bangkok, Thailand. Bangkok, Thailand. 14-21 August 2002.

Future directions

Project requires ongoing funding to monitor catchments. Questions remain about depth of rooting of mallees – do these eventually go to bedrock? How do they interact with groundwaters? What soil properties represent a barrier to root growth?

Phase farming with trees

Team Leader: Richard Harper

Aims

Develop a new farming system that controls recharge and reduces the risk of salinity developing

Summary of progress

- Funding obtained from the Rural Industries Research and Development Corporation (RIRDC) to establish field trials at Wooroloo, Corrigin and Wickepin. These trials are evaluating the effectiveness of different tree species, planting densities and nutrition on depth of rooting and water use. Field trials established in 2000 and 2001. Measurements of tree growth and water use are ongoing. Measurement of depth of water depletion under a range of 5-7 yr old plantings. Completion in 2004. Project in conjunction with A/Profs Keith Smettem and Lyn Abbott, UWA.
- This system, which involves rotating short rotations of woody perennials with agriculture offers promise as a way of removing stored soil water to depths of several metres and thus providing a buffer against leakage from crops. It overcomes problems associated with tree/crop competition and the need to disperse revegetation across farmland, without displacing farming. Modelling has shown that the general premise is correct; field experimentation is required to validate the modeling and determine whether the basic premise – viz. rapid water depletion under trees is viable. Issues such as cheap establishment, stump removal and products are being considered in other projects.
- Several outputs have been produced in the past.

Publications

- Hatton, T. J., Dawes, W., and Harper, R. J. (2002). Woodlots in rotation with agriculture. In 'Trees, Water and Salt – an Australian guide to using trees for healthy catchments and productive farms' (Stirzaker, R., Vertessy, R., and Sarre, A. Eds) (Rural Industries Research and Development Corporation: Canberra.). pp 43-55.

- Robinson, N., Harper, R.J., Archibald, R.D. and Stilwell, A.T. (2002). The interaction of tree roots and subsoils. In Proceedings 'Future soils: Managing soil resources to ensure access to markets for future generations,' Perth, Western Australia, 2-6 December, 2002.
- Smettem, K.R.J. and Harper, R.J. Growth and survival of bluegums (Eucalyptus globulus) in a water limited environment: implications for phase farming. In Proceedings 'EucProd 2002: International Conference on Eucalypt Productivity,' Hobart, Tasmania, 10-15 November, 2002.

Future directions

- A small international workshop on "Phase Farming with Trees" could be held in Perth, with outside funding. Outputs would include a special journal issue/book.
- Papers will be published in coming year outlining the proposed system (from RIRDC scoping study) and measurements of water depletion under trees.

Greenhouse accounting – carbon sequestration in soils in dryland forestry and rangeland systems

Team Leader: Richard Harper

Aims

Determine the amounts of carbon that are sequestered in agricultural and rangeland systems through revegetation. This will provide information to underpin carbon investment in these areas.

Summary of progress

- Member of the CRC Greenhouse Accounting Management Team. Measurements of carbon contents following revegetation of farmland. Seeking project funds to undertake assessment of greenhouse implications of rangeland management, particularly pastoral destocking.
- Measurements made of soil carbon under mallee belts and mature plantings of Eucalypts in the Collie catchment. Some funding obtained from Griffin Energy and the CRC Greenhouse Accounting for this work. Little change in soil carbon content following revegetation. Some changes in organic matter quality. Prospectus for private investment in carbon sequestration plantings using native species developed. Presentation on the effects of salinization on carbon budgets made to CRC GA Annual Science Meeting. Carbon losses following wind erosion of agricultural land can be around 3-4 t C/ha.

Publications in the past year:

- D'Souza, N., Harper, R.J., Robinson, N, Stilwell, A. and Archibald, R.D. (2002). Soil carbon: effects of tree establishment on soil quantity and quality. In Proceedings 'Future soils: Managing soil resources to ensure access to markets for future generations,' Perth, Western Australia, 2-6 December, 2002.
- Harper, R. J., and Gilkes, R. J. (2001). Some factors affecting the distribution of carbon in soils of a dryland agricultural system in southwestern Australia. In 'Assessment Methods for Soil Carbon Pools.' (R. Lal, J. M. Kimble, R. F. Follett, and B. A. Stewart Eds), pp. 577-91. (Lewis Publishers: Boca Raton, Florida.)
- Harper, R.J. 2002. The four aces: overcoming multiple natural resource management problems in Western Australia through the establishment of greenhouse sinks. Consultancy to Griffin Energy, Perth. 28 pp
- Webb, B., Murphy, D., Harper, R., Warren, J., and Jasper, D. (2000). Tree crops can increase soil carbon in sandy soils of Western Australia. In Proceedings 'Remade Lands 2000. International Conference on the Remediation and Management of Degraded Lands,' Fremantle, WA, 30 November - 2 December. Promaco Conventions, Perth. pp 156-157.

- Harper, R. J., Gilkes, R. J., and Hill, M.J. and Carter, D. J. (in review). The incidence of wind erosion as related to soil properties, geomorphic history and carbon emissions in a dryland farming system in south-western Australia. Earth Surface Processes and Landforms,

Future directions

- National review of the effects of salinization on greenhouse emissions has been commissioned by the CRC Greenhouse Accounting.
- Determine the effects of rangeland management on carbon stocks.
- Further develop the concept of using native vegetation as a carbon sink in Biodiversity Recovery Catchments.

Performance of *Eucalyptus globulus* in relation to site conditions

SPP #93/130, #93/138

Team Leader: Richard Harper

Aims

Determine the effect of soil and climate factors on the growth and survival of *E. globulus*.

Summary of progress

- Write up of existing data sets.
- Work has continued on wrapping up projects related to *E. globulus*, undertaken for the FPC. Strong effects of climate and soils on growth and survival of *E. globulus* are apparent. Principles can be adapted, with calibration, to farmland revegetation across south-western Australia generally – these will be summarized in the "Australian Farm Forestry Site Selection Manual".

Several outputs have been produced in the past year:

- Archibald, R., Little, K., and Harper, R. J. (2002). Managing bluegum (*Eucalyptus globulus*) coppice. Tree Note 35.
- Harper, R. J., Edwards, J. G. and McGrath, J. F. (2002). Quantifying the effect of soil morphology on the performance of *Eucalyptus globulus* plantations established on farmland. 1. Climate. In Proceedings 'EucProd 2002: International Conference on Eucalypt Productivity,' Hobart, Tasmania, 10-15 November, 2002.
- Harper, R. J., Edwards, J. G. and McGrath, J. F. (2002). Quantifying the effect of soil morphology on the performance of *Eucalyptus globulus* plantations established on farmland. 2. Soil morphology and fertility. In Proceedings 'EucProd 2002: International Conference on Eucalypt Productivity,' Hobart, Tasmania, 10-15 November, 2002.
- Harper, R. J., McGrath, J.F and Carter, J.O. (2002). A pedo-geomorphic approach to predicting drought deaths in *Eucalyptus globulus* (Labill.) plantations. Paper 1745 in Symposium 40, "New developments in the evaluation and management of forest soils". '17th World Congress of Soil Science,' Bangkok, Thailand. Bangkok, Thailand. 14-21 August 2002.
- Harper, R. J., Ryan, P. J., Booth, T. H., McKenzie, N. J., and Gilkes, R. J. (in review). 'The Australian Farm Forestry Site Selection Manual.' Rural Industries Research and Development Corporation, RIRDC Research Report Project CAL-4A. 115 pp.
- Harper, R.J. and McGrath, J.F., 2001. Yield potential of Tasmanian blue-gums (*Eucalyptus globulus*) in the 600 - 800 mm rainfall zone near Collie, with special reference to South West Share-farms, Report to Forest Products Commission. 26 pp.

- Harper, R.J. and Tille, P.J. (2001). South-west Land Interpretation Report. Final Report To National Landcare Program. Project No. 935356.
- Ryan, P. J., Harper, R. J., Laffan, M. D., Booth, T. H., and McKenzie, N. J. (2002). Developments in site assessment for farm forestry in Australia and the relationship to scale, productivity and sustainability. Forest Ecology and Management,

Future directions

Procedures and concepts produced in developing a site evaluation system for *E. globulus* will be equally useful for farm-forestry in the wheatbelt. Potential to undertake similar work on defining the site requirements of major species suitable for revegetation in the wheatbelt.

Productivity and drought risk to *Eucalyptus globulus* in the Mediterranean climate of south-western Australia

SPP #99/08

Team Leader: Joe Kinal

Aims

- Establish quantitative relationships amongst soil depth, climate, leaf area index, water use, growth and the development of water stress in blue gum plantations.
- Develop a capacity to predict the leaf area index that is sustainable on a given site.
- Recommend silvicultural options for achieving a sustainable leaf area index and wood production.

Summary of progress

- This project has been in progress for 4 yrs and will continue for another 2 yrs.
- Experimental plots have been established at 5 sites across a range of climatic zones. At each site, nitrogen addition and thinning were used to establish plots with a range of leaf areas. Regular measurements of soil water content, plant water status, leaf area index and growth have been made.
- The results show that it should be possible to manage drought risk by managing site fertility to modify leaf area index at sites where soil nitrogen limits growth. On ex- pasture sites, where soil fertility has been enhanced through previous agricultural management, reducing stand density is the most appropriate strategy for managing the growth-risk trade-off. In order to maximize growth, the trees must be exposed to some water stress but further increases in water stress increase risk without increasing production.
- CABALA, a process model of plantation growth and water balance, was revised by adding a function to predict predawn leaf water potential from estimated plant available soil water. This model was applied to some of the sites in the current study and shows promise as a risk management tool for quantifying the risk associated with specific sites and plantation management strategies.
- The project will continue to monitor the growth and development of water stress as the existing soil water stores are depleted. When the soil water stores are exhausted it should be possible to quantify the growth rates and water use patterns of rainfall-dependent plantations. It should also be possible to define the risk associated with leaf area indices higher than those sustainable in rainfall dependent plantations.

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

SPP #2000/03

Team Leader: Joe Kinal

Aims

To investigate the hydrologic impacts of timber harvesting and the associated silvicultural treatments in the intermediate rainfall zone (IRZ, 900 – 1100 mm/yr) of the Jarrah forest. This project also addresses part of Ministerial Condition 12-3 attached to Forest Management Plan 1994-2003, which states that DCLM shall monitor and report on the status and effectiveness of silvicultural measures in the IRZ to protect water quality.

Summary of progress

- This project has been in progress for 3 yrs and should continue for a further 3 yrs.
- The experimental treatment applied to 4X catchment was the standard phased-logging prescription and follow-up silviculture for second order catchments in the IRZ. The experimental treatment applied to 6C catchment was a more intensive harvesting prescription and follow-up silviculture than the standard. Wuraming catchment remained untreated as a control. Timber harvesting was conducted in summer 2000/01, and the subsequent silvicultural treatments in autumn 2001. A silvicultural burn was applied to 4X and 6C in spring 2002.
- Records of groundwater levels, stream flow, stream salinity and rainfall for the 11 yrs prior to 1999 have been obtained from the Water and Rivers Commission. DCLM has continued to monitor these variables since 1999, and stream water turbidity since 2002. Changes in overstorey density have been assessed from measurements of crown cover, crown density index, basal area, and stocking taken before and after the treatments.
- In the first year following treatments there was no apparent treatment effect on groundwater levels, probably because of the atypically dry winter. In the second year following treatments, the standard treatment continued to have no apparent effect on groundwater recharge. In contrast, groundwater levels rose by about 0.1 m on the hillslopes in response to the intensive treatment. The magnitude of these changes is much smaller than the changes in groundwater level in response to the timber harvesting and associated silvicultural practices of the early 1980s where average groundwater levels rose more than 1.7 m in the valleys and hillslopes in the first 2 yrs following treatment.

Genetic variation in exotic and endemic plantation and rehabilitation species

RPP #27/78

Team Leader: Richard Mazanec

Aims

To examine genetic variation in relevant species and determine the best seedlots for use in operational plantings.

Summary of progress

Several species were worked on over the last year:

Eucalyptus viminalis

- Two *E. viminalis* trials were established in 1990 near Bridgetown and in the Wellington catchment. The species is considered a potential sawlog species in rainfall zones out to about 650 mm annual rainfall.

- The Bridgetown trial was measured for diameter and form. Multivariate analysis techniques using the program ASREML were used to produce best linear unbiased predictions of breeding values for diameter, straightness and branching. Estimated breeding values were then incorporated into a selection index which ranks the trees according to merit.
- Wide variation in provenance variation was found in diameter and in form. The best performing provenance was from Apollo Bay in Victoria, followed closely by trees from Kangaroo Island, South Australia.
- Highly variable growth rates amongst provenances of *E. viminalis* highlight the importance of matching seed source to local conditions. In this trial, the mean dbh of the best provenance was 40% higher than the trial average and some 200% better than the worst provenance.
- This work has had immediate application in the capture of the best genetic material from the Bridgetown trial. Scion material from has been grafted from 24 of the best unrelated individuals for inclusion in clonal seed orchards. Furthermore, the seed store at the FPC plant propagation centre now uses seed from the best 2 provenances for operational planting. Manuscript in preparation.

Eucalyptus saligna

- *E. saligna* trial was established near Willowdale minesite. Considered a potential sawlog species in areas with > 650 mm annual rainfall.
- Trial was measured for height diameter and form. Multivariate analysis techniques using the program ASREML were used to produce best linear unbiased predictions of breeding values for individual tree volume , straightness and branching. Estimated breeding values were then incorporated into a selection index which ranks the trees according to merit.
- Wide variation in provenance variation was found in volume and in form. The best performing provenance was from Batemans Bay NSW, which is considered a natural hybrid of *E. saligna* and *E. botryoides*. Worst provenances were from the far north Queensland.
- Highly variable growth rates amongst provenances of *E. saligna* highlight the importance of matching seed source to local conditions. In this trial, the mean volume of the best provenance was over 200% higher than the trial average and some 540% better than the worst provenance. It is important that farmers and other organizations interested in planting this species be given the opportunity to grow seed from the best available seed lots.
- This work has had immediate application in the capture of the best genetic material from the trial. Scion material from has been grafted from 32 of the best unrelated individuals for inclusion in clonal seed orchards. The FPC seed store plant propagation centre now uses seed from the best operational provenances for operational planting.

C. maculata

- Spotted gum trials established in 1982 were measured at age 13.5 yrs at Jarrahdale and Huntly. The objective of these trials was to determine the best species out of *Corymbia maculata C. variegata*, *C. variegata* and *C. henryi*, identify the best provenances and select parent trees for grafting into a clonal seed orchard. Considered a potential sawlog species in areas with > 650 mm annual rainfall.
- Trials were measured for height, diameter and form. As no family identity was maintained in the trial, only phenotypic selection was possible. Selection was carried out on stem volume and form using block adjusted data.
- Data written up and submitted to Australian Forestry for publication.
- Sixteen provenances of Spotted gum including eight provenances of *Corymbia variegata*, 7 provenances of *Corymbia maculata* and one provenance of *Corymbia henryi*, were assessed for growth and form in 2 trials established on bauxite mines in the northern Jarrah forest of Western Australia. At Jarrahdale *C. henryi* yielded the highest volume (4.8 m^3 ha^{-1} yr^{-1}) followed by *C. maculata* (4.6 m^3 ha^{-1} yr^{-1}) and *C. variegata* (3.9 m3 ha^{-1} yr^{-1}). At Huntly *C. maculata* yielded the

highest volume (3.3 m^3 ha^{-1} yr^{-1}) followed by *C. henryi* (3.2 m^3 ha^{-1} yr^{-1}) and *C. variegata* (2.8 m^3 ha^{-1} yr^{-1}). Form was similar at both sites with *C. variegata* having the highest proportion of single stemmed trees (79% at Jarrahdale and 75% at Huntly) followed by *C. maculata* (75% and 71%) and *C. henryi* (63% and 59%). For straightness of single stemmed trees *C. variegata* and *C. maculata* were similar on both sites (score 3.7 and 3.6) whilst *C. henryi* was the most crooked (score 3.4 and 3.2). C. variegata (score 3.7 and 3.9) had the smallest branches followed by *C. henryi* (score 3.4 and 3.5) and C. maculata (score 3.2 and 3.2). Genotype by site interaction was not significant at the species level between Jarrahdale and Huntly nor at the provenance within species level. Despite minor rank changes, best provenances of *C. maculata* and *C. variegata* tended to be the same at both sites.

- Selection of the best species as well as best provenances within species is important for this group. *C. maculata* averaged 18% higher volume growth than *C. variegata* at both sites and better form. At Jarrahdale the best macualta provenance averaged 19% greater volume production than the worst maculata provenance. At Huntly the best *C. maculata* provenance averaged 48% greater volume production than the worst *C. maculata* provenance. These results again emphasize the importance of identifying the best seed sources for use in operational planting. An important finding is that the best provenances on one site tend to be good performers on other sites such as the Wellington catchment.
- This work has had immediate application in the capture of the best genetic material from the trials and future directions for breeding. Scion material from has been grafted from a further 7 unrelated individuals for addition to existing clonal orchards. The FPC seed store plant propagation centre now uses seed from the best operational provenances for operational planting.

E. botryoides

- *Eucalyptus botryoides* is a species of potential value in the eucalypt saw log project. Three trials were planted in 1989 at Huntly mine site, Wellington catchment and Busselton. An additional trial was established on Worsley mine site in 1990.
- Inspection of the trials indicated that the Wellington catchment trial had been badly damaged by parrots and was of no value for form assessment. The trial at Huntly was established on a difficult site and many of the trees were quite small. At Busselton high mortality had rendered the trial of little value for genetic evaluation. The trial at Worsley mine site was in quite good condition and would be of value in form and volume assessment. Over the past financial year the Busselton trial was assessed and marked for thinning and the Wellington trial was measured for DBH with a view to selecting the largest trees from the best families for inclusion in clonal seed orchards.
- Comparison of mean diameters at age 3 and age 12 in the Wellington catchment indicated relatively poor correlation (r = 0.64). This in turn suggests that selection should be delayed beyond 3 yrs. Heritability was low (h2 = 0.13 ± 0.03) suggesting that high selection intensities will be required to make significant gains.
- Wellington trial data was analysed and an index for selection of highest diameters trees created.

Oil Mallee project

Data analysis is conducted as required for the selection of best genetic material in various trials. Best genetic material is selected on the basis of the data collected and thinning plans constructed on the basis of breeding values for height/vigour and oil yield. In the last year data for *E. angustissima* were analysed and a thinning plan was constructed.

Indian Sandalwood Project

DCLM has made considerable investment in time and money researching the establishment of an Indian sandalwood industry on the Ord River irrigation project near Kununurra. A range of trials addressing host selection, silviculture and genetics were established throughout the 1990s until 2001.

In this project 2 progeny trials were analysed along with 5 other host /sandalwood provenance trials. Results were written up and included in a larger report to the FPC. In addition, selections of the best genetic material were made on- site to enable capture in a grafting program and or seed collection.

Increasing productivity of Karri regrowth stands by thinning and fertilizing

SPP #93/106

Team Leader: Lachlan McCaw

Aims

- This study provides 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

- Four major thinning experiments have been established on sites spanning a broad range of site quality, and measurements extend over periods of 10-15 yrs.
- Thinning can increase the diameter growth rates of retained trees by up to 40 % without reducing stand growth overall. Growth responses tend to be greatest for codominant trees and persist for at least 10 yrs after thinning, although the magnitude of the response decreases with time. Addition of moderate amounts of Phosphorus (up to 250 kg/ha) at the time of thinning can further increase diameter growth of retained trees by up half that again of thinned but unfertilized trees. Responses to added Nitrogen have been inconsistent across sites and apparently transitory.
- The Warren block site has a high incidence of infection by *Armillaria luteobubalina* that has resulted in butt scarring and some mortality of potential crop trees. The incidence and severity of damage caused by Armillaria has been assessed in 1995 and again in 2000, and the results prepared for publication by Dr Richard Robinson.
- In January 2002 the thinning experiment at Sutton block was re-measured fully, including tree height, diameter and bark thickness. This provides a10 yr period of post-treatment monitoring. Data have been entered into a database and validated, with some preliminary analysis of comparative growth responses between treatments.

Publications

- Breidahl, R. and P. Hewett (1995). A review of silviculture in the Karri (*Eucalyptus diversicolor*) forest. CALMScience 2: 51-100.
- McCaw, L. and M. Rayner (1995). Research for management of regrowth Karri forest in Western Australia. Institute of Foresters of Australia Newsletter 36: 2-6.
- McCaw, L. and M. Rayner (1997). Enhancement of timber productivity in native forests. Paper prepared for the Comprehensive Regional Assessment, Western Australian Regional Forest Agreement Steering Committee.

Future directions

All 4 experiments have now been monitored for at least 10 yrs post-treatment, and it would be expected that responses to thinning are now in a declining phase. The need for ongoing monitoring should be reviewed in the context of strategic directions set in the new Forest Management Plan, in particular the allowable level of harvest from regrowth stands of Karri.

Espacement effects on the development and form of regrowth Karri stands

SPP #93/107

Team Leader: Lachlan Mccaw

Aims

The aim of this project is to investigate the effects of initial stocking and espacement on stand growth, individual tree growth and form of Karri planted following clearfelling harvest operations.

Summary of progress

- This project comprises 2 replicated spacing trials established in 1982 (Nairn forest block) and 1990 (Wheatley forest block) that have been measured periodically since then. Spacings vary from much wider than current practice to much closer spacings and higher densities. The Wheatley experiment also provides a comparison between planted seedlings and a naturally regenerated stand thinned to equivalent spacings of 4 m x 4 m and 2 m x 2 m. Measurement made so far support the use of higher initial stockings (>2000 stems per ha) to encourage good stem form and clean branch abscission. There is no evidence of an adverse affect on stand or individual tree growth at densities up to 3000 per ha because of the strong self-thinning dynamics of Karri.
- In even-aged Karri stands a stocking density of 1666 stems per ha at establishment is considered the minimum necessary to produce trees with a clean bole length of 18 m or more. Lower planting densities are consistently associated with short bole length and the persistence of large live branches on the stem.
- Data from a re-measurement of the Wheatley experiment undertaken during October 2000 were analysed and compiled into a report on the development of standardized measures of regeneration success for sustainable management of Australia's native forests. The data were used to evaluate the effectiveness of the existing regeneration stocking standard applied to Karri, as part of a broader investigation of regeneration standards for native forests in southern Australia.

Publications

- Breidahl, R. and P. Hewett (1995). A review of silviculture in the Karri (*Eucalyptus diversicolor*) forest. CALMScience 2: 51-100.
- Lutze et al. (2001). Standardized measures of regeneration success for sustainable management of Australia's native forests. Final Report for WAPIS Project PN 99.180 to address Montreal Indicator 2.1.g. Centre for Forest Tree Technology, December 2001.
- McCaw, L. and M. Rayner (1995). Research for management of regrowth Karri forest in Western Australia. Institute of Foresters of Australia Newsletter 36: 2-6.
- McCaw, L. and M. Rayner (1997). Enhancement of timber productivity in native forests. Paper prepared for the Comprehensive Regional Assessment, Western Australian Regional Forest Agreement Steering Committee.

Future directions

- This project should be maintained as an important benchmark study, and would not require a high level of funding or staff commitment to do so. Periodic visits at 5 yearly intervals would be desirable to ensure the integrity of signage, tree tags and other plot infrastructure, and if possible a 5 yearly re-measurement program should be continued.
- There is an opportunity to use this study as the basis for studies of the impact of branching habit on the incidence if defect in Karri.

Project Vesta – prediction of high intensity fire behaviour in dry eucalypt forest

SPP #97/03

Team Leader: Lachlan Mccaw

Aims

The aims of the project are to:

- develop a national fire behaviour prediction system for dry eucalypt forests,
- quantify changes in fire behaviour as fuels develop with age,
- develop new algorithms describing the relationship between fire spread, wind speed, and fuel characteristics,
- characterize wind speed profiles in forests with different overstorey and understorey structures.

Summary of progress

This project is part of a collaborative study involving the Department and CSIRO Forestry and Forest Products, with a component of external funding provided through a voluntary levy raised on members of the Australasian Fire Authorities Council.

Major achievements to date:

- Completion of field experiments (104 experimental fires) in February 2001.
- Over 5 000 copies of a brochure on Important warnings for this summer (1999) were printed and distributed to rural fire authorities and land management agencies throughout Australia and New Zealand.
- Two videos have been produced (Project Vesta and The Dead Man Zone). The Dead Man Zone was copied onto CD and over 300 were distributed throughout Australia and New Zealand.
- 7 conference papers have been presented at bushfire and forestry conferences.

Publications

- Cheney, N.P., Gould, J.S., McCaw, L. (2001). The Dead Man Zone - a hitherto ignored area of fire fighter safety. Australian Forestry 64: 45-50.
- Sullivan, A.L. and Knight, I. (2001). Estimating error in wind speed measurements for experimental fires. Canadian Journal of Forest Research 31: 410-409.
- Preliminary findings have been disseminated to fire agencies throughout Australia and New Zealand, with over 50 seminars or training workshops to fire agencies since March 1998.
- The Project Vesta scientific team have conducted over 75 media interviews (press, radio and television) since January 1998.
- Information about smoke dispersal from experimental fires has been provided to a national project that aims to improve the capability for predicting the quantity and trajectory of smoke from bushfires.
- Regular progress reports have been provided to sponsors, including the Australasian Fire Authorities Council.

A cost benefit analysis of Project Vesta by independent consultants from The Centre for International Economics found that the project had a large return on investment and that benefits were positive even under the most conservative set of assumptions.

Future directions

The project is c. 90 % complete, and the key scientific staff are working collaboratively to finalize data analysis, model development and publication tasks. Key objectives still to be achieved include investigating:

- the effect of bark load on spotting and rate of spread.
- the relationship between fuel age, fuel load, fuel structure, wind speed and rate of spread.
- alternative measures of fuel hazard to replace fuel load.
- the effect of upper air instability and wind speed on fire behaviour.

The scientific team intend to develop a business and marketing plan for the technology transfer of Project Vesta findings that will:

- Determine the type of material or package that best serves the fire agencies and managers need (e.g. knowledge base, text book, meters, tables, computer-based decision support system, lesson plans and material, web sites, etc)
- Determine funding and resources required to undertake this extension work.
- Depending on requirements investigate the need to engage other parties to assist i.e. AFAC.

Regeneration success measures and monitoring methods for sustainable forest management, criteria 2.1.g

SPP #2001/03

Team Leader: Lachlan McCaw

Aims

To develop cost-effective, standardized methods to determine regeneration success (including stocking, species composition and early seedling growth) in native forests as a basis for continuous improvement in on-ground operations, aggregation of data to regional and national levels, and accreditation.

Summary of progress

- This project is part of a collaborative study involving state forest management agencies in WA, Victoria, Tasmania, New South Wales and Queensland, together with the University of Melbourne. The project has been coordinated by Mark Lutze, Natural Resources and Environment Victoria, and funded by the Commonwealth Government Wood and Paper Industry Strategy.
- Data from the Wheatley experiment were analysed and compiled into a report on the development of standardized measures of regeneration success for sustainable management of Australia's native forests. The data were used to evaluate the effectiveness of the existing regeneration stocking standard applied to Karri, as part of a broader investigation of regeneration standards for native forests in southern Australia.
- Lutze *et al*. (2001). Standardized measures of regeneration success for sustainable management of Australia's native forests. Final Report for WAPIS Project PN 99.180 to address Montreal Indicator 2.1.g. Centre for Forest Tree Technology, December 2001.

Future directions

This project was completed in December 2001, and the project plan can be terminated. All external funding owed to the Department has been received.

Stimulating the adoption of commercial tree crops in 450 to 650 mm rainfall zone (Natural Heritage Trust Project No. 993093 and 003128)

Team Leader: Richard Moore

Aims

This project aims to increase the adoption of farm forestry in the 450 to 650 mm rainfall zone of WA. The main strategy is to raise the skills and confidence of farmers in using commercial trees, especially pine, mallee eucalypts and eucalypts for sawlogs, as part of their farming operations.

Summary of progress

- Four regional Farm Forestry Development Officers are employed under the NHT funded Project; Michael Power in Albany, Paul Le'Gear in Moora, Chrissy Rob in Katanning and Volker Mischker in Esperance.
- Staff involvement; Moore 50% and Hingston 50%.
- Project funds are expected to last until the 2nd half of 2003.
- Moore *et al.* (2001). Putting Together the Total Package – Farm Forestry Extension in WA. In Proc: IUFRO Conference on Forestry Extension, Lorne, Victoria. Oct 2001, outlines the approach being taken.
- Increasing farmer skills and confidence in farm forestry requires a multi-pronged approach, including:
- Demonstrating - working with leading landowners to plan, implement and manage operational examples of farm forestry.
  Providing input – supporting NRM projects which require the use of commercial trees; e.g. the Natural Diversity Recovery Catchment Projects such as Lake Bryde and Lake Muir.
- Carrying out R&D – collecting additional growth data, e.g. for *E. occidentalis* and *Allocasuarina huegeliana*.
  Evaluating – using local data in economic assessments, including assessments from the farmer perspective.
  Training – support training programs such as Master TreeGrower Program and farmer-driven field days.

Future directions

- The Project has provided strong regional support for farm forestry development and implementation. The challenge is to find the resources to keep the extension program going until the "ball is rolling".
- The Master TreeGrower Program is a central plank of the project. It does increase farmer's skills and confidence in farm forestry. "Lead-in" and "follow-up" programs are being developed. Funds are being sought through regional groups for a State Co-ordinator for farm forestry education and training.

Private forest and woodland management and utilization study (Natural Heritage Trust Project No. 993094)

Team Leader: Richard Moore

Aims

- To review and document current legislative and administrative requirements for management of native forest and woodland on private land (Part 1).

- To review existing literature and knowledge on management of native forest for multiple benefits (Part 2).
- To demonstrate management options by establishing demonstrations in each major forest type (Part 3).
- To produce guidelines on the management of private native forest (Part 4).
- To prepare and deliver training on the management of private native forest and woodland to landowners and advisers (Part 5).

Summary of progress

- The 2-3 yr project is to be completed by June 2003.
- Project Steering Committee – Richard Moore, John Bartle. Bob Hingston, Peter Beatty, Lachie McCaw, Graeme Olsen and Judi Pitcher
- Part 1 completed by consultant. The report - "A Review of Legislative, Administrative and Marketing Issues Relevant to Sustainable Management of Private Native Forest in the South West of Western Australia" is ready for launching and distribution.
- Part 2 completed by consultant. The report – "A Review of Technical Knowledge and Experience in Managing Private Native Forest" is ready for launching and distribution.
- A handbook on guidelines for landowners is being prepared by a consultant (Part 3).
- The establishment of demonstrations of well managed private native forest is underway (Part 4). A consultant has been contracted to coordinate the work.

Future directions

- How best to launch Reports 1 and 2 is currently being investigated. A formal launch would help to raise community awareness. The topic is a sensitive one, especially amongst conservation groups.
- The outcomes from Parts 1 to 4 (i.e. 2 reports, one handbook and 3 to 6 demonstration sites) will help Farm Forestry Development Officers and others assist landowners who want guidance on managing their own native forests.

The New Eucalypt Sawlog Industry project (NESI)

Team Leader: Richard Moore

Aims

- To improve farm profitability and sustainability
- To improve water quality in key water catchments.
- To establish a core resource for a new eucalypt sawlog industry.
- To create new commercial opportunities for rural communities including downstream processing to add value.

Summary of progress

- NESI is the outcome of more than 20 yrs of R&D by the Farm Forestry Unit to develop eucalypts for timber in the 450 to 650 mm rainfall zone.
- The Project is being jointly developed by 4 government agencies – the Forest Products Commission, the Department of Conservation and Land Management, the Water and Rivers Commission and the Department of Agriculture in partnership with Regional Plantation Committees.

- The NESI project is focused in the water recovery catchments.
- The goal for stage one of the Project is to establish a resource with the capacity to produce 150,000 m3 per year of high-grade eucalypt sawlogs as soon as possible (about 1000 ha per yr).
- The Forest Products Commission has developed a joint venture agreement for the Project.
- Moore, R.W. and Buckton, M. (2002), Eucalypts for High-grade Timber – Building a New Industry Centred on Farmland. In Proc: National Low Rainfall Farm Forestry Conference, Horsham, Sept. 2002, describes the Project.
- Five hundred hectares of eucalypts for high-grade timber were planted on farms by FPC in the 450 to 600 mm annual rainfall zone during 2002.
- Richard Moore, Bob Hingston (50% each) & the 4 Farm Forestry Development Officers are supporting the Project by establishing new trial plantings, monitoring existing plots, locating interested landowners, training private growers, carrying out economic evaluations and disseminating information.

Future directions

- It is widely recognized that the NESI project can deliver the economic, social and environmental benefits envisaged. The challenge is to deal successfully with a range of issues that must be overcome if the necessary momentum is to be achieved. Key issues include the need to:
- Collect additional data on growth for *E. saligna*, *E. cladocalyx* and *E. maculata*.
- Confirm recovery and grade of timber produced from logs milled under operational conditions.
- Continue monitoring to confirm improvement in quality of water resources.
- Control damage caused by the Australian ringneck parrot.

Maritime pine yield study

Team Leader: Peter Ritson

Aims

- Develop an operational system for site quality assessment of *P. pinaster* plantations on farmland in WA.
- Develop a model to predict stemwood yield.

Summary of progress

- Fieldwork completed. Some analysis, writing up and publication to be completed this year (2002/03).
- This work based on assessments of 175 plots of *P. pinaster* located in areas from north of Northampton to east of Esperance, mostly in the 400 – 600 mm/yr rainfall belt. Extensive measurements of site index (stand top height growth), yield and environmental (soils, landform, climate) variables have been completed.
- A report on the site quality prediction has been produced for FPC. This is to revised following analysis of the latest (2002) measurements of stand top height and volume growth of the younger (age < 15 yrs) plots. This should give much more reliable estimates of production capacity.
- Re-measurement of all plots originally measured at ages < 15 yrs will also give much more confidence in projecting growth to the rotation end (anticipated around 30 yrs) and therefore predicting yields over a full rotation.

- FarmWood (growth model) supplied to FPC along with yield estimates. The growth curves for FarmWood were developed from stem analysis of farm-grown *P. pinaster* as periodic measurement data were not available.
- Stem form was also assessed on all trees in the measurement plots and an analysis of factors affecting stem form supplied to FPC (report and PowerPoint presentation).

Biomass carbon studies

Team Leader: Peter Ritson

Aims

- Develop equations to estimate biomass and carbon content of individual trees from easily measured variables such as DBH.
- Develop a model to predict biomass accumulation and carbon sequestration of farm forestry species.

Summary of progress

- Extensive field sampling of *P. pinaster* and *E. globulus* complete.
- Some work has been published (*P. pinaster*, in Forest Ecology and Management). Other work is to be published (*E. globulus*, as CRC Greenhouse Accounting activity) and stand-level model (FarmWood).

Future directions

- Ongoing processing and reporting of carbon inventories of BP plantations.
- Carbon sequestration studies of sawlog plantations for water resource catchments.
- Biomass and carbon mass prediction equations have been developed for *P. pinaster* and *E. globulus*. These predict biomass or carbon from stem diameter (measured at a height of 10 cms if small tree or breast height for other trees) and height to crown base in the case of *P. pinaster* (accounts for pruning of some trees). The *P. pinaster* equations have already been applied in inventory of BP plantations.
- The FarmWood model has been developed to include biomass and carbon sequestration by building on the stemwood volume growth model. So far it has been calibrated for *P. pinaster* and *E. globulus*. The model has been supplied to and used by FPC mostly for *P. pinaster*. It will predict future carbon sequestration and so has application for planning and marketing carbon sequestration projects.
- Some further development of FarmWood is required, particularly:
    - Include simulation of belt planting as well as block planting. (The required data for *P. pinaster* are available from stem analyses but require further analyses).
    - Refinement in the method for simulating thinning. (To be attempted using data from thinning experiments).
    - Further calibration of the decay functions for logging residues (slash & roots) and wood products. (Decay functions for logging residues to be obtained from our CRC Greenhouse Accounting study just commenced).
    - Progress has also been made in developing method for carbon inventory of plantations. This has included the processing and reporting of annual inventories of the BP plantations. For the 2001 inventory this included the development of methods for a complete uncertainty analysis of all estimates using Monte Carlo techniques.

CRC Greenhouse Accounting studies on biomass carbon

Team Leader: Peter Ritson

Aims

To provide greater certainty to estimates of carbon stored in woody vegetation for project scale and national scale accounting.

Summary of progress

Our studies fit within the CRC Greenhouse Accounting (CRC GA) Sub-Program A2 (Carbon in woody vegetation). The work is on-going in that the CRC GA is planned to run to 2006. Some of our projects are complete as outlined below.

Progress is discussed for each of our 3 study areas in WA.

1. Evaluation of root-sampling strategies

    - The root systems of 2 *E. globulus* trees (2 & 8 y.o.) have been sampled intensively with c. 60 soil cores to 6 m depth for each tree. This will enable us to characterize the horizontal and vertical root distributions. The objective is to allow computer simulation, testing and comparison of alternative root sampling strategies.
    - One major spin-off from this study was the equipment Stan Sochacki developed for taking the required volumetric soil/root samples. This equipment is now regarded as state-of-the-art for root sampling. It is the only equipment available that will cut cleanly through roots of any diameter and soils of any hardness. Copies of the equipment have been sold and are in use by our CRC GA partners in NSW and Queensland.

2. Factors affecting root: shoot ratio

    - Assessment of above-ground biomass is relatively easy compared to assessment of below-ground (root) biomass. However, if the ratio of below-ground to above-ground biomass (root:shoot ratio) can be reliably predicted only above-ground biomass need be assessed to allow scaling up to an estimate of total tree biomass. This is the basis of these studies where the effect of various factors (age, species, management and environment) on root: shoot ratio are being studied in WA and NSW (SF NSW) and Queensland (QDPIE).
    - Results from analysis of the *P. pinaster* data indicate that root: shoot (R:S) ratio is highest in very small (young) trees declining rapidly to around 0.4 in open-spaced trees and 0.25 in close-spaced trees. Results for *E. globulus* also indicate R:S declines rapidly with age/size to around 0.4 (low productivity sites) or 0.2 (high productivity sites).
    - Studies in a nitrogen fertilizer trial with *P. radiata* (Vasse 9 plantation) showed that, although increasing N increased stem growth there was no change in R:S ratio (root growth increased at a similar rate to above-ground growth). This result was contrary to results from other studies (all on seedlings and herbaceous plants) which indicated that as nutrients increase, R:S decreases.

3. Decay of harvest residues

    - This study, just commenced with measurements at 2 sites (*P. pinaster* and *E. globulus*) clearfelled in September, is planned as our major activity in the CRC GA over the next 3 yrs.
    - Then basis for the study is that knowledge of the decay rates of tree parts left after harvest is essential for carbon accounting in forests subject to harvest. Measurement of tree roots, in particular, is not practical in routine biomass/carbon inventory so reliable models of root decay rates must be developed. Such studies have not been undertaken elsewhere.
    - Complementary study approaches will be followed.
    - Sequential sampling: repeated measurements over 4 yrs at sites subject to harvest in 2001/02 to study early changes.

- Chronosequence sampling: single assessments of sites with a variety of ages post-harvest (to characterize longer-term changes).

A comparison of chemical and biological methods for control of Armillaria in regrowth Karri

SPP #95/01

Team Leader: Richard Robinson

Aims

To compare chemical and biological methods for the control of Armillaria in regrowth Karri.

Summary of progress

SPP completed and paper published: R.M. Robinson and R.H. Smith (2001). Fumigation of regrowth Karri stumps with metham-sodium to control Armillaria luteobubalina. Australian Forestry 64: 209-215.

The use of metham-sodium as a possible control agent for armillaria root disease was studied on 13-yr-old Karri (*Eucalyptus diversicolor*) regrowth stumps. As a consequence its effect on colonization by wood decay organisms was also examined. *Armillaria luteobubalina*-infected stumps, with volumes of about 2000 cm^3 (11-12 cm diam.) and 8000 cm^3 (21.5-23.5 cm diam), were treated with 500 ml of metham-sodium and examined after 3½ yrs. Control stumps with volumes of about 4000 cm3 (16-17 cm diam.) were not treated. Compared to untreated stumps, the volume of uncolonized wood and advanced decay was significantly greater in metham-sodium treated stumps. The volume of stump colonized by *A. luteobubalina* was lower in metham-sodium treated stumps than in untreated stumps. In stumps with a volume of 2000 cm^3, treatment with metham-sodium eliminated *A. luteobubalina* from 40% of the stumps and enhanced colonization by white rot organisms, including an unknown species which colonized 45-60% of the volume of the stumps in which it occurred. The use of fumigants to control Armillaria root disease in regrowth forests is, however, very labour intensive, costly and creates health and safety issues for the operator, and is considered not to be a practical option.

Below ground incidence of *Armillaria luteobubalina* in regrowth Karri

SPP #98/06

Team Leader: Richard Robinson

Aims

The project has 2 aims. Across a range of site types within the Karri regrowth estate, (A) determine whether Armillaria infection is restricted to individual trees showing symptoms or is actively spreading to neighbouring trees via root contact and (B) compare levels of Armillaria infection (i.e. % of trees infected), as determined by above ground symptoms with actual below ground incidence.

Summary of progress

- Field work and analysis completed and paper submitted to journal: Incidence of Armillaria root disease in Karri regrowth forest is underestimated by surveys of aboveground symptoms.
- In high quality Karri regrowth stands, intensive survey based on aboveground symptoms of Armillaria root disease underestimated true levels of disease by at least 20% and sometimes up to 40%. The results challenge the reliability of surveys based on measuring aboveground disease symptoms. While most disease was established within the subdominant stratum, a very high proportion (30-60%) of the dominant trees was also infected. Within the study areas 15 distinct genotypes of *A. luteobubalina* were identified. Individual genotypes existed as clones, with 2-3 clones per hectare.

These factors need to be considered in stand management planning and yield predictions. A broader study, including lower quality sites, needs to be undertaken to determine if these findings apply to all Karri regrowth types.

Future directions

Recommendations regarding the control of Armillaria root during thinning operations in regrowth forest have been implemented in the new Karri Silvicultural Guidelines.

The effect of fire on the fruiting of fungi in Karri regrowth forests

SPP #98/15

Team Leader: Richard Robinson

Aims

To assess the effect wildfire has on the fungal flora in Karri regrowth forests.

Summary of progress

- Field work will continue until Dec 2002.
- Data analysed and a scientific paper to be prepared in 2003.
- Three annual reports have been prepared and an article published: R.M. Robinson (2001) Fruits of Fire. Landscope 16 (4): 48-53, and a book chapter has been accepted for publication R.M. Robinson and N.L. Bougher. The response of fungi to fire in Jarrah (*Eucalyptus marginata*) and Karri(*Eucalyptus diversicolor*) forests of south-western Australia, in: Fire in South-Western Australian Ecosystems: Impacts and Management.
- In December 1997, a wildfire swept through a large tract of 20-25 yr old Karri regrowth forest in the south-west Western Australia. Immediately following the fire, plots were established in the burnt stands and in similarly aged unburnt stands. Over the next 3 yrs (from January 1998 to December 2000) the fungi fruiting in the plots were recorded. A total of 304 species of fungi, which produced 34 558 fruitbodies, were recorded in burnt and unburnt plots. The number of species recorded each year was 167, 177 and 193 respectively in 1998, 1999 and 2000. In the first year, 68 species fruited on the burnt plots of which 81% occurred exclusively on the burnt plots. In 1999 and 2000 the species exclusive to the burnt sites reduced to 60% and 51% respectively. There was a noticeable change in the composition of the species recorded on the burnt plots each year. In 1999 there was a 71% change in species composition compared to 1998. In 2000 the change was 48% from that in 1999 and 81% change from that of 1998. Such changes were attributed to the process of species succession, occurring as the burnt sites recovered from the fire. However, part of the change may also be due to natural variation in fruiting patterns. On the unburnt sites, changes of 37% and 30% were observed in successive years and a 42% change in the species present in 2000 compared to those in 1998.In each successive year there was an increase in the number of species recorded on both burnt and unburnt sites in the same year. In 1998 it was 8%. In 1999 and 2000 it was 21% and 28%. As the litter and trash built up on the burnt sites, more species previously found only on unburnt sites were recorded on the burnt sites. At the end of 3 yrs, the amount of litter on the burnt sites was approximately one-third and the amount of trash about one-half that measured on the unburnt sites. The pyrophilous fungi, those species that appear to be exclusive to the burnt sites, fitted into 4 broad groups. The first group consisted of those fungi that fruited from subterranean sclerotia and were stimulated by, and fruit within days of the fire, or in the first autumn or spring. Fungi in this s group were recorded only in the first year. The second group is made up of species that fruited exclusively on burnt soil in the first autumn following the fire and were not recorded in the second year. The third group contains species that fruited on the burnt soils in the first season following the fire and continued through the second year in smaller numbers. The fourth group fruited on the burnt sites for 3 consecutive years. Generally they were recorded in large numbers in the first year then in low numbers in the following 2 yrs. A number of fungi fruited for the first time on the burnt sites in 2000, 3

yrs following the fire. Further monitoring is necessary in order to ascertain whether their presence is truly reliant on fire. The results show that to maximize fungal biodiversity in regrowth and natural eucalypt forests a mosaic of stands with different times since fire is needed.

Future directions

- After December 2002 it is proposed to continue monitoring every 5 yrs.

The effect of thinning on Armillaria root disease in Karri regrowth

Team Leader: Richard Robinson

Aims

To assess retrospectively the effect of thinning on Armillaria root disease in the Warren Thinning Trial (Barker Rd, Pemberton).

Summary of progress

- This study is ongoing, with one paper accepted for publication: R.M. Robinson. Short-term impact of thinning and fertilizer application on Armillaria root disease in regrowth Karri (*Eucalyptus diversicolor* F. Muell.) in Western Australia. Forest Ecology and management.
- The incidence of Armillaria root disease was recorded during routine measurement of a silvicultural experiment designed to test the effect of thinning and nitrogen fertilizer application on the growth of Karri regenerated after clearfelling. The experiment was established in 1984 when the stand was 12 yrs old. Ten years after thinning the level of disease increased significantly with increased thinning intensity, and disease accounted for 51% of the mortality in the plots thinned to 200 stems/ha. Fifteen years after thinning, the level of infection had increased in all treatments but was still significantly lower in the unthinned treatment. In the thinned treatments, 54-63% of the trees ranked in the largest 200 stems/ha were infected, and 50-100% of the mortality within these trees was attributed to *Armillaria luteobubalina*. In the unthinned treatment, no mortality within the dominant trees was associated with disease. Ten years after thinning and fertilizer treatments, it could not be determined whether fertilizer application had had any effect on the level of disease. Whole tree thinning, which results in stump and root removal, is discussed as a viable management option in high quality Karri regrowth stands infested with *Armillaria luteobubalina*.

Future directions

It is proposed to further analyse data to assess the effect of *Armillaria luteobubalina* infection on tree growth and yield.

FORESTCHECK: Macrofungi, coarse woody debris and litter

Summary of progress

- Ongoing.
- Monitoring for 2002 completed.
- Report submitted.
- Analysis, cataloguing and verification of voucher specimens is continuing.

Macrofungi

- A total of 192 species of macro fungi were recorded across all the sites. Preliminary analysis shows that there were no obvious differences in species diversity between the treatments, but the abundance

in the gap treatment appears to be higher. Species diversity and abundance on the Kingston gap treatment, however, does appear to be higher than the same treatment at Thornton and Carter.

- Species composition at each site has not yet been investigated. This may have some bearing on the higher abundance in the gap treatments. Field observation suggests that within these treatments there was a higher number of wood decay species that tend to fruit in high numbers. Some species may also reflect the state of decay of the wood on these sites as they appear to be early colonizers of wood and are not found in such large numbers on well-rotted wood. Some species may also prefer burnt wood.

Litter, Small Wood and Twigs (SWT) and Coarse Woody Debris (CWD)

- Litter loads on all sites ranged from 2.1 t ha^{-1} to 10.2 t ha^{-1}, and generally reflect the ages of the various treatments. The uncut control at Easter is an oldgrowth site and has the greatest accumulation of litter, while the gap at Carter has only recently been cut and burnt and has the lowest litter load. The TEAS treatments have similar litter loads to that on the uncut controls. Litter is rapidly accumulating on the older gap treatments at Kingston and Thornton. As was the case with the litter, the SWT loads generally reflected the age of the forest within the treatments. Loads ranged from 0.2 t ha^{-1} to 1.1 t ha^{-1}. The heaviest load being on the old growth site at Easter and the lowest loading being on the gap at Thornton. The TEAS have similar loads to that on the uncut controls. This component of the ground cover is very variable. The greatest volume of CWD was measured at the Thornton gap site. This may be due to the fact that 1 end of this transect was close to the road where logs and debris that had been pushed into heaps. Generally, however, all treatment sites had volumes of CWD within the range of that found on the uncut control sites, about 110-300 m^3 ha^{-1}. The quality or state of decay was not assessed, but observation suggests that the wood on the gap and shelterwood sites was more solid that that generally found on the uncut controls.

Future directions

Will look at the relationship between litter loads and CWD volumes and the composition of the fungal community found in each treatment. They can also be included and used in the analyses of the data collected by other FORESTCHECK teams.

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

SPP #93/112

Team Leader: Mike Stukely

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 DCLM/FPC seed orchard for production of Pc-resistant Jarrah (NHT Project 003072 – “Producing Dieback Resistant Jarrah for land and forest rehabilitation”).

Summary of progress

- Primary selection, and propagation of dieback-resistant Jarrah (DRJ) clonal lines, completed.
- Monitoring of field validation trials is continuing.

- Establishment of the production DRJ Seed Orchard at Manjimup is in progress.
- Testing of resistant progeny from early field trials is in progress.
- Conference paper presented 2001.
- Journal paper in preparation on field survival of clonal DRJ.
- Landscope article on DRJ still to be written.
- All elite (DRJ) selections from the screening trials to date have now been propagated by tissue culture at Alcoa's Marrinup laboratory.
- The superiority (in terms of both survival and growth rate) of DRJ clones in earlier field trials has now been maintained for up to 14 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.
- Stage 1 of planting DRJ clones in the major production seed orchard (NHT Project 003072) at the FPC Manjimup Plant Propagation Centre was carried out in 2001, with good results (survival 80%). Stage 2 was on target for planting in July 2002, and clones are now to be produced for Stage 3 (infill planting) in 2003. First seed is expected to be produced within 5 yrs.
- Early field inoculation trials, where all but the most resistant trees have died, are now producing some seed. Collections have been made for progeny testing, and seedlings raised for inoculation in summer 2002-03 (NHT Project 003072). This will give the first indication of the likely performance of the DRJ seed orchard progeny.
- A paper was presented at the IUFRO 2nd International Conference "Phytophthora in Forests and Natural Ecosystems", Albany, October 2001: "Progress in selection and production of Jarrah (*Eucalyptus marginata*) resistant to *Phytophthora cinnamomi* for use in rehabilitation plantings".

Future directions

- Carry out inoculation trials in 2002-03 on seedling progeny of survivors in early field inoculation trials (NHT Project 003072).
- Infill planting of DRJ Seed Orchard at Manjimup PPC in 2003 (following completion of Stage 2 in 2002 as part of NHT Project 003072).
- Maintenance of the seed orchard will be done by staff of the FPC Seed Centre, after establishment. Research aspects will necessarily include initial testing of progeny for Pc resistance, 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.
- 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 DCLM managers, community groups and land holders for use in rehabilitation plantings of degraded forest and cleared sites. Further work on field establishment is needed (see SPP #94/06).
- The DRJ growth rates regularly seen in our trials indicate that Jarrah has potential for use as a plantation species in suitable environments, and also in reafforestation programs linked to the Salinity Action Plan on suitable sites in the landscape (e.g. mid to upper slope water recharge areas). Jarrah has been included in a small number of trials here, and should be assessed further.
- Linkage with Jarrah genetics trials of R. Mazanec.

Dieback-resistant Jarrah establishment in operational forest rehabilitation sites

SPP #94/06

Team Leader: Mike Stukely

Aims

To re-establish Jarrah, initially using clonal, dieback-resistant plants, in operational Diseased Forest Rehabilitation (DFR/FIRS) sites.

Summary of progress

- Plantings established in 1994–1999. Survival is being monitored.
- About 20 plots (in addition to the Validation Trials, SPP #93/112) were established between 1994 and 1999, in forest rehabilitation sites in Jarrahdale, Dwellingup, Mornington and Busselton Districts.
- Survival has been variable, from below 20% on very harsh sites to c.80 % on better sites.
- Further field assessment work was deferred in 2001-02, due to the NHT project taking priority.

Future directions

With the DRJ Seed Orchard now established, this SPP needs to be re-worked to incorporate trials of site preparation for Jarrah seedling establishment in forest sites. This will develop on the earlier work started by G. Stoneman (SPP #93/94). The cost of DRJ clones, and their often-poor root production after transplanting, makes them unsuitable for large-scale trials of this type (or for operational use).

Vegetative propagation by grafting of dieback-resistant Jarrah for seed orchard establishment

SPP #95/14

Team leader: Mike Stukely

Aims

To assess the feasibility of grafting to capture and vegetatively multiply Dieback-Resistant Jarrah (DRJ) selections for establishment in seed orchards (NHT Project 3072).

Summary of progress

- First round of trials completed summer 2001-02.
- Rootstocks are being raised for 2002-03 trials.
- Grafting trials are being carried out by FPC staff with plant material supplied by DCLM. Low success rates were achieved in the first trials, and these were compounded by problems with maintaining adequate watering in summer. The second set of trials will be done at Wanneroo propagation centre, with larger numbers of plants.

Future directions

If grafting can be used successfully with Jarrah, this method can be used to propagate DRJ lines that are difficult to tissue-culture, which will permit their inclusion in seed orchards.

Mundulla Yellows disease in WA

Team Leader: Mike Stukely

Aims

To monitor Mundulla Yellows (MY) disease occurrence and spread in Western Australia.

Summary of progress

- Monitoring is continuing, and reports of new occurrences are being investigated. Samples have been sent to Dr Dagmar Hanold (University of Adelaide, Waite Campus) to be tested for MY-RNAs. Collaboration with and assistance to Dr Hanold is continuing. An article was published in Landscope.
- Monitoring of MY in WA by DCLM commenced in October 2000, with the visit of Dr Hanold as part of the national MY survey. Collaboration with Dr Hanold has continued.
- MY symptoms have been recorded in WA in *Eucalyptus marginata*, *E. todtiana*, *E. camaldulensis*, *E. salmonophloia*, *E. loxophleba*, *Corymbia calophylla*, and *C. ficifolia*, and in several eastern states eucalypt species grown in WA. 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 can be used – *E. camaldulensis*, *E. salmonophloia*, *E. loxophleba* and *Corymbia calophylla*.
- MY symptoms have still not been seen in undisturbed forest in WA.
- Article published in Winter 2002 edition of Landscope: "Mundulla Yellows – a new tree-dieback threat", by D.Hanold, M.Stukely and J.W. Randles. This provides an overview of what is known about MY, and the priorities for research so that management strategies for MY can be developed as soon as possible.
- See separate document (Briefing Note – recent observations on Mundulla Yellows in WA – M.Stukely, 23 October 2002) for the latest developments, since July.
- M.Stukely has been appointed to represent DCLM and WA on the national Mundulla Yellows Task Group that will be reporting to LWBC.

Future directions

- Monitoring of existing and new occurrences of MY in WA needs to continue (low-key).
- Priority must be given to investigating any reports of MY-like symptoms associated with either *E. globulus*, oil mallees, other plantations, or nurseries (or their surrounds), or with vegetation in areas of high conservation value. [This work can be linked to the VHS.]
- More DCLM and FPC staff in relevant areas need to be informed of what to look for in identifying possible MY symptoms, and be encouraged to report them.
- Transects are to be established in WA for monitoring spread of MY from known infections to healthy vegetation (as part of Dr Hanold's program).
- Collaboration with and assistance to Dr Hanold should continue.
- Once a rapid test for MY has been developed and proven, it should be applied in WA without delay (through the DCLM Vegetation Health Service). There is likely to be an ongoing need for screening of planting stock from nurseries, as well as for the routine testing of suspect symptomatic trees.
- Small-scale trials could be carried out here (in collaboration with Dr Hanold) to examine aspects of MY such as transmission (by seed, pollen, insects, other soil vectors?), host range, and the effects of environmental factors such as nutrition, herbicides, and other stresses. Funding for these will need to come from DCLM/FPC.

The ecology of the ngwayir (*Pseudocheirus occidentalis*) and koomal (*Trichosurus vulpecula*) within the Jarrah forests of Western Australia

SPP #02/04

Team Leader: Adrian Wayne

Aims

- Comparative survey method trials – trapping, spotlighting, scat surveys.
- Investigation into the life histories of ngwayir and koomal – reproduction, growth, demographics, survivorship.
- Analysis of habitat selection – spatial use and patterns between individuals, sexes and species, home ranges, habitat selection for day refuge and night activities.
- Analysis and identification of how environmental factors explain the current distribution and abundance of ngwayir and koomal – including climate, vegetation and habitat, logging and fire history, and other disturbance factors.

Summary of progress

- Comparative survey method field trials largely completed by March 2002. The majority of associated analyses completed by April 2002. As a result improved trapping methods were developed and more efficient means of spotlight detection were identified. Drafting of a manuscript for publication has commenced.
- Life history and habitat selection studies were established in the field May – August 2002. A total of 27 ngwayir and 23 koomal have been radio-collared within a single study site. Bimonthly collection of life history data on study animals began in June 2002. Monthly radio-tracking for diurnal and nocturnal location and habitat use data commenced August 2002. Associated databases established by September 2002.
- Presentations on possums and research have been given at CRES, Australian National University, June 2001; Australian Mammal Society Possum and Gliders Symposium, Brisbane, July 2001; RPCC Research Working Group 4 (Native Forest Management) Perup, April 2002; WA Dept. Conservation and Land Management, Warren Region Nature Conservation Program meeting, Manjimup July 2002; and ABC South West Regional Radio, live phone interview August 2002.

Future directions

Planned achievements for 2002/2003:

- Maintain radio-collared population of possums (20 of each species) at the Orient study site (Perup), including the recollaring of animals in Nov-Dec 2002 and May-June 2003.
- Continue life history trapping sessions every second month and monthly radio-tracking for diurnal and nocturnal location and habitat use data. These field programs are planned to continue for at least 12 mths at which stage the data and field program will be reviewed to determine whether it will continue for a further 12 mths.
- Design and complete the habitat surveys for the ranges of the radio-collared study animals to provide data for the habitat selection analyses.
- Finalize the design for the distribution and abundance study in preparation to begin the associated field program by April 2003.
- Submit publication on the Comparative Survey Method Trials.

FORESTCHECK: Soil disturbance monitoring

Team Leader: Kim Whitford

Aims

- To monitor the intensity and extent of changes to soil physical properties induced by logging.
- Establish a database to examine the change in these properties over long time periods.
- Examine the relationship between visual assessments of soil disturbance and soil compaction.
- Commence the establishment of a database that over time and across sites could enable the use of visual assessment as a surrogate for bulk density measurements.
- Examine the relationship between visual assessment of soil disturbance and shear strength.
- Examine the relationship between bulk density and soil shear strength.

Summary of progress

- Field work, analysis, and reporting complete for this reporting year.
- The extent of soil disturbance cannot be readily determined on retrospective sites or recently logged sites that have experienced post harvest silvicultural treatments and/or fire.
- The intensity of soil disturbance cannot be successfully determined from visual assessment on retrospective sites or recently logged sites that have experienced post harvest silvicultural treatments and/or fire.
- On retrospective sites, operational categories are best identified when good quality aerial photography collected a short time after the completion of logging is available, and no post harvest soil disturbance, such as machine knock down, has occurred.
- Soil shear strength is unlikely to provide meaningful information on the long-term changes in soil condition because of the influence of soil moisture and the effect of gravel and roots in the soil.
- The design of FORESTCHECK, which is intended to accommodate a wide variety of monitoring exercises, is unsuited to monitoring the extent of soil disturbance. This is best done shortly after the completion of logging operations.
- Similar the intensity of disturbance from logging operations is best determined shortly after the completion of logging operations.
- Soil disturbance monitoring within FORESTCHECK is best confined to measurements of bulk density at known locations with clearly identified operational categories or disturbance classes that could be used to determine the changes in the intensity of disturbance over time at representative sites.

Evaluation of key soil indicators of sustainability in Australian Mediterranean forests (Indicators 4.1d, 4.1e)

Team Leader: Kim Whitford

Aims

This project consisted of 3 separate studies. Part 1 examined the impact of fire frequency on soil carbon and nitrogen and soil bulk density in the Jarrah and Karri forests of south-west Western Australia. Part 2 examined the utility of survey techniques of the draft protocol for Montreal Indicator 4.1e at 3 sites in the Jarrah forests, and Part 3 examined the effects of compaction caused by timber harvesting, on tree growth in the Karri forests.

Summary of progress

- Field work, analysis, and reporting complete.
- Three reports submitted to and reviewed by FWPRDC.
- Requires revision of 2 reports for submission to journal for publication.

Part 1

I examined the impact of fire frequency on soil organic carbon and nitrogen and bulk density in Jarrah and Karri forests. Two effects were consistently observed. Regular burning increased the fine earth bulk density, and reduced the concentration of carbon and nitrogen in the surface soil. Within a site the total mass of carbon and nitrogen in the surface soil layer was unaffected by fire frequency, however fire related changes in the bulk density of the soil altered the concentration of carbon and nitrogen in this layer. The correlation between soil carbon concentration and bulk density indicates that these changes with fire treatment are expressions of changes to soil processes that closely relate to these 2 soil attributes.

There were also gross differences in the mass of litterfall between the sites. Within a site litter mass decreased with fire frequency and the carbon content of the litter was constant across fire treatments. The mass of carbon stored in the litter on each treatment was driven by the mass of litter on the site. However within a site the nitrogen concentration of the litter decreased with increasing fire frequency and the mass of nitrogen in the leaf litter was generally lower on regularly burnt treatments.

Part 2

Survey techniques proposed in the draft protocol for Montreal Indicator 4.1e (Rab 1999) were used to compare the extent and intensity of disturbance on 3 faller's blocks in the northern Jarrah forest of south-west WA. This process was used to examine the relationship between visually assessed soil disturbance, bulk density, and soil strength, and to investigate a variety of displacement and coring techniques for measuring bulk density in gravelly forest soils.

Fine earth bulk density was a more informative measure than total bulk density and provided a more meaningful basis for interpreting the Indicator in these soils. Bulk density measurements were expensive and time consuming to collect. A modified version of the visual disturbance classification system of the draft protocol (Rab 1999) yielded meaningful assessments of changes to soil physical properties and has the potential to contribute to the cost effective implementation of Montreal Indicator 4.1.e in studies where assessment is conducted a short time after logging.

Part 3

I examined the effects of soil compaction on tree and stand growth at 4 Karri stands. Log extraction caused significant increases in soil compaction on major snig tracks and this caused severe localized growth suppression of Karri regrowth.

Tree growth on snig tracks was 26% of that on the control plots 10 m away from the snig track, and across the 4 sites ranged from 16% to 54% of growth on control plots. This reduction in growth occurred as significantly reduced diameter and height growth and significantly lower stand density on snig tracks. The growth suppression on snig tracks is substantial. However, tree and stand growth immediately adjacent to the snig tracks was enhanced, with these transition areas having greater diameter and height growth than control areas, and significantly higher stand density than control areas. Averaged across the 4 sites we studied this increase in growth adjacent to the snig tracks compensated for the loss of growth that occurred on the snig tracks. This growth response varied between sites and was greatest on the 2 sites with the highest growth rates (11.5 m^3 ha^{-1} yr^{-1}) where the increased growth on transitional areas exceeded that lost from the snig tracks by c. 3.4 m^3 yr^{-1} for every hectare of snig track. However on sites with lower growth rates (6.7 m^3 ha^{-1} yr^{-1}) there was a net loss in stand growth, of the order of 2.5 m^3 yr^{-1} for every hectare of snig track, due to growth reduction on the snig tracks. On sites with growth rates of this order (7 to 10 m^3 ha^{-1} yr^{-1}), snig track compaction caused a loss in site productivity and particular care should be taken to minimize the area of snig tracks and the compaction of snig tracks.

Establishment of Jarrah (*Eucalyptus marginata*) in shelterwood areas and on dieback 'graveyard' sites

SPP #93/94

Team Leader: Kim Whitford

Aims

This SPP originally consisted of 8 parts. Only parts A and H are relevant to this report (see status, below). Experiment A examined factors associated with the failure of shelterwood regeneration. Experiment B examines the effect of stand density and fertilizing on the quantity of seed-fall.

Summary of progress

SPP #93/94 consisted of 8 experiments (A – H) examining Jarrah shelterwood regeneration. Experiment A has finished, and requires reporting. Data collection processing and analysis for experiment B have been completed. Experiment B is currently being written up. Experiment D was established twice and failed due to unsatisfactory burns which did not activate seedfall. Experiment H (clone establishment) was set up and transferred to Mike Stukely for ongoing monitoring. Experiments C, E, F, and G were never commenced, as funding was not provided.

Experiment A

Results from experiment A were inconclusive due to poor regeneration burns. However the results obtained do emphasize the importance of several factors in shelterwood establishment: a satisfactory seed crop must be present on the stand, a hot and complete burn of the stand is necessary, once established seedlings must be protected from fire.

Experiment B

The effect of stand density and fertilizing on the fall of flowers, fruits, seeds and associated plant parts was studied over 41 mths on 30 plots in the Jarrah (*Eucalyptus marginata*) forest (Inglehope Jarrah growth experiment). Although fertilizer did increase the production of buds and flowers, this increase was not significant. The increased production of flowers did not mature, and the resulting production of seed was the same on both fertilized and unfertilized plots. Reducing stand density (thinning occurred 30 yrs prior to this study) did not produce a significant or consistent response in the production of buds, flowers, and fruits. The stand with the highest basal area produced the least number and weight of flowers, fruit, and seed.

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 #93/95

Team Leader: Kim Whitford

Aims

- To develop allometric relationships between tree and stand parameters, and the size and abundance of hollows in Jarrah and Marri trees and CWD.
- To develop relationships between tree and stand parameters, the size and abundance of hollows in Jarrah and Marri trees and CWD, and the use of these trees by selected species of fauna.

- To determine the effects of the logging-and-burning treatments on the abundance of hollow-bearing trees and CWD, and to relate this to the abundance of selected species of fauna.

Summary of progress

- Field work, analysis, and reporting complete. 5 papers published, 1 Landscope article, 1 manuscript in review.
- Defined the relationship between tree age and diameter for Jarrah and Marri.
- Determined the age of hollow bearing Jarrah and Marri and the ages of trees bearing hollows suited to various bird and mammal species.
- Identified 130 yrs as a realistic minimum age to hollow formation for forest management purposes.
- Determined that the minimum Primary Habitat tree diameter (70 cm) corresponds to a tree age of 171 yrs.
- Developed descriptions of ranges of hollow sizes used by various species of birds and mammals.
- Developed an improved method of defining the dimensions of hollows used by fauna.
- Produced basic data on: hollow occurrence, distributions of hollow sizes, interrelationships between hollow dimensions, shapes of hollows, hollow orientations, and the order and sizes of branches bearing hollows.
- 90% of hollows in the forest are borne on trees with diameters between 20 and 100 cm.
- There are c. 100 hollows/ha in the Jarrah forest. About 90% of these are small, i.e. c. 10 hollows/ha are potentially usable.
- Identified the relationship between hollow occurrence and the following tree attributes: tree age, DBH, crown size, crown condition, tree status (alive/dead), tree species, amounts of dead wood in the crown, termite damage, and tree lean. These are the basis of the current prescription.
- Predictive relationships developed. These enable predictions of hollows occurrence across the forest for individual fauna species and allow investigation of different H tree retention strategies.
- Examined factors affecting habitat tree longevity and determined the relationship between probability of tree fall and tree and stand attributes
- Identified relationship between log attributes and occurrence of hollows (CWD component by Matt Williams).
- Assessed risk to different species as a basis for determining hollow management strategies.

Cost-effectiveness of 3 methods of applying glyphosate herbicide to Jarrah (*Eucalyptus marginata*) standing trees and cut stumps

SPP #96/04

Team Leader: Kim Whitford

Aims

- To compare the costs and effectiveness of the 2 methods of stem injection of glyphosate herbicide to standing Jarrah trees in spring. Methods were: a) notching the sapwood and injecting a liquid mixture into the notch, and b) Ecoplug capsule treatment.
- To compare the costs and effectiveness of the 3 methods of applying glyphosate herbicide to Jarrah tree stumps. Methods were; a) spraying the cut stump with a liquid mixture from a backpack, b) spraying the cut stump with a liquid mixture from a pressure pack, and b) Ecoplug capsule treatment.

Summary of progress

- Field work, analysis, and reporting complete.
- The Ecoplug capsule treatment was most expensive ($72 m^{-2}), c. 4 times the total cost of using a backpack ($16 m^{-2}) or pressure pack ($21 m^{-2}) per m^2. When these costs were corrected to account for the different doses applied in the treatments, the total cost of the pressure pack treatment ($16 m^{-2}) was less than the cost of the backpack treatment ($17 m^{-2}). The mortalities observed in the 3 cut stump treatments (96%, 93%, and 95%) were not significantly different ($p > 0.25$).
- Pressure packs of glyphosate are recommended for treating cut stumps where the convenience and flexibility of a prepared and packaged product are of benefit. Problems with this product need to be resolved. The cans corroded after 6 months of storage. Operators using this product must wear a glove to protect the hand holding the can from spray bounce.

PERTH OBSERVATORY

Group Manager: Dr James Biggs

Information

Core Function

Team Leader: James Biggs

Aims

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'. The aim of this core function is to provide relevant and timely astronomical information.

Summary of progress

- 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.
- Milestones for Activities 1, 2 & 4 involved the maintenance of the level of activity and user participation. The table below indicates that whilst the levels were not always maintained they were still close. This was deemed acceptable especially given the Observatory-wide emphasis on the increase in visitor attendance in the Education core function. Furthermore, customer surveys suggest that the quality of Observatory information remains high and response to information requests remains timely.
- The provision of up-to-date information resources had mixed success in achieving its milestones. A new library database was tested and was found to be satisfactory. However, time was unavailable to create 2 posters that highlight the Observatory's activities, and reduced funding hampered the creation of a part-time promotion position. These 2 milestones were also applicable to Activity 5.
- Volunteers continued to provide assistance in the preservation and restoration of Observatory archives. Thus, the milestone for this Activity 6 was achieved.

Activity	2001/2002	2000/2001
Telephone enquiries	11,138	12,665
Information line	1,001	2,036
Email enquiries	535	-
No. talks, lectures etc	89	80
Talk attendance	2,899	3,534

Consultations	57	13
Newspaper, radio & TV	149	171
www page hits	875,783	677,514
Positive responses to 'quality' question in customer surveys	98%	99%
Satisfaction of information requests as they occur	98%	99%

Future directions

The activities and milestones remain the same for this financial year. The activities are detailed above and most milestones entail the maintenance of the level of activity at least at the previous year's level. An update to the milestone for Activity 3 is the actual use of the library database system.

Research

Core Function

Team Leader: James Biggs

Aims

- Provision of astronomical research in the following areas:
- Monitoring brightness changes in stars, comets, gravitational lensing events and other celestial bodies, and participate in their further study.
- Determining positions of minor bodies (asteroids and comets) and targets of opportunity and forwarding these to the International Astronomical Union for publication and dissemination.
- Searching for extra-galactic supernovae in low-redshift spiral galaxies.
- Conducting spectrographic observations of relatively bright celestial objects.
- Testing the suitability of appropriate Western Australian sites for astronomical observations.
- This program directly addresses the State Government's 'Innovate WA' Policy objective of 'strengthen and improve the educational and research capacity of the state', and with a recommendation in the Final Report of the (Australian) Innovation Summit Implementation Group; Innovation: Unlocking the Future (2000),
- 'Publicly funded basic research plays an important role in supplying much of the knowledge, skills and new ideas critical to a competitive and innovative economy.'

Summary of progress

Progress in individual projects is detailed in each SPPs' section below. Observatory staff published a total of 5 papers in refereed international journals and another 4 in minor publications (poster papers, abstracts etc). 100% of referred papers submitted were published (100% in 00/01) and 68% of astronomical targets of opportunity were effectively studied (63% in 00/01).

Future directions

The future direction for each SPP is discussed in the sections below.

Imaging and CCD photometry of transient and variable sources

SPP #98/11

Team Leader: James Biggs

Aims

The aim of this project is to image newly-discovered celestial objects and/or poorly known variable sources. This project will result in:

- Increased knowledge of Solar System objects
- Discovery of new Solar System objects
- Increased knowledge of the structure and processes within stars

Summary of progress

This project met its milestones with successful observations conducted (in collaboration with colleagues in the USA using the Hubble Space Telescope, notably U. Cincinnati) of targets T Cha, LkCa15-4S, DM Tau, CI Tau and HD104237. These data were also reduced in preparation for analysis and publication.

One poster paper was presented at the Gillett Conference, USA:

- M.L. Sitko, (U. Cincinnati), 9 others, J. D. Biggs (Perth Obs.) & M.S. Hanner (JPL). 2002. “Mid-IR Spectroscopy of Dusty Protostellar Disks: A Game Plan”, poster paper, Gillett Conference, USA.

Two conference abstracts were also published:

- Grady C., 9 others & Biggs, J. D., "The Environment and Outflow of the G-type T Tauri Star SU Aur", 2002. Bulletin of the American Astronomical Society.
- Danks, A., 9 others & Biggs, J. D., "The Environment and Wind of the Herbig Ae Star HD104237: HST/STIS Coronagraphic Imaging and HST/STIS and FUSE FUV spectroscopy", 2002. Bulletin of the American Astronomical Society.

Also the position of the optical counter-part to the x-ray source 1RXS J232953.9+062814 was published in an International Astronomical Union Circular (Biggs, J. D. & others. "1RXS J232953.9+062814", 2001. IAU Circ., No. 7749.)

Future directions

Suitable targets will be observed as time and resources permit.

Astrometry of minor planets, comets and targets of opportunity

SPP #98/12

Team Leader: James Biggs

Aims

- Position measurements of minor bodies assists the determination of 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 objects position facilitates other specialized types of observation (and these not need be restricted to the visible part of the electromagnetic spectrum).
- Position measurements of targets of opportunity such as supernovae provide confirmation of their existence as well as facilitate follow-up observations with other instruments.

Summary of progress

- An increased number of minor body positions were published in 2001/2002, the total being 662, an increase over the 520 for 2000/2001. Twelve of these were confirmation observations of 5 newly discovered Near Earth Objects (NEOs), 35 were confirmation observations of 10 newly discovered comets and 292 were useful observations of other NEOs necessary to refine their orbits.
- In order to minimize equipment down time 3 dehumidifier systems were tested on the Mike Candy Telescope (MCT) during winter observations. A system based on an infra red lamp was far more economical and efficient compared with a basic radiant heater and a commercial dehumidifier.
- A PC was purchased and integration of the telescope and camera control functions was started.
- An application for a Shoemaker Grant from the Astronomical Society of the Pacific was submitted. Even though it was ranked in the top 10 of all applications, funding was unsuccessful because of the small aperture of the Mike Candy Telescope compared with the equipment available to other applicants.

Future directions

- Monitoring of NEOs will continue with the milestone an increased number of published positions.
- Further integration of telescope and camera control onto one PC will be attempted.
- Another enhancement will be the construction of a dedicated infra red lamp-based dehumidifier system for MCT enclosure.

Astronomical seeing evaluation of sites in WA

SPP #00/06

Team Leaders: James Biggs

Aims

This project involves the testing of appropriate Western Australian sites regarding their suitability for astronomical observations. This will provide information necessary for the planning of future facilities.

Summary of progress

Site evaluation observations were conducted atop Mt Singleton as part of a Landscope Expedition to Ninghan Station. Observatory staff and Landscope volunteers acquired c. 30 hrs of useful data.

Future directions

Future key activities include the monitoring of the seeing at Bickley for a further 5 nights, and, the output of a preliminary report regarding the analysis of observations at one remote site.

Education

Core Function

Team Leader: Peter Birch

Aims

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'.

The aims of this core function are:

- Provision of relevant and timely education services,
- Demonstration of science in action, and
- Facilitation of the development of the tourism potential of astronomy.

Summary of progress

Key activities in this core function include:

- Provision of lectures, talks, workshops etc,
- Provision of astronomy activities for visitors; star viewing, day time guided tours, astronomy field nights etc, and
- Measurement of customer satisfaction and perception of quality.
- Most of the milestones for these activities involved the maintenance of the level of activity and user participation. Also, activity 2 had an additional milestone of implementation of a new activity – the PC-based 'cloudy night' virtual star viewing.
- The implementation of the cloudy night virtual star viewing was successful and facilitated the conduct of more Star Viewing Nights and, and in turn, the attainment of the attendance milestone. The Daytime Guided Tours also achieved the attendance milestone. However, the attendance milestones for Astronomy Field Nights and talk/lectures were not achieved even thought their level of activity milestone was. This reflects the fact that the attendance at Astronomy Field Nights and talks is somewhat beyond our control. The percentages of satisfied customers, those with raised astronomy awareness and perception of educational quality were still very high and not statistically different from previous years.

Activity	2001/2002	2000/2001
Star Viewing Nights	185	142
Night Visitors	6107	5120
Daytime guided tours	122	126
Day visitors	3607	3304
Astronomy Field Nights	27	23
Field Night attendance	2833	4676
Lectures and Talks	89	80
Talk attendance	2899	3534
Student consultations	57	13
Customer satisfaction (star viewing and guided tours)	94%	98%
Astronomy awareness raised	95%	97%
Educational quality	96%	99%

Future directions

It is planned to continue the current activities, with similar milestones. Additional milestones include:

- Activity 1 - implementation of off-site PC-based presentations,

- Activity 2 - implementation of a new activity – star viewing for the disabled, and implement a new booking system.
- Develop and market astronomy education resources - creation of a new educational resource – teacher resource kit, and manual operation of Project Astronet (internet telescope), and
- Creation of equipment for daytime astronomy – acquisition of an H□ telescope with which to safely view the detailed structure of the Sun.

Variable Star Observations

SPP #98/09

Team Leader: Peter Birch

Aims

Continuous brightness monitoring of variable stars is the focus of this project. This will lead to an increased knowledge of the structure and processes within stars.

Summary of progress

- This project met its milestones with successful observations conducted and data reduced for publication.
- A paper detailing the results from the combined observations (in November 2000) of 12 observatories in conjunction with the Whole of Earth Telescope Project (WET) of the variable star HR1217 was submitted.
- Observations were also undertaken of DME binary BPM 71214 with Kawka and Koch of Murdoch University. A paper analysing these observations and other binary stars was submitted for publication.

Future directions

Participation in international variable star monitoring programs will continue as time and resources permit, with the milestone remaining 'the successful observations and reduction of data for publication'.

Imaging and Spectrophotometry of Comets

SPP #98/10

Team Leader: Peter Birch

Aims

- Monitoring cometary brightness changes in specific wavelength bands.
- Observing comets over a wide range of heliocentric distances both pre-perihelion and post-perihelion, and
- Imaging 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

- This project attained its milestone of successful observation of comets and reduction of data for publication. Observations can only be made when comets are suitably accessible to Perth

Observatory equipment.

- Comets Linear 2000 WM1 and Ikeya Zhang were observed photometrically in late 2001.
- Comet Borrelly was observed only on 2 occasions, as it was the subject of a spacecraft flyby.

Future directions

- A paper detailing the observations of Comets Linear 2000 WM1 and Ikeya Zhang is in preparation.
- Comet Hale-Bopp was the subject of a long-term study at different locations, and a paper discussing this is in preparation.
- Newly discovered comets will continue to be observed as they become available in the Southern Hemisphere. The next planned comprehensive observing program is for early 2004, when the bright Comet LINEAR 2001 Q4 will be available.
- Further observations will be made of Comet Tempel in late 2004/early 2005 when it becomes available in southern skies in the lead up to the Deep Impact Mission.
- Commissioning of an automated focuser for the PLAT should begin in 2003 and facilitate an increased number of observations.

Supernova Search

SPP #98/14

Team Leader: Ralph Martin

Aims

The Perth Automated Supernova Search is a search for extra-galactic supernovae in low redshift spiral galaxies. The search uses the 61cm Perth Lowell Automated Telescope (PLAT) at the Perth Observatory.

The aims of the Supernova Search are:

- 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.

Summary of progress

- The collection a new set of archive images for the supernova search using the observatory's new Apogee CCD camera was completed. Monitoring of these galaxies for supernovae commenced in January 2001.
- Data from a cloud detector is now available to the PLAT— this allows the telescope to run in "unattended" mode. Where unattended mode is defined as leaving the telescope to collect and analyse data for extended periods (up to 12 hours). During the first 4 months of unattended operation a 15% increase in the number of digital images collected has been recorded. Although this is a significant improvement, in the amount of data, further "tuning" of the PLAT's software will give additional increases.
- Unattended operation of the PLAT has resulted in the recovery 6 known supernovae. We are confident, therefore, of discovering unknown supernovae using the upgraded software and hardware.
- R Martin completed his M Sc. (Physics). His thesis entitled "Methods for an Automated Supernova Search" was reviewed favourably by the examiners.

Future directions

- Photometric monitoring of Southern Hemisphere supernovae commenced in October 2002 and development of a data reduction pipeline is proceeding.
- Commissioning of an automated focuser for the PLAT should begin in 2003 and facilitate an increased number of observations.
- The milestone for unattended operation of Lowell Telescope is 20 nights/yr.

Monitoring Gravitational Microlenses

SPP #98/13

Team Leader: Andrew Williams

Aims

The main aims of the project are to use precise light curve measurements to characterize the statistics and kinematics of Galactic microlensing events, to detect extra-solar planets, and gain information on the stellar population in and around the Galactic Bulge. This is achieved through an international collaboration - PLANET – with 19 members in 9 countries. Access to telescopes in Perth, South Africa, Chile, Tasmania and Canberra allows 24-hr monitoring during the bulge season (April-August).

Summary of progress

The 01/02 year has seen several major refereed publications for PLANET and has thus achieved its milestone:

- Two papers summarizing the extrasolar planet detection efficiency over the first 5 yrs of the PLANET collaboration (1995-99). These give the first lower limits ever published for the frequency of planets around Sun-like stars: “No more than 1/3rd of M-class dwarfs in the Galactic Bulge have Jupiter-mass planets between 1.5 and 4 AU.”
- A paper giving estimates of stellar masses, velocities and atmospheric properties in the microlensing event EB-2K-05, using PLANET photometry. This is the first complete solution for all parameters in a microlensing event using photometry.
- A cautionary paper describing an anomaly seen in the lightcurve of MB-99-47 that at first glance, appears to be due to an extra-solar planet – but is actually a binary star, not a planet.
- An overview of the PLANET project and its results for astronomers outside the microlensing field.

In addition, the yearly PLANET meeting was held in Perth during November 2001, using facilities at the University of Notre Dame in Fremantle. Out of the (then) 16 members, 10 attended, and the meeting was both productive and enjoyable for all.

Future directions

- Improvements in weather sensor software will allow fully unattended observing on the Lowell Telescope, leaving the system to acquire images and shut down as needed. The milestone for this activity will be 20 nights of unattended observing. This will facilitate greater efficiency, although it cannot be used for all PLANET work due to the need to detect and respond immediately to microlensing anomalies.
- The April-August 2002 bulge season included many prime events, and work on analysing that data will be undertaken.
- Commissioning of an automated focuser for the PLAT should begin in 2003 and facilitate an increased number of observations.