Jan Rayner

CALM**Science** Division

OPERATIONS PLAN

PROJECT TEAM PLANS

1999-2002

Department of Conservation and Land Management

CONTENTS

INTRODUCTION

The purpose of the CALM**Science** Division, as defined by our mission statement, is;

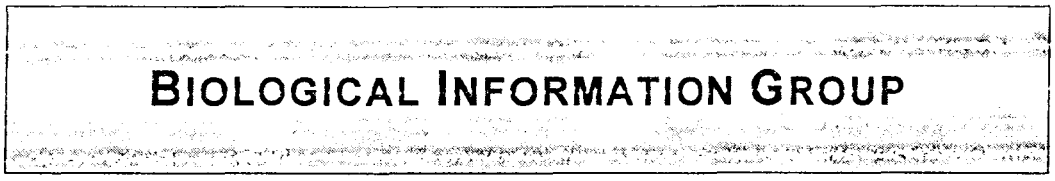
"***To provide up-to-date and scientifically sound information to uphold effective*** *conservation and land management in Western Australia".*

A three-tiered planning process is in place to ensure that the Division achieves its mission. The Strategic Plan (1999-2004) sets out the role of the Division by providing an overview of its mission, broad objectives and strategies. It also describes the aim of the four Key Science Themes (Groups) and the objectives, strategies and indicators of success of the projects that support these themes.

In addition to preparing a five year Strategic Plan, the Division is committed to a formal triennial evaluation of its performance and to a review of CALM's research priorities. As part of this triennial evaluation and planning process, the Division will report on its activities and outcomes over the last three years and, in consultation with CALM's primary program managers, regional and district staff, revise its operations to reflect changing priorities. Such a review was last undertaken in 1998 and gave rise to the 1998-2001 Operations Plan.

This Operations Plan provides further detail about the objectives, significance, benefits, methods, milestones, outputs and outcomes of the Project Teams which have been assembled to support the Key Science Themes. The Operations Plan also describes the Division's operational structure and identifies specific science projects and staff that support the Project Teams. Further detail about science projects is contained in the Science Project Plans (SPPs) which can be accessed via the CALM**Science** Division web site or by contacting the Director.

A summary of SPPs active in the various CALM Regions is contained in Appendix 1.


BIOLOGICAL INFORMATION GROUP

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Collections Management

PROJECT LEADER:

Chang Sha Fang, Herbarium

CORE FUNCTIONS:

Maintain and extend the State's scientific collection of specimens the Western Australian Herbarium (PERTH) to adequately represent taxon distribution and variation, and,

Maintain currency of names in the corporate names database (WACENSUS), the State Collection and the specimen database (WAHERB).

STAFF:

Staff	Location	FTE
S Carroll	Herbarium	0.5
K Knight	Herbarium	0.7
J Eygenraam	Herbarium	0.5
M Falconer	Herbarium	1.0
C S Fang	Herbarium	0.5
C Parker	Herbarium	0.5
P Spencer	Herbarium	1.0
K Veryard	Herbarium	1.0
Vacant TO		1.0
Plus 29 volunteers (4 FTE)		
Total		6.7

OBJECTIVES:

- Ensure safe and adequate storage of the State Collection for perpetuity.
- Collect and process voucher specimens of plants, algae, fungi, bryophytes and lichens and incorporate them into the State Collection.
- Acquire appropriate voucher specimens for all plant related studies in CALM and collaborating external organisations
- Ensure that all voucher specimens are accurately named prior to incorporation.
- Adopt relevant published research information so that the collections are curated according to current taxonomic information.
- Maintain the names database WACENSUS.
- Maintain the specimen database WAHERB.
- Maintain the Library holdings database WALIB.
- Facilitate access to and the loan of specimens for taxonomic studies.
- Collaborate with kindred organisations to increase taxonomic research capacity on WA Flora.
- Ensure that the specimens of each taxon are accurately identified according to accepted circumscription.
- Improve the quality of material received for incorporation.
- Photograph/acquire prints of all WA type specimens not represented in PERTH by a specimen.
- Expand and maintain ancillary collections (Spirit, carpological, wood & plant fossils).
- Process and incorporate backlogs of specimens

SIGNIFICANCE & BENEFITS:

The acquisition and databasing of annotated, accurately identified and well-curated specimens from the State will enable the State Collection to underpin conservation of Western Australia's unique and diverse flora.

METHODOLOGY:

Protocols as set out in manual of herbarium techniques (copy available in the Herbarium library).

SCHEDULE OF TASKS:

1998

- Mount all incoming specimens.
- Incorporate all mounted specimens and returns of loans.
- Interact with plant survey research programs (local).
- Interact with plant survey research programs (interstate and international).

- Ensure that all specimens are accurately named and curated and the data captured on WAHERB prior to incorporation.
- Validate label data.
- Validate geocodes.
- Maintain a pest free environment.
- Facilitate inter-herbarium loan of specimens for taxonomic studies.
- Expand Reference Herbarium Collection to reflect 90% of the currently accepted WA species.

1999

- As for 1998.
- Reduce specimen backlogs to 30%.
- Reduce WA Type specimen photograph backlog to 50 %.
- Formalise program to recover specimens from all flora licences issued.
- Expand Reference Herbarium Collection to reflect 100% of the currently accepted WA species.

2000

- As for 1998.
- To attain a total holding of 0.5 million specimens (approximately 40 specimens per taxon).
- Achieve significant repatriation of type collections of WA taxa held in other herbaria.
- Acquire building extensions to adequately and safely house the collection.
- Ensure safe and adequate storage of the State Collection for perpetuity.
- Incorporate all backlog of appropriate specimens.
- Photograph all backlog of Type Specimens.
- Commence data capture of ancillary collection to link to WAHERB.
- Add specimens to the Reference Herbarium Collection to reflected variation of species.

MILESTONES:

- Annual increment of 5 000 named and well annotated specimens to the collection per year.
- Adequate representative collection of voucher specimens from CALM plant-based projects.

OUTPUTS:

- Training in specimen collection and processing.
- Improved field collection manuals.
- Development of collaborative arrangements which add to flora knowledge of the state collection.

OUTCOMES:

- International recognition as a State Collection which is relevant to conservation and land management.
- Ready access by managers to accurate available information on WA flora and fungi.
- Direct advice on taxonomy and distribution of conservation taxa.
- Authenticated lists of conservation taxa.
- Inventory of species records on conservation estate.

ADOPTION STRATEGY

Ongoing maintenance and extension of the State Collection through utilisation of databases to accomplish an adequate representation of the State flora.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Regional Information Network

PROJECT LEADER:

Chang Sha Fang, Herbarium

CORE FUNCTIONS:

Developing and operating a Regional Information Network to empower Landcare and kindred Groups to access information on native and alien WA flora.

Training Network Groups to collect well documented voucher specimens and thus make substantial contributions to CALM corporate knowledge of native flora and weed species of the State.

STAFF:

Staff	Location	FTE
S Carroll	Herbarium	0.5
C S Fang	Herbarium	0.5
J Gathe*	Herbarium	0.4
M Hislop*	Herbarium	1.0
M Lewington*	Herbarium	0.5
B Mahon	Herbarium	0.2
P Pigott	Herbarium	0.8
J Wheeler	Albany	0.1
*=externally funded 13 volunteers 2.0 FTE		
Total		4.0

OBJECTIVES:

- Create a network of regional "para taxonomists" whose activities are focused on local herbaria.
- Increase specimen based knowledge of the native and alien WA flora.
- Develop a self-sustaining, comprehensive plant information system.
- Empower local groups of para-taxonomists to be custodians of knowledge of their own regional plants through skills training and education.

SIGNIFICANCE & BENEFITS:

- Acquisition by the CALM Herbarium of well collected specimens and habitat information.
- Greater awareness and appreciation of the WA flora by the community.
- Improved local knowledge of flora conservation by regional groups.
- Documentation of the distribution, and biology of WA weeds.
- Increased availability of tourism information to local Groups.
- CALM access to enthusiastic and trained regional "para-taxonomists".
- Direct links and benefits to salinity action and other conservation programs, including Landcare Groups.

DESCRIPTION:

- Utilization of external funds to establish and maintain three coordinating staff based at the CALM Herbarium.
- Development of efficient support systems to coordinate and extend the Network.
- Establish a team of well trained volunteers to liaise with and train regional "para-taxonomists" and also to supplement an efficient identification service for plant specimens.
- Actively forge links with salinity, Landcare, weed study and infotourism groups in WA regions.
- Communicate with community groups by newsletter, direct contact and training sessions to increase the number of participating Groups.

METHODOLOGY:

- Communicate regularly with groups by newsletter and arrange training/education sessions on using computer software and hardware: access to relevant literature.
- Actively promote the vouchering of detailed and quality specimens from regional Groups.
- Provide and maintain systems to ensure currency of names in all Regional herbaria.
- Arrange and conduct training workshops to improve and update skills of regional Groups.
- Provide specialist training for the specific needs of weed specimen collection and documentation of biological and habitat characteristics.
- Recruit and train new volunteer "parataxonomists" to staff identification unit.

SCHEDULE OF TASKS:

1998

- Consolidate and motivate the team of consultant botanists, administration, databasing staff and volunteers.
- Consolidate links with the current registered regional herbaria.
- Organize and conduct 2 training workshops for the volunteer botanists based in PERTH.
- Organize and conduct 3 training and education workshops in the regions.
- Organize and conduct 1 computer training and education workshop in PERTH.
- Expand the network of regional herbaria from 36 to 50.
- Identify and incorporate into the State Collection 4000 specimens from the regional herbaria.
- Apply for funding for a Weed Information Network to parallel the existing network.

1999

- As for 1998, with the same number of workshop training sessions.
- 20 % increase (from 50 to 60) in the number of participating regional herbaria.
- Identify 7000 specimens from regional herbaria.
- Develop the Weed Information Network as far as funding permits.

2000

- As for 1999, with the same number of workshop training sessions.
- 10 % increase in the number of participating regional herbaria.
- Identify 10000 specimens from regional herbaria.
- Continue to develop the Weed information network as far as funding permits.

MILESTONES:

- 5000 specimens added to the State Collection annually.
- 65 active regional herbaria with up to date and properly verified specimens.
- A task force of 1000 trained and enthusiastic "para-taxonomists".
- Improved information systems on naturalized and non naturalized weed taxa.

OUTPUTS:

- Training sessions to equip para-taxonomists to collect vouchered data for conservation and land management purposes.
- Improvement in public appreciation of the State's flora.
- Significant improvement in State knowledge of WA native and alien plant taxa.
- Improved habitat data and biological information on threatened taxa.
- Assessment of weeds of State significance.

OUTCOMES:

- Thousands of well annotated significant additions to the State Collection.
- Increased knowledge of the States native and alien flora.
- New taxa and range extension to contribute to the adequacy and representatives of the State Collection.
- A support system of well trained and enthusiastic CALM volunteers.

- Creation of an internationally recognized model to show how herbaria and herbarium taxonomy can be made directly relevant to conservation

ADOPTION STRATEGY:

- Establishment of a broad-based management team to guide the project under general direction.
- Monthly meetings to review progress, plan training sessions and improve systems and service.
- Adoption of effective methods to maintain enthusiasm of all parties by effective communication.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Information Systems Administration

PROJECT LEADER:

Mike Choo, Herbarium

CORE FUNCTION:

LAN support for CALM**Science** Division

STAFF:

Staff	Location	FTE
M Choo B Reid Vacant TO	Herbarium Busselton	0.2 0.2 1.0
Total		**1.4**

PROJECT OBJECTIVES:

- To provide the necessary LAN infrastructure to support the objectives of the CALM**Science** Division.

SIGNIFICANCE & BENEFITS:

- This project is responsible for the provision and management of LANs at Woodvale Research Centre, CALM Herbarium Research Centre/Como Research Centre, Busselton Research Centre and Manjimup Research Centre.

- LANs provide a central component in the Division's communication strategy as well as giving access to the Intranet and Internet and facilitating correspondence with co-researchers worldwide.
- This project provides essential and fundamental support to all Research Projects and Service work carried out by the division.

DESCRIPTION:

- Establishment, maintenance and continued upgrading of a network for electronic communications within CALMScience, within other CALM Divisions and with other scientific organisations.
- Configuration of machines for LAN/WAN and Internet connectivity.

METHODOLOGY:

- Design of LAN architecture and specifications.
- Installation of equipment and software.
- Ongoing maintenance of equipment and software.
- Upgrading of equipment and software.
- Configuration of PCs and other equipment to connect to LAN.
- Configuration of PCs to connect to Internet.
- Technology Watch.
- Retraining as necessary.
- Liaison with CALM's Executive IT Management Committee.
- Liaison with CALM's IMB.

SCHEDULE OF TASKS:

This is a core function.

MILESTONES:

This is a core function.

OUTPUTS:

- Server replacement at the Busselton and Manjimup Research Centres.
- Establishment of second server at Manjimup.
- Hub replacement at the Woodvale Research Centre.
- Year 2000 Compliance File.
- Year 2000 Compliance - Administrative Instructions for CALMScience
- Year 2000 Compliance Report and Test Results for Como, Herbarium and Woodvale.
- Year 2000 Compliance Report and Test Results for the Observatory to be completed in June 1999.
- Year 2000 Compliance report for KE Texpress.
- Year 2000 Compliance reports for WAHERB, WACENSUS, WALIB, CALMLIB and FLORABASE.

- Smoother continuous operation of CALM**Science** LANS.
- Ongoing maintenance of LANs at CALM**Science** Research Centres
- Ongoing maintenance of KE Texpress and related database systems.

OUTCOMES:

- Year 2000 Compliance - Levels 1 and 2 checking and remediation. Como, Herbarium & Woodvale centres- completed; the Observatory to be completed in June 1999.
- Identification of Y2K risk areas (eg. Bioprospecting extracts & cryogenic storage) and development of contingency plans.

ADOPTION STRATEGY:

This is a core function.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Information Systems Research & Development

PROJECT LEADER:

Nicholas Lander. Herbarium

CORE FUNCTIONS:

Development, extension and management of CALM corporate botanical databases:

WACENSUS – W.A. plant names
WAHERB – CALM Herbarium specimen data
DESCAT – W.A. flora; descriptive catalogue
WABIOTA – biological attributes of W.A. taxa
MAX – W.A. taxa editing utility and electronic collecting tool

SCIENCE PROJECTS:

93/0014	Databasing (WACENSUS) and Publication of the Census of Western Australian Plants
95/0005	WAThreatened Flora descriptive database
95/0009	Taxonomic database of WA plant genera
96/0007	Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota
96/0013	DELTA Database Engine
TBA	Phytophthora interactive identification & information retrieval system
TBA	Non-linear modelling (SPP submitted for approval)

STAFF:

Staff	Location	FTE
I Abbott	Crawley	0.05
A Chapman	Herbarium	0.2
M Choo	Herbarium	0.8
P Gioia	Herbarium	0.7
N Lander	Herbarium	0.6
T Macfarlane	Manjimup	0.4
N Marchant	Herbarium	0.05
B Richardson	Herbarium	0.5
M Yung	Woodvale	1.0
P Wilson*	Herbarium	0.8
S Woodman	Herbarium	0.4
Total		**5.5**

Ken Aplin (WA Museum, external collaborator)

OBJECTIVES:

- To develop the methodology and provide the mechanisms for utilizing information technology to satisfy the specialized needs of the Division.
- To research and develop new approaches in integrating information and systems across hardware and software platforms and geographical locations.
- To develop new and improved research methods appropriate to the Division's requirements.
- To collaborate with scientists on projects requiring a high level of analytical sophistication.
- To raise and maintain standards of research, planning and analysis and to ensure efficient design, information management and analysis in the Division.
- To communicate and integrate with other groups within CALM and other appropriate external organisations to allow for exchange of research findings, ideas, data, software and other products.

SIGNIFICANCE & BENEFITS:

This project will develop the platforms and systems for the management, integration and delivery of current and reliable information (descriptive, nomenclatural, spatial, ecological, biological) on the biota of Western Australia to all CALM staff who have need of them. It will contribute informing layers to corporate decision systems (eg RFA, CALM Fire). It will greatly facilitate the identification of species and the efficient retrieval of information about them. Thus it will provide a basic resource for a broad range of research, conservation and management projects.

DESCRIPTION:

This project comprises a number of core function and individual Science Projects:

TBA WAHERB - Databasing and Publication of WA Herbarium Specimen Information

The project fundamentally entails the design and development of the database and related procedures to enable the management of various procedures related to the curation, movement and storage of the collection. It also forms the core of the regional information network where community-based regional herbaria contribute duplicate collections to the state herbarium in return for maintenance of the specimens' identity in both collections. With data storage and maintenance procedures in place, focus has turned to developing methods for making quality information available for a broad range of research and management uses within CALM.

TBA DESCAT - The Western Australian Flora - A Descriptive Catalogue

This project is a joint project of the WA Herbarium, Wildflower Society of WA and Kings Park and Botanic Garden, funded predominantly by the Gordon Reid Foundation for Conservation. A brief standard description for every taxon is maintained in a database format, which allows flexible output to a range of electronic and printed media. While hard copy publication is the first goal, ongoing maintenance of the currency of this dataset will ensure an up to date description for all new taxa will be available at any time, via (for example) a web interface or interactive identification software. With additional characters the dataset has the potential to develop into an online flora for the state.

TBA WABIOTA

The project will involve the warehousing of a range of datasets in a single GIS environment. The data will be organized to facilitate their extraction for use within specialized collaborative projects such as Fire Decision Support Systems or Disease Management Systems. It is anticipated that funding for this project will be partly assisted by these collaborative ventures. 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.

TBA Max: Development of a species editing utility and electronic collecting book

The project involves the employment of a consultant to develop the software, based on two programs already in use: SEDIT and Herbie. The new program, Max, represents the incorporation of these two DOS-based programs in to a single 32 bit environment.

93/0014 Databasing (WACENSUS) and Publication of the Census of Western Australian Plants

The project fundamentally entails the design and development of the database and related procedures to enable the management of taxonomic and nomenclatural changes to WA plant names. It is also a basic component for a number of related datasets within CALM such as Wildlife Branches DRF database and CALMScience's WAHERB specimen database, as well as the

species master list for databases developed using the SEDIT and MAX database utility

With data storage and maintenance procedures in place, focus has turned to producing hard copy publication of the Census. Further development of a web interface integrating a range of related datasets which, together with WACENSUS, will provide an authoritative and comprehensive information base on the states flora.

Ultimately methods will be developed such that this data will contribute to the compilation of the Australian Plant Names Index and through this to the international Plant Names Project, a joint initiative of the ANBG, Kew and Harvard.

95/0005 WA Threatened Flora descriptive database

Development of an interactive database system containing descriptive, edaphic, geographic, ecological and management data concerning all WA Declared Rare Flora with eventual extension to include Priority taxa.

95/0009 Taxonomic database of WA plant genera

Development of a taxonomic database of Angiosperm (flowering plant) genera for WA, designed for interactive identification and information retrieval.

96/0007 Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota

Determination of relationship between frog species richness and CALM estate; investigation of the application of this information in assessing management priorities for existing conservation of future proposed reserves; development of methodologies for assessing the suitability of WA Museum and Herbarium point data for species richness analyses, identifying collector bias and prioritizing collector effort.

96/0013 DELTA Database Engine

The adoption of the DELTA methodology at the WA Herbarium has demonstrated the need to manage taxonomic projects and their associated data within an institutional framework. To do this requires a change in emphasis, from a project-oriented approach to a more global institutional one.

This project will develop a database 'engine' which manages the taxonomic descriptive data coded in DELTA from broad-brush projects (eg DesCat, WAGenera, Flora of the SW, Angiosperm Familes, Threatened Flora Database), and research project related work (eg Astereae, Wattle, Thysonotus). The database engine may be viewed as an *institutional complement* to the existing DELTA system that effectively transforms project oriented systems into a holistic institutional one. A built-in translator will provide the interface with the available DELTA tools by allowing data to pass smoothly between the DELTA projects and the database engine (using standard DELTA formatted ASCII files thus making it available to a range of corporate information systems. The database engine will

provide the mechanism for intelligent data input, project and character list management, incorporation of changes to data in associated fundamental data sets, error and exception reporting, data editing and all other database management facilities. It will provide the mechanism for manipulating data across projects, while within projects, it allows views based on partial character selection.

TBA Phytophthora interactive identification & information retrieval system

Further development of a sophisticated interactive database system containing descriptive, ecological, growth and geographic data covering all species of Phytophthora (world-wide), together with character and taxon images, with eventual extension to include genetic and allozyme data.

TBA Non-linear modelling

The predator and prey species populations for several CALM**Science** Division projects (eg Fox Control) will be modeled and effects such as prey switching by the predators will be analyzed. Properties of the solutions will also be analyzed, such as the stable and unstable equilibrium points in the population phase space. Statistical methods will be employed to fit the data to the model and determine the values of certain parameters of interest, such as the intrinsic growth rate.

METHODOLOGY:

TBA WAHERB - Databasing and Publication of WA Herbarium Specimen Information

The corporate database WAHERB has been designed in the object-oriented database system TEXPRESS, which provides fast word-based querying across massive textual datasets of the type found in larger museum or herbarium collections. The database is maintained in line with data standards such as the HISPID3 (Conn 1996), recently provisionally adopted as the Taxonomic Databases Working Group international specimen data exchange standard. It integrates with WACENSUS WA plant names standard to ensure accepted names are vouchered and represented in the state collection, and so that names are standardised throughout the database. Developments of the data for integration with other corporate datasets using a GIS interface, or via the web HTTP standard are continuing.

TBA DESCAT - The Western Australian Flora - A Descriptive Catalogue

A brief coded description of every WA plant species is captured and maintained in a database linked to the Census of WA Plant names species master list, ensuring currency of names. As required, data can be exported into the international standard DELTA format and from there transformed into natural language descriptions for presentation in hard copy or web pages. It may also be developed as an interactive identification tool. Integration with other corporate datasets via the web HTTP standard are also underway.

As an adjunct, an image database is being developed with the aim of producing a standard composite image for all WA flora. The project has currently compiled 5,000 single images and nearly 400 plant species composite images. While this work will take some years, it is the first consolidated compilation of digital flora images undertaken.

TBA WABIOTA

A range of candidate datasets will be analyzed for incorporation into WABIOTA. (This task has been partially completed as an outcome of an RFA project – Distribution mapping and key ecological attributes of plants). A database will be implemented within a GIS environment utilizing Arc/Info and Oracle. Software will be purchased that will allow the display of GIS data over the internet. A facility will be developed which will allow the user to display, in a standard Web browser, distribution data organized by relevant themes (eg DRF/Priority, endemics) and other biotic and abiotic information such as phytogeographical boundaries or soil maps.

TBA Max: Development of a species editing utility and electronic collecting book

Consult with users of current system (HERBIE). Write specifications for MAX. Program to be written by external consultant in Borland DELPHI.

93/0014 Databasing (WACENSUS) and Publication of the Census of Western Australian Plants

Ongoing design of TEXPRESS forms and reports; validation of names and related information; generation of text for published (hard copy) version of WACENSUS; design and scripting of form-based interactive system accessible via CALMWeb and NatureBase; integration with Descriptive Catalogue and other available taxon descriptions, images, maps (generated from WAHERB), etc.

95/0005 WAThreatened Flora descriptive database

Use of DELTA coding system to construct descriptive database for Declared Rare Flora including morphological and other descriptive data; scanning and editing of taxon images and character illustrations; creation of standard map images derived from WAHERB and Ken Atkins' databases. Production of natural language descriptions in formats required for Threatened Flora book and for presentation on CALMWeb. Development of INTKEY interactive identification and retrieval package.

95/0009 Taxonomic database of WA plant genera

Use of DELTA coding system to construct descriptive database for all WA Angiosperm genera including morphological and other descriptive data derived from the available literature; scanning and editing of taxon images and character illustrations; creation of standard map images derived from WAHERB. Production of natural language descriptions in formats required for Flowering Plant Genera of WA book and for presentation on CALMWeb and NatureBase. Development of INTKEY interactive identification and retrieval package.

96/0007 Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota

Validate frog records and implement corrections at museum. Grid data according to specified cell size and count distinct species within each cell. Generate contour from cells. Assess meaningfulness of results and identify shortcomings of specimen database. Determine relationship between collector effort and distance from road network and identify collection priorities. Use point data for each species and generate prediction of distribution based on climatic data using BIOCLIM. Regenerate species richness contours using predictive data. Use geographic range envelopes supplied by Ian Abbott and repeat BIOCLIM prediction and compare with previous results. Overlay species richness with various CALM estate types and identify representation within each estate type.

96/0013 DELTA Database Engine

Review of the DELTA descriptive language and associated softwares. Review of CALM's DELTA projects. Define and specify the Institutional DELTA Engine. Decide on the hardware and software platform for installation. Write program for DELTA Database Engine application. Develop protocols for managing descriptive data at the institutional level. Develop and test the system. Implement the system and conversion of existing DELTA projects into the institutional framework. Provide user education and documentation.

TBA Phytophthora interactive identification & information retrieval system

Use DELTA coding system to construct a descriptive database based on most current literature (Irwin et al.) including morphological and other descriptive data. Scan and edit taxon images, and character illustrations. Develop INTKEY interactive identification and information retrieval tool customised to requirements of VHS.

TBA Non-linear modelling

Develop pilot software using Fortran 77 for preliminary testing. Survey the available literature for suitable software to be adopted for development of the final application. For an ecological project, a set of ODEs will be derived, with their parameters estimated from the field data. Then the behavior of the solutions of these ODEs, which form the model, will be plotted and analyzed. Explore alternative approach using the ODEs and the field data to estimate the parameters. Develop a practical procedure for using and refining these models. Investigate equivalent flora population projects in CALM.

SCHEDULE OF TASKS:

95/0005 WATHreatened Flora descriptive database

1998

- Refinement of character list and adaptation for non-expert use
- Generation of natural language descriptions & delivery to Threatened Flora book

- Generation of HTML descriptions & incorporation in WA Herbarium Intranet system
- Completion of initial data uptake (funding permitting)
- Submission of Threatened Flora book for publication by Corporate Relations
- Image uptake (ongoing, by volunteers)

1999 - 2001
- Image uptake (ongoing, by volunteers)
- Commence uptake of descriptive data for Priority Taxa (funding permitting)
- Generation of HTML descriptions & incorporation in WA Herbarium Intranet system

2001
- Publication of comprehensive manual of all WA Priority Flora, including CD-ROM interactive system

93/0014 Databasing (WACENSUS) and Publication of the Census of Western Australian Plants

- Publication of the hard copy Census of WA Plants.
- Further develop intranet web interface for integration with CALM's NatureBase web site and presentation of names data for general access by CALM staff and the public.
- Upgrading of hardware to cater for increased demand.
- Automated data mirroring for integration with WAHERB and the web interface.

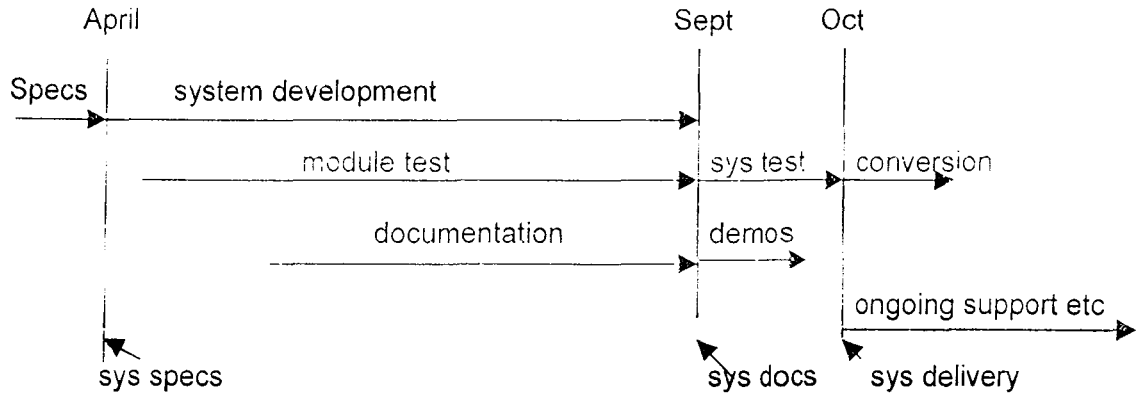
96/0007 Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota

Estimate validation requirements	1 week	Dec, 98
Literature Review	1 week	Dec, 98
Project Design	1 week	Dec, 98
SPP Approval Process	1 month	Dec, 98 - Jan, 99
GIS Development	4 months	Dec, 98- May, 99
Validate data	4 months	Jan - May, 99
Analysis of results	1 month	May - Jun, 99
Writing up and Submit to journal	1 month	Jun - Jul, 99

95/0009 Taxonomic database of WA plant genera

1998
- Complete the basic descriptive data entry.
- Checking of the data.
- Production of HTML descriptions and placing them in an appropriate place on the CALM Web.
- Placing of interactive identification system (preliminary version) on the CALM Web.
- Image selection and scanning, Phase 1.
- Preparation of a CD -ROM for publication.
- Presentations of the system to appropriate audiences.

96/0013 DELTA Database Engine



WAHERB - Databasing and Publication of WA Herbarium Specimen Information

- Full adoption of HISPID data exchange with all incoming and outgoing exchange material.
- Upgrading of hardware to cater for increased demand.
- Further develop intranet web interface for integration with CALM's NatureBase web site and controlled presentation of specimen data to national and international research associates.
- Automated data output for warehousing in WABIOTA biological database.
- Development of SQL interface for direct integration with end user GIS frontends such as ARCView.

DESCAT - The Western Australian Flora - A Descriptive Catalogue

- Develop to publication of the Western Australian Flora - A Descriptive Catalogue.
- Maintain the data on a weekly basis in line with changes occurring in WACENSUS.
- Further develop intranet web interface for integration with CALM's NatureBase web site and controlled presentation of descriptive data to CALM staff and the public.
- Further develop an interactive key presentation of the dataset incorporating character and species images and maps.
- Develop to publication a CD product containing the interactive identification tool, a systematically arranged set of web pages and available images which are customised to work with both.

TBA Phytophthora interactive identification & information retrieval system

1997/8

- Refine character list prior to uptake of data published by Irwin et al (1997).
- Code additional data and reconciliation of previously scored data with that presented in Irwin et al (1997).
- Scan taxon images.
- Refine character images previously scanned.
- Develop INTKEY system, customisation and testing.
- Deploy new INTKEY system at VHS.

- Negotiate copyright issues with use of taxon and character images.
- Write up paper discussing the system, its strengths & weaknesses, future work, etc.

1998/9
- Code genetic & allozyme data from Irwin et al (1997), Carstairs et al, etc.
- Extend system to reflect variant taxonomies.
- Publish CD-ROM.

Max: Development of a species editing utility and electronic collecting book

- Develop alpha and beta versions.
- Solicit feedback from users.
- Write documentation.
- Release production version
- Solicit feedback.
- Commence development of Version 2.
- Demonstration of software at various field centres.

TBA Non-linear modelling

1998-1999
- Modelling for Fox project.
- Modelling of Rabbit RCD virus.

1999-2000
- Modelling of botanical subject (to be determined).

WABIOTA

1998-1999
- Analyse and warehouse data from existing sources.
- Purchase Web deployment software.
- Development single theme to display plant distribution data.

1999-2000
- Develop fire theme.
- Develop Phytophthora theme.
- Add other biotic and abiotic layers.

2000-2001
- Develop bioprospecting theme.
- Develop ecosystem theme

MILESTONES:

95/0005 WAThreatened Flora descriptive database

- Completion of data scoring (Declared Rare Flora).
- Generation of natural language descriptions & delivery to Threatened Flora book coordinator.

- Publication of Threatened Flora book.
- Delivery of HTML descriptions for incorporation in WA Herbarium Intranet system.
- Completion of image uptake and editing by volunteers.
- Creation and uptake of map images.
- Testing and editing of INTKEY interactive system.
- Apply for grant(s) to extend coverage to all Priority flora (subject to availability of funding).

93/0014 Databasing (WACENSUS) and Publication of the Census of Western Australian Plants

- Publication of the hard copy Census of WA Plants.
- WACENSUS hardware platform upgraded and able serve a 100% increase in traffic via web interface.
- WACENSUS launched as part of a science and information query interface on NatureBase web site.
- WAHERB and web interface updated on a regular automated basis with WACENSUS names data.

96/0007 Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota

- Completion of Data Validation.
- Generation of Distribution Models.
- Compilation of Species Richness Maps.
- Publication of paper.

95/0009 Taxonomic database of WA plant genera

- Completion of data entry.
- Placement of HTML descriptions and interactive identification system on the CALM Web.
- Completion of first phase of image preparation.
- Completion of CD files for publication.

96/0013 DELTA Database Engine

- System Specifications.
- Completion of Unit testing.
- System Documentation.
- Completion of system testing.
- System Delivery.
- Transfer of WACENSUS.
- Availability of institutional system to users.
- Transfer of remaining DELTA Projects.

WAHERB - Databasing and Publication of WA Herbarium Specimen Information

- All outgoing exchange and loan material accompanied by a HISPID 3 compliant data file.

- WAHERB hardware platform upgraded and able serve a 100% increase in traffic via web interface.
- WAHERB launched as part of a science and information query interface on NatureBase web site.
- WABIOTA updated on a regular automated basis with WAHERB specimen data.
- ARCView access directly to the WAHERB dataset for divisional end-users.

DESCAT – The Western Australian Flora - A Descriptive Catalogue

- Publication of the Western Australian Flora - A Descriptive Catalogue.
- DESCAT database successfully maintained in line with changes occurring in the WA Census.
- WA Flora database descriptions launched as part of a science and information query interface on NatureBase web site.
- Production of an interactive key presentation.
- Publication the CD product.

TBA Phytophthora interactive identification & information retrieval system

- Completion of data scoring ex Irwin et al (1997).
- Completion of image scanning and editing.
- Completion of testing and customisation of INTKEY system.
- Deployment of new INTKEY system at VHS.
- Completion & submission of paper.
- Completion of character analysis and coding of genetic & allozyme data.
- Incorporation of Keyword system to enable variant taxonomies.
- Deployment of extended INTKEY system at VHS.
- Publication of CD ROM.

Max: Development of a species editing utility and electronic collecting book

- Alpha version.
- Beta Version.
- Production Version.
- Version 2.

TBA Non-linear modelling

- Completion of modelling for Fox project.
- Completion of modelling of Rabbit RCD virus.
- Completion of modelling of botanical subject.

WABIOTA

- Deployment of plant species distribution data theme over web.
- Deployment of additional themes as per above schedule.

OUTPUTS:

Note: The following lists outputs from 1990 until the present

Conferences, Seminars, Lectures

- Chapman, A.R. & Paczkowska, G. (Friday 6 September 1997). Talk on the Descriptive Catalogue project, with Grazyna Paczkowska, WA Herbarium.
- Chapman, A.R. (23 - 26 September 1997). Convener of the Australian Herbarium Information Systems Committee - HISCOM meeting. Adelaide.
- Chapman, A.R. (Tuesday 4 November 1997). Presentation of HISCOM97 (Herbarium Information Systems Committee 1997) Minutes and Action items at the 1997 Council of the Heads of Australian Herbaria, Hobart.
- Chapman, A.R. (Monday 29 September 1997). Talk on Descriptive Databases to the Software and Systematics Forum, 1997 ASBS Symposium, Adelaide.
- Chapman, A.R. & N.S. Lander (1997). Mini-course on descriptive database methodology for Zoology 3 students at the University of Western Australia.
- Gioia, P. (1996). Supplementing Geographic Information Systems with Expert Systems in Catchment Planning. 10th Annual ESRI and ERDAS User Conference Proceedings. Perth.
- Lander, N.S. (1997). Western Australian Threatened Flora: Interactive Identification and information retrieval. Descriptive Databases to the Software and Systematics Forum, 1997 ASBS Symposium, Adelaide.
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- Macfarlane, T.D. (1996). Spreading the botanical word - Western Australian experiences with electronic dissemination of floristic information, Beyond the Floras Conference, Oct. 1996. Melbourne.
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- Gioia, P. *Distribution mapping and key ecological attributes of plants – an RFA biodiversity project.* Presentation to CALM Corporate Executive, February 26th, 1998

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- Chapman, A.R. N.S. Lander, T.D. Macfarlane & M.D. Dallwitz (1995). DELTA and Hyper-Text Markup Language. DELTA Newsletter 11: 5-7.
- Chapman, A.R., M. & P. Gioia (1995). The Smart Collection. Landscope 10 (4): 49-53.
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- Curry, S. & A.R. Chapman (1996). Update to the informal names used in "Flora of the Perth Region". Nuytsia 10(3): 463-464.
- Curry, S. & A.R. Chapman (1996). Update to the informal names used in "Flora of the Kimberley Region". Nuytsia 10(3): 464-466.
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- Gioia, P.G. (1996). The Role of GIS and Expert Systems in Developing Catchment Plans Based on Sustainable Land Use Principles. PgDipSci Thesis, University of Western Australia..
- Gioia, P., Pigott, J.P. & Chapman, A.R. (1998) Map 5: Species Richness and Map 15: Declared Rare and Priority Flora in Anon (1998) *Comprehensive Regional Assessment – A Regional Forest Assessment for Western Australia*.
- Gioia, P., Pigott, J.P. & Chapman, A.R. (1998) Data review for terrestrial species and Flora species assessment, Biodiversity Chapter, *Report for Regional Forest Assessment*, Western Australia.
- Halse, S.A., R.M. Vervest, D.R. Munro, G.B. Pearson & F.H. Yung (1992). Annual Waterfowl Counts in South-Western Australia – 1989/90. Technical Report 29. CALM, Perth.
- Halse, S.A., R.M. Vervest, G.B. Pearson, F.H. Yung & P.J. Fuller (1994). Annual Waterfowl Counts in South-Western Australia – 1990/91. Technical Report 29: 107-129. CALM, Perth
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- Lander, N.S. (1993b). A common directory for plant taxonomic databases. DELTA Newsletter 8: 16.
- Lander, N.S. (1994a). Problems with image display under Intkey? DELTA Newsletter 10: 12.
- Lander, N.S. (1994b). Spotlight on DELTA features: Diagnoses and DELTA. DELTA Newsletter 10: 15.
- Lander, N.S. (1994c). The DELTA System: Its application to plant toxicology. In: Colegate et al. (eds). Plant-Associated Toxins: Agricultural, Phytochemical and Ecological Aspects, CAB International: Wallingford, U.K., pp. Xx-xx.
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- Macfarlane, T.D. (1995). A DELTA database project for the plant genera of Western Australia. DELTA Newsletter 11: 4.
- Jones, D.S. & N.S. Lander (1995). A revision of the scalpellomorph subfamily Calanticinae sensu Zevina (1978). In F.R. Schram & J.T. Hoeg (eds). New Frontiers in Barnacle Evolution. Crustacean Issues 10. Balkema, Rotterdam/Brookfield. Pp 15-41.

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- Macfarlane, T.D., N.S. Lander, A.R. Chapman & M.J. Dallwitz (1995). DELTA and Hyper-Text Markup Language. DELTA Newsletter 11: 5-7.
- Macfarlane, T.D., N.S. Lander & A.R. Chapman (1995). Angiosperm family identification and the Flora of Australia: a comment. Australian Systematic Botany Newsletter 83: 2-8.

CALMWeb & NatureBase web interfaces.

- CALMWeb: CALMScience Division
- WACENSUS
- WAHERB
- CALM Library
- CALM Herbarium Library

Publications in preparation

- Beard, J.S, A.R.Chapman & P. Gioia (1998). Endemism in three world mediterranean floristic regions.
- Chapman, A.R. & P. Gioia (1998). Census of Western Australian Plants.
- Gioia, P. (1998). MAX User's Guide. CALM, Perth.
- Paczkowska, G. & A.R. Chapman (1998). The Western Australian Flora – A Descriptive Catalogue.
- Paczkowska, G. & A.R. Chapman (1998). CD: The Western Australian Flora.
- Smith, M J, Kay, W R. ---, Yung, F H, Morris, R H, Halse, S A, AUSRIVAS: Using macroinvertebrates to assess ecological condition of rivers in W.A. Submitted to Freshwater Biology, Nov 1997.
- Yung, F.H., P. De Tores P., S.A. Halse & M.J. Smith (1998). Relational database normalisation in the natural and physical sciences. Submitted to the Journal of the Royal Society of W. A.
- Yung, F.H. & S.A. Halse (1998). How to manage database development for an ecological project, and how not to. To be submitted to the Royal Society of W.A.

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- Chapman, A.R. (1990). Systems analysis for the curation of new herbarium collections. WA Herbarium, CALM, Perth.
- Chapman, A.R. (1990). Label generation for new specimens in the WA Herbarium. WA Herbarium, CALM, Perth.
- Chapman, A.R. (1991). WAHERB Specimen Database User Guide. WA Herbarium, CALM, Perth.
- Chapman, A.R. (1991). WAHERB Specimen Beginners Guide. WA Herbarium, CALM, Perth.
- Chapman, A.R. (1992). SID Payment Tracking System User Guide. WA Herbarium, CALM, Perth.
- Chapman, A.R. & P. Gioia (1993). Queensland Herbarium (BRI): Analysis of Strategic Priorities and Database Recommendations. CALM, Perth.
- Chapman, A.R. & P. Gioia (1996). Critical Assessment of the Plant Bio-diversity Information System. Prepared for the Botanic Gardens of Adelaide and State Herbarium. CALM, Perth

- Chapman, A.R. (1994). Ghisalberti Plant Chemistry Database: A report on the Database Structure and Content and a Costing of Tasks Required to Upgrade this Database. CALM, Perth.
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- Chapman, A.R. & N.S. Lander (1995). Conceptual Plan for the Implementation of a Corporate World Wide Web Server for CALM. CALM, Perth.
- Curry, S. & A.R. Chapman (1995). Western Australian Herbarium Index, April 1995. CALM, Perth.
- Choo, M. P. Gioia, A.R. Chapman & C. Farrell (1995). WASPP Administrators Guide. CALM, Perth.
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- Gioia, P. (1994). Declared Endangered Flora Database User's Guide. CALM, Perth.
- Gioia, P. (1994). Declared Endangered Flora Database System Administrator's Guide. CALM, Perth.
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- Gioia, P. & A.R. Chapman (1998). RFA Map 5 Species Richness in the WA Forest regions. *In* RFA Report [add details].
- Paczkowska, G., A.R. Chapman, G.J. Keighery & M. Choo (1994). A Descriptive Catalogue of Western Australian Plants – The Monocots. Final Report to the Gordon Reid Foundation for Conservation. Wildflower Society of WA, WA Herbarium and Kings Park & Botanic Garden.
- Raines, J.A., Yung F. H. and Burbidge A. H., Wetlands of Outstanding Ornithological Importance for the Register of the National Estate in South-West Western Australia, Report to the Australian Heritage Commission, June 1995.

Systems Developed & Currently Deployed

- Chapman, A.R. WAHERB databases system.
- Chapman, A.R. et al. CALMLib database system.
- Chapman, A.R. & B.S. Mahon. CALM Herbarium Library database system.
- Choo, M., A.R. Chapman, P.G. Gioia, N.S. Lander. WASPP: Science Project Proposal management system.
- Gioia, P. & A.R. Chapman. WACENSUS database system.
- Gioia, P. Herbie.
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- Lander, N.S., DELTA Menu System for Windows. Released on Internet, 9 June 1994 at spider.ento.csiro.au/delta/dmswin/dmswin@.exe

Editorial

- Macfarlane, T.D., A.R. Chapman & N.S. Lander [eds]. DELTA Newsletter 8: 1-22.
- Chapman, A.R., T.D. Macfarlane, & N.S. Lander [eds]. DELTA Newsletter 9: 1-24.
- Chapman, A.R., T.D. Macfarlane, & N.S. Lander [eds]. DELTA Newsletter 10: 1-24.
- Macfarlane, T.D., N.S. Lander & A.R. Chapman [eds]. DELTA Newsletter 11: 1-22.
- Chapman, A.R., T.D. Macfarlane, & N.S. Lander [eds]. DELTA Newsletter 12.

OUTCOMES:

- Improved dissemination of scientific knowledge aiding recognition and management of WA biota by CALM staff and the general public (publications, CALMWeb, NatureBase, CD-ROM, etc.).
- Gains in the efficiency and quality of identification of WA flora and pathogen species.
- Integration of descriptive, specimen, nomenclatural and image data with related corporate databases.
- More accurate and efficient management of conservation flora populations.
- Development of repository for taxon-based biological data concerning distribution, fire response, Phytophthora sensitivity, pollination, rooting systems, horticulture, essential oils, weed behaviour, pharmaceutical activity, etc.
- Provision of informing layers fundamental to the development of computer-aided decision support systems (eg RFA, Salinity Action Plan, CALM Fire, reserve acquisition, disturbance impact assessment).
- Improved basis for the development of species and ecological community models.
- Raised public profile of Departmental role in documenting and managing the WA biota and the CALM estate.

ADOPTION STRATEGY:

93/0014 Databasing (WACENSUS) and Publication of the Census of Western Australian Plants

- Increased awareness of the role of the census as a fundamental dataset underpinning science and conservation efforts within CALM and the state.
- Increased consultation of the WACENSUS database during survey and research projects.
- Increased use of the WACENSUS database in species and ecological community research, management and operations projects and procedures.

95/0009 Taxonomic database of WA plant genera

- Broad dissemination of the information aiding recognition of the states' Flora via publication of book, interactive CDs and web pages, and derivative publications.

96/0007 Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota

- Provision of species richness maps for consideration during reserve planning.

95/0005 WA Threatened Flora descriptive database

- Broad dissemination of the information aiding recognition of the states' Threatened Flora via publication of book, interactive CDs and web pages.

96/0013 DELTA Database Engine

- Demonstrate the system at the divisional level followed by dissemination of supporting documentation.
- Hand over control of the system to the institutional custodian.
- Populate the system with DELTA project data by the institutional custodian.
- Make the institutional data and system available to researchers at the project level.

TBA WAHERB -- Databasing and Publication of WA Herbarium Specimen Information

- Increased awareness of the role of the specimen collection in vouchering science and conservation efforts within CALM and the state.
- Increased use of the collection for securely maintaining material from a greater range of survey and research projects.
- Increased use of the specimen collection and its database in species and ecological community research, management and operations projects and procedures.

TBA Descriptive Catalogue of WA Plants

- Broad dissemination of the information aiding recognition of the states' flora via publication of books, CDs and web pages.

TBA Phytophthora interactive identification & information retrieval system

- A prototype of the Phytophthora identification system has been in daily use by staff at CALM's Vegetation Health Service for the past year and has already proven its worth in recognizing a species of Phytophthora new to WA.
- The current revision incorporating the most current morphological and growth data will be deployed shortly.
- Publication of a paper and CD-ROM will be of wide general interest and usefulness to plant pathologists world-wide since the currently available tools are merely paper-based data-matrices.

TBA Max: Development of a species editing utility and electronic collecting book

- Increased efficiency of creation and maintenance of ecological and taxonomic database systems by scientists throughout CALM via public release of software and associated documentation.

TBA Non-linear modelling

- Optimization of experimental design and strategy by preliminary modeling of predator-prey relationship.

TBA WABIOTA

- Querying of WABIOTA.
- Collaborative ventures with CALM staff utilising WABIOTA data.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Descriptive Taxonomy and Biosystematics

PROJECT LEADER:

Terry Macfarlane, Manjimup

SCIENCE PROJECTS / CORE FUNCTIONS:

93/0008	Taxonomy and inventory of WA flora: legumes, grasses and lilies.
93/0010	Taxonomic review and conservation status of Western Australian plant groups
93/0011	Taxonomic studies of species on the Declared Rare and Priority Flora List.
93/0006	Taxonomic studies in the Asteraceae, tribe Asterineae
93/0015	Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)
93/0016	Taxonomic Revision of *Beaufortia* R.Br.
94/0011	A new Generic Classification for Rutaceae
95/0008	Taxonomy of new, rare and priority plant species of the southern forests.
TBA	Taxonomic study of *Leucopogon* in W.A.
TBA	Taxonomic Revision and Flora of Australia account of the *Baeckea* Group (Myrtaceae)
TBA	Resolution of species problems in *Hibbertia*
TBA	Taxonomic Revision of *Agonis*
TBA	DNA studies on various genera
TBA	Flora of Australia account of *Kennedia*

STAFF:

Staff	Location	FTE
A Chapman	Herbarium	0.8
N Lander	Herbarium	0.1
T Macfarlane	Manjimup	0.6
B Richardson	Herbarium	0.2
B Rye	Herbarium	0.5
Total		**2.2**

OBJECTIVES:

- To provide a picture of biodiversity in W.A. by means of reliable censuses of organism groups and a system of classification reflecting the relationships of organisms.
- To define species and provide an authoritative scientific nomenclature for them.
- To develop and make available descriptive and image information and means of identifying organisms.
- To augment scientific collections of organisms and relevant database systems.

SIGNIFICANCE & BENEFITS:

- This project will provide the scientific input to biodiversity inventory for W.A., which provides the essential basic information on which species conservation and ecosystem management are based.
- As it is based on the major physical collections of W.A. organisms and associated library, databases and staff expertise and research, the Project provides a uniquely verifiable, authoritative and maintained resource.

DESCRIPTION:

- The objectives of the project are met from a number of individual science projects, most of which concern plants although some work involves animals.
- The objectives are long-term, but individual projects are of limited.

f) Censuses

The Vascular Plant Census has developed over nearly 20 years. Important features are that it is kept up to date and that entries are verifiable through specimens or published articles, and changes are only made after critical assessment, which requires a good knowledge of the International Code of Botanical Nomenclature. Significant staff resource is allocated to the scientific filtering of additions and amendments. Some of the information derives from taxonomic research conducted within this Project. Censuses are central to other species information databases.

P. Wilson will provide within this Project a checking and consultancy role for modifications to the Census data for Vascular Plants.

The computer system development and maintenance aspects are a function of Information Technology Research and Development Project. Data entry is a function of Collections Management Project.

2. System of classification

The grouping of species into genera, families and higher groups is important information that expresses properties of the organisms and helps people to understand how species relate to one another. The classifications are not static because new information or interpretations continually accumulate, through research within the Project and externally.

Relevant SPPs:

3. Scientific nomenclature

We follow the internationally accepted standard method of naming organisms, to ensure that our work meets the standards of the world scientific community. It links to the defining of species, through the objective method of associating names with type specimens.

4. Defining species

Original taxonomic research is carried out to define individual species. This is necessitated by perceived problems with some species (as to whether one or more species occur in a particular circumstance, and where each lives, and how they may be recognised). Outcomes include combining so-called species into fewer real species, and the recognition of previously unknown or undescribed species. Substantial resources are put into the defining of species of conservation interest (threatened or endangered) so that the resource for conserving, and legal protection is given to species whose definition is founded on science.

Relevant SPPs:
93/0008
95/0007
93/0010
93/0011

5. Descriptions and images

Descriptions provide the definitions of species (and other groupings such as genera), and are the source of information used to provide keys and other identification tools, and they also provide information about organisms for publications and reports. Descriptions are prepared for scientific articles, Floras and field guides, reports, and also for databases and computer network information systems.

6. Database systems

Databases provide ways of storing and maintaining descriptive information in an organised electronic form. This relatively new methodology provides improved efficiency for resources used in the work a single input of data can provide many uses of the data, various kinds of output, both electronic and hard copy, and permits entirely new ways that people can access and use taxonomic information Databases and their outputs are equivalent to traditional hard copy publication.

7. Collections

The scientific collections of specimens are augmented by this Project through the improvements in identifications of existing specimens via the process of taxonomic research (e.g. the defining of species), and also through the new collections made in the course of field investigations. W.A. is still relatively poorly collected in many respects, so this is a very relevant aspect of the Project, improving the physical basis on which our knowledge of the biota is based. There is a close link with Collections Management Project, which has the responsibility for curation and maintenance of the collections.

METHODOLOGY:

f) **Censuses**
Maintenance of lists of names and associated information on the basis of specimen-based records and published records. Involves assessing changes for reliability and validity.

2. System of classification
Taxa (of whatever rank from species or below to family or above) are arranged according to some assessment of relationship, the measure depending on the purpose of the work and on the preferences of the scientists concerned. Examples include the use of morphological data only, or including anatomical, cytological or molecular data, and assessing the relationships by an implicit process or by explicit computer analysis, such as phenetic or cladistic methods.

3. Scientific nomenclature
Names applied to organisms in compliance with the relevant Code of Nomenclature.

4. Defining species
Species defined on the basis of data derived from morphological study of specimens, field investigations for features visible only in situ or in life, and for seasonal factors, and environmental correlations, and also molecular (e.g. isozyme) or cytological information where available.

5. Descriptions and images
Descriptions are prepared partly conventionally and partly using the DELTA system, although there is a transition to using DELTA almost exclusively because this is the form best suited to departmental databases.

6. Database systems
Descriptive data stored in database systems has many advantages over previous methods where descriptions were prepared manually for each use, and the electronic text files were not necessarily retained after hard copy publication. With databases, the information is prepared once, retained permanently in electronic form, and used perhaps many times to provide output, including publications.

The data prepared in the course of the taxonomic research will contribute to various databases being developed under Information Technology Research and Development Project, and will also use the software developed under that Project's DELTA Database Engine work.

7. Collections
Specimen collections will be made in the course of field work intended for working out detailed distributions, habitat parameters and other aspects of the biology of species as part of taxonomic work. The collections, with full annotations and GPS coordinates, will represent a part of the accessions to the main permanent collections, particularly the Herbarium.

SCHEDULE OF TASKS:

93/0008 Taxonomy and inventory of WA flora: legumes, grasses and lilies.

1998

- Completion and submission of Flora of Australia accounts of Stipeae and *Amphipogon.*
- Completion of paper on *Urodon.*
- Prepare paper for Monocots II Symposium (Sydney, Sept. - Oct. 1998).
- Carry out liaison on grass information.

93/0010 Taxonomic review and conservation status of Western Australian plant groups

1998
- Resolution of taxonomic problems relating to Conservation taxa as required.
- Publication of results of taxonomic investigations on Conservation flora.
- Dissemination of results of taxonomic studies on Conservation flora through other means where publication is not appropriate (i.e. internal memos, unpublished reports).
- Record information in DELTA for corporate descriptive databases in addition to conventional publication.
- Provide assistance and advice (as required) to ensure integrity of taxonomic and nomenclatural data in WACENSUS.
- Maintain curation of eight families and 12 additional genera in the general herbarium collection. Undertake additional curatorial responsibilities as required.

93/0011 Taxonomic studies of species on the Declared Rare and Priority Flora List.

- Conduct research on selected taxa and resolve the taxonomic problems.
- Publish the results in formal journal articles.

93/0006 Taxonomic studies in the Asteraceae, tribe Asterineae

- Continue research on *Olearia* (funding permitting).

93/0015 Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)

Information to come.

93/0016 Taxonomic Revision of Beaufortia R.Br.

Information to come.

95/0008 Taxonomy of new, rare and priority plant species of the southern forests.

1998
- Analyse available information and complete specimen examination.
- Prepare or complete three papers and submit for publication.

TBA Taxonomic study of Leucopogon species complexes in W.A.

1998/99
- Define scope of study.
- Decide on methodology to be employed.
- Commence study of herbarium specimens including types as the first phase.

1999/2000
- Collecting trip completed.
- DNA laboratory training commenced.
- Study of specimens and data collection commenced.

TBA Taxonomic Revision and Flora of Australia account of the Baeckea Group (Myrtaceae)

1998
- Prepare and submit funding application.

1999
- Appoint staff and commence project (if funding application successful).

TBA Resolution of species problems in Hibbertia

1998/99
- Finalise studies in *Hibbertia mucronata* group.
- Prepare paper for publication.

TBA Taxonomic Revision of Agonis

1998/99
- Complete study of type specimens.
- Study further populations to refine species concepts.
- Publish any names needed by other projects.

MILESTONES:

93/0008 Taxonomy and inventory of WA flora: legumes, grasses and lilies.

- Submission of articles.
- Presentation of symposium talk.
- Completion of liaison talks/excursions.

93/0010 Taxonomic review and conservation status of Western Australian plant groups

- Resolution of 10 or more taxonomic problems relating to Conservation taxa (existing and new projects).
- Publication or dissemination of results of taxonomic investigations on Conservation flora (new projects).
- Complete and submit (to journal) five papers listed below as "In preparation", and prepare draft of *Dampiera* review.

- Provision of taxonomic advice and assistance for 100 or more WACENSUS-related queries.
- Complete curation of *Melaleuca* holdings in line with recently completed draft treatment of this genus.
- Processing of 215 Fuhrer photograph-voucher collections.

93/0011 Taxonomic studies of species on the Declared Rare and Priority Flora List.

- Submission of research papers.
- Contributions submitted to Wildlife Branch for input to Flora List.
- Specimen curation completed for plant groups on which research completed.

93/0006 Taxonomic studies in the Asteraceae, tribe Asterineae

93/0015 Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)

93/0016 Taxonomic Revision of Beaufortia R.Br.

95/0008 Taxonomy of new, rare and priority plant species of the southern forests.

- Submission of research papers.
- Contributions submitted to Region office and Wildlife Branch for input to Flora List.
- Relevant specimen curation completed.

TBA Taxonomic study of Leucopogon species complexes in W.A.

1998/99
- SPP completed.
- Postgraduate topic proposal drafted.
- DELTA character list prepared.
- Examination and photography of relevant type specimens in European collections.

1999/2000

- Detailed project design and timetabling submitted.
- Enrolment for postgraduate studies.
- Internal seminar given on project design and preliminary results.

TBA Taxonomic Revision and Flora of Australia account of the Baeckea Group (Myrtaceae)

- ABRS grant application submitted.

TBA Resolution of species problems in Hibbertia

- Specimens examined and annotated, data recorded.

TBA Taxonomic Revision of Agonis

- Decisions on correct names based on examination of type specimens communicated to relevant parties including Herbarium databases and collection.
- Draft research paper commenced.

OUTPUTS:

Lepschi, B.J. (1996). Recognition and distribution of *Solanum hoplopetalum* and *S. hystrix* in Australia. *Nuytsia*, 10: 467-470.

Lepschi, B.J. (1996). A taxonomic revision of *Macarthuria* (Molluginaceae) in Western Australia. *Nuytsia*, 11: 37-54.

Lepschi, B.J. (1996). A new subspecies of *Harnieria kempeana* (Acanthaceae) from Western Australia. *Journal of the Adelaide Botanic Garden*, 17: 153-156.

Lepschi, B.J. (1997). Review of the taxonomic status of *Adenanthos dobagii* (Proteaceae). Unpublished report submitted to D.J. Coates, Species Conservation Section (Bioconservation Group), Department of Conservation and Land Management.

Gibson, N., Lyons, M.N. & Lepschi, B.J. (1997). Flora and vegetation. *In* Lyons, M.N. & Chapman, A. (eds). A biological survey of the Helena and Aurora Range, eastern goldfields Western Australia. Unpublished report for Environment Australia, Canberra.

Anon. (1997). Will the real Woollybush please stand up? *Landscope*, 12: 9. [uncredited contribution by BJL].

Lepschi, B.J. & Macfarlane, T.D. (1997). *Digitaria aequiglumis* - a new weed for Western Australia. *Nuytsia*, 11: 425-427.

Gibson, N., Lyons, M.N. & Lepschi, B.J. (1997). Flora and vegetation of the eastern goldfields ranges, Part I: Helena and Aurora Range. *CALM Science*, 2: 231-246.

Publications in press:

Lepschi, B.J. (199*). Notes on the genus *Lepidium* (Brassicaceae) in Western Australia, including the description of a new taxon. *Nuytsia*

Lepschi, B.J. (199*). A taxonomic revision of *Leptomeria* (Santalaceae). *Australian Systematic Botany*

Lepschi, B.J. (199*). *Leptomeria*. *In* Walsh, N.G. and Entwisle, T.J. (eds.), *Flora of Victoria, Volume 4*. Inkata Press, Melbourne.

Lepschi, B.J., Lally, T.R. & Maslin, B.R. (199*). Endangered - *Acacia volubilis*. *Landscope*

Olmstead, R.G., Reeves, P.A. & Lepschi, B.J. (199*). Confirmation of a monophyletic Chloanthoideae (Lamiaceae) comprising tribes Chloantheae and Prostanthereae. *Lamiales Newsletter* [informal progress report]

Publications in preparation:

Lepschi, B.J. & Puttock, C.F. (199*). Leaf anatomy of selected Western Australian Gnaphalieae (Asteraceae). *Botanical Journal of the Linnaean Society*

Keighery, G.J. & Lepschi, B.J. (199*). New chromosome counts for some Western Australian Gnaphalieae (Compositae). *Compositae Newsletter*

Lepschi, B.J. (199*). Taxonomy and phylogeny of *Pithocarpa* (Asteraceae: Gnaphalieae). *Nuytsia*

Lepschi, B.J. (199*). Notes on the genus *Lythrum* (Lythraceae), including a review of the genus in Western Australia. *Nuytsia*

Olmstead, R.G., Reeves, P.A. & Lepschi, B.J. (199*). Confirmation of a monophyletic Chloanthoideae (Lamiaceae) comprising tribes Chloantheae and Prostanthereae. *Australian Systematic Botany* [formal publication of this work] Herbarium

Other anticipated publications (from work currently underway):

A review of the genus *Dampiera* (Goodeniaceae) in Western Australia.

A revision of *Olax benthamiana*, with a note on *O. scalariformis* (Olacaceae).

Notes on two poorly known species of *Gyrostemon* (Gyrostemonaceae).

Macfarlane, T.D. (1984). Taxonomic clarification of the *Lomandra odora* group (Xanthorrhoeaceae or Dasypogonaceae). *Nuytsia* **5**: 13-24.

Macfarlane, T.D. (1984). *Lomandra nutans* (Xanthorrhoeaceae or Dasypogonaceae), a new species from the Stirling Range area, Western Australia. *Nuytsia* **5**: 171-175.

Macfarlane, T.D. (1986). *Wurmbea*. In: Jessop, J.P. (ed.). "Flora of South Australia." Edn 4. Part IV, pp. 1771-1773. (South Australian Government Printing Division: Adelaide.)

Lee, A.T. & Macfarlane, T.D. (1986). *Lomandra*. In: George, A.S. (ed.). "Flora of Australia." Vol. 46, pp. 100-141. (Australian Government Publishing Service: Canberra.)

Macfarlane, T.D. (1986). *Lomandra*. Appendix: new taxa, combinations, lectotypifications. In: George, A.S. (ed.). "Flora of Australia." Vol. 46, pp. 223-224. (Australian Government Publishing Service: Canberra.)

Macfarlane, T.D. (1986). Two new species of *Wurmbea* (Colchicaceae or Liliaceae s. lat.) from south western Australia. *Nuytsia* **5**: 407-413.

Macfarlane, T.D. (1987). *Phlebocarya, Tribonanthes, Haemodorum, Wurmbea, Burchardia, Iphigenia*. In: George, A.S. (ed.). "Flora of Australia." Vol. 45. (Australian Government Publishing Service: Canberra.)

Potesilova, H., Macfarlane, T.D., Guenard, D. & Simanek, V. (1987). Alkaloids and phenolics of *Wurmbea* and Burchardia species. *Phytochemistry* **26**: 1031-1032.

Macfarlane, T.D. (1988). Poaceae subfamily Pooideae. In: Soderstrom, T.R., Hilu, K.W., Campbell, C.S. & Barkworth, M.E. (eds). "Systematics and Evolution of Grasses." (Smithsonian Institution Press: Washington, D.C.)

Macfarlane, T.D. (1993). *Wurmbea calcicola* (Colchicaceae), a new species from Cape Naturaliste, south western Australia. *Nuytsia* **9** (2): 233-236.

Macfarlane, T.D. (1994). *Chamaexeros longicaulis* (Dasypogonaceae), a new species from Walpole, south western Australia, with additional notes on *Chamaexeros*. *Nuytsia* **9** (3): 375-382.

Macfarlane, T.D. and van Leeuwen, S.J. (1995). *Wurmbea saccata* (Colchicaceae), a lepidopteran-pollinated new species from Western Australia. *Nuytsia* **10**(3): 429-435.

Simon, B.K. & Macfarlane, T.D. The distribution and biogeography of Western Australian grasses. In S.D. Hopper et al. (eds.) "Gondwanan Heritage: Past, Present and Future of the Western Australian Biota." (Surrey Beatty: Chipping Norton.) In press.

Macfarlane, T.D. & Wardell-Johnson G. *Anthocercis sylvicola* (Solanaceae), a rare new species from the tingle forests of Walpole, south-western Australia. *Nuytsia*. In press.

Macfarlane, T.D. (1996). A paradox: some eucalypts are no longer *Eucalyptus*. SID News (Newsletter of the CALMScience Division, Department of Conservation and Land Management, Western Australia.) Reprinted in IFA Newsletter 37(6): 13-15 (1996) (The Institute of Foresters of Australia.).

Hibsch-Jetter, C., Soltis, D. & Macfarlane, T.D. (1997). Phylogenetic relationships of *Eremosyne pectinata* Endl. (Saxifragaceae sensu lato) based on *rbcL* sequence data. *Plant Systematics and Evolution* 204: 225-232.

Macfarlane, T.D. (1997). Reasons why plant names change, with some recent W.A. examples. The Plant Press 2: 3-6. (Western Australian Regional Herbaria Newsletter.)

Barker, W.R. & Rye, B.L. (1993). *Spyridium tricolor* (Rhamnaceae), a disjunct new species from the Great Australian Bight. Journal of the Adelaide Botanic Gardens 15: 153-157.

Rye, B.L. (1983). A morphometric and anatomical study of the *Darwinia diosmoides* complex (Myrtaceae) in south-western Australia. Nuytsia 4: 411-421.

Rye, B.L. (1983). *Darwinia capitellata* (Myrtaceae), a new species from south-western Australia . Nuytsia 4: 423-426.

Rye, B.L. (1984). Four new names for *Pimelea* species (Thymelaeaceae) represented in the Perth region. Nuytsia 5: 1-11.

Rye, B.L. (1984). A new species and a new combination among the Proteaceae represented in the Perth region. Nuytsia 5: 25-30.

Rye, B.L. (1988). A revision of Western Australian Thymelaeaceae. Nuytsia 6: 129-278.

Rye, B.L. (1989). A new species of *Pimelea* (Thymelaeaceae) from south-western Australia. Nuytsia 7: 59-62.

Rye, B.L. (1994). A conservation priority list for the Tiliaceae of Western Australia and a taxonomic review of the species occurring in the Eremaean Botanical Province. Internal Report, Dept. of Conservation and Land Management. [Como, W.A.] 26 pp.

Rye, B.L. (1994). A contribution to the taxonomy of the Tiliaceae of Western Australia. Nuytsia 9: 415-418.

Rye, B.L. (1994). Corrections to "Flora of the Kimberley region". Nuytsia 9: 418-420.

Rye, B.L. (1994). Thymelaeaceae : the family. Australian plants 17 (139): 297-327.

Rye, B.L. (1995). New and priority taxa in the genera *Spyridium* and *Trymalium* (Rhamnaceae) of Western Australia. Nuytsia 10: 119-140.

Rye, B.L. (1995). New and priority taxa in the genera *Cryptandra* and *Stenanthemum* (Rhamnaceae) of Western Australia. Nuytsia 10: 255-305.

Rye, B.L. (1996). *Granitites*, a new genus of Rhamnaceae from the south west of Western Australia. Nuytsia 10: 451-457.

Rye, B.L. (1996). A taxonomic review of the genera *Lachnostachys*, *Newcastelia* and *Physopsis* (Chloanthaceae) in Western Australia. Nuytsia 11: 79-107.

Rye, B.L. (1996). A synopsis of the genera *Pomaderris*, *Siegfriedia*, *Spyridium* and *Trymalium* (Rhamnaceae) in Western Australia. Nuytsia 11: 109-131.

Rye, B.L. (1997). Three new annual species of *Schoenus* (Cyperaceae) from the south-west of Western Australia. Nuytsia 11: 263-268.

Rye, B.L. (1997). The Rhamnaceae of the Kimberley region of Western Australia. Nuytsia 11: 287-292.

Rye, B.L. (1997). A synopsis of the annual species of Cyperaceae from central and southern Western Australia. Nuytsia 11: 383-423.

Rye, B.L. & Trudgen, M.E. (1995). *Cryptandra monticola* (Rhamnaceae), a new species from the Pilbara region of Western Australia. Nuytsia 10: 307-310.

Wheeler
Wheeler, J.R. (1984). Taxonomic notes on some Western Australian species of *Hibbertia* (Dilleniaceae). Nuytsia 5: 31-42.

Wheeler, J.R. (1989). *Hibbertia hooglandii* (Dilleniaceae), a new species from the Kimberley Region, Western Australia. Nuytsia 7: 69-73.

Wheeler, J.R. (1994). New species of *Hibbertia* (Dilleniaceae) from the northern wheatbelt area of Western Australia. Nuytsia 9: 427-437.

Future:
Planned paper in Nuytsia (1999/2000)

OUTCOMES:

Most SPPs contribute to the Declared Rare and Priority Flora List, directly through informal information to Wildlife Branch, or indirectly through re-identifications of specimens, new collections and Rare Flora Report Forms. Two SPPs specifically provide an investigative role for improving the quality of the List and an advisory role for Wildlife Branch.

Taxonomic studies result in published research papers, expert identification of specimens, and improvements to the databases. These form primary resources for the function Biodiversity Inventory, and provide a basis for many other aspects of CALM's research and management work.

Liaison with CALM and other groups such as LCDCs on the identity, occurrence and properties of native plants, particularly grasses. This function is proving important in educating people in the Wheatbelt about the ground layer of herbaceous plants as components of remnant vegetation, and in distinguishing between weedy and native grasses. Use of grasses in restoration, particularly of saline areas, is an important spinoff from taxonomic expertise.

ADOPTION STRATEGY:

Taxonomic work is primarily published as research papers in the CALM journal Nuytsia, and so is accessible to staff with a technical interest and background until incorporated into Floras and information systems. The Regional Floras Project provides a major information access.

The major means of conveying taxonomic information to general CALM users is via the Census, in which names are kept current and replaced synonyms are also shown but with non-current status. The Web version of the Census (implemented by the Information Technology R&D Project) is a particularly efficient means of disseminating information,

having attached descriptive etc information. Databases will increasingly provide taxonomic information.

More important changes or developments have been publicised in talks, direct communication with Regional or Operations staff, and in email or newsletter articles (e.g. Macfarlane's articles on some Eucalyptus species changing to Corymbia in SID News and Institute of Foresters Newsletter; and on name changes in general, with examples, in the Regional Herbaria newsletter).

CALMScience Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Forest Region Flora

PROJECT LEADER:

Judy Wheeler, Albany

SCIENCE PROJECTS / CORE FUNCTIONS:

93/0013	Flora of the lower south west
TBA	Flora of the Albany Region

STAFF:

Staff	Location	FTE
M Lewington	Herbarium	0.3
N Marchant	Herbarium	0.05
J Wheeler	Albany	0.9
Total		**1.25**

OBJECTIVES:

- To produce authoritative and user-friendly guides to the flora of various regions of Western Australia.
- To contribute to curation of herbarium records.
- To gather morphological data on regional taxa and store in DELTA format in corporate databases.

SIGNIFICANCE & BENEFITS:

- This project will provide a means of easy and reliable identification of plants from various regions.
- Moreover, it provides information, flora descriptions and line drawings for the corporate databases which underpin departmental dissemination of biological information.
- The information provided can be presented in both hard-copy and electronic formats.

DESCRIPTION:

- Production of a series of regional handbooks which will enable users to easily and accurately identify the plants from those regions. The emphasis is on providing information in a user-friendly format which will be readily understood by non-taxonomists and is supplemented by numerous small line drawings.
- Publication will be in conjunction with Corporate Relations Division.
- Further off-shoot publications along the lines of the department's "Bush Books" will occur.

METHODOLOGY:

- It is necessary to develop sufficient taxonomic understanding of every group of native and naturalised vascular plants in each given region to enable a concise flora description to be written for every species. Specimens from the WA Herbarium, regional herbaria and relevant literature are utilised.
- The basic information obtained is also entered into a DELTA database to aid key generation and also to provide information for the corporate databases.
- Line drawings are commissioned to supplement existing drawings available for use.
- The scanned images and completed flora descriptions are readily available for use in other projects as well for the corporate databases.

SCHEDULE OF TASKS:

1998:
- Complete editing of text.
- Prepare key to genera.
- Complete required illustrations.
- Prepare text and illustration for publication (putting text into "Pagemaker", scanning and sizing of illustrations and insertion into text).
- Prepare basic species list for the Albany flora.
- Seek funding for purchase of illustrations and technical assistance for Albany flora.
- Commence discrimination of taxa and preparation of flora descriptions for Albany flora.

1999:
- Continue discriminating taxa and preparation of flora descriptions for Albany flora.

2000:
- Complete preparation of flora descriptions.
- Prepare associated publications.

2001:

- Edit text.
- Prepare key to genera.
- Prepare text and illustrations for publication.

MILESTONES:

- Completion of text editing.
- Completion of key for southwest flora.
- Handover of manuscript for publication.
- Completion of checklist of plants for Albany flora.
- Preparation of text for each plant family for Albany flora.
- Completion of draft text for Albany flora.
- Publication of associated booklets.
- Completion of text editing.
- Completion of key to genera for Albany flora.
- Handover of manuscript for publication.

OUTPUTS:

Publications to date:
Marchant *et al* 1987. Flora of the Perth Region.
Wheeler *et al* 1992. Flora of the Kimberley Region.
Wheeler. J. 1996. Common trees of the south west forests.
Kenneally, K., Thomson, C., Done, C and Wheeler, J. 1996. Common plants of the Kimberley.
Wheeler. J. 1997. Wildflowers of the South Coast.
Chalmers, L. and Wheeler, J. 1997. Native vegetation of estuaries and saline waterways in south Western Australia.
Chalmers. L. and Wheeler, J. 1997. Native vegetation of freshwater rivers and creeks in south Western Australia.
Wheeler, J. and Keighery, G. 1997. Wildflowers of Shark Bay.

Publications in preparation:
Plants of the Forest - Dunsborough to Denmark

Future publications:
Plants of the Albany Region
Several small "Bushbook "style publications

OUTCOMES:

- The information provided by this project (both electronic information and hardcopy handbooks) will facilitate identification of plants in the south west of the state and hence benefit conservation of both ecosystems and individual plant species.
- The first of the projects (flora of the lower south west) will provide user-friendly descriptions of more than 2,000 species and further projects will build on this.
- As well as speeding up ecological studies, the information will help to more rapidly highlight new taxa in need of conservation.

- The project will contribute directly to the dissemination of current taxonomic information on WA flora.
- Associated "bush book" style publications will raise the public profile of the department and increase community understanding of the flora and the need for conservation.

ADOPTION STRATEGY:

- The information will be readily available to relevant CALM land managers, ecologists and also to our many volunteers who may alert us to populations of rare and endangered taxa.
- The information will also be available to scientists and managers of other government departments, to the public at large and to the many wildflower enthusiasts.
- Associated publications will also be available and are particularly useful for promoting our environment to tourists.

CALMScience Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Regional Forest Assessment

PROJECT LEADER:

Paul Gioia, Herbarium

SCIENCE PROJECTS / CORE FUNCTIONS:

Completed RFA projects

- RFA Biodiversity: Distribution mapping and key ecological attributes of plants.
- RFA Biodiversity: Species of special interest.
- RFA Biodiversity: Distribution, habitat quality and species richness mapping of fauna.

No SPP's recorded in WASPP

Proposed SPP's:

- Fire-response characteristics and phenology of vascular plant species in southwest forests of WA.
- Evaluating environmental change in southwest forests using key indicator species

STAFF:

Staff	Location	FTE
I Abbott	Crawley	0.05
R Cranfield	Manjimup	0.7
P Gioia	Herbarium	0.2
N Marchant	Herbarium	0.05
P Pigott	Herbarium	0.2
Total		**1.2**

Definition

The definition of forest in the context of this Plan includes the woodlands and forests of the lower southwest of WA. Specifically it focuses on the area covered by the 1997 Western Australian RFA. It is anticipated that studies of biodiversity and species attribution should be extended to include some associated woodlands in this area because of their significance to conservation in WA.

OBJECTIVES:

- Completion of report on flora project for Region Forest Agreement for WA (1997).
- Documentation of biological/ecological characteristics of biota in the southwest forest ecosystems of WA.
- Identification of key indicator species suitable for monitoring environmental change.
- Establish criteria for assessing the sustainability of landuse patterns in forest ecosystems of WA.
- Maintenance of a framework for biodiversity research towards the 2003 WA RFA.

SIGNIFICANCE & BENEFITS:

- Fire response theme for forest flora data in WABIOTA
- Detection of biodiversity hotspots
- Assessment of areas where landuse not is sustainable
- Disturbance theme for wheatbelt flora data (JPP) in WABIOTA

DESCRIPTION:

- Multidisciplined projects to document assess and evaluate change in forest ecosystems of WA. Both landscape scale and species level research will be undertaken to support the sustainable conservation and management of forest ecosystems.

METHODOLOGY:

- RFA Biodiversity projects have been completed. Final report completed and under review.
- Normal write-up and review procedures will be followed to complete new tasks and achieve milestones.
- Data collected from RFA survey plots (ecological attributes project) will be analyzed to assess categories of attribute types and relationships between plots. Linear and multivariate techniques will be used. This will provide the basis for a WABIOTA theme.

SCHEDULE OF TASKS:

RFA Biodiversity

1997/98

- Gioia and Pigott to complete RFA Biodiversity report (April 98)
- Gioia and Pigott to finish literature survey and introduction for publication (May 98)

1998/99
- Gioia and Pigott to complete draft paper for internal review (July 98)
- Gioia and Pigott to correct ms and submit paper for publication (Sept 98)
- Gioia and Pigott to finalize publication (Jan 99)

1999/2000
- Commitments finalized

Attributes of southwest forest species

1998/99
- Cranfield and Pigott to finalize ID and databasing of RFA lichen collection (June 98)
- Cranfield and Pigott to start data synthesis of species attribution data (July 98)
- Cranfield and Pigott to report on data analysis (Sept 98)
- Pigott and Williams to analyze RFA plot data (Dec 98)
- Star compiling disturbance attributes

MILESTONES:

RFA Biodiversity

1997/98
- Presentation to Corporate Executive (Feb 98)
- Presentation to Herbarium staff (March 98)
- Completion of Biodiversity report (flora projects) (April 98)

1998/99
- Publication of methodology paper in refereed journal (Dec 98)

Attributes of southwest forest species

1998/99
- Publish RFA lichen species list (July 98)
- Draft paper on analysis of 120 sites in jarrah forest (Feb 99)
- Report on attributes of southwest forest species (May 99)

OUTPUTS:

Reports & Seminars

Abbott, I. (1998) Detecting areas of faunal species richness: a preliminary study. Report for the Regional Forest Agreement, Western Australia.

Pigott, J.P. (1998). Species richness maps for mammal fauna, land birds, waterbirds, reptile fauna, termites, butterflies and *Catasarcus* weevils in the southwest of Western Australia. In:

Abbott, I. (1998) Detecting areas of faunal species richness: a preliminary study. Report for the Regional Forest Agreement, Western Australia.

Gioia, P. Distribution mapping and key ecological attributes of plants - a RFA Biodiversity project. Presentation to CALM Corporate Executive, February 26 1998.

Gioia, P., Pigott, J.P. and Chapman, A.R. (1998a). Map 5: Species Richness and Map 15 Declared Rare and Priority Flora in Anon (1998). Comprehensive Regional Assessment - A Regional Forest Agreement for Western Australia.

Planned communications 1998

Gioia, P., Pigott, J.P., Chapman, A.R. (1998b). Data review for terrestrial species and Flora species assessment, Biodiversity Chapter. Report for the Regional Forest Agreement, Western Australia.
Gioia, P., Pigott, J.P., Chapman, A.R. (1998c). Plant species richness gradients in south-west Western Australia using predicted distributions. In prep. *Aus. J. Ecol.*
Cranfield R.J. (1998). Lichen species of the jarrah forest.
Pigott, J.P. and Cranfield R.J. (1999). Environmental relationships distinguishing jarrah forest plots established for the 1997 Western Australian RFA.

OUTCOMES:

RFA Biodiversity

- Results of RFA Biodiversity projects have been used in the formulations of options for the WA RFA 1998.

Attributes of southwest forest species

- Species attributes used for decision-making about forest management practices

ADOPTION STRATEGY:

RFA Biodiversity

- Additional protection to areas of high biodiversity with changes to reserve system in WA.

Attributes of southwest forest species

- Information to assist managers improve forest management

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biological Information

PROJECT TITLE:

Bioprospecting

PROJECT LEADER:

Neville Marchant, Herbarium

CORE FUNCTIONS:

- Establishment and management of a comprehensive plant extracts library with voucher specimens incorporated in the State Collection.
- Marketing of extracts in accordance with WA Government protocols.

STAFF:

Staff	Location	FTE
C Bailey	Crawley	0.2
R Cranfield	Manjimup	0.3
R Davis	Herbarium	1.0
N Marchant	Herbarium	0.05
Total		**1.55**

OBJECTIVES:

- Collect and process bioprospecting samples of WA vascular flora.
- Develop collaborative business ventures to on-sell extracts for screening.
- Ensure adequate financial returns to CALM.
- Ensure that collection of material does not compromise conservation values of habitats or taxa.

SIGNIFICANCE & BENEFITS:

- Establishment of methodologies for the sustainable utilisation of WA biota.
- Addition of knowledge of WA flora through collection of well documented specimens.
- Potential for the provision of funds for conservation.
- Enhance taxonomic studies by providing supplementary data on biology, distribution habitat preferences, variation and chemistry.

DESCRIPTION:

- Plan field collecting to maximise benefits to the State Collection.
- Utilise appropriate computer systems support to record precise field locations of voucher collections.
- Enhance taxonomic capacity to support bioprospecting.

METHODOLOGY:

- Collaborate with the Chemistry Centre and other appropriate organisations to ensure acceptable processing methods for extracts.
- Develop efficient databasing and tracking systems for recollection of samples if required.
- Ensure appropriate storage of extract library.
- Collaborate with appropriate organisations to screen samples for bioactivity.

SCHEDULE OF TASKS:

1998

- Identify all voucher specimens of current Extract Library holdings.
- Add additional extracts to increase the range of taxa.
- Negotiate equitable deals to utilise extracts for potential pharmaceuticals and other products.

1999

- Develop a collaborative venture with appropriate organisation to screen extracts.
- Extend the taxonomic and geographic scope of the extract library where appropriate.

2000

- Integrate bioprospecting activity with a commercial organisation.
- Extend the extract Library to cover other organisms such as Actinomycetes and fungi.

MILESTONES:

- 7000 extracts in the extract Library.
- collaboration with commercial developments to ensure returns to the State.

OUTPUTS:

- Addition of vouchered material to the State Collection.
- Supplementation of morphological taxonomic methods with chemistry data.

OUTCOMES:

- Development of collaborations with commercial enterprises, ensuring Government, commercial and conservation requirements are met.

ADOPTION STRATEGY:

- Appeal for collaborative partners.
- Extension of the extract Library to cover more taxa.
- Maintenance of systems to ensure efficient support for bioprospecting.

BIODIVERSITY CONSERVATION GROUP

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Western Shield - Fauna Recovery

PROJECT LEADER:

Dr Tony Friend, Albany

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0017	Database of mammal records from Australian islands
93/0053	Recovery plan for the Chuditch
93/0063	Western Swamp Tortoise recovery plan
93/0065	Conservation of the Western Bristlebird
93/0066	Radio tracking of translocated Noisy Scrub-birds
93/0142	Translocation of the western RT Possum
93/0144	Quenda translocation methods
93/0145	Factors affecting establishment in the numbat reintroduction program
93/0159	Ecology and conservation of WA pythons
93/0163	Genetics and ecology of the Western Barred Bandicoot
95/0016	Experimental management and monitoring of desert RW populations
93/0054	Effect of fox control on habitat utilisation by the mainland quokka
93/0149	An assessment of the effect of fox control on Red-tailed Phascogale populations
93/0052	Conservation of the Thevenard Island Mouse
93/0056	Recovery plan for the Shark Bay Mouse
95/0011	Status and ecology of the Dibbler in WA
96/0008	Recovery of Gilberts Potoroo
98/0005	Status, ecology and conservation of the Pilbara Olive Python
97/0009	Monitoring of selected vertebrate communities in Perup Nature Reserve
98/0016	Status of the Pebble-mound Mouse
99/0011	Recovery plan implementation for the Lancelin Island Skink
WD/0056	Ground Parrot recovery
TBA	Return to Dryandra

STAFF:

Staff	Location	FTE
A.A Burbidge	Woodvale	0.4
A.H Burbidge	Woodvale	0.15
T. Butler*	Albany	1.0
P. deTores	Woodvale	0.25
M. Dillon	Dwellingup	0.15
T. Friend	Albany	1.0
P. Fuller	Woodvale	0.2
B. Johnson	Woodvale	0.9
K. Morris	Woodvale	0.15
D. Moro	Woodvale	1.0
D. Pearson	Woodvale	0.75
J. Rolfe	Woodvale	0.05
P. Speldewinde*	Woodvale	0.5
T. Start	Kununurra	0.25
N. Thomas	Woodvale	1.0
A. Williams	Woodvale	0.9
*=externally funded		
TOTAL		**8.65**

OBJECTIVES:

- Develop the protocols required for the conservation of threatened vertebrates in Western Australia.
- Provide up to date information on the conservation status of threatened vertebrates, to make recommendations on the listing of threatened vertebrates, and to contribute to the ranking of threatened taxa for recovery priority.
- Identify processes which may detrimentally impact on threatened vertebrates and assist in the development of strategies to control these processes.

SIGNIFICANCE & BENEFITS:

Remnant populations of a significant number of threatened vertebrates (particularly mammals) are found in Western Australia. Research being implemented under this project underpins the greatest translocation program carried out anywhere in the world. Apart from the increase in conservation status of species targeted, reconstruction of the vertebrate fauna will restore ecological processes dependent upon their presence. The program will benefit the biological communities immensely, but the benefits to the human community flowing from a new access to Australian animals cannot be overstated. Massive educational and ecotourism opportunities will certainly result.

DESCRIPTION:

The Western Shield Fauna Recovery project provides a scientific grounding for management prescriptions relating to the conservation of threatened fauna. As foxes and feral cats are primary threatening processes for fauna conservation, there is considerable interaction with the Western Shield – Exotic Predator project. This project consists of science plans involving survey, habitat research and determination of status of threatened vertebrates, research on reintroduction methods, and research into efficient predator control methods which minimise non-target effects. Most science plans focus on single species conservation, with priorities for research being set using IUCN criteria.

METHODOLOGY:

This projects consists of science plans with diverse methodologies. These include survey using live trapping techniques (cage, Elliott, pit traps); ecological research including breeding biology, refuge locations, and diet; determination of status and abundance using mark - recapture methods; translocation methodologies, and research into effect of exotic predator control. Specific methodologies are referred to in the science plans.

SCHEDULE OF TASKS:

(See Milestones or SPPs).

MILESTONES:

There are many milestones specific to individual science plans:

96/0008 - Recovery of Gilbert's Potoroo

- Appoint technical officer - March 1998
- Finalise Recovery Plan - June 1998
- Finalise captive management plan - June 1998
- Complete analysis of hair samples -June 1998
- Maintain captive colony - ongoing

95/0011 - Status and ecology of the Dibbler

- Complete Interim Recovery Plan - March 1998
- Breed progeny of captive dibblers - March 1998
- Appoint student to continue ecological work (April 1998)
- Select island for translocation - July 1998
- Translocate zoo animals - October 1998
- Meet EA funding obligations if funding renewed.

98/0016 - Status of pebble-mound mice

- *Pseudomys chapmani* removed from WA list (1997/98)
- *P. chapmani* removed from Commonwealth list (submitted)
- Paper on biology and status of *P. chapmani* MS completed June 1998

- *Pseudomys* sp (Gardner Range) collected October 1997
- Genetic distance analysis completed
- Taxonomy liaising with van Dyck and Woinarski – ongoing

98/0005 – Status, ecology and conservation of the Pilbara Olive Python

- Develop radio-telemetry study at three or four sites – May 1998
- Collect data on morphometrics and meristics for taxonomic clarification - ongoing
- Analyse distribution and status data and write-up – November 1999
- Complete radio-telemetric study, analyse and write-up – May 2000

93/0159 – Ecology and conservation of WA pythons

- Completion of Carpet Python field radio-telemetry work at Garden Island and Dryandra – March 1999
- Complete vertebrate prey assemblage survey – March 1998
- Carry out microhabitat sampling to assess python habitat use – August 1999
- Analyse and write-up home range and habitat use data – May 1999
- Analyse faecal pellets and conduct necropsies for dietary information – November 1999
- Publish data on diet and reproductive behaviour of Carpet Pythons – November 1999
- Carry out surveys for Woma Pythons in northern Wheatbelt - ongoing
- Complete examination of specimens, analyse and write-up taxonomic study of south-western Woma python – November 1999.

95/0016 – Experimental management and monitoring of desert rock-wallaby populations

- Continuing baiting and monitoring of rock-wallaby population at Townsend Ridges - ongoing
- Collection of genetic samples for analysis in association with Macquarie University - ongoing
- Develop a project and techniques for long-term feral predator baiting by Aboriginal contractors - ongoing.

WD/0057 – Recovery plan implementation for the Lancelin Island Skink

- Publish Recovery Plan – May 1999
- Regularly monitor skink populations on Lancelin Island – November 1999 then every 2-3 years.
- Investigate possible translocation sites (if required) – by June 1999
- Conduct surveys to clarify mainland status - ongoing
- Continue liaison with Recovery Team members on issues such as captive breeding and visitor management on Lancelin Island - ongoing

93/0053 – Recovery plan for the Chuditch

- Completion of research into the impact of timber harvesting in the Jarrah forest on Chuditch - June 1999.
- Completion of research into the impact of prescribed burning on Chuditch in the Jarrah forest - June 1999.
- Completion of monitoring of impact of fox control on Chuditch in the Jarrah forest - October 1998.

- Completion of monitoring success of translocation to Lake Magenta Nature Reserve - February 1999.
- Completion of monitoring success of translocation to Cape Arid National Park - February 2000.
- Undertake translocation to Kalbarri National Park – June 1999
- Maintenance of captive breeding colony Perth Zoo until June 2000

93/0056 – Recovery plan for the Shark Bay Mouse

- Completion of monitoring Bernier Island population - June 2001.
- Completion of monitoring Doole Island population - June 2001.
- Completion of reintroduction to Peron Peninsula - October 1998.
- Completion of monitoring success of reintroduction to Peron Peninsula -June 2000.
- Completion of second reintroduction to Herisson Prong - June 2000.
- Maintenance of captive breeding colony Perth Zoo until June 2000

93/0052 – Conservation of the Thevenard Island mouse

- Completion of monitoring Thevenard Island population - June 2001.
- Completion of monitoring Serrurier Island population - June 2001.
- Completion of House Mouse bait station trials on Thevenard Island October 1998.
- Completion of House Mouse control program - ongoing as eradication is unlikely.
- Completion of mainland surveys - ongoing with mining company assistance.
- Review of status - June 1999.

93/0144 - Quenda translocation methods

- Submit underpass movement monitoring proposal to MRWA (April 1998)
- Complete progress report (May 1998)
- Complete monitoring program at Dongolocking (hand over to District May 2000)
- Write paper on population growth in translocated quenda populations under fox control (December 1998)

93/0145 - Factors affecting establishment in the numbat reintroduction program

- Carry out Stirling Range reintroduction (begin November 1998)
- Complete radio-tracking monitoring at Dragon Rocks (October 1999)
- Complete radio-tracking monitoring at Hills Forest (October 2000)
- Establish diggings survey regime at Karroun Hill (May 1999)
- Write paper on numbat translocation (February 2000)

93/0163 - Genetics and ecology of the western barred bandicoot

- Write paper on home range at White Beach, Dorre Island (December 1998)
- Analyse results of cross-breeding experiment and write up (February 1999)
- Apply for funds for analysis of variability within and between populations (April 1999)

TBA - Return to Dryandra

- Write SPP (May 1998)
- Establish populations of 5 species in 20 ha enclosure (October 1998)

- Carry out translocation of Western Barred Bandicoots to Dryandra Woodland (outside fence) - September 1998.

93/0149 - An assessment of the effect of fox control on RT Phascogale populations

- Finish habitat attribute assessment with ATCV (April 1998)
- Write paper on effect of fox control (December 1998).

93/0066 - Radio-tracking of translocated Noisy Scrub-birds

- Obtain sufficient understanding of male scrub-bird behaviour/requirements to enable significant improvements in translocation success rate -1999
- Obtain sufficient understanding of female scrub-bird behaviour/requirements to enable significant improvements in translocation success rate - 1999

WD/56 - Ground Parrot recovery

- Establish monitoring program in place - 1998
- Complete surveys of Cape Arid and Waychinicup - 1999
- Write Recovery Plan - 2000

93/0065 - Conservation of the Western Bristlebird

- Complete 5 year review of Research Plan funding - 1998
- Undertake translocation - 1999
- Establish at least one population west of Albany - 2003

93/0054 – Effect of fox control on habitat utilisation by the mainland Quokka

- Obtain annual estimates of quokka abundance at known mainland sites – June 1999, 2000. 2001
- Complete analysis of habitat use in presence of fox control – June 2000
- Ground truth and complete predictive model – June 2001

93/0142 – Translocation of the Western Ringtail Possum

- Complete Leschenault study - June 1999
- Complete Yalgorup National Park and Lane Poole Study - June 2000

OUTPUTS:

This project is only newly formulated and the vast majority of recent output has been the result of the previous administrative structure. The typical output from an individual Science Project (SPP) is a series of reports (generally to the funding agency), one or more major scientific publications in a refereed journal, at least one seminar to a science audience, formal and informal talks with CALM field staff and/or rural community members and a *Landscope* article. Recovery Plans are also prepared for threatened taxa.

93/0054: Publications

Sinclair, L. and Morris, K. 1996. Where have all the quokkas gone. Landscope, 11(2); 49-53.

The Quokka. In Maxwell, S., Burbidge, A.A. and Morris, K.D. (Eds) (1996). The 1996 Action Plan for Australian *Marsupials and Monotremes*. Australian Nature Conservation Agency, Canberra.

Seminars/Presentations

de Tores, P. 1997. Review of quokka distribution and overview of current research. Presented as part of workshop on fire management in relation to the quokka. Bushfires Board, Como. Western Australia.

Miscellaneous

Report

Anon. June 1997. New quokka find at bauxite mine. In Miners Write. Alcoa Newsletter.

93/0142: Publications

de Tores, P., Rosier, S. and Paine, G. 1998. Conservation of the western ringtail possum, *Pseudocheirus occidentalis*: Review of distribution; and translocation of rehabilitated possums. In Proceedings from Australian Mammal Society Conference, 5-8 July 1998.

De Tores, P. Rosier, S and Paine, G. 1998. Conserving the western ringtail possum. *Landscope* 13(4): 28-35.

The western ringtail possum. In Maxwell, S., Burbidge, A.A. and Morris, K.D. (Eds) (1996). *The 1996 Action Plan for* Australian *Marsupials and Monotremes*. Australian Nature Conservation Agency, Canberra.

Reports

Burbidge, A. A. and de Tores, P. 1998. Western ringtail possum (Pseudocheirus occidentalis) Interim Recovery Plan 1997-1999. Unpublished report prepared for the Western Ringtail Possum Recovery Team. Department of Conservation and Land Management Perth, Western Australia.

De Tores, P. 1995. Translocation Proposal for the Western Ringtail Possum, Pseudocheirus occidentalis. Unpublished report for the Department of Conservation and Land Management, Science and Information Division, Woodvale.

De Tores, P. and Lynch, R. 1995. Conservation of the western ringtail possum: Re-introduction at Yalgorup National Park. Unpublished brochure for Department of Conservation and Land Management, Perth, Western Australia.

De Tores, P. and Rosier, S. 1995. Leschenault Peninsula Draft Management Plan. Department of Department of Conservation and Land Management, Perth, Western Australia.

De Tores, P. and Rosier, S. 1996. Port Geographe Development Site, Area 2 - western ringtail possum survey and translocation. Unpublished report for the Department of Conservation and Land Management.

De Tores, P. and Rosier, S. 1997. Harvey Basin Allocation Plan: Western Ringtail Possum Survey Unpublished report prepared for Water and Rivers Commission, East Perth Western Australia.

De Tores, P., Rosier, S., Burbidge, A. and Himbeck, K. 1995. Interim Wildlife Management Guidelines for the Western Ringtail Possum, Pseudocheirus occidentalis. Unpublished

draft report for Department of Conservation and Land Management, Perth, Western Australia.

De Tores, P. 1996. Western Ringtail Possum Management Program. Revision of Appendix 4 of the Port Geographe Development Environmental Monitoring and Management Program. Unpublished report prepared for the Western Ringtail Possum Port Geographe Development Technical Committee.

Crow, M. 1996. Translocation of the western ringtail possum, Pseudocheirus occidentalis, from the Port Geographe Development Site, Busselton, to Yalgorup National Park. Unpublished report prepared for the Department of Conservation and Land Management, Perth, Western Australia.

Lynch, R. 1995. Translocation of the western ringtail possum, *Pseudocheirus occidentalis*, from the Port Geographe Development Site, Busselton, to Yalgorup National Park, May-July 1995. Unpublished report prepared for the Department of Conservation and Land Management, Perth, Western Australia.

Seminars/Presentations

de Tores, P. September 1996. A background to the western ringtail possum translocation to Lane Poole Reserve and overview of the research component of the northern jarrah forest fox control and research program. Presentation to the Lane Poole Reserve Community Advisory Committee, Dwellingup, Western Australia.

De Tores, P. 22 July 1998. Update on the northern jarrah forest fox control and research program, Operation Foxglove, chuditch monitoring results and western ringtail possum translocation program. Presentation to the Lane Poole Community Advisory Committee, Dwellingup, Western Australia.

De Tores, P., Rosier, S. ad Paine, G. July 1998. Conservation of the western ringtail possum, *Pseudocheirus occidentalis*: Review of distribution; and translocation of rehabilitated possums. Presentation at the Australian Mammal Society Conference, University of Western Australia, Perth.

Field Days

de Tores, P. and Rosier, S. 1995. Seminar updating results from western ringtail possum translocation and half day field site inspection at Leschenault Peninsula translocation release sites. Leschenault Peninsula Conservation Park, Western Australia.

De Tores, P. and Rosier, S. 1997. Presentation to 3rd year University of Western Australia natural resource students and day/evening field inspection of the Leschenault Peninsula western ringtail possum translocation site. Leschenault Peninsula Conservation Park, Western Australia.

Miscellaneous

Television Report

GWN (Regional, WA) News 24 July 1996. Reported on first release of western ringtail possums at Lane Poole Reserve.

OUTCOMES:

Science staff involved in this project have had, and continue to have, major involvement in the formulation of policy on threatened fauna, and in management methods already in place

and planned for the future. In particular, the Western Shield fauna recovery program was designed by personnel from this project team, and its members are heavily involved in advising and training District staff as well as in the field implementation of its actions.

ADOPTION STRATEGY:

- Outcomes of research programs are rapidly communicated to field staff working alongside Project Team personnel.
- Project Team members are involved in Western Shield planning and implementation groups, and research results are quickly incorporated into current programs.
- As research results are published, they are available for a wider audience.

CALM**Science** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Western Shield - Introduced Predator Control

PROJECT LEADER:

Paul de Tores, Woodvale

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0046	Relative acceptability of bait material to feral cats
93/0047	Measuring the effectiveness of 1080 baiting to control feral cats
93/0057	Control and ecology of the red fox in WA
93/0083	Fitzgerald River NP mammal population responses to baiting
93/0157	Control and ecology of the red fox in WA – native fauna response to 1080 baiting over large areas at 3 baiting frequencies
94/0009	The development of microsatellite probes to investigate the social organisation of foxes
95/0005	A conservation strategy for the western desert rock-wallaby
95/0015	1080 longevity in laid meat baits
96/0001	Fox population dynamics
96/0005	Effects of feral cat control on the sex ratios of rock-wallaby populations
96/0014	Broadscale cat control research
97/0005	Fox and cat density estimates, survivorship, and home range estimates in the presence of 1080 baiting within the NJF – a pilot study.
WD/0042	Montebello islands fauna rehabilitation project – rat and cat eradication phase

STAFF:

Staff	Location	FTE
D. Algar*	Woodvale	1.0
A.A. Burbidge	Woodvale	0.1
J. Cocking*	Dwellingup	1.0
P. de Tores	Woodvale	0.75
M. Dillon	Dwellingup	0.85
K. Himbeck*	Dwellingup	1.0
J. Kinnear	Woodvale	1.0
G. Liddelow	Manjimup	0.2
B. MacArthur*	Dwellingup	1.0
N. Marlow*	Woodvale	1.0
M. Maxwell*	Dwellingup	1.0
M. Onus	Woodvale	1.0
J. Sinagra*	Woodvale	1.0
* = externally funded		
Total		**10.9**

OBJECTIVES:

- Develop efficient methods for control of foxes and feral cats in Western Australia by:
    - refining existing fox control methodologies;
    - developing alternative strategies/techniques for fox control;
    - determining if, where and when cat control is required; and
    - developing cat control techniques and regimes.

SIGNIFICANCE AND BENEFITS:

- Use of 1080 (sodium monofluoroacetate) to control foxes has resulted in increases in fauna abundance at numerous conservation reserves and other reserves in Western Australia. Similarly use of 1080 is now seen as an essential component of fauna translocation programs. In both cases, use of 1080 has become a routine management operation based on sound scientific research.

- More recently, research has concentrated on large scale fox control with the view to determining cost effective prescriptions for operational use of 1080 over large areas. This has been complemented by research on alternative strategies for control, namely biological control through immunocontraception (fertility control). The long term benefit will be the development of an integrated approach for fox control, using a combination of conventional 1080 baiting strategies and fertility control.

- Control of feral cats has been identified as an essential adjunct to fox control. In arid and semi arid environments it has been well demonstrated that cat numbers increase when fox numbers are reduced. Techniques currently being examined provide the potential to control cats in these environments. The long term benefit will be the ability to control

foxes and cats in arid and semi arid environments and therefore enable native fauna populations to increases and be sustained.

- Similarly, it has now been shown that predation by cats increases in forest areas in the presence of fox control. This is presumably as a result of an increase in cat abundance as a result of fox control. However the impact of this on native mammal populations in the forest has not yet been demonstrated. Current research will determine whether cat numbers do increase and will determine whether such increases are a threat to native fauna populations in forested areas. Control strategies will be developed to control cats if they are deemed to be a threat to native fauna in forested areas of the southwest and wheatbelt reserves.

DESCRIPTION:

- **93/0046:** *Relative acceptability of bait materials to feral cats*: aims to determine the acceptability of a range of bait types for use in control of feral cats.

- **93/0047:** *Measuring the effectiveness of 1080 baiting to control feral cats*: aimed to determine the effectiveness of standard 1080 meat baits for use to control feral cats. This SPP has been terminated and is now incorporated into SPP 96/0014.

- **93/0057:** *Control and ecology of the red fox in Western Australia: Fox work. (Examining fox demography when populations reduced to simulate reduction by fertility control)*: aimed to reduce fox density on agricultural land abutting large tracts of CALM managed multiple use forest to simulate the effect of fertility control and determine the level of fertility control required to reduce fox populations to levels to allow native fauna populations to increase and be maintained. This SPP has been terminated and is now incorporated into SPP 96/0001.

- **93/0083:** *Fitzgerald River National Park mammal population responses to baiting*: aims to determine the level of predator control required over relatively large areas to enable resident indicator species to increase and to assess whether there is a response by smaller mammals.

- **93/0157:** *Control and ecology of the red fox in Western Australia – native fauna response to 1080 baiting over large areas at three baiting frequencies*: aims to determine the frequency of 1080 baiting required to reduce fox density sufficiently over large tracts of multiple use forest to allow native fauna populations to increase and be sustained. The project further aims to determine the level of fox density required to result in a sustainable increase in native fauna abundance.

- **94/0009:** *The development of microsatellite probes to investigate social organisation of foxes*: aimed to investigate the social organisation of foxes, specifically to determine whether a dominance hierarchy or mated pair social system exists and further to determine sexual contact rate.

- **95/0005:** *A conservation strategy for the western desert rock wallaby*: aims to develop a strategic plan to assure survival of the Calvert Range population of *Petrogale lateralis*.

- **95/0015:** *1080 longevity in laid meat baits*: will determine the lethal life of 1080 meat baits and the effect of rain on 1080 meat baits.

- **96/0001:** *Fox population dynamics*: aims to reduce fox density to approximately 20% of existing density in pastoral areas to simulate density reduction through fertility control, and in doing so, model the effects of fertility control to determine the level of fertility control required to maintain fox populations at low levels.

- **96/0005:** *Effect of feral cat control on the sex ratio of rock wallaby populations*: aims to test the hypothesis that selective predation by feral cats on female rock-wallabies is responsible for a bias in rock-wallaby sex ratio.

- **96/0014:** *Broadscale cat control research*: aims to develop an efficient and cost effective broadscale feral cat control strategy.

- **97/0005:** *Fox and cat density estimates, survivorship and home range estimates in the presence of 1080 baiting within the northern jarrah forest of southwest Western Australia – a pilot study*: aims to assess the suitability of conventional and satellite telemetry to determine whether foxes are surviving successive 1080 baiting events and to determine home range and survivorship of foxes and cats within the northern jarrah forest.

METHODOLOGY:

- **93/0046**: The methodology consisted of a series of pen and field cafeteria trials examining a range of bait mediums and additives to find the most acceptable/attractive bait type for feral cats

- **93/0047**: See SPP 96/0014.

- **93/0057**: See SPP 96/0001.

- **93/0083**: Methodology involved splitting FRNP into two halves. The western half was baited twice yearly and the eastern half left unbaited.. Medium sized mammal abundance was estimated in both areas. Baiting regime changed to 4 times per year over all of FRNP in 1996.

- **93/0157**: Implemented 3 different 1080 baiting regimes and an unbaited control. Regimes are at different baiting frequencies, 2,4 and 6 baitings/year using 4.5mg dried meat baits delivered aerially and from vehicles at 5 baits/km^2.
  Monitoring long term fauna response for the suite of resident mammal fauna at each treatment. Response monitored through trapping (wire cage, Elliott and pitfall traps) (initially twice yearly, increased to 4 times/year from July 1998) and spotlighting (twice yearly).
  Intensively monitoring survivorship (through movement sensitive mortality radio-telemetry) of a translocated indicator species (woylie) at each treatment.
  Intensively monitoring survivorship (through movement sensitive mortality radio-telemetry) of the common brushtail possum at each treatment.
  Monitoring fox density through sandplot technique.

- **94/0009**: Completed.

- **95/0005**: Fox and cat baiting implemented at Calvert Range and rock wallaby abundance estimated through trapping and spotlighting transects.

- **95/0015**: 1080 concentrations in dried meat baits determined over a variety of environmental conditions. Work undertaken by Win Kirkpatrick at Curtin University.

- **96/0001**: Live capture and radio-collaring of foxes in baited treatment site
  Aerial 1080 baiting (5 baits/km^2, using 3.0mg 1080 dried meat baits) over approx 3180 km^2 of treatment site
  Maintenance of a buffer zone (through 1080 baiting) around treatment site to minimise immigration
  Population sampling (non-destructive sampling to estimate post baiting density at treatment site and at control site)
  Post breeding season destructive sampling (using cyanide, trapping, shooting) at both sites to determine relative population density and litter size.

- **96/0005**: Rock wallaby abundance estimated at sites where cat and fox control implemented and compared with sites where only fox control has been implemented.

- **96/0014**: Develop a simple and efficient census technique: The methodology involves assessment of a trapping technique to census feral cat abundance. This will be conducted at several sites using a trap removal technique and subsequent eradication of all animals to determine percentage efficiency of the technique for cat census.
  Determine the timing of baiting programs to maximise efficiency: Routine bait uptake trials, including ground and aerial laid baits, will be conducted on a monthly and/or seasonal basis to assess when cats are consuming baits and the extent of bait consumption. This will enable prescriptions to be formulated on baiting efficiency across seasons.
  Determine baiting efficiency across geographic zones: As above across a number of geographic zones.
  Examine levels of baiting intensity to provide cost effective control: Use of biomarker methodology, recently developed, to assess baiting efficiency at a series of baiting intensities. This will be conducted at a series of sites across WA to provide data on the optimum baiting levels for effective baiting.
  Collaboration in felid-specific toxin research: All information withheld due to 'commercial in confidence' restrictions.

- **97/0005**: Live trapping (victor soft catch traps) of foxes and cats within 6 baitings/year treatment and unbaited control of the northern jarrah forest (Operation Foxglove) project. Supplemented by wire cage trapping for cats.
  Radio-telemetry monitoring from aircraft (using movement sensitive mortality radio-telemetry) of all trapped foxes and cats and satellite monitoring of 1-2 foxes and cats.

SCHEDULE OF TASKS:

(see Milestones or SPPs)

MILESTONES: (Project performance will be measured by progress against milestones. Milestones must be measurable and reflect progress towards achieving objectives)

- **93/0046**: Completed.

- **93/0047**: See SPP 96/0014.
- **93/0057**: See SPP 96/0001.
- **93/0083**: October 1998 – final trapping at research sites. Analyse data and publish.
- **93/0157**: December 1995: first data on survivorship of radio-collared woylies
  September/October 1996, 1997 1998 and 1999: annual estimates of fox density
  July 1996, 1997, 1998: annual analysis of woylie survivorship
  September 1998: complete intensive radio telemetry monitoring of woylie survivorship
  October 1999-January 2000: complete all field work
  June 2000: final analysis of trapping, radio-telemetry. spotlight and fox density data.
- **94/0009:** Completed.
- **95/0005:** July 1998 – assess RW population to determine if baiting is assisting recovery.
  October 1998 – continue cat baiting with sausage baits.
  July 1999 - assess RW population
- **95/0015:** December 1998 - Complete MSc thesis. Final Report to CALM
- **96/0001:** July 1995-Aug 1997: Monitor fox density in control site, treatment site and baited buffer surrounding the treatment site.
  August 1995: Impose fox baiting to reduce fox density in treatment site.
  Sept 95-May 96: Permit reinvasion of depopulated area to determine timing of recolonisation.
  Aug -Dec 1997: Destructively sample fox populations in control and treatment sites and in baited buffer zone.
  June 1999:All data to be analysed and 8 manuscripts to be submitted for publication.
- **96/0014:** See table in schedule of tasks.
- **97/0005:** June 1999 – analysis of fox and cat survivorship and home range data

OUTPUTS: (Reports, publications, seminars, field days etc.)

- **93/0046**:

Publications

Algar, D. and Sinagra, J.A. (written but withheld because of patent). A technique, using cafeteria trials, to assess feral cat bait preferences.

Algar, D. and Sinagra, J.A. (written but withheld because of patent). Pen trials examining bait preferences by cats.

Reports

See SPP 93/0047

Internal CALM reports, external reports seminars and workshops

See spp 96/0014

Methods of broadscale cat control and fox control at a numbat re-introduction

- **93/0047:**

Publications

Algar, D., Sinagra, J.A. and McGuire, J. (written but withheld because of patent). The use of iophenoxic acid to label feral cats consuming baits.

Fisher, P., Algar, D. and Sinagra, J.A. (submitted). Use of Rhodamine B as a systemic bait marker for feral cats.

Algar D. and Smith, R. 1998. Approaching Eden. *Landscope*. 13(3): 28-34

Reports

Methods of broadscale cat and fox control at a numbat re-introduction site: progress report, September 1993: Feral Pests Program, Project 11.

Methods of broadscale cat and fox control at a numbat re-introduction site: final report, December 1993: with Appendix February 1994: Feral Pests Program, Project 11.

Methods of broadscale cat and fox control at a numbat re-introduction site: progress report, June 1994: Feral Pests Program, Project 11.

Methods of broadscale cat and fox control at a numbat re-introduction site: final report year 2: Feral Pests Program, Project 11.

- **93/0057**:

Publications

See SPP 96/0001

Reports

Marlow, N. 1994. Control and ecology of the red fox in Western Australia: a report submitted to the Australian Nature Conservation Agency for the period 1993-94.

Marlow, N. 1995. Control and ecology of the red fox in Western Australia: a report submitted to the Australian Nature Conservation Agency for the period 1994-95.

Marlow, N. 1996. Control and ecology of the red fox in Western Australia: a report submitted to the Australian Nature Conservation Agency for the period 1995-96.

'Fox population dynamics and social organisation' In the CRC annual report for 1993-4.

'Fox population dynamics and social organisation' In the CRC annual report for 1994-5

Seminars/ Presentations

Marlow, N. March 1994 'Fox population dynamics and biological control'. Seminar presented to annual CRC scientists meeting at Braidwood, NSW.

Marlow, N. May 1995. 'Fox population dynamics and biological control'. Seminar presented to annual CRC scientists meeting at Braidwood, NSW.

Marlow, N. November 1995. 'Fox population dynamics and biological control'. Seminar presented at CALM headquarters Como.

- **93/0083**: No publications.

- **93/0157:**

Publications

de Tores, P. 1994. Operational guidelines for the control of the Red Fox, *Vulpes vulpes*, through the use of Sodium monofluoroacetate or '1080' on CALM managed estate and in other CALM programs. Report for the Department of Conservation and Land Management, Perth, Western Australia.

De Tores, P. 199?. Controlling the Red Fox. In, Exploring CRC Research. Highlights of Environmental Cooperative Research Centres in Australia. Department of Industry, Science and Tourism, Canberra.

De Tores, P.J., Himbeck, K., Dillon, M., Cocking, J., MacArthur B. and Rosier S.M. 1998. Large Scale fox Control in the northern jarrah forest of southwest Western Australia. In Proceedings of 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia.

F H Yung, P J de Tores, S A Halse and M J Smith. Importance of relational database normalisation. (submitted to *Journal of the Royal Society of Western Australia*).

Reports

de Tores, P. 1994. Translocation Proposal for the woylie, *Bettongia penicillata*. Unpublished report for the Department of Conservation and Land Management, Science and Information Division, Woodvale.

De Tores, P. 1995. Fox Control in the northern jarrah forest. In *1995 Mammal Conservation Course: Batalling Field Study Centre, 23-27th October, 1995*. Department of Conservation and Land Management, Western Australia, pp. 107-110.

De Tores, P. 1996. Prey Response to 1080 Baiting Over Large Areas. 1995-96 end of year report to The Australian Nature Conservation Agency, Feral Pests Program. Part only of end year report for FPP Project Number 8: Control and Ecology of the Red Fox in Western Australia.

De Tores, P. 1998. Control and Ecology of the Red Fox in Western Australia - Prey Response to 1080 Baiting Over Large Areas. 1996-97 end of year report to Environment Australia National Feral Animal Control Program ISP#05.

Seminars/Presentations

de Tores, P. November 1995. Seminar at the University of NSW: Translocation of the brush-tailed bettong or woylie, *Bettongia penicillata*, and 1080 baiting for fox control in the northern jarrah forest of southwest Western Australia. Presented as part of upgrading studies to Ph.D. UNSW, Sydney.

De Tores, P. August 1996: Research perspective of Operation Foxglove. Presentation to the Western Australian Naturalists' Club, Darling Range Branch. Kalamunda.

De Tores, P. February 1997. An update of Operation Foxglove. Presented to CALM's Swan Region, regional leaders meeting, CALM, Kelmscott

de Tores, P. September 1996. A background to the western ringtail possum translocation to the Lane Poole Reserve and overview of the research component of the northern jarrah forest fox control and research program. Presentation to the Lane Poole Reserve Community Advisory Committee, Dwellingup, Western Australia.

De Tores, P. July 1997. Update on research progress for the northern jarrah forest fox control and research program, Operation Foxglove. North Head Quarantine Station. Presentation as part of 5 year review of the VB CRC, Canberra.

De Tores, P. Date? Update on the northern jarrah forest fox control and research program, Operation Foxglove. Presentation to Alcoa's Research Group, Booragoon, Perth Western Australia.

De Tores, P. 6 May 1998. Large Scale fox Control in the northern jarrah forest of southwest Western Australia. Presentation at 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia.

De Tores, P. May 1998. Update on research progress for the northern jarrah forest fox control and research program, Operation Foxglove. Presentation as part of renewal process for VB CRC, Canberra.

De Tores, P. 22 July 1998. Update on the northern jarrah forest fox control and research program, Operation Foxglove, chuditch monitoring results and western ringtail possum translocation program. Presentation to the Lane Poole Community Advisory Committee, Dwellingup, Western Australia.

Field Days

de Tores, P. July 1997. Overview of Operation Foxglove. Presentation to local media at the noisy scrub bird release, Hoffmans Mill, Western Australia.

De Tores, P., Himbeck, K., Cocking J., MacArthur, B., Maxwell, M., Morris, K., and Armstrong, R. 2-3 March 1998. Hosted Environment Australia representatives for 2 day field trip of research sites and presented overview of the northern jarrah forest fox control and research program.

De Tores, P., Dillon, M., Himbeck, K., Cocking J., MacArthur, B. and Maxwell, M. 24 February 1998. Hosted regional television crew (GWN), Sunday Times reporters and CALM Executive Director for field day examining the northern jarrah forest fox control and research program, Operation Foxglove, research sites.

De Tores, P., Rosier, S., Dillon, M., Himbeck, K. Cocking J., MacArthur, B. and Maxwell, M. 9-11 July 1998. Organised and hosted the Australian Mammal Society Post Conference Tour. The post conference tour examined the northern jarrah forest, Operation Foxglove, research sites.

Miscellaneous

Newspaper article

Jacobson, I. *Cunning CALM outfoxes foxes.* The Sunday Times. Sunday, 1 March 1998, p28.

Television Report

GWN (Regional, WA) News 2 March 1998. Reported on Operation Foxglove.

- **94/0009:**

Publications (submitted to journal)

Lade, J., Robinson, N. and Marlow N. Limited allelic variability in red foxes (*Vulpes vulpes*) across mainland Australia. Submitted to Molecular Ecology.

Publications (in prep.)

Marlow, N. and Groth, D. The development of microsatellite probes to determine the social organisation of red foxes (*Vulpes vulpes*).

- **95/0005:** No publications. Report provided on recommendations for ongoing management.

- **95/0015**: No publications. Report provided on progress.

- **96/0001**:

*Publications (*submitted.)

Marlow, N. and Thomson, P. Fox population dynamics in the Carnarvon area. Submitted to CALMNews and Landscope.

Publications (in prep.)

Marlow, N., Thomson, P., and Algar, D. The demographic characteristics and social organisation of a population of *Vulpes vulpes* in Carnarvon W.A.

Thomson, P., and Marlow, N. An assessment of fox density and bait uptake in the Northern Jarrah forest of WA.

Thomson, P., and Marlow, N. Home-range usage of red foxes *(Vulpes vulpes)* in an agricultural area of south western Australia.

Marlow, N. and Thomson, P. Effectiveness of a baiting campaign and buffer zones in the pastoral zone of Western Australia.

Thomson, P., and Marlow, N. Compensatory breeding in a reduced population of red foxes *(Vulpes vulpes)* in the pastoral zone of Western Australia.

Marlow, N. and Thomson, P. The population dynamics of red foxes *(Vulpes vulpes)* in the pastoral zone of Western Australia.

Marlow, N. and Thomson, P. The timing and distance of dispersal of red foxes *(Vulpes vulpes)* in an agricultural area of south western Australia.

Reports:

Control and ecology of the red fox in Western Australia: a report submitted to Environment Australia for the period 1996-97

Control and ecology of the red fox in Western Australia: a report submitted to Environment Australia for the period 1997-98

Fox population dynamics and control: a report submitted to the VBCRC for the period 1996-97

Fox population dynamics and control: a report submitted to the VBCRC for the period 1997-98

Final report to the Department of Commerce and Trade by the Co-operative Research Centre for the Biological Control of Vertebrate Pests. (100pp).

Seminars/ Presentations

Marlow, N. November 1995. Fox population dynamics and control. Seminar presented to CSIRO staff at Gungahlin, Canberra.

Marlow, N. November 1995. Fox population dynamics and control. Seminar presented to the Australasian Wildlife Management Society in Christchurch New Zealand.

N. Marlow October 1996. Seminar presented at CALM Woodvale. 'Fox population dynamics and biological control'.

Marlow, N., Thomson, P., Rose, K. and Kok, N. May 1998. Population compensation in the red fox: a preliminary analysis. Presentation at the 11th Australasian Vertebrate Pest Conference, Bunbury, Western Australia.

Thomson, P., Marlow, N., Rose, K. and Kok, N. May 1998. The effectiveness of large-scale fox baiting and buffer zones in Western Australia.. Presentation at the 11th Australasian Vertebrate Pest Conference, Bunbury, Western Australia.

- **96/0005**: No publications. Report provided on recommendations for rock wallaby management.

- **96/0014**:

Publications

Methods of broadscale control of feral cats in WA. Final Report, January 1996. Feral Pests Program, Project 11.

Internal CALM Reports

Cat control for Montebello Renewal

Cat control for Project Eden

Feral cats, Wanjarri Nature Reserve

External Reports

Control of feral cats: Nifty Copper Operations

Control of feral cats: Argyle Diamonds

Seminars

Feral cat research. CALM Workshop, Nov. 1993.

Research on control of feral cats, CALM**Science** seminar, Dec.1993.

Research on control of feral cats, Midwest Information Exchange, March 1994.

Research on control of feral cats, Applied Sciences, Kalgoorlie College, April 1994.

Feral Cat Control. Mammal Conservation Course, Oct. 1994.

Feral cats: An update on control methods and some new advances. National Rock Wallaby Symposium, South Australia, Nov. 1994.

Research on the control of feral cats, Applied Sciences, Kalgoorlie College April 1995.

Research on control of feral cats. Mammal Conservation Course, Oct. 1995.
Development of a feral cat bait. CALM Introduced predator workshop, Bunbury, March 1996.
Exotic Predators. Mammal Conservation Course, Sept 1996.
Cat Research Update. Review meeting for Western Shield, April 1997.
Feral cat research. Kalgoorlie Naturalists Club, June 1997.
Exotic Predators. Mammal Conservation Course, October 1997.
Feral Cat Control. Arid Zone Recovery Workshop, Broome, May 1997.

Miscellaneous
Participation in a number of newspaper articles, television interviews and provision of material for Corporate Relations pamphlets articles etc.

- **97/0005:** No publications/reports to date.

OUTCOMES: (Changes to policy, management prescriptions etc.)

- **93/0046:** Recommendation of an appropriate bait for use in control of feral cats
- **93/0047:** See SPP 96/0014.
- **93/0057:** See SPP 96/0001.
- **93/0083:** Recommendation of appropriate 1080 fox baiting regime for large areas
- **93/0157:** Will provide management prescriptions for large scale 1080 baiting.
- **94/0009:** Data obtained supported the presence of a mated pair social organisation in the pastoral zone rather than dominancy hierarchies. However, no definitive conclusions can be made form the analyses because the technique was limited by very high levels of homozygosity in the fox population studied. No further analyses of this data are warranted.
- **95/0005:** Baiting regimes will be determined for Calvert Range and Depuch Island for conservation of *Petrogale lateralis*.
- **95/0015:** Will identify the appropriate concentration of 1080 required for 1080 meat baits for fox control and will determine maximum time that 1080 baits remain lethal in field situations.
- **96/0001:** Buffer zones were shown to be effective in minimising reinvasion of protected zones by foxes. A buffer width of 10 km was shown to be adequate.
  Reinvasion of protected areas by foxes was shown to occur predominantly in autumn. The baiting of reserves during this season should maximise the cost-effectiveness of lethal fox control.
- **96/0005:** Will determine whether cat control strategies are required at wheatbelt rock-wallaby sites.
- **96/0014:** Recommendation of appropriate cat control methodology and development of operational prescriptions for cat control.
- **97/0005:** Will determine the need for incorporating cat control strategies when controlling foxes in the southwest.

ADOPTION STRATEGY: (Describe how outcomes will be implemented)

- **93/0046:** Introduction of an appropriate bait for feral cats, if required, or integration with existing fox baiting.
- **93/0047:** See SPP 96/0014.
- **93/0057:** See SPP 96/0001.
- **93/0083:** If required, amendment to 1080 fox baiting regimes

- **93/0157:** If required, amendment to 1080 fox baiting regimes. Will be incorporated through revision of the Fox Control Manual.
- **95/0005:** Baiting to be continued under Western Shield, monitoring continued by CALMScience.
- **95/0015:** Results will be incorporated into operational baiting regimes to maximise efficacy of 1080 baiting.
- **96/0001:** Results will be incorporated into operational baiting regimes to maximise the efficacy of 1080 baiting. Buffer zones will be used in the implementation of fertility control when an effective immunocontraceptive product is available.
- **96/0005:** If findings reveal the requirement for cat control, control will have been implemented at two sites through the research phase. Baiting regimes at additional sites will be modified through liaison with regional and district staff.
- **96/0014:** If required, broadscale implementation of a baiting regime(s) for feral cats. Implemented through development of operational prescriptions for cat control.
- **97/0005:** If required, amendment to 1080 fox baiting regimes to ensure cat control measures are implemented concurrently. Will be incorporated through revision of the Fox Control Manual and through development of operational prescriptions for cat control.

CALMSCIENCE DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Western Everlasting - Flora Recovery

PROJECT LEADER:

Dr David Coates, Herbarium

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0042	Conservation biology of rare and threatened flora
93/0043	Seed biology, seedbank dynamics and the long term germ plasm storage of WA flora especially rare, threatened and commercially utilised flora
93/0044	A quadrat based monitoring system for endangered flora
93/0045	Population based surveys, conservation status and area based wildlife management programs for rare and threatened flora
93/0048	Weed threats and control in populations of WA's rare and threatened flora.
93/0070	Control and management of *Armillaria luteobubalina* in native plant communities
93/0081	Control and management of *Phytophthora cinnamomi* in native plant communities
93/0049	Development of a GIS-based decision support tools in the control of *Phytophthora*
93/0068	Integrating strategies for the control of *Phytophthora cinnamomi* with phosphite
93/0069	Use of debiltating factors and host resistance to control *Diplodina* canker in *Banksia coccinea* communities
96/0012	Susceptibility of major soil types of the FRNP to infestation by *P. megasperma* and *P. cinnamomi*
96/0009	Resurvey and analysis of Podger's dieback sites after 30 years.
98/0001	Selection for resistance to *Phytophthora cinnamomi* in *Banksia coccinea*
98/0003	Genetics and biosystematics for the conservation, circumscription and management of Western Australian flora
99/0005	WATTLE, a computer-based information system for the genus *Acacia*

99/0010	To test the susceptibility of rare and threatened flora in CALM's seed collection to *Phytophthora*
TBA	To evaluate the extent to which *P. megasperma* and other biotypes of *Phytophthora* pose a threat to higher plant communities of the Weld catchment and region, FRNP and region, and northern sandplain

STAFF:

Staff	Location	FTE
L. Broadhurst	Herbarium	0.5
M. Byrne	Herbarium	0.5
D. Coates	Herbarium	1.0
A. Cochrane*	Herbarium	1.0
H. Coleman	Herbarium	0.8
C. Crane	Como	1.0
R. Fairman	Dwellingup	1.0
P. Gioia	Herbarium	0.1
V. Hamley	Herbarium	0.5
B. Maslin	Herbarium	0.8
B. McDonald	Herbarium	0.5
L. Monks	Herbarium	1.0
F. Obbens*	Herbarium	1.0
S. Patrick	Herbarium	1.0
B. Shearer	Como	1.0
C. Yates	Herbarium	1.0
*=externally funded		
Total		**12.7**

OBJECTIVES:

- Develop protocols required for the conservation and recovery of rare, threatened flora and other priority flora in WA. These protocols will be based on an adequate understanding of the population dynamics, reproductive biology and population genetics of target taxa.

- Establish and maintain an *ex situ* germplasm storage facility, develop storage technologies for rare and threatened flora and develop methodologies for translocation programs.

- Provide up to date information on the conservation status of rare and poorly known flora (priority flora), make recommendations on the annual addition of taxa to the declared Rare Flora list and assist in the ranking and prioritization of threatened taxa for recovery

- Identify processes (e.g weeds, disease, fire) that detrimentally impact on native flora particularly rare and threatened species and develop strategies for the control of these processes

- Provide phylogenetic and molecular systematic xxx data that will assist in the description, classification and conservation of the Western Australian flora

- Investigate the impact and control of *Phytophthora* root rot and other plant diseases such as *Armillaria* and *Diplodina* canker, specifically:

    - develop strategies and protocols for the control of *Phytophthora* root rot through the application of phosphite.
    - research the impact and control of *Phytophthora* taxa other than *P. cinnamomi.*
    - develop a GIS decision support expert system for setting priorities for the control of Phytophthora in threatened flora populations and threatened communities.
    - research the susceptibility of threatened flora to *P. cinnamomi* to assist in priority setting for control.
    - research the impact and control of *Armillaria* and *Diplodina* canker

SIGNIFICANCE & BENEFITS:

- A sound scientific basis for the prioritisation, conservation and management of rare and threatened flora, and other flora of special interest.

- Development of control measures for the introduced *Phytophthora* root rot, perhaps the most significant threatening processes to the flora in south west Western Australia:
    - Research has already made significant advances in the control of this disease through the use of phosphite.
    - Further major advances are expected with the refinement of phosphite application techniques and a better understanding of the mode of action of phosphite.

- Control of other plant pathogens such as *Armillaria* and *Diplodina* canker although not as high priority, is also important particularly in ecosystems where *Phytophthora* root rot is not considered to be a major threat

DESCRIPTION:

- *Conservation biology and management of threatened and other priority flora.*
  Currently there are some 90 critically endangered taxa which form the primary focus of this research. Taxa from the following genera have been or are currently under investigation: *Acacia, Banksia, Dryandra, Eremophila, Verticordia* and *Stylidium* and orchids

- *Ex situ germ plasm storage and research, and re-introduction methodologies.*
  The Threatened Flora Seed Centre (TFSC) is responsible for the ongoing collection and storage of rare and threatened flora, particularly critically endangered taxa. Its function covers not only storage but research into seed biology and seed storage methodologies. Closely linked with this facility are experimental translocations, based on material from the seed store, which are planned for June 1998. These translocations are designed to investigate a range of re-introduction methodologies that may be suitable for critically endangered taxa.

- *Conservation status of rare and threatened flora.*
  Publication of area based rare and threatened flora management programs have been the primary focus of this work. It is envisaged that this work will be largely completed in the next two years as the Districts take over the production and / or up dating of their management programs. Survey of priority flora considered to be critically endangered will continue if supported by NHT funding.

- *Impact and control of weeds.*
  Research into the impact and control of weeds on critically endangered flora commenced in Oct 1997 following NHT funding and will continue for the next two years. For threats in relation to plant diseases see below.

- *Application of phosphite and control of Phytophthora.*
  Research will focus on improving application techniques particularly in relation to frequency of repeat spraying, concentration of applied phosphite and method of delivery.

- *Impact and control of other Phytophthora taxa.*
  A range of *Phytophthora* taxa other than *P. cinnamomi* have been identified in Western Australia and studies to date indicate variable impacts on the native flora although generally less severe than *P. cinnamomi.* This research focuses on the level of threat and control of these other taxa.

- *GIS decision support expert system*
  Setting priorities for the control of *Phytophthora* particularly in relation to application of phosphite is a difficult task given the number of species and ecological communities under threat. This work is directed towards the development of GIS based decision support tools which can assist in setting priorities for control.

- *Susceptibility of threatened flora to P. cinnamomi.*
  At present there is only limited data on the susceptibility of many rare and threatened flora to *Phytophthora*. A more accurate assessment of susceptibility will improve our capacity to set priorities and plan recovery actions

- *Impact and control of Armillaria and Diplodina canker*
  Although overall lesser threats than *Phytophthora* root rot, *Armillaria* and *Diplodina* canker can cause severe damage in some plant communities. Researching impact and possible control will be important for the conservation and management of those communities

METHODS:

- *Conservation biology and management of threatened and other priority flora.*
  Currently there are some 90 critically endangered taxa which form the primary focus of this research. The aim is to gather data on the following:
  - Soil seed bank dynamics and the role of various factors (disturbance, fire, competition, rainfall) in recruitment and seedling survival
  - Reproductive strategies, phenology and seasonal growth.
  - Mating system and pollination biology
  - Population genetic structure, levels of genetic diversity and minimum viable population size

- Ex situ germ plasm storage and research, and re-introduction methodologies
  Methods will involve:
  - Development *ex situ* conservation strategies such as propagation protocols and germplasm storage techniques
  - Development of re-introduction techniques through a series of experimental re-introductions which will start in May 1998 and continue for at least the next three years.

  - *Conservation status of rare and threatened flora.*

    This generally involves the collation of available data on selected rare and threatened flora, survey and the preparation of Rare Flora Report forms, and the publication of area based rare and threatened flora management programs

  - Identification and amelioration of weeds.
    The impact and control of weeds on endangered plant populations is being assessed by a series of replicate treatment control plots on populations of 12 endangered taxa. This work will continue for the next two years

  - Application of phosphite and control of Phytophthora.
    Will determine:
    - length of time phosphite gives protection and phosphite levels in the host
    - application technologies such as type of surfactant and method of delivery
    - movement of phosphite in the plant
    - monitoring possible phytotoxic effects of phosphite on native flora, mammals and soil biota.

  - Impact and control of other Phytophthora taxa.
    - the development systems for the accurate identification of *Phytophthora* taxa
    - assessing the of level of threat of each taxon
    - determining methods of control, where appropriate

  - GIS decision support expert system
    - developing an inventory of *Phytophthora cinnamomi* distribution and transforming those data into a GIS format
    - mapping the distribution of threatened / priority flora
    - prioritizing flora populations based on proximity to *P. cinnamomi* infections
    - using *Banksia* as an exemplar for further development of a decision support system for prioritizing areas for *P. cinnamomi* management

  - Susceptibility of threatened flora to P. cinnamomi
    - pot trials to estimate and rank susceptibility of threatened flora to *P. cinnamomi*

- *Impact and control of Armillaria and Diplodina canker.*

MILESTONES:

- *Conservation biology and management of threatened and other priority flora.*
  - March 1998 - Honours student commences conservation genetics studies on critically endangered *Acacia lobulata* and *Acacia schiophanes*

- April 1998 - commence work on NHT funded program - conservation biology of six critically endangered *Verticordia* taxa
- April 1998 - commence work on NHT funded program - conservation biology and management of six critically endangered *Acacia* taxa
- Oct 1998 - submit paper on Mating systems and conservation genetics of endangered *Lambertia* species to *Conservation Biology*
- Nov 1998 - submit review on conservation genetics of endangered WA plants to *Aust. J. Bot.*
- Feb 1999 - MSc student completes thesis work (population ecology) on three endangered *Dryandra* species
- Feb. 1999 - submit paper on conservation genetics of endangered *Verticordia* species to *Aust. J. Bot*
- Feb 1999 -submit final report on three endangered *Dryandra* species to Endangered Species Program
- April 1999 - submit final report (year 1 of funding) on conservation biology and management of six critically endangered *Acacia* taxa to Endangered Species Program
- April 1999 - submit final report (year 1 of funding) on conservation biology and management of six critically endangered *Verticordia* taxa to Endangered Species Program

- *Ex situ germ plasm storage and research, and re-introduction methodologies*
  - March 1998 - apply / pursue ongoing support (salaries and budget) for TFSC
  - March 1998 - submit seven translocation proposals for approval to cover experimental re-introductions for critically endangered plants
  - May 1998 - commence experimental re-introductions
  - January 1999 confirm budget for 1999 - 2000

- *Conservation status of rare and threatened flora*
  - June 1998 - Publish Esperance and Moora Districts Threatened and Poorly Known Flora Management programs
  - July 1998 - Publish *Banksia cuneata* Recovery Plan
  - Sept 1998 - decide on survey program for high priority rare and poorly known flora if NHT funding approved
  - March 1999 Appoint survey Botanist

- *Identification and amelioration of weeds*
  - April 1998 - complete weed control / impact database
  - May 1998 - set up weed control monitoring sites on six endangered flora
  - Oct 1998 - submit final report (year 1 of funding) on "Critically Endangered Plants - weeds research and control" to EA Endangered Species Program

- *Plant diseases – impact and control.*
  - April 1998 - submit review of five year research program covered in objectives 1-4 above Environment Australia, Endangered Species Program
  - April 1998 - complete assessment of phosphite aerial trials
  - May 1998 - submit detailed report to Environment Australia, Endangered Species Program on 1997/98 research covered in objectives 1-4 above
  - May 1998 - complete assessment of combined injection/spray trial at Lakes Rd demonstrated effectiveness of phosphite after fire.
  - July 1998 - B. Komorek commence mode of action of phosphite research (CALM PhD scholarship)

- Oct 1998 - consider research priorities based on allocation of NHT funding. Apply to ED for funding if NHT funding unsuccessful.
- Sept 1998 - complete and submit for approval three draft publications on phosphite control of *Phytophthora*
- Sept 1998 - commence use of avirulent isolates to control virulent isolates of *C. melanocraspeda* in priority stands of *B. coccinea*.
- Dec. 1998 - complete inoculation trials for susceptibility of 38 endangered flora to *Phytophthora*

OUTPUTS:

Seminar series on plant conservation genetics to be held in April 1999.

f) **Flora conservation publications:**

1990

Hopper, S.D. and Coates, D.J. Conservation of genetic resources in Australia's flora and fauna. *Proc. Ecol. Soc. Aust.*, 16, 567-577

Coates, D. J. and Marchant, N. Growing in a Wild State. *Landscope*, 6. 49-53.

Kelly.A., Coates D.J., Herford, I., Hopper, S.D., O'Donoghue,M. and Robson,L. Declared rare flora and other plants in need of special protection in the Northern Forest Region. Western Australian Wildlife Management Program No 5, Department of Conservation and Land Management, Perth

Hopper, S., Van Leeuwin, S., Brown, A. and Patrick, S. *Western Australia's Endangered Flora*. Department of Conservation and Land Management, Western Australia.

Sampson, J.F., Hopper, S.D. and Coates,D.J. *Eucalyptus rhodantha*. Western Australian Wildlife Management Program. No 4 Department of Conservation and Land Management, Perth.

1991

Coates, D. J. 1991. Gene flow along corridors. In *The Role of Corridors*. Eds D. A. Saunders and R. J. Hobbs. Surrey Beatty, Chipping Norton, NSW.

f) Byrne M. and James S.H. Genetic diversity in the cycad, *Macrozamia riedlei*. Heredity 67:35-39.

1992

Coates, D. J. 1992. Genetic consequences of a bottleneck and spatial genetic structure in the triggerplant Stylidium coroniforme. Heredity, 69, 512-520

Coates, D. J. and Sokolowski R. E. S. 1992. The mating system and patterns of genetic variation in Banksia cuneata A. S. George (Proteaceae) Heredity, 69, 11-20.

Patrick, S. Aponogeton hexatepalus, Eucalyptus rhodantha, Asterolasia nivea, Gastrolobium glaucum, Banksia brownii, Stylidium coroniforme, Darwinea carnea, Thomasia sp. (York). In Threatened Australian Plants. Eds. Leigh, J.H. and Briggs, J.D. Australian National Parks and Wildlife Service, Canberra.

1993

Kelly, A. E. Taylor, A. Langley, M. A. , Spooner, A. and Coates, D. J. 1993. Declared rare flora and other plants in need of special protection in the Metropolitan Area . Wildlife Management Program No 10. Department of Conservation and Land Management. Perth.

Mollemans, H., Brown, P. H. and Coates. D. J. 1993. Declared rare flora and other plants in need of special protection in the Merredin District. Wildlife Management Program No 9. Department of Conservation and Land Management, Perth.

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OUTCOMES:

- *Conservation biology and management of threatened and other priority flora*
  - sound scientific basis for management prescriptions and recovery actions in Endangered Flora Recovery Programs

- *Ex situ germ plasm storage and research, and re-introduction methodologies*
  - maintenance of genetically representative *ex situ* germplasm collections of threatened flora
  - provision of appropriate material for re-introduction programs
  - prescriptions for re-introduction programs

- *Conservation status of rare and threatened flora*
  - recommendations for additions/deletions to the State listing of Declared Rare Flora
  - publication of District /Regional based management strategies for threatened and priority flora

- *Identification and amelioration of weeds*
  - management prescriptions for the control of weeds and rehabilitation of critically endangered plant populations

- *Application of phosphite and control of Phytophthora*

- preparation of Phospnite operations manual and detailed prescriptions (surfactant, time of application. frequency of application) for the use of phosphite on threatened flora populations and threatened/priority communities

- *Impact and control of other Phytophthora taxa*
  - an improved identification method of *Phytophthora* taxa
  - a clear assessment of the threat posed by *Phytophthora* taxa, other than *P. cinnamomi*, to threatened flora and ecosystems

- *GIS decision support expert system*
  - a system for the prioritization of threatened/priority flora populations and threatened communities for management of *Phytophthora* particularly in relation to the application of phosphite

- *Susceptibility of threatened flora to P. cinnamomi*
  - a ranking of threatened flora susceptibility to *P. cinnamomi* which will assist in the prioritization process in the GIS decision support system.

- *Impact and control of Armillaria and Diplodina canker*
  - an assessment and recommended controls for *Armillaria* and *Diplodina* canker where they are considered to be a significant threat to flora

ADOPTION STRATEGY:

- *Conservation biology and management of threatened and other priority flora*
  - through actions recommended in approved Threatened Flora Recovery programs.

- *Ex situ germ plasm storage and research, and re-introduction methodologies*
  - though ongoing maintenance of the TFSC
  - as actions in approved Translocation Programs

- *Conservation status of rare and threatened flora*
  - Protection of threatened flora following listing and gazettal as Declared Rare Flora
  - through actions recommended in approved District/Regional based flora management programs

- *Identification and amelioration of weeds*
  - through adoption of weed control programs on critically endangered plant populations by Districts and regions

- *Plant diseases – impact and control.*
  - all operational outcomes related to the management and control of *Phytophthora* such as phosphite application techniques and methods for prioritizing site/population selection for phosphite application will be implemented via operational manuals and recommendations to the CALM Dieback Coordinator.
  - control and management of other diseases will be implemented through reports and recommendations to the Director Regional Operations and operations staff in the Districts and Regions.

CALM**Science** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Carnarvon Basin Biological Survey

PROJECT LEADER:

Allan Burbidge, Woodvale

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0035 Biological survey of the southern Carnarvon and northern Irwin Phytogeographic Districts.

91/0022 Assessment (in a regional context) of the conservation values of VCL near Coolcalalaya.

STAFF:

Staff	Location	FTE
A.H. Burbidge	Woodvale	0.6
N. Gibson	Woodvale	0.3
S. Halse	Woodvale	0.1
G. Keighery	Woodvale	0.2
N. McKenzie	Woodvale	0.6
Total		**1.8**

Note: Many other CALM**Science**, WA Museum and UWA staff were involved in this project. The FTE's above are indicative of current (November 1998) involvement.

OBJECTIVES:

- Assess the adequacy of the current regional reserve system in the southern Carnarvon and northern Irwin Phytogeographic Districts on the basis of patterns of disturbance of plants and animals.
- Design an optimal regional reserve system which would fill major gaps identified by the above process.

SIGNIFICANCE & BENEFITS:

- An improved basis on which to prioritise efforts to improve and manage the conservation reserve system and to manage wildlife in the region between Kalbarri and Lake MacLeod (an area of about 7.5 million hectares). (Note: this is an area with a significant bias in the existing reserve system (see eg IBRA summary)).

DESCRIPTION:

Plants and animals have been sampled from representative quadrats across the southern Carnarvon Basin, to determine patterns of distribution of these organisms at the level of species assemblages. Environmental parameters (eg soil chemistry) have been sampled at the same sites, to provide an explicit basis on which to interpolate these patterns of occurrence. These data are being used to (1) investigate the distribution patterns of various groups of organisms (eg vascular plants, reptiles, ground dwelling spiders), (2) when combined, to assess the adequacy of the current conservation reserve system and (3) make recommendations about future management of the biodiversity values of the southern Carnarvon Basin.

METHODS:

Sampling from permanently marked quadrats (trapping grids, vegetation transects) located to cover geographical and major geomorphological variation throughout the study area: see grant application and e.g. McKenzie *et al.* (1991) Kimberley Rainforests (Surrey Beatty). Terrestrial and aquatic communities have been sampled. Organisms sampled include vascular plants, vertebrate and selected invertebrate animals.

Data have been analysed using pattern analysis (eg classification, ordination); GLIM used as required.

SCHEDULE OF TASKS:

Refer to relevant Science Plan.

MILESTONES:

Plan survey	1993
Select and establish quadrats	April – May 1994
Sample in two seasons	Main sampling June 1994 – May 1995, supplementary sampling in November 1995 and March 1996
Identify all collections/observations	July 1994 – July 1997
Enter data, run analyses	July 1997 – August 1998
Write reports	January 1998 – January 1999
Edit and referee reports, send to EA	February 1999
Publish	February 1999 –June 1999
Companion booklet for managers	September 1999
Communicate to managers	Seminar series March 1999, meetings with Mid West staff April 1999

OUTPUTS:

- A report (including over 20 chapters) to be published as a *Supplement to the Records of the WA Museum.*
- A seminar series involving CALM**Science** and WA Museum staff, will be presented in March 1999
- The format of other outcomes is still to be decided, but will include visits to the Mid West region to discuss outcomes with CALM managers, pastoralists, etc. A 'plain English' booklet has also been considered, to communicate the overall findings and suggestions on ways in which management can better cater for the retention of native plants and animals in the study area.

OUTCOMES:

The results will enable the targeting of acquisition of lands for conservation purposes, or selection of areas in which to focus with respect to voluntary conservation agreements, etc. Particularly relevant to the current purchase program of pastoral properties in the Murchison – Gascoyne region.

ADOPTION STRATEGY:

- Liaison with officers in Nature Conservation Division who are involved in land acquisition, Land for Wildlife, MOUs, etc.
- Liaison with CALM staff in Mid-west Region.

CALM**Science** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Marine Fauna Conservation and Management

PROJECT LEADER:

Dr Bob Prince, Woodvale

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0018	Seabird breeding island database
93/0040	Conservation of Marine Turtles – Western Australian Region
93/0041	Dugong Conservation – northern Western Australia

STAFF:

Staff	Location	FTE
K. Morris **B. Prince**	Woodvale Woodvale	0.05 1.0
Total		**1.05**

This project relies heavily on the use of volunteers and CALM District staff for implementation.

OBJECTIVES:

- Understand and promote regional conservation of marine turtles and dugong (and other marine megafauna as required) and their habitats in Western Australia.
- Improve environmental management practices of industries and other focal activities affecting the tropical coastal waters and associated coastal habitats occupied by marine turtle and dugong.
- Ensure sustainability and promote acceptance of customary indigenous harvesting practices.

- Enhance appreciation of the wildlife by the general public so that the above objectives may be more easily accomplished.

SIGNIFICANCE & BENEFITS:

- Provides information supporting acquisition and management of CALM's significant marine conservation estate (eg, Shark Bay World Heritage Area and Marine Park).
- Provides a focus for the development of better knowledge of globally significant marine wildlife populations in the western Australian region.
- Provides a focus for the development and improvement of better environmental management planning and practice for industry and related activities affecting sub-tropical and tropical coastal and offshore areas of Western Australia.
- The marine turtle work in particular is also contributing to an appreciation of the need for regional scale integration in planning for and implementation of effective conservation programs.

DESCRIPTION:

This project focuses on an understanding and management of the marine turtle and dugong populations in WA waters. The marine wildlife conservation work included within the Western Australian Marine Turtle Project and the related dugong project has a common ecological and management focus, with the primary linkage being between dugong and the green turtle via the coastal seagrass communities on which the dugong is primarily dependent and which also provide significant food resources for some part of the green turtle populations. Seagrass community and productivity work currently on hold is an essential part of this whole.

Much of the dugong work has focused on discovery of significant populations at sea, the building of external links to promote more intensive field study of Western Australian dugong populations (eg, program developed and implemented by Paul Anderson), and collaborative links with James Cook University personnel and others to further investigate problems of stock identity, ecology, and other aspects of dugong biology. More recently, regional scale-population abundance and distribution surveys have been implemented on a similar cooperative basis for the dugong populations within the Shark Bay WHA, and the Ningaloo Marine Park-Exmouth Gulf areas (conducted mid-year 1989 and 1994 to date, next survey in program due mid1999 will include the Pilbara coast, previously unsurveyed). The special problem of developing sustainable management arrangements for continuing indigenous dugong harvest and the adoption of necessary practical measures to achieve this has been of primary importance in work in the West Kimberley region, WA.

Hunting and use of the green turtle is of even greater importance than the dugong to Australian tropical coastal Aboriginal people. Both animals are considered culturally by the hunters as parts of a single resource, so an integrated management approach is needed for both. Management of sustainable green turtle exploitation involves more complex problems of regional scale and community cooperation however, due to differences in biology between these species. Other species of marine turtles may also be used in part or whole (ie, the turtle and/or its eggs). Western Australian green turtle populations were also subject to substantial legal commercial exploitation until the early 1970s without any great knowledge of these populations being obtained, or known.

The Western Australian coast is the sole sea coast of the SE Indian Ocean basin, and thus contains the breeding beaches supporting the major marine turtle populations of the region. Because of the basic connectedness of breeding to feeding habitats of the adult marine turtles, but also the commonly wide separation of these areas, marine turtles provide a fauna that can integrate environmental management and conservation issues at a regional scale. Being easily visible, and approachable, and compelled to use both terrestrial and marine habitats during their life, these animals also readily provide an appreciation of the link between necessary integrity of each habitat for conservation. The particular management problems peculiar to each circumstance are also identifiable and able to be investigated and dealt with as required. Substantial opportunities for recreational contact and appreciation of marine turtles do exist within CALM managed conservation estate, but this resource is not yet fully utilized. Necessary management and presentation standards and approaches are presently poorly developed.

METHODOLOGY:

The dugong and marine turtle work in progress constitutes a core management focus, starting from a setting where comprehensive basic resource data were largely unknown (dugong populations, marine turtle species presence, abundance, and distribution), where some existing interactions of importance to conservation could be identified (commercial turtle and indigenous customary turtle and dugong fishery, incidental fishery/wildlife interactions etc), where developing further management interactions could be anticipated (development and expansion of the offshore oil and gas industry at sea and involving island turtle breeding locations, mainland development of ports, industries, and towns, and an increasing demand for recreational opportunities and passive wildlife appreciation), and where a marine conservation focus was not yet developed.

Methods adopted include problem identification, analysis, and resolution as practicable with appropriate stakeholders, resource discovery and definition of appropriate wildlife management units, and implementation of long term longitudinal wildlife population studies to provide necessary understanding of the biology, ecology, habitat use, and dynamics of representative species management units in response to spatial and temporal change at the necessary time scale.

Mark/recapture techniques and population genetics analyses are standard tools in this endeavour. Dedicated surveys complemented by acquisition of networked observational data assist in necessary resource documentation. Museum material appropriate to the fauna Is collected. External funds, other resources, colleagues/collaborators, and volunteer labour required to implement and support the required Field studies are sought and obtained as practicable. Project management integration and services are provided. Liaison and interaction with stakeholders and other program participants Is maintained.

MILESTONES:

- This project lacks recurrent funding support and is particularly dependent on volunteer labour, community and stakeholder support and acquisition of external and extra-CALMScience funds and cooperation to maintain the minimum required field population studies programs and to enhance the necessary achievable science. Accordingly, the first essential task each year is to secure the funds and resources required to implement

the annual marine turtle sampling program for the long term population studies (March through November)

- Marine turtle site resources and funds are identified and secured, necessary commitment of extra CALM staff and key volunteer colleagues obtained, and volunteer labour recruited as appropriate for each field site (August through November).

- Necessary arrangements made for transport accommodation and essential back-up support for teams on-site in the field during each annual nesting turtle population work program of the WAMTP (August through November).

- The nesting turtle seasonal sampling programs implemented (mainly September through March - core contact period for most major study sites late November through early February, but hawksbills earlier start, asynchronous, annual).

- Participation of key trained staff required at major sites, also a requirement to maintain contact with work teams and key volunteers at other sites as practicable. Implement additional quality control checks for study sites where able, and promote appropriate responses according to results. Provide for problem resolution and additional encouragement to work teams where needed. (primarily December - January; annual).

- Collect and collate sampling data from each study site. Attend to data entry, verification, and audit of consolidated data for addition to WAMTP database (February -April; annual).

- Prepare summaries of new seasonal data by site, and integrate with previous data. Prepare brief summary reports for distribution to CALM District staff, program participants and supporters as required. Expand to provide essential seasonal reports to funding agencies where required (April - June; annual).

- Respond to providers of tagged turtle reports as required (ad hoc, as received; any time throughout year).

- Interact with stakeholders in definition of, and in seeking appropriate resolution of management interaction problems (dictated by seasonal timing of interaction events and mutually acceptable programming of activities of parties involved, any time throughout year).

- Dugong project work has similar elements, but in different combination with different time frame long term, and requiring only a small task force with particular expertise for execution of regional population surveys (continuing focus). Undertake aerial survey mid 1999 (Shark Bay, Exmouth, Pilbara coasts)

- Interact with scientific colleagues/collaborators in doing particular investigations, and analyses, and in preparation and publication of appropriate reports and papers (continuing focus).

- Development of an integrated approach to wildlife conservation and environmental management with the necessary investigative science, monitoring and feedback analytical structure to enhance necessary knowledge, develop better management practices, and increase understanding of processes involved and responses that may occur. Finalise the draft marine turtle management plan by May 1999.

- Maintenance of the continuing core project work without any further interruption in the near future. This includes identifying future direction of work and responsibilities for leadership of the project within CALM. Meet with Director Nature Conservation March 1999.

- Upgrade and maintain marine turtle database so that appropriate reports can be generated – by April 1999.

- Finalise CALM input into national draft recovery plan for marine turtles by December 1998.

- Finalise draft of Dugong management plan by August 1999.

OUTPUTS:

- Annual reports to Environment Australia 1986-1994.
- Contribution to National Recovery Plan for Marine Turtles
- Progress reports to CALM Districts and other relevant staff.
- Management plan for Marine Turtles in WA waters
- Management plan for Dugong in WA waters.
- Comprehensive bibliographies in draft management plans

OUTCOMES:

- Development of Departmental marine turtle and dugong management programs.
- Greater involvement of trained District staff in turtle and dugong management programs.
- Support for acquisition of marine conservation estate, focus on better environmental planning and management through environmental assessment process of EPAIDEP, and in collaboration with stakeholders in the oil and gas, fishing and tourism industries; in management of CALM marine conservation estate, and in conservation of the wildlife at large elsewhere.
- Continuing evolution of management practice and applications.

ADOPTION STRATEGY:

- Finalising draft management plans
- District staff training.
- Updating turtle database.
- Greater interaction with District staff and Aboriginal communities.

CALM**Science** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Aquatic Ecosystems Conservation

PROJECT LEADER:

Jim Lane, Busselton

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0058	Lake Clifton nutrient inputs
93/0059	RAMSAR Wetlands Monitoring Guidelines
93/0060	Monitoring wetlands in WA conservation reserves
93/0062	Busselton wetland disturbances & Black Swan breeding
93/0013	Affect of Dawesville Cut on adjacent estuary vegetation
93/0162	Aquatic invertebrate surveys and atlas
93/0093	Conservation Biology of Vulnerable Frogs
98/0008	Taxonomy and zoogeography of aquatic oligochaetes of Western Australia
99/0012	Silver Gull monitoring
99/0013	Breeding ecology and conservation of the Banded Stilt
99/0014	Directory of important wetlands – third edition
99/0015	Tropical inter-tidal benthic invertebrate communities
99/0016	Affect of Dawesville Cut on adjacent estuary waterbirds
99/0017	Assessment of biota and physico-chemistry of Byenup-Muir wetlands
TBA	Assessment of vegetation and current use of Vasse-Wonnerup estuary by waterbirds

STAFF:

Staff	Location	FTE
A. Clark	Woodvale	1.0
N. Gibson	Woodvale	0.2
S. Halse	Woodvale	0.15
J. Lane	Busselton	0.5
G. Pearson	Woodvale	0.5
A. Wayne	Woodvale	0.05
A. Webb	Woodvale	0.1
Total		**2.5**

OBJECTIVES:

- Provide the scientific information needed for conservation of Western Australian wetland ecosystems and maintenance of waterbird populations.
- Provide the scientific information needed for effective implementation of the *Wetlands Conservation Policy for Western Australia* (Government of Western Australia 1997).

SIGNIFICANCE & BENEFITS:

- Western Australia has an enormous diversity of wetlands from tidal mangroves and mudflats, through coastal lakes, swamps and marshes, to inland salt lakes, springs and claypans. These support a rich natural heritage of plant and animal life.
- Most of Western Australia's internationally and nationally (and many regionally) significant wetlands are within existing or proposed reserves managed by CALM. CALM is also largely responsible for implementation of international wetland and migratory bird agreements in Western Australia.
- The recently released *Wetlands Conservation Policy for Western Australia* commits the Government to *"identifying, maintaining and managing the State's wetland resource, including the full range of wetlands values, for the long term benefit of the people of Western Australia".* CALM has been designated lead agency to coordinate implementation of the Policy.
- The Aquatic Ecosystems project will contribute to fulfilment of the Government's policy commitment to conserve Western Australia's wetland resources.

DESCRIPTION:

This project involves a number of wetland research activities spanning a broad range of wetland types and conservation issues in WA, from the tropics to the temperate south west. The project is currently focussed on the conservation of wetland ecosystems in the south west and Roebuck Bay areas. In particular the impact of disturbances, such as increased salinity and changed water levels on the wetland quality, are being assessed. To date most work has concentrated on the conservation of waterbird populations and this will continue. Research on other wetland fauna such as threatened frog populations will commence shortly.

METHODOLOGY:

- Annual water level assessments of lakes in the south west.
- Water quality analysis of selected wetlands.
- Waterbird population monitoring.
- Fringing vegetation quality assessment.
- Survey of benthic invertebrate fauna.
- Identification of important feeding and nesting sites for waterbirds.
- Survey and monitoring of threatened frog population.

MILESTONES:

- Review of management of the Vasse-Wonnerup wetland system in relation to mass fish deaths (1997).
- Assessment of nature conservation values & water chemistry of Byenup-Muir swamp system (1998).
- Preparation of 3rd edition of *Directory of important Wetlands in Australia* (1998).
- Identification & nomination of Wetlands of International Importance (Ramsar Convention) (1998). Guidelines for monitoring of ecological character of Ramsar Sites (1998).
- Breeding ecology and conservation of the Banded Stilt in Western Australia (1999).
- Monitoring of waterbird use of Peel-Harvey estuary following opening of Dawesville Channel (1999).
- Survey of distribution and abundance of benthic fauna of Roebuck Bay (1998-1999).
- Assessment of use by waterbirds of Vasse-Wonnerup system following changes in management (1999)
- Design of program for monitoring trends in health of plant communities of Vasse-Wonnerup (1998).
- Monitoring of wetlands in Nature Reserves and National Parks of Western Australia *(ongoing).*
- Document distribution. endemicity & conservation status of aquatic invertebrates in WA *(ongoing).*
- Conservation biology of threatened frogs.

Other tasks will be proposed following approval of a Program of Action for implementation of the *Wetlands Conservation Policy for Western Australia.*

OUTPUTS:

- Contribution to the preparation of the *Wetlands Conservation Policy for Western Australia.*
- Annual reports on the impact of the Dawesville Cut on the waterbirds and vegetation of the Peel Har Inlet.
- Report on the mass fish deaths in the Vasse – Wonnerup wetland.
- Report on nomination of Ramsar wetlands.
- Seminars, lectures, field excursions, interest group briefings and media releases are also proposed appropriate to the task, eg Frogwatch
- Selected publications:

Chapman, A. and Lane, J.A.K (1997). Waterfowl usage of wetlands in the south east arid interior of Western Australia, 1992-3. *Emu 97*: 51-59.

Davies, P.M. and Lane, J.A.K. (1996). The impact of vegetated buffer zones upon water and nutrient fl into Lake Clifton. *Journal of the Royal Society of Western Australia.* **79**: 155-160.

Government of Western Australia (1997). *Wetlands Conservation Policy for Western Australia.* 23pp

Halse, S.A. (1991). Report on the conservation value of the area west of the Preston River mouth, Leschenault Inlet. In *Bunbury Port Authority: Wetland Reclamation: assessment of the conservati value of reclamation Areas A1 and A2.* Kinhill Engineers, Victoria Park. Pp1-14.

Halse, S.A, Williams, M.R., Jaensch, R.P.,and Lane, J.A.K. (1993). Wetland characteristics and waterb use of wetlands in south-west Australia. *Wildlife Research* **20** pp 103-126.

Halse, S.A., and Storey, A.W. (1996). Aquatic invertebrate surveys and water quality of Perth Airport swamps. Report to the Federal Airports Corporation and Australian Nature Conservation Agency Department of CALM, WA.

Halse, S.A., Pearson, G.B., Vervest, R.M., and Yung, F.H. (1995). Annual waterfowl counts in south-w Western Australia. 1991/92. *CALMScience* **2**: 1-24.

Halse, S.A., Shiel, R.J., and Pearson, G.B. (1996). Waterbird and aquatic invertebrates of swamps on Victoria – Bonaparte mudflat, northern Western Australia. *Journal of the Royal Society of Weste Australia.* **79**: 217-224.

Lane, J. (1986). Migratory waders. *Landscope*, 1 (4):17-21. Department of CALM.

Lane, J.A.K. (1986). The birdlife of the Blackwood River Estuary: environmental study of the Blackwoc River Estuary: In *A Report to the Estuarine and Marine Advisory Committee of the Environmenta Protection Authority*. EPA, Western Australia Technical Report 7 pp 1-49.

Lane, J.A.K., and McComb, A.J. (1988). Western Australian wetlands. In *The Conservation of Australi Wetlands.* Eds A.J. McComb and P.S. Lake. Surrey Beatty, Sydney pp127-146.

Lane, J. (1990). Swamped with birds. *Landscope*, 5 (3):17-22 Department of CALM.

Lane, J, Jaensch, R.P., and Lynch, R. (1996). Western Australia. In *A Directory of Important Wetlands Australia,* 2nd edition. Australian Nature Conservation Agency, Canberra. Pp 759-943.

Lane, J.A.K., Hardcastle, K.A., Tregonning, R.J. and Holtfreter, G.J (1997). Management of the Vasse Wonnerup wetland system in relation to sudden, mass fish deaths. Technical Report on behalf o Vasse Estuary Technical Working Group.

Storey, A.W., Vervest, R.M., Pearson, G.B., and Halse, S. A. (1993). Wetlands of the Swan Coastal P Volume 7. waterbird usage of wetands on the Swan Coastal Plain. Water Authority of Western Australia., Leederville pp1-168.

Storey, A.W., Lane, J.A.K., and Davies, P.m. (final draft). Monitoring the ecological character of Austral Wetlands of International Importance (Ramsar Convention). Report to Environment Australia, Canberra 109pp.

OUTCOMES:

Outputs are intended to guide and influence policy and management prescriptions for management of individual wetlands, their fauna, and their catchments. Examples include Roebuck Bay, Peel-Harvey estuary, Byenup-Muir system, Vasse-Wonnerup and proposed additional Ramsar Sites, and WA wetlan generally. Involvement with community groups is also an outcome of this project.

ADOPTION STRATEGY:

Outcomes will be achieved by wide dissemination and promotion of results and implications of research findings and by active involvement in management and policy decision-making processes where practicable.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation

PROJECT TITLE:

Salinity Action Plan

PROJECT LEADER:

Greg Keighery, Woodvale

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

98/0020 Biological Survey of the Agricultural Zone
98/0018 Wetland Monitoring

STAFF:

Staff	Location	FTE
A.H. Burbidge	Woodvale	0.2
N. Gibson	Woodvale	0.4
N. Guthrie	Woodvale	1.0
S. Halse	Woodvale	0.5
J. Harvey	Woodvale	0.15
A. Hopkins	Woodvale	0.3
G. Keighery	Woodvale	0.5
E. Ladhams	Woodvale	1.0
J. Lane	Busselton	0.5
B. Lowdon	Woodvale	1.0
M. Lyons	Woodvale	1.0
N. McKenzie	Woodvale	0.3
J. McRae	Woodvale	1.0
W. Muir	Woodvale	1.0
A. Pinder	Woodvale	1.0
J. Rolfe	Woodvale	0.95
T. Rose	Woodvale	1.0
P. Van Heurck	Woodvale	1.0
A. Webb	Woodvale	0.9
Total		**13.7**

OBJECTIVES:

- Provide a regional perspective on nature conservation priorities to help determine and prioritise management actions in the wheatbelt, particularly in relation to combating increasing salinity.
- Identify and prioritise recovery catchments with respect to nature conservation values.
- Provide baseline data for future monitoring.
- Assist in provision of plant lists useful for economic and conservation re-vegetation programs.

SIGNIFICANCE & BENEFITS:

- A major 'whole of Government' initiative to conserve the remaining biodiversity of the wheatbelt (Salinity Action Plan).
- Provides an objective overview of the bio-diversity and biogeography of the Agricultural Zone.
- Provides long term monitoring sites in a highly disturbed ecosystem.
- Provides a series of recovery catchments to help maintain bio-diversity.

DESCRIPTION:

A four year project to survey the biota of the largely cleared Agricultural Zone, especially those at risk from rising water tables and increasing salinity. Catchments will be selected for recovery actions and within these plants and animals will be inventoried at several hundred terrestrial and aquatic sites. Monitoring of these sites at a later date will provide information on changes to the biota. The other major part of the SAP is to undertake extensive plantings of native and introduced trees and shrubs to reverse the trend of rising water tables and increasing salinity

METHODOLOGY:

Standard biological survey design utilising pit and Elliott trap lines, plant quadrats and aquatic sites stratified according to standard climatic, soil and landscape parameters. Methodology and costings already subject to detailed approval by Director of Nature Conservation and Corporate Executive.

MILESTONES:

- 1997/98: Central Band of Agricultural Zone surveyed. One catchment chosen.
- 1998/99: Northern Band surveyed, Two catchments chosen.
- 1999/2000: Southern Band surveyed, Two catchments chosen.
- 2000/2001: Completion of gap survey, write up, choose final catchments.

OUTPUTS:

- February 1998 report to Environment Australia on the "Flora of the Lake Muir – Unicup Catchment."
- 4-6 reports per year to the Salinity Action Council, NHT.
- Seminars as requested.
- Major publication on the biota of wheatbelt at completion.

OUTCOMES:

- Adoption and management of selected recovery catchments.
- Amelioration of a major threatening process to the biodiversity of the wheatbelt region of WA.

ADOPTION STRATEGY:

Findings from this work will be combined with other relevant SAP work and used to develop a strategy that modifies land management practices in the wheatbelt region, so that the problems associated with rising water tables and increasing salinity are reversed.

CALM**Science** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Monitoring Rabbit Calicivirus Disease

PROJECT LEADER:

Dr Tony Start, Kununurra

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

97/0010 Rabbit Calicivirus

STAFF:

Staff	Location	FTE
P. Fuller **S. Gilfillan*** **A. Start** *=externally funded	Woodvale Albany Kununurra	0.2 1.0 0.25
Total		**1.45**

This is a collaborative project with Agriculture WA and some of their staff are also involved.

OBJECTIVES:

- Monitor and document the impact of the introduced Rabbit Calicivirus Disease on rabbit populations and the consequent effects on indigenous biota.

SIGNIFICANCE & BENEFITS:

- CALM will acquire sound data on rabbit impacts on various communities and be able to assess the options and cost/benefits of actively managing rabbits. The effect of rabbits on

biological diversity, conservation values and landscape stability are areas that CALM has not addressed.
- This is part of a National program. Other components of the National program address epidemiology of RCD and protocols for pro-active use of the disease as a control method, including delivery on baits and optimal conditions for virus re-introduction.

DESCRIPTION:

- Study sites are located in an arid area, the Nullarbor, and a mesic area, South Stirling. The latter is a co-operative venture with AgWA.
- The Nullarbor has 2 sub-sites, Forrest and Plumridge Lakes (both in Nature Reserves and both used on the 1980s Nullarbor biological survey). South Stirling has 3 sub-sites, SRNP, remnant vegetation on farmland and farmland. CALM runs the SRNP and part of the remnant veg sites.
- Change in rabbit abundance and various biotic attributes are recorded at each site and rabbits are sampled for data on exposure to RCV, demography, etc.

METHODOLOGY:

Rabbit exposure to RCV by serum testing for antigens; rabbit demography determined by eye lens weight; rabbit abundance by spotlight counts, dung counts and warren counts; vegetation response (a) by species abundance and cover in quadrats used for dung counts and (b) by exclosures on western myall seedlings (c) by demographic profiles of long-lived plants that have palatable seedlings; feral predators and macropods by spotlight counts; small vertebrates by pit and Elliott trapping

MILESTONES:

- Nullarbor sampled at 4 monthly intervals commencing April 1997, South Stirlings, bi-monthly to September 1998.
- Prepare 4-monthly report for RCV Science Sub-committee (these are combined with reports from other Australian sites in to a National Progress report).
- Prepare "final" National report on initoila 2 year study by June 1999, (S Gilfillan responsible for WA site reports, AN Start responsible for bio-diversity component of the National Report).
- Prepare scientific publications – December 1999.

Note. (a) most projects started late and funds are available to continue till end of 1998 in WA.
(b)two years is inadequate for some attributes to find a new equilibrium and application has been made to ANZECC and ARMCANZ fro a 2-year extension. ANZECC has approved funds for our work subject to Commonwealth contributing. The Commonwealth Minister has not decided.

OUTPUTS:

- Reports - see above
- Start, A.N., and Gilfillan, S. (1998). Run, Rabbit. *Landscope* 13 (4): 49-53. CALM Perth.

- Address to Vertebrate Pest Workshop in Albany due March 1998 (SG)
- Public talk - in Perth due June 1998 (ANS)
- Talk-back radio - One in Perth March 1998 (ANS), others in Albany (SG)
- Publish results – draft Manuscripts by March 1999 (SG)

OUTCOMES:

Will depend on results. E.g. effectiveness of RCV as a control agent, amenability of the virus to pro-active application, benefits of reduced rabbit numbers. Preliminary assessment suggests it will be of limited value to biodiversity conservation in the mesic south west, but of considerable value in arid areas where it has persisted and is now apparently endemic.

ADOPTION STRATEGY:

To be determined when costs and benefits are better understood.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Disturbance Management Ecology

PROJECT LEADER:

Dr Tony Start, Kununurra

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0160	Using prescribed fire to rehabilitate landscapes disturbed by mining exploration in the arid zone.
93/0090	Effect of fire on plant communities at Tutanning NR.
93/0141	Fire-mulga study
93/0085	Post-fire response of mallee heath shrubland at Stirling Range NP
93/0086	Fire-induced mosaics in semi-arid shrubland and woodland communities
93/0026	Rainforest management and monitoring
93/0092	Fire effects on desert vertebrates
93/0075	Effects of spring and autumn prescribed burning on small vertebrates in Jarrah forest (Batalling)
93/0076	Prescribed burning & conservation of Jarrah forest invertebrate communities (Batalling)
RPP 53/91	Effects of fire on plant species and communities at Stirling Range National Park
TBA	Fire effects on *Callitris* and other fire sensitive plants in the Kimberley
TBA	Factors affecting sustainable use of riparian zones in tropical savannas

STAFF:

Staff	Location	FTE
B. Bromilow	Karratha	0.2
N. Burrows	Crawley	0.01
P. Fuller	Woodvale	0.6
T. Handasyde	Kununurra	1.0
J. Harvey	Woodvale	0.4
A. Hopkins	Woodvale	0.25
B. Johnson	Woodvale	0.1
L. McCaw	Manjimup	0.05
D. Pearson	Woodvale	0.2
T. Start	Kununurra	0.4
S. van Leeuwen	Karratha	0.2
C. Ward	Manjimup	0.1
A. Wayne	Manjimup	0.05
Total		**3.56**

PROJECT OBJECTIVES:

- Understand disturbance processes and their effects on bio-conservation, particularly on CALM-managed estate.
- Develop options for the management of disturbance.
- Provide information to land-managers and decision-makers so that they can plan and manage biological communities and land by the best possible practices commensurate with CALM objectives.

SIGNIFICANCE & BENEFITS:

Many environmental processes have profound effects on land and biological communities. Some are natural, others are products of human activity but both can be manipulated or managed. CALM's ability to manage land and biological communities in accordance with published objectives depends on its ability to manipulate or manage disturbing processes appropriately. This project addresses issues in areas where the State will benefit from an enlarged array of practical management options and improved quality of management decisions and practices.

DESCRIPTION:

The project focuses on the impact of fire on ecosystems. However, through activities associated with CALM's membership of the Co-operative Research Centre for Sustainable Development of Tropical Savannas, a range of disturbance factors affecting riparian communities in the Kimberley are also being addressed. The array of fire-related SPPs involve studies in most CALM Regions (Kimberley, Pilbara, Goldfields, South Coast, Wheatbelt, Central Forest, Southern Forest) and biomes (tropical savanna, spinifex deserts, arid woodlands, mesic shrublands and south west forests). The SPPs include: site-specific

case studies as well as generic studies. Issues include application of fire as a management tool as well as the interaction of various fire regimes with vegetation, floristics, vertebrates and invertebrates.

METHODOLOGY:

A variety of methods are used. They all employ normal scientific processes of investigation. That is, documenting observations, developing hypotheses or models to explain the observations and using experiments to test the hypotheses or models. In addition to this process, most SPPs are documenting the status quo so that future generations can observe change from a knowledge base-line that is not often available to today's scientists.

Two significant issues need to be highlighted.
These studies are less amenable to external funding (and thus there are fewer consultants than in many other projects) because the cycle of fire and regeneration may be slow, particularly in arid lands. Moreover, many long-term fire effects are the product of fire regimes; that is, the cumulative effect of many fires. Thus, fire studies tend to be very long term whereas funding agencies usually want quick results. The project must rely heavily on CALM funds and the willingness of CALM and the Division to proceed with long-term projects. However, many beneficial products spin-off along the way.

Results of many studies, particularly those involving compromise between competing objectives (eg provision for fauna requiring long-unburned habitat and protection of commercial assets) are difficult to quantify in the way that other CALM**Science** SPPs can be (e.g. New species described: New populations of threatened species established) because outcomes are often in the form of knowledge that empowers managers choose operational strategies which are appropriate to particular circumstances; . A reasonable measure of success is improvement in the range of options available to managers and the reliability with which they can obtain planned outcomes. The corollary is equally valid: Planners and managers need to know the down-side of each option.

SCHEDULE OF TASKS:

The quantity and variety of SPPs preclude construction of a meaningful task schedule for the entire Project. Most studies have a satisfactory schedule for data acquisition although ideals and expectations are often compromised by outcomes of application for resources resources. However the Project needs to rigorously address a write-up back-log.

MILESTONES:

93/0085 – *Post-fire response of mallee heath shrubland at Stirling Range National Park (L. McCaw)*

- Assess fuel loads – March annually
- Assess species composition – October annually
- Assess seed production on selected species - biannually
- Report on annual assessments and update database.

93/0092 – Fire effects on desert vertebrates (D. Pearson)

- Post fire sampling trips in March and December 1998

- Data analysis: April – August 1998
- Write-up of response of vertebrates to different fires – complete by February 1999
- Write up results of invertebrate work – November 1999

93/0090 – Effects of fire on plant communities at Tutanning NR (A. Hopkins)
- 3 Manuscripts to be submitted by December 1998

RPP 53/91 – Effects of fire on plant species and communities at Stirling Range NP (A. Hopkins)
- Draft report available for review by December 1998

93/0141 – Fire – Mulga study (S. van Leeuwen / A.N. Start)
- Successful completion of experimental burns by the end of 1997
- Commence sorting and identification of ant specimens during 1998
- Continue identification and processing of flora and fauna specimens
- Complete two sampling sessions by the end of 1999.
- Prepare for publication in 1999 a paper on fauna and flora of mulga woodlands in the south east Pilbara

TBA - Tropical savannas riparian study (A.N. Start)
- June 1998: finalise project plan and obtain funding from the TS-CRC
- Sept 1998 :participate in 3-year review of the CRC; thereafter in accordance with project design
- prepare SP for CALMScience December 1998.
- Employ Technical Officer (TS-CRC funds) December 1998-12-18
- Start to acquire data sets December 1998
- Field work 1999-2000.

TBA - Tropical savannas fire study (A.N. Start)
- March 1998: Attend workshop in Darwin
- Collaborate with Regional Ecologist and develop the study March 1999
- With Regional Ecologist, negotiate funds with NT colleagues and apportion those available between ourselves by March 1999l
- Commence field work March 1999.

93/0075 - Effects of spring and autumn prescribed burning on small vertebrates in Jarrah forest (A. Wayne)
- Continue with biannual sampling (April, October)
- Review with Manager April 1998

OUTPUTS:

- Several seminars on response of mallee heath to fire to CALM District and Regional staff and public interest groups. Data contributed to CALM Corporate database on species response strategies.

- Several publications on the responses of various taxa to fire in the desert are in preparation. Past publications using data from this study include six papers:

- Three manuscripts on the impact of fire at Tutanning NR. Seminar proposed.

- Draft report on fire in the Stirling ranges NP.

- Knowledge gathered on the fire – Mulga study contributed to 'Proposed Additions to the Central Hamersley Range Conservation Estate' report. Knowledge has also contributed to the Environmental Management Plans being developed by several Pilbara resource develop proponents.

- Final report prepared on the impact of fire on Jarrah forest invertebrates.

- Research proposals developed for the Tropical Savanna – riparian study.

- A natural resource atlas of the Ord River's riparian communities. This will be added to and updated over the next two years.

- Improved knowledge of the fire-sensitive communities of the Kimberley Region

OUTCOMES:

- Results from the impact of fire on the vegetation structure and floristics of the Jarrah forest have and will continue to influence applied fire regimes in these forests and provide scientific basis for selecting appropriate fire regimes. This research also provides long-term monitoring of the effects of repeated burning, and establishes scientific principles for managing fire in the jarrah forest ecosystem.

- Development of guidelines for the minimum fire frequency in mallee-heath communities, with particular reference to use of fire as a management tool for *B. coccinea* populations and other species affected by fungal cankers.

- CALM has responsibility for the management of 4.5 million hectares of desert national parks and nature reserves. There is potential for collaborative management of a much larger area with Aboriginal councils and other land-holders. Fire is an important management issue and this research will provide direction on how fire can be used to best achieve the conservation of bio-diversity.

- Impact of fire on the management of wheatbelt nature reserves incorporated into Wheatbelt Regional Management Plan

- On-going liaison with South Coast managers on role of fire in management of Stirling Range NP.

- Input into Wildfire Threat Analysis planning and input into fire management plan and burning program for Karijini National Park and adjacent pastoral leases.

- Contributions to recommendations for proposed additions to Karijini National Park.

- Contributions to development of a Natural Resources Management Area (NRMA) proposal for mulga woodland conservation.

- Contributions to the development of interim management guidelines for the mulga woodlands NRMA.

- Contributions to impact assessments of proposed resource developments within the Hamersley Range mulga woodlands.

- Contributions to station plans for neighbouring Hamersley Iron owned pastoral leases.

- Input into Hamersley Iron exploration program and code of environmental conduct during exploration.

- Improved knowledge and management options for vulnerable components of the Kimberley's natural resources.

ADOPTION STRATEGY:

- Development of policy and management options for the use of fire to control cankers in *B. coccinea* and other species affected by stem cankers and use of fire in management of mallee-heaths, eg Stirling Range NP.

- Outcomes of the fire–desert work can be adopted by operations staff in the Goldfields Region (already a progressive process); and used for the production of management plans for desert nature reserves and background data for workshops/discussions between CALM and other land-holders.

- Outcomes from the Tutanning fire study will be adopted through input into Wheatbelt Regional Management Plan. Knowledge will be made available to Wheatbelt regional staff (and other people) through on-going liaison. Besides empowering the staff responsible for routine management tasks the knowledge will be useful to staff responsible for implementing nature conservation initiatives in the Region under the Salinity Action Plan and Bushcare Program.

- Outcomes of the Mulga fire study will be adopted through communication with CALM planning teams and managers as well as through liaison with external agencies and development proponents e.g. Department of Environmental Protection (and the EPA), Department of Resource Development and Department of Minerals and Energy, Hamersley Iron Pty Ltd and BHP Pty Ltd Areas with high biological richness and nature conservation value throughout the Hamersley Range mulga woodlands will be identified and the impacts exploration and pastoral operations on mulga woodlands will be provided wherever necessary. Contribution to the development of the Pilbara Fire Planning Team's burning proposals, assistance of regional staff with the development and maintenance of Wildfire Threat Analysis maps, Fire Control Working Plans and burning (hand and aerial) programs within the Hamersley Range conservation estate.

- Adoption strategies for the tropical savanna riparian study and fire study are yet to be developed. Two key elements will be communication with stake-holders and development of an Atlas of resources of the Ord River's riparian communities. It will include use-related issues.

- The adoption strategy for the jarrah forest fire – invertebrate work will be developed as part of the review in 1999.

CALM**SCIENCE** DIVISION

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Remnant Vegetation Reconstruction

PROJECT LEADER:

Dr Neil Gibson, Woodvale

SCIENCE PROJECTS PLANS / CORE FUNCTION:

93/0022	Conservation status of butterflies.
93/0038	Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain.
93/0077	Bridal creeper control and ecology in WA.
93/0078	Ecology of understorey communities and soil seed banks of remnant salmon gum woodland.
97/0002	Weeds of WA: advice, liaison, publicity and documentation.

STAFF:

Staff	Location	FTE
N. Gibson	Woodvale	0.05
G. Keighery	Woodvale	0.2
A. Williams	Woodvale	0.1
M. Williams	Como	0.1
Total		**0.45**

OBJECTIVES:

- Provide detailed scientific information for the management of the conservation values of remnant bushland and regional parks.

SIGNIFICANCE & BENEFITS:

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

DESCRIPTION:

The project aims to determine the conservation status of plant species and communities across the Swan Coastal Plain and determine the conservation status of butterfly taxa across the south west. The project also involves studies on the major weed species impacting on remnant vegetation and a study on the regeneration of degraded salmon gum community in the wheatbelt.

METHODOLOGY:

Conservation status of plant species and plant communities of the coastal plain are being assessed by compilation of plot based survey and surveys of reserves in the conservation estate. The conservation status of butterflies is being assessed by databasing CALM collections and linking it with other major collections. There are ongoing efforts to document the distribution and ecology of environmental weeds, assemble information on most efficient control measures and ongoing liaison to pass on this information.

MILESTONES:

93/0038 – Floristic survey of the remnant heaths and woodlands of the Swan Coastal Plain.

- Complete reports on conservation status of the vascular plants of the Swan Coastal Plain - Bunbury to Busselton March 1998, Pinjarra to Bunbury June 1998, Perth to Pinjarra July 1998, Moore River to Perth July 1998.
- Co-organise workshop on Tuart forests, biology, ecology, conservation and management. (March 1998).
- Continue input into Bushplan - interdepartmental review of the conservation reserves of the metropolitan section of the Swan Coastal Plain, finalise by December 1998.

93/0022 – Conservation status of butterflies.

Database CALM's collections of butterflies and link it with other major collections:

- Database CALM's collection at Como (l/1/1999 - 31/12/1999)
- Database CALM's collection at Woodvale (1/1/2000 - 31/12/2000)
- Database CALM's collection at Manjimup (l/1/2001 - 30/6/2001)

- Establish a link between CALM's database and the database at Agriculture WA (l/1/1999 - 30/6/1999)

- Establish a link between CALM's database and the database at the WA Museum (l/1/2001 - 30/6/2001)

- Undertake a review of the distribution, conservation status and ecology of Western Australian butterflies. documenting particularly the known threats and areas where more data are needed. (l/1/1998-31/12/1999):

- Publish a review of the distribution, conservation status and ecology of Western Australian butterflies, documenting particularly the known threats and areas where more data are needed (l/1/1998-31/12/1999)

- Conduct surveys of those species presently thought to be, or identified in the review as being, poorly known, of uncertain taxonomic status, or of conservation concern:

- Conduct survey work within Stirling Range & Watheroo NPs to obtain distributional data and DNA collections of *Candalides hyacinthinus* ?ssp, *Hypochrysops ignitus* ?ssp and *Ogyris otane*s ?ssp. (within 1/1/1999 30/6/2001, depending on availability of funds)

- Conduct survey work within Stirling Range NP to obtain further data on the life history of *Ogyris otanes*. (within 1/1/1999 – 30/6/2001, depending on availability of funds)

- Conduct survey work throughout the south west to obtain distributional data and DNA collections of *Trapezites* spp. (within 1/1/1999 - 30/6/2001, depending on availability of funds)

- Conduct survey work throughout the south west to obtain distributional data and DNA collections of *Theclinesthes* spp. (within 1/1/1999 - 30/6/2001, depending on availability of funds)

- Increase public awareness of the need to conserve invertebrates and inform them of CALM's commitment to invertebrate conservation and research. (Continuous for the life of the project):

- Talk to Darling Range Branch Wildflower Society, Aug. 1998 (August 1998)

- Publish Landscope article on jewel butterflies (scheduled for March 1998)

- Publish the "Backyard Bugs" bush book (before 1/1/1999)

- Publish scientific papers on the taxonomy of *Candalides hyacinthinus, Hypochrysops ignitus, Ogyris otanes, Trapezites* spp. And *Theclinesthes* spp. (within 1/1/1999 - 30/6/2001, depending on availability of funds)

97/0002 – Weeds of WA: advice, liaison, publicity and documentation

- Up to date internet access for scientists and community groups to information about environmental weeds in Australia and overseas May 1998

- Internet access for scientists and community groups to information about environmental weeds in WA June 1998
- Liaison with Environmental Weeds Action Network (EWAN) 'Weed for 1998' and 'Weedbusters Week' (September 1998)
- Attend meetings of ANZACC Working Group on Weeds of Environmental Concern. (On going)
- Completion of Environmental Weed Strategy of WA. (late 1998)
- Liaison with CALM districts and regions (On going)
- Co-authored "Western Weeds". (Dec 1997)
- Contributed to Australian Quarantine and Inspection Service report on new weeds records 1971-1995. (March 1998)

93/0077 – Bridal creeper control and ecology in WA

- Liaison about current distribution with CSIRO and UWA
- Liaison about control trials with Perth District April 1998
- Liaison with Environmental Weeds Action Network (EWAN) 'Weed for 1998' and 'Weedbusters Week' September 1998

93/0078 – Ecology of understorey communities and soil seed banks of remnant salmon gum woodland.

- Publish Landscope article (October 1998)
- Publish vegetation paper (November 1998)
- Present UWA seminar (May 1998)
- Complete discussion for soil seed-bank paper (June 1998)
- Presentation to Taarblin Catchment Group (December 1998)
- Seek approval and make changes to soil seed-bank paper (September 1998), publish March 1999
- Inspect and photograph plots (June & October 1998)
- Prepare draft paper on temporal changes in vegetation paper (September 1998)

OUTPUTS:

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- Williams, A.A.E., Williams, M.R. & Atkins, A.F. (1997) Notes on some western Australian butterflies. *Victorian Entomologist 27:44-49.*

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- Williams, A.A.E. & Atkins, A. F. (1997) Notes on the life history of the Western Australian skipper *Mesodina hayi* Edwards and Graham (Lepidoptera: Hesperiidae). *Australian Entomologist.*

- Barrett, M.D. & Williams, M.R. (1998, in press) Distribution of the Western Petalura dragonfly *Petalura hesperia* Watson in Western Australia. *Pacific Conservation Biology.*

- Williams, M., Williams. A. & Lundstrom, T. (1998, in press) Jewels of the west. *Landscope 13(4):.*

- Williams, A.A.E., Williams, M.R. & Hay, R.W. (1998, in press) A new species *of Trapezites* hübner (Lepidoptera: Hesperiidae) from Western Australian. *Australian Entomologist.*

- York-Main, B., Hunter. J. & Williams, M.R. (in prep) Spineless Wonders: Backyard Bugs. CALM Bush Book.

Verbal presentations

Seminars and Field days

- 12/1992: Cicadas. Western Australian Insect Study Society, Western Australia; synopsis in: Newsletter of the WA Insect Study Society, January 1993 pp.2-4.
- 2/1994: The role of the amateur in butterfly conservation. Western Australian Insect Study Society, Western Australia; synopsis in: Newsletter of the WA Insect Study Society, April 1994 pp.3-4.
- 6/1994: Butterflies. Kensington primary school, Western Australia.
- 8/1994: The wood white butterfly. Western Australian Insect Study Society, Western Australia; synopsis in: Newsletter of the WA Insect Study Society, October 1994 pp.2-3.
- 10/1994: Bring back the butterflies. Friends of Yellagonga Regional Park, Western Australia.
- 10/ 1 994: Bring back the butterflies. Workshop conducted by the entomological society of Australia, Western Australian branch, York, Western Australia.

- 12/1994: Recent discoveries on butterfly/ant associations. Western Australian Insect Study Society. Western Australia; synopsis in: Newsletter of the WA Insect Study Society, February 1995 pp.5-7.
- 4/1995: Panel discussion on butterfly gardening. Western Australian Insect Study Society, Western Australia; synopsis in: Newsletter of the WA Insect Study Society, August 1995 pp.5-6.
- 5/1995: Butterfly gardening. WA Naturalists Club, Armadale branch, Western Australia.
- 10/1995: Butterflies of the south west. Toodyay Naturalists Club, Western Australia.
- 7/1996: Butterflies of the south west. WA Naturalists Club, Wanneroo, Western Australia.
- 8/1997: The primitive scorpion fly *Austromerope poultoni.* Western Australian Insect Study Society, Western Australia; synopsis in: Newsletter of the WA Insect Study Society, October 1997 p.3.
- 10/1997: Butterfly watching around Perth. Extension course, University of Western Australia; synopsis in: Extension, Late Spring (6 Oct- 1 6 Nov 1997), p5.
- 2/1998: Attracting butterflies to your garden. Cottage Garden Circle, South Perth WA.
- Remnant salmon gum (Eucalyptus salmonophloia) woodlands in the central southern wheatbelt of WA and Research management update on bridal creeper (Asparagoides asparagoides) in the Busselton District. October 15 1997, Busselton Naturalists Club, RSL Hall Busselton.
- Remnant vegetation at Yilliminning Rock. Granite Outcrops Symposium, WA Royal Society, September 14-15, 1996. University of Western Australia, Crawley.
- Management options for remnant salmon gum (Eucalyptus salmonophloia) woodland. Bio-Conservation and Sustainable Resource Groups Seminar Series (Science and Information Division), Dept of CALM Como, August 22, 1996.
- Managing remnant York (*Eucalyptus loxophleba*) and Salmon Gum (*E. salmonophloia*) woodlands in the wheatbelt. Ukati and Catchment Groups, August 17 1995. Goomalling. Featured in Stocker, L. (1996) Video - Nature Conservation and Landcare: Perspectives from Rural Community Groups Institute for Science and Technology Policy, Murdoch University WA.

Interviews

- 5/1994: Bring Back the Butterflies. RTR FM, Western Australia.
- 1/ 1 995: The butterfly *Ogyris idmo.* The West Australian Newspaper, Western Australia.
- 3/1995: The butterfly *Danaus chryssipus.* The West Australian Newspaper, Western Australia.
- 3/1995: The butterfly *Danaus chryssipus.* ABC Regional Radio, Broome, Western Australia.
- 3/1996: Butterfly gardening. ABC Radio, Perth, Western Australia.
- 9/1997: Flora for Fauna: plantings to attract butterflies into the garden. 6PR Radio, Perth, Western Australia.

OUTCOMES:

- Surveys of remnant bushland on the coastal plain has led to recognisation of threatened ecological communities. As a result land management practices and land use planning practices have been changed to protect these communities and lands have been acquired from the conservation estate

- The review of the distribution, conservation status and ecology of Western Australian butterflies may have implications for CALM's burning policy.

- Environmental Weed Strategy of WA will have major implications for CALM policy & management prescriptions in relation to weeds on the conservation estate.

- AQIS review found increase in weed invasion over last two decades which will result in increase funding at the Commonwealth level.

- Provide access and networking of environmental weeds information to community groups and assist EWAN project officer in providing community groups with extension advice on controlling environmental weeds

- Improved communication of CALMScience environmental weeds research to CALM Districts

- Assist Perth District with control prescription for Bridal Creeper

- Assist EWAN with extension advice on Bridal Creeper.

- Landholders and CALM staff use results to improve management and rehabilitation of degraded Salmon Gum woodlands by altering current practices.

ADOPTION STRATEGY:

- Management of significant bushland remnants enhanced through recognition in BUSHPLAN. management plans, recovery plans and planning strategies.

- More detail knowledge of areas critical for butterfly conservation will allow areas to be conserved and managed by way of management and recovery plans.

- A detailed weed strategy will outline best control strategies across the conservation and public estates. Implementation will be by management plans.

- Perth District to more effectively control bridal creeper in Yanchep NP and Woodmans Point CP and community groups (through EWAN project officer) to more effectively control bridal creeper in remnants.

- Provide results through direct communication and publications with landholders and CALM staff. Then able to ascertain future needs.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

Monitoring River Health

PROJECT LEADER:

Dr Stuart Halse, Woodvale

SCIENCE PROJECTS / CORE FUNCTIONS:

95/0006	Monitoring river health initiative – Western Australia
98/0004	First national assessment of river health – North-west Australia
98/0022	First national assessment of river health – Wheatbelt Region

STAFF:

Staff	Location	FTE
D. Cale*	Woodvale	0.4
S. Halse	Woodvale	0.25
W. Kay*	Woodvale	1.0
M. Scanlon*	Woodvale	1.0
M. Smith*	Woodvale	1.0
*=externally funded		
Total		**3.65**

Plus Water and Rivers Commission contribution (0.30 FTE)

OBJECTIVES:

- Produce baseline data about community composition of rivers/streams in WA.
- Develop a model to assess river health based on macroinvertebrates present in the river.
- Test the model in a preliminary assessment of river condition throughout WA and refine it so the model can be used routinely by management staff.

SIGNIFICANCE & BENEFITS:

- Improved knowledge of WA's river invertebrate fauna, its distribution and conservation status (there have been no systematic surveys previously and much of the State has never been sampled).
- Provision of a relatively cheap and reliable tool for routine assessment of river health.

DESCRIPTION:

The project has been described in *Landscope* (Autumn 1997). In summary, a model (called AUSRIVAS) is being developed to predict the macroinvertebrate families present in undisturbed rivers on the basis of a group of conservative environmental variables (latitude, river size etc). Using these variables, the 'natural' fauna of rivers suspected to be disturbed can be predicted and compared with the actual fauna. The extent of departure from prediction is a measure of disturbance.

The project is national under the auspices of the National River Health Program. Each State and Territory is developing AUSRIVAS models and project support is provided nationally.

Water and Rivers Commission are a partner in the project and will take over the running of it once it becomes a routine management operation. At present, they have an officer 30% assigned to the project to facilitate liaison and they chair the inter-departmental project steering committee.

METHODOLOGY:

These are described in detail in Smith *et al.* (1999, *Freshwater Biology* in press) as well as the *Landscope* article. The methodology is that used in the British RIVPACS program, which has been extensively published. The major additional feature is that methods of applying confidence intervals to assessments are currently being developed.

MILESTONES:

These are detailed in the project contracts with LWRRDC and EA. In summary, they are:
f). . . . .@ @ Sample baseline sites
f). . . . .@ @ Develop models
f). . . . .@ @ Test and refine models in by assessing river health in wheatbelt
f). . . . .@ @ Test and refine models in by assessing river health in north-west
f). . . . .@ @ Test and refine models in by assessing river health in forest areas

Milestones listed in the LWRRDC and EA contract schedules reflect completion of the scheduled tasks above, as well as relating to funding schedules, communication activities, quality control and other issues.

OUTPUTS:

Smith, M., Kay. W., Pinder. A. and Halse, S. 1997. Spineless indicators. *Landscope* **12** (3), 49-53.

Kay, W.R., Smith, M.J., Pinder, A., McRae, J.M., Davis, J.A. and Halse, S.A. 1999. Patterns of distribution of macroinvertebrate families of north-western Australia. *Freshwater Biology* (in press).

Knott, B. and Halse, S.A. 1999. *Pilbarophreatoicus platyarthricus* n. gen.,n. sp. (Isopoda, Phreatoicoidea, Amphisopidae) from the Pilbara region of northern Western Australia. Records of the Australian Museum (in press).

Smith, M.J., Kay, W.R., Edward, D.H.E., Richardson, K., Papas, P., Pinder, A.M, Cale, D., Horwitz, P.H.J., Davis, J.A., Simpson, J.C, Yung, Y.H., Norris, R.H. and Halse, S.A. 1999. AUSRIVAS: Using macroinvertebrates to assess ecological condition of rivers in Western Australia. *Freshwater Biology* (in press).

Additional papers are expected to be produced on the river assessments and model refinements, as well as annual reports to LWRRDC and EA.

Large workshops were held in 1995 and 1996 with overseas/eastern states speakers as part of technology transfer, another is planned for early 1999. Seminars have been given annually at National River Health Program workshops. Seminars have been given to other audiences in 1994, 1995 (ASL), 1996 (INTECOL), 1998 (Fitzroy River Workshop) and posters were presented in 1997(International Conference – What is River Health?). It is intended to present information on the project at least annually at technical meetings.

Two field days were held for small groups in 1997 (Leschenault Catchment Group, Ribbons of Blue/Waterwatch Coordinators), a two-day training workshop was held for WRC staff at Bunbury and other field days/workshops are planned.

OUTCOMES:

- Information for SOE reporting. AUSRIVAS will be flagged in the 1998 State SOE report and river assessments will be used in the national 2000 SOE report.
- Waters and Rivers Commission (WRC) will use AUSRIVAS as one of the major assessment tools in their State of the Rivers program.
- AUSRIVAS can be used to assess condition of any sites suspected to be impacted (eg it will be used in 1998 in the Collie Basin rehabilitation project)
- Systematic surveys of WA rivers will allow broad geographic patterns to be elucidated and highlight areas of particular biogeographic interest (see Kay *et al* 1998), as well as providing much material for taxonomists. Several new species have already been identified from the surveys (eg Knott and Halse 1999).

ADOPTION STRATEGY:

There is a national strategy to facilitate adoption of AUSRIVAS through mechanisms such as the incorporation of AUSRIVAS into National Water Quality Guidelines.

Within WA, adoption is being overseen by the project steering committee and WRC. The 30% FTE from WRC is chiefly responsible for facilitating this process. WRC has nominated 3 'demonstration' catchments where AUSRIVAS outputs can be applied to current water

management problems and these have been sampled. WRC has a commitment to long-term use of AUSRIVAS and provided $5,500 in 1997/98 for project staff to run a short course on sampling and identification.

The first broadscale management use of the river assessments will be the SOE reporting process and this has already been arranged.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Biodiversity Conservation Group

PROJECT TITLE:

CAR Reserve System

PROJECT LEADER:

Norm McKenzie. Woodvale

SCIENCE PROJECT PLANS / CORE FUNCTIONS:

93/0031	Botanical survey of the central Pilbara within the Karijini National Park
93/0030	Biological survey of the Barlee Range Nature Reserve
93/0037	Floristic survey of the coastal communities of the Warren Botanical Subdistrict
93/0166	Floristic survey of the Goldfields woodlands
93/0034	A biological survey of Cape Arid National Park
93/0026	Rainforest management and monitoring
93/0025	Eastern Goldfields survey
91/0057	Survey software and analysis
93/0028	Ecomorphological clues to community structure: Bat and lizard guild studies, bat echolocation studies
93/0027	Buccaneer Archipelago survey
93/0029	Mandora Palaeoriver / Radi Hills survey
94/0003	Conservation of Western Australia's vegetation assemblages
93/0165	Ecological studies Lesueur National Park
93/0091	Development of a Departmental monitoring program
93/0032	Preliminary survey of the biological and cultural resources of the Western Desert Ranges
93/0033	Biological survey of Yanchep National Park
99/0001	Biological survey of the Burrup Peninsula
99/0002	Botanical survey of the Pilbara tussock grasslands
99/0003	Biological survey of the Little Sandy Desert
99/0004	Karijini taskforce
WD/0045	Floristic survey of the Darling Scarp
WD/0028	Tropical Savanna CRC

STAFF:

Staff	Location	FTE
B. Bromilow	Karratha	0.8
A.H. Burbidge	Woodvale	0.5
S. Claymore	Woodvale	1.0
N. Gibson	Woodvale	0.05
A. Hopkins	Woodvale	0.45
G. Keighery	Woodvale	0.1
M. Langley	Woodvale	1.0
N. McKenzie	Woodvale	0.1
D. Pearson	Woodvale	0.05
T. Start	Woodvale	0.1
S. van Leeuwen	Karratha	0.8
Total		**4.95**

OBJECTIVES:

- Inventory the composition of assemblages of WA's indigenous plant and animal species across the bioregions of WA, focussing particularly on potential and existing nature conservation reserves.
- Identify gaps in the existing reserve network and specific areas of land that most efficiently lead to a CAR reserve system in WA.
- Provide a quantitative basis for the long term ecological monitoring of WA's biodiversity.
- Develop and incorporate contemporary methods and strategies of sampling and data analysis in surveys.

SIGNIFICANCE & BENEFITS:

- Development of a comprehensive, adequate and representative reserve system for WA.
- Quantitative data collected on the conservation status and trend, distribution, ecological roles and environmental scalars of the species comprising the WA biota to guide conservation decisions Statewide.
- Contemporary methods of ecological survey used; methodologies published in refereed journals.

DESCRIPTION:

- A systematic zoological and botanical survey of the bioregions of WA, and of other areas of particular biogeograhical interest.
- Development of databases and other relevant techniques to assist in decision making processes relating to reserve acquisition.
- Provision of advice on reserve selection.

METHODOLOGY:

- GIS desk-top study of the comprehensiveness of the existing reserve system in terms of vegetation formations, with identification of gaps.

- quadrat-based, stratified-random field surveys, that sample species composition and physical attributes. Thus, data from several surveys in the same region can be incorporated in a regional survey, being amenable to quantitative analyses of assemblage composition in relation to environmental gradients to identify significant scalars. Conventional taxonomic approaches to identification are used.

- review, develop and test aspects of the sampling and analysis when scope to do this during survey projects is limited by time-cost constraints. They include hands on workshops, detailed theoretical studies of resource allocation mechanisms within guilds, and methods of remotely sensing the presence of cryptic species, and pit-trap design development.

- field survey of desert environments and of the knowledge of indigenous people, both biological and cultural. It has a land-use decision - species conservation emphasis.

MILESTONES:

99/0001 - Burrup Peninsula Survey
- Field sampling completed: Oct 98
- Specimen identified and data-based: Nov 98
- Incorporation of specimens into appropriate repositories: Dec 98
- Submission of progress reports to Heritage Council: quarterly, commencing Feb 98
- Preparation of Draft Final report: Dec 1998
- Final report to Heritage Council: Mar 99

99/0002 - Botanical Survey of Tussock Grasslands
- Incorporate 1996 -1997 collected specimens into herbarium: Dec 98
- Submit progress reports to Heritage Council: quarterly, commencing Feb 98
- Complete 1998 field sampling program: Nov 98
- Develop GIS, particularly geological, fire history and land system themes: Dec 98

99/0003 - Little Sandy Desert Survey
- Specimens identified and data-based: Oct 98
- Incorporate specimens into appropriate repositories: Dec 98
- Field sampling completed: Oct 98
- Submit progress report to EA: Aug 98
- Prepare Draft Final report: Dec 1998
- Final report to EA: June 99

99/0004 - Karijini Taskforce
- Final report: Sept 1999

93/0031 - Central Pilbara Uplands Survey
- Incorporate 1995 -1997 collected specimens into herbarium: Oct 98
- Submit progress reports to EA: Jul 98 & Dec 98
- Complete field sampling program: Nov 98
- Develop GIS, particularly geological, fire history and isoflor themes: Dec 98

93/0030 - Barlee Range Survey

- Completion of data analyses: Mar 98
- Incorporation of Flora specimens into herbarium: Sep 98
- Submission of Draft Final report to Heritage Council: Apr 98
- Submission of Final Report to Heritage Council: June 98
- Publish survey report in CALMScience: Dec 98

93/0166 - Eastern Goldfields Ranges Survey

- Three papers accepted for publication
- Four reports accepted by Aust. Heritage Commission

WD/0045 - Darling Scarp Survey

- Report submitted and accepted by Aust. Heritage Commission

RPP31/90 - Yanchep NP Survey

- Publish report: Dec1999.

93/0034 - Cape Arid NP Survey

- Publish report: Dec 2000

WD/0028, 93/0026 - Limestone range CRC survey, Kimberley surveys

- Specimens of plant and land snail identified and data list compiled: July 1997.
- Landsnail sampling data assessed for repeatability in species presence-absence and relative abundance.: May 1998
- Compile and analyse data: Dec 1998
- Survey quadrats in the Oscar Ranges: May 1999
- Identify specimens and compile data: Aug 1999
- Write report: Dec 99.

93/0025 - Eastern Goldfields Survey

- Data-bases of vertebrates from 3 Goldfields cells compiled by June 1998
- Data-bases of plants from 6 Goldfields cells compiled by June 1998

91/0057 - Survey methodology, analysis and software

- GLIM workshop successful and useful as part of Carnarvon Basin analyses.
- New compositional analysis software improves Carnarvon Basin PATN analysis interpretation.
- Shallow coned pit traps and cloth fences used in Salinity Action Plan survey, and provide consistent results for much less effort and staff input than in previous surveys.
- Publish paper on patterns in the composition of a rainforest ant communities in relation to disturbance in conjunction with J. Majer (Curtin) in late 1997.

93/0028 - Ecomorph & community structure

- Recordings from the 13 Carnarvon Basin survey areas identified by Jan 1998, the first biogeographical analysis of compositional patterns in a WA regional bat fauna undertaken, and a report prepared for publication by Feb 1998.
- Ultrasound recordings from the 3 Little Sandy Desert survey areas identified by July 1997.
- Bat flight performance mechanisms identified from experiments and analysis, and a tight relationship to observed patterns in resource partitioning by Coolgardie microbats was shown in Feb 1998

93/0027 - Buccaneer Archipelago
- None in 1998

93/0029 - Mandora-Radi Hills
- None in 1998

94/003 - Conservation of WA vegetations
- Publish map and memoir of WA vegetation: Dec 1998
- Provide report to Environment Australia on IBRA pilot study: Dec 1998
- Provide report to Environment Australia on potentially threatened vegetation units in the Agricultural Region: July 1999
- Provide report to Environment Australia on conservation status of WA ecosystems in 2 yrs time.

93/0165 - Botanical survey of Lesueur
- Publish paper on Mount Michaud: June 1999
- Publish paper on lateritic uplands: June 1999
- Publish paper on flora and veg of all land units: Dec 1999

93/0091 - Monitoring
- Revise manuscript and submit for publication: Dec 1998

93/0032 - Desert Range Survey
- No funding was available during 1997-8, but data collected on Mallee Fowl, Dusky Grass-Wrens, Marsupial Moles, Woma Pythons and Giant Desert Skinks during fieldwork on SPP 95/0016.
- Collaborated with Ngaanyatjarra Council and CALM Goldfields Region on Indigenous Protected Area proposal in Central Aboriginal Reserve.

OUTPUTS:

NRS/08 - Karijini Taskforce
Final report: Sept 1999

NRS/05 Little Sandy Desert Survey (in past 12 months)
Three progress reports to EA
Two radio interviews on regional ABC radio
One article in WA Newspaper and I in regional newspaper
Landscope expedition: Sep 98
Recommendations for additions to Priority Flora List

NRS/06 Burrup Peninsula Survey
Recommendations for changes and deletions from the Priority Flora List
Recommendations relating to protection of areas of high floristic and impact mitigation
Two articles in Regional Newspaper
Four progress reports to Heritage Council
One radio interview on regional ABC

93/0031 Central Pilbara Uplands Survey
One article in Regional Newspaper
One radio interview on regional ABC

Recommendations for changes to the Priority Flora List
Contributed to 'Proposed Additions to the Central Hamersley Range Conservation Estate' report.

93/0030 Barlee Range Survey
Recommendations for changes to the Priority Flora List
Seminar to Nickol Bay Naturalist Club

NRS/07 Botanical Survey of Tussock Grasslands
Recommendations for changes to the Priority Flora List
Contributed to 'Proposed Additions to the Central Hamersley Range Conservation Estate' report.

93/0166 Eastern Goldfields Ranges Survey
Gibson, N., Lyons, M.N. and Lepschi, B.J. (1997). Flora and vegetation of the eastern goldfield ranges. Part 1, Helena and Aurora Range. CALMScience 2. Pp. 231-246.
Gibson, N. and Lyons, M.N. (1998) Flora and vegetation of the Goldfield Ranges. 2, Bremer Range. Journal of the Royal Society of Western Australia (in press).
Gibson, N. and Lyons, M.N. (1998) Flora and vegetation of the Goldfield Ranges. 3, Parker Range. Journal of the Royal Society of Western Australia (in press).
Gibson, N. and Lyons, M.N. (1997). Floristic survey of Middle and Southern Ironcap, Digger Rocks and Hatter Hill of the eastern goldfields of Western Australia. Department of Conservation and Land Management, Western Australia, pp. 1-23.
Gibson, N. and Lyons, M.N. (1997). Floristic survey of the Highclere Hills of the eastern goldfields of Western Australia. Department of Conservation and Land Management, Western Australia, pp. 1-25.
Gibson, N. and Lyons, M.N. (1997). Floristic survey of the Hunt Range, Yendilberin and Watt Hills of the eastern goldfields of Western Australia. Department of Conservation and Land Management, Western Australia, pp. 1-27.
Gibson, N. and Lyons, M.N. (1997). Floristic survey of the Mt. Manning Range of the eastern goldfields of Western Australia. Department of Conservation and Land Management, Western Australia, pp. 1-24.

WD/0045 Darling Scarp Survey
Markey, A. (1997) A floristic survey of the northern Darling Scarp. A report to CALM, EPA and WACC for AHC.

93/0033 Yanchep NP Survey
Science Div. Seminar in ca. 1993

93/0034 Cape Arid NP Survey
nil

WD/0028, 93/0026 Limestone range CRC survey, Kimberley surveys
Past Publications
McKenzie, N.L. Chapman, A. & Youngson, W.K. (1975). "Mammals of the Prince Regent River Reserve, North-west Kimberley, W.A." pp 69-74. In: Miles, J.M. & Burbidge, A.A. (Eds). *A Biological Survey of the Prince Regent River Reserve, North-west Kimberley, Western Australia.* Wildl. Res. Bull. West. Aust. No. 3, 1-116. (Dept Fish. Wildl.: Perth).
McKenzie, N.L., Chapman. A., Youngson, W.K. & Burbidge, A.A. (1977). "The Mammals of the Drysdale River National Park". Pp 69-74. In: Kabay, E.D. & Burbidge, A.A. (Eds), *A*

Biological Survey of the Drysdale River National Park, North Kimberley , Western Australia. Wildl. Res. Bull. West. Aust. No. 6, 1-133. (Dept Fish. Wildl.: Perth).
Burbidge.A.A. and McKenzie, N.L.(Eds)(1978). *The Islands of the North-West Kimberley, Western Australia.* Wildl. Res. Bull. West. Aust. No. 7, 1-47. (Dept Fish. Wildl.: Perth).
Burbidge, A.A. & McKenzie, N.L.: "Introduction". Pp 5-11.
Burbidge, A.A., Marchant, N.G., McKenzie, N.L. & Wilson, P.G.: "Environment". Pp 12-21.
McKenzie, N.L., Burbidge, A.A., Chapman, A. & Youngson, W.K.: "Mammals". Pp 22-28.
Burbidge, A.A. & McKenzie, N.L.: "Conclusions and Recommendations". P. 46.
McKenzie, N.L. & Rolfe, J.K. (1979). A further Mangrove Kingfisher record from Western Australia. *West. Aust. Nat.* **14**, 159.
Kitchener, D.J., Keller, L.E., Chapman, A., McKenzie, N.L., Start, A.N. & Kenneally, K.F. (1981). "Observations on Mammals of the Mitchell Plateau area, Kimberley, Western Australia" pp 123-168. In: *Biological Survey of Mitchell Plateau and Admiralty Gulf, Kimberley, Western Australia.* 274pp. (W.A. Museum: Perth).
McKenzie, N.L. (1981). Mammals of the South-west Kimberley, Western Australia: biogeography and recent changes. *J. Biogeog.* **8**, 263-280.
McKenzie,N.L. (1981). A new dunnart from Australia's tropical sandy deserts. *S.W.A.N.S.* **11**(4), 9-12.
McKenzie, N.L. (Ed.) (1981). *Wildlife of the Edgar Ranges Area, South-west Kimberley, Western Australia.* Wildl. Res. Bull. West. Aust. No. 10, 1-71. (Dept. Fish. Wildl.: Perth).
McKenzie, N.L. & Kenneally, K.F.: "Background". Pp 7-31.
Youngson, W.K., Henry, J. & McKenzie, N.L.: "Mammals". Pp 39-45.
McKenzie, N.L.: "Conclusions and Recommendations". Pp 68-71.
McKenzie, N.L. (Ed.) (1983). *Wildlife of the Dampier Peninsula, South-west Kimberley, Western Australia.* Wild. Res. Bull. West. Aust. No 11, 1-83 (Dept Fish. Wildl.: Perth).
McKenzie, N.L. & Kenneally, K.F.: "Background and Environment". Pp 5-23.
McKenzie, N.L.: "Mammals". Pp 40-52.
McKenzie, N.L.: "Conclusions and Recommendations". Pp 78-83.
Burbidge, A.A., McKenzie, N.L. & Kenneally, K.F. (1987). *Nature conservation reserves in the Kimberley, Western Australia.* 164pp (Western Australian Dept Conservation and Land Management, Perth).
McKenzie, N.L., Kenneally, K.F. & Winfield, C. (1987). Western Australia's rainforests. *Landscope* **3**(2), 16-22.
Kenneally, K.F. & McKenzie, N.L. (1989). Piecing together the remnants. *Landscope* **4**(3), 50-52.
Burbidge, A.A., McKenzie, N.L. & Kenneally, K.F. (1991). *Nature conservation reserves in the Kimberley, Western Australia.* (Western Australian Dept Conservation and Land Management, Perth).
Kenneally, K.F. & McKenzie, N.L. (1991). Competing for paradise. *Landscope* **6**(4), 35-38.
Friend, G.R., Morris, K.D. & McKenzie, N.L. (1991). The mammal fauna of Kimberley rainforests. In: *Kimberley Rainforests.* (Eds: N.L. McKenzie, R.B. Johnston & P.G. Kendrick). (Surrey Beatty & Sons, New South Wales).
McKenzie, N.L. (1991). An ecological survey of tropical rainforests in Western Australia: Background and methods. In: *Kimberley Rainforests.* (Eds: N.L. McKenzie, R.B. Johnston & P.G. Kendrick). (Surrey Beatty & Sons, New South Wales).
Solem, A. & McKenzie, N.L. (1991). Biogeographical patterns of land snail assemblages in Kimberley rainforests . In: *Kimberley Rainforests.* (Eds: N.L. McKenzie, R.B. Johnston & P.G. Kendrick). (Surrey Beatty & Sons, New South Wales).
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McKenzie, N.L. & Belbin, L. (1991). Kimberley rainforest communities: Reserve recommendations and management considerations. In: *Kimberley Rainforests Australia.* (Eds: N.L. McKenzie, R.B Johnston & P.G. Kendrick) (Surrey Beatty & Sons, New South Wales).
McKenzie, N.L., Johnston, R.B. & Kendrick, P.G. (eds)(1991). *Kimberley Rainforests Australia.* 490 pp. Surrey Beatty & Sons, New South Wales.
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Russell-Smith, J., McKenzie, N.L. and Woinarski, J.C.Z. (1992). Conserving vulnerable habitat in north-western Australia: the rainforest archipelago. In: Moffatt, Ian & Webb, Ann (Eds) *"Conservation and development issues in north Australia."* Australian National University, North Australia Research Unit workshop, Darwin, September 1991.
McKenzie, N.L., Kenneally, K.F., Done, C & Griffin, T. (1992). King Leopold's Treasures. *Landscope* **7**(3), 43-47.
Kenneally, K.F. & McKenzie, N.L. (1994). Rainforests and bats. *Landscope* **9**, 34-40.
Future Publications
Write report: Dec 99.

93/0025 Eastern Goldfields Survey
Previous publications
Bavistock, P.R., Adams, M., Archer, M., McKenzie, N.L. & How, R. (1983). An electrophoretic and chromosomal study of the dasyurid marsupial *Ningaui*. *Aust. J. Zool.* **31**, 381-392.
Biological Survey Committee, Western Australia (1984). The biological survey of the Eastern Goldfields of Western Australia - Introduction and Methods. *Rec. West. Aust. Mus. Suppl.* No. 18, 1-19.
McKenzie, N.L. & Hall, N.J. (1992). A biological survey of the eastern Goldfields of Western Australia. Part 8. The Kurnalpi - Kalgoorlie Study Area. *Rec. West. Aust. Mus.* Suppl. No. **41**, 1-125.
Hall, N.J. & McKenzie, N.L. (1993). A biological survey of the eastern Goldfields of Western Australia. Part 9. The Norseman - Balladonia Study Area. *Rec. West. Aust. Mus.* Suppl. No. **42**, 1-138.
McKenzie, N.L. & Hall, N.J. (1994). A biological survey of the eastern Goldfields of Western Australia. Part 10. The Sandstone - Sir Samuel and Laverton - Leonora Study Areas. *Rec. West. Aust. Mus.* Suppl. No. 47, 1-166.
McKenzie, N.L. & Hall, N.J. (1995). A biological survey of the eastern Goldfields of Western Australia. Part 11. The Boorabbin-Southern Cross Study Area. *Rec. West. Aust. Mus.* Suppl. No. 49, 1-167.
Burbidge, A.A., McKenzie, N.L. & Hall, N.J. (1995). A biological survey of the eastern Goldfields of Western Australia. Part 12. The Mount Manning- Mount Elvire Study Area. *Rec. West. Aust. Mus.* Suppl. No. 49, 169-312
Many articles in the Western Australian Newspaper written by Alex Harris
Talk at public launch of Eastern Goldfields reports in 1997
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91/0057 Survey methodology, analysis and software
Youngson, W.K. & McKenzie, N.L. (1977). An Improved Bat-Collecting Technique. Bull. Aust. Mamm. Soc. **3**(2), 20-21.

Hopper, S.D., Burbidge, A.A., Hopkins, A.J.M., Kinnear, J.E., Lane, J.A.K., McKenzie, N.L. & Prince, R.I.T. (1979). "Establishment and management of nature reserves for threatened vertebrates in Western Australia". In: *A vanishing heritage: the problem of endangered species and their habitat*. (Nature Conservation Council: Wellington).
McKenzie,N.L. (1981). A new dunnart from Australia's tropical sandy deserts. *S.W.A.N.S.* **11**(4), 9-12.
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McKenzie, N.L. (1983). The *Ningaui*. *Nature Walkabout* **19**(1), 24-27.
Strahan, R. (Ed.) (1983). *The Australian Museum Complete Book of Australian Mammals: the National Photographic Index of Australian Wildlife*. (Angus & Robertson: Sydney). Species accounts for *Isoodon auratus, Mesembriomys macrurus, Sminthopsis hirtipes, Ningaui ridei, Nyctophilus arnhemensis* and *Sminthopsis longicaudata.*
McKenzie, N.L. (1988). "Biogeography and its use for setting priorities for management." In: *Ecological theory and biological management of ecosystems.* (Eds: Saunders,D.A. & Burbidge A.A.) Occasional Paper 1/88 (Western Australian Dept. Conservation and Land Management: Perth).
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Johnson, K.A., Burbidge, A.A. & McKenzie, N.L. (1989). "Australian macropodoidae: status, causes of decline and future research and management." Pp 641-657. In: *Kangaroos, wallabies and rat-kangaroos* (Eds: Grigg, G.C., Jarman, P.J. & Hume, I.D.). (Australian Mammal Society: Sydney).
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McKenzie, N.L. (1994). Western Australia. In: Toward an interim biogeographic regionalisation for Australia (R. Thackway & I.D. Cresswell, eds) . Australian Nature Conservation Agency, Canberra.
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1997-8 Publications etc

Ashe, C., Bond, T., Bosworth, P. Creswell, I.D., Dick, R., Margules, C., McKenzie, N.L., Olsson, K., Parkes, D., Peters, D., Sattler, P., Robinson, A.C., Shorthouse, D., Thackway, R. and Woinarski, J. (1997). Interim Scientific Guidelines for Establishing the National Reserve System. ANZECC SCC scientific taskforce report, version 5.0, 26 May 1997. Environment Australia, Canberra.

Majer, J.D., Delabie, J.H.C. and McKenzie, N.L. (1997). Ant litter fauna of forest, forest edges and adjacent grassland in the Atlantic rain forest region of Bahia, Brazil. *Insectes Sociaux* **44**, 255-266.

Lecture to Murdoch University graduate students on ecological survey methods in 1997.

Future Publications

Hopkins, A.J.M. & McKenzie, N.L. (in MS). Options for long-term monitoring of arid and semi-arid terrestrial ecosystems in Australia. Paper presented to CSIRO ALTERM workshop, Canberra, in 1994.

McKenzie, N.L., Hall, N. and Muir, W.P. (in MS). The non-volant mammals of the Irwin-Carnarvon study area. In: *Biota of the Carnarvon Basin, Western Australia.*

McKenzie, N.L. Rolfe, J.K., Aplin, K., Cowan, M. & Smith, L.A. (in MS). The herpetofauna of the Irwin-Carnarvon study area. In: *Biota of the Carnarvon Basin, Western Australia.*

Rolfe, J.R. (in MS). Comparison of the methods used to capture herpetofauna. In: *Biota of the Carnarvon Basin, Western Australia.*
GLIM workshop. July 1997
McKenzie & Keighery (in prep). Patterns in the biodiversity of the Carnarvon Basin. In: *Biota of the Carnarvon Basin, Western Australia.*

93/0028 Ecomorph & community structure
McKenzie, N.L. (1983). Bats -- a part of our vanishing heritage. *S.W.A.N.S.* **13**(3), 3-7.
McKenzie, N.L. & Rolfe, J.K. (1986). Structure of bat guilds in the Kimberley mangroves, Australia. *J. Anim. Ecol.* **55**, 401-420.
Start, A.N. & McKenzie, N.L. (1989). Bats, bats and more bats. *Landscope* **3**(4), 49-53.
McKenzie, N.L. & Start, A.N. (1989). "Structure of bat guilds in mangroves: disturbance and determinism." Pp 167-178. In: *Patterns in the structure of mammalian communities.* (Eds: Morris, D.W., Abramski, Z., Fox, B.J. & Willig, M.R.). Special Publication (Texas Tech. University: Lubbock).
Fullard, J., Koehler, K., Surlykke, A. & McKenzie, N.L. (1991). Ecolocation ecology and flight morphology of insectivorous bats (Chiroptera) in south-western Australia. *Aust. J. Zool.* **39**(1), 427-438.
McKenzie, N.L., Gunnell, A., Yani, M. & Williams, M. (1995). Correspondence between flight morphology and foraging ecology in some Palaeotropical bats. *Aust. J. Zool.* **43**(3), 241-257.
McKenzie, N.L. (1995). Arnhemland Long-eared Bat, *Nyctophilus arnhemensis.* In: Strahan, R. (Ed.) The Australian Museum Complete Book of Australian Mammals, 2nd Edition (Angus & Robertson, London).
McKenzie, N.L. (1995). Little Northern Mastiff-bat, *Mormopterus loriae.* In: Strahan, R. (Ed.) The Australian Museum Complete Book of Australian Mammals, 2nd Edition (Angus & Robertson, London).
McKenzie, N.L. (1995). Northern Mastiff-bat, *Mormopterus beccarii.* In: Strahan, R. (Ed.) The Australian Museum Complete Book of Australian Mammals. 2nd Edition (Angus & Robertson, London).
Start, A.N. & Mckenzie, N.L. (1995). Western False Pipistrelle, *Falsistrellus mckenziei.* In: Strahan, R. (Ed.) The Australian Museum Complete Book of Australian Mammals, 2nd Edition (Angus & Robertson, London).
McKenzie, N.L. (1995). Mangrove Pipistrelle, *Pipistrellus westralis.* In: Strahan, R. (Ed.) The Australian Museum Complete Book of Australian Mammals, 2nd Edition (Angus & Robertson, London).
Lecture on bat faunal structural determinants to UWA Zoology in 1996
1997-8 Publications
Hall, L, Richards, G., McKenzie, N.L. & Dunlop. N. (1998). Importance of abandoned mines as fauna habitat. *Symposium on Conservation Outside Nature Reserves, 5-8 February 1996.* University of Queensland, Brisbane.
Future Publications
McKenzie, N.L. & Muir, W.P. (in MS). The bats of the Irwin-Carnarvon Study Area. In: *Biota of the Carnarvon Basin, Western Australia.*
Bullen & McKenzie (in prep). Morphometric predictors of flight performance in bats.
Six species recovery outline manuscripts sent to EA for the Bat Action Plan

93/0027 Buccaneer Archipelago
Previous Publications
McKenzie, N.L., Fontanini, L., Lindus, N.V. & Williams, M.R. (1995). Biological survey of Koolan Island, Western Australia. 2. Zoological notes. *Rec. West. Aust. Mus.* **17**, 249-266.

93/0029 Mandora-Radi Hills

Previous Publications

Wyrwoll, K.H., McKenzie, N.L., Pederson, B.J. & Tapley, I.J. (1986). The Great Sandy Desert of northwestern Australia: the last 7000 years. *Search* **17**, 208-210.

Wyrwoll, K.H., Hopwood, J. & McKenzie, N.L. (1992). The Holocene palaeohydrology and climatic history of the northern Great Sandy Desert - Fitzroy Trough: with special reference to the history of the north-western monsoon. *Climatic Change* **22**, 47-65.

94/003 Conservation of WA vegetations

to come

93/0165: Botanical survey of Lesueur

to come

93/0091: Monitoring

Written for a workshop presentation on ALTERM in 1995.

93/0032: Desert Ranges Survey

to come

OUTCOMES:

99/0001 - Burrup Peninsula Survey

- Input into Burrup Landuse Plan
- Input into level of assessment and impact review for proposed developments
- Change in the status of three Priority Flora species

99/0002 - Botanical Survey of Tussock Grasslands

- Contributed to recommendations for proposed additions to Karijini National Park
- Contributed to development of a Natural Resources Management Area proposal for mulga woodland conservation.
- Contributed to impact assessments of proposed resource developments
- Change in the status of one Priority Flora species
- Input into Wildfire Threat Analysis planning for Karijini National Park
- Input to fire management plan and burning program for Karijini National Park
- Input to station plans for neighbouring Hamersley Iron owned pastoral leases

99/0003 - Little Sandy Desert Survey

- Pastoralists made aware that reserve acquisition recommendations are imminent
- Change in the status of five Priority Flora species
- Change in the status of two species of scheduled fauna

99/0004 - Karijini Taskforce

- Eventually, extensions to Karijini National Park.

93/0031- Central Pilbara Uplands Survey

- Change in the status of four Priority Flora species
- Input into Wildfire Threat Analysis planning for Karijini National Park
- Input into fire management plan and burning program for Karijini National Park
- Contributed to recommendations for proposed additions to Karijini National Park
- Contributed to development of a Natural Resources Management Area proposal for mulga woodland conservation.

- Contributed to impact assessments of proposed resource developments
- Input into station plans for neighbouring Hamersley Iron owned pastoral leases
- Input into Hamersley Iron exploration program

93/0030 - Barlee Range Survey
- Contributed to development of strategies to mitigate the impact of stock and feral animals on freshwater claypan and associated drainage system.
- Contributed to recommendations for addition to the existing reserve
- Change in the status of five Priority Flora species
- Contributed to development of protocols for mineral exploration activities within the reserve
- Input into Wildfire Threat Analysis Plan

93/0166 - Eastern Goldfields Ranges Survey
- Located populations of more than 20 rare and priority plants
- Identified and defined 24 rare flora communities
- Liaised with region on management, mining and reservation issues

WD/0045 - Darling Scarp Survey
- Located populations of more than 24 rare and priority plants
- Identified and defined 4 rare flora communities
- Liaised with region on management and reservation issues

RPP31/90 - Yanchep NP Survey
- Survey areas now being managed as ALTERM monitoring sites.
- Locations of rare flora and fauna, with mgmt strategies, transferred to park staff.

93/0034 - Cape Arid NP Survey
- Survey areas now being managed as ALTERM monitoring sites.
- Locations of rare flora and fauna, with mgmt strategies, transferred to park staff.

WD/0028, 93/0026 - Limestone range CRC survey, Kimberley surveys
- Region advised of importance of the rainforest communities on the ranges as rare communities under threat (fire mgmt) and presence of locally endemic species and genera.
- Region advised of importance of acquiring areas of the ranges as conservation reserves for regional plan.

93/0025 - Eastern Goldfields Survey
- Compiled data-base will allow quantitative assessment of gaps in the region's reserve system, a basis fror improving representativeness and comprehensiveness from the perspective of the biodiversity.

91/0057 - Survey methodology, analysis and software
- Cheaper vertebrate sampling method used in Salinity Action Plan allowed 100 quadrats/year by 4 staff over a period of 5 months.
- An average of 16 referee reports per year.

93/0028 - Ecomorph & community structure
- A wider array of taxa can now be included in biogeographic surveys: microbats, the only indigenous mammal taxa that is still compositionally intact throughout Australia.
- Recommending two WA bats as "vulnerable, and one as near threatened.
- Contributions made to EA's Bat Action Plan.

- Identification of a potentially new species of *Vespadalus* from the eastern Kimberley.

93/0027 - Buccaneer Archipelago
- A variety of islands in the Bucaneer Archipelago have been recommended as conservation reserves in the Kimberley Regional Planning Study and the update of the CTRC System 7 report.
- A basis for assessing the ecological recovery of Koolan Island post-mining is available.

93/0029 - Mandora-Radi Hills
- Areas around the Mandora Salt Marsh were recommended for conservation reserve in the System 7 update compiled by DEP.

94/0003 - Conservation of WA vegetations
- A more comprehensive reserve system.

93/0165 - Botanical survey of Lesueur
- National park has been declared and a management plan prepared.
- Planned mine and power station in park averted.

93/0091- Monitoring
- background review of subject, monitoring policy on hold.

93/0032 - Desert Ranges Survey
- better management of desert conservation reserves.

ADOPTION STRATEGY:

99/0001 - Burrup Peninsula Survey
- Notify and liaise with development proponents, DEP, DRD and Pilbara Development Commission of areas of high biological richness
- Notify Pilbara Region and Wildlife Branch of species conservation status

99/0002 - Botanical Survey of Tussock Grasslands
- Contribute to Pilbara Fire Planning Team's burning proposals
- Notify Pilbara Region and Wildlife Branch of species conservation status
- Assist regional staff with the maintenance of Wildfire Threat Analysis maps.
- Notify development proponents, DEP, DRD and DOME of areas of high biological richness
- Liaise with Hamersley Iron over exploration activities and pastoral operations
- Liaise with regional staff and BFB on botanical values of upland sites
- Make additional recommendations for reserve additions where existing and proposed conservation estate is not representative of botanical values.

99/0003 - Sandy Desert Survey
- Two reserve recommendations impacting on both Pilbara and Goldfields Regions
- Contribute to Pilbara Regional Management Plan
- Negotiations over land claims, pastoral and mining issues.
- Development of a fire management plan for reserve additions.
- Feral animal control plan, especially for camels and donkeys.
- Notify Pilbara Region and Wildlife Branch of species conservation status

99/0004 – Karijini Taskforce

- Land purchase etc, the Pilbara is an IBRA high priority region.

93/0031 - Central Pilbara Uplands Survey

- Notify development proponents, DEP, DRD and DOME of areas of high biological richness
- Liaise with Hamersley Iron over exploration activities and pastoral operations
- Liaise with regional staff and BFB on botanical values of upland sites
- Make additional recommendations for reserve additions where existing and proposed conservation estate is not representative of botanical values.
- Notify Pilbara Region and Wildlife Branch of species conservation status
- Assist regional staff with the maintenance of Wildfire Threat Analysis maps.
- Contribute to Pilbara Fire Planning Team's burning proposals

93/0030 - Barlee Range Survey

- Obtain funds from Environmental Protection Branch to fence of areas of significant value (already achieved)
- Liaise with adjacent pastorals regards stock musters
- Liaise with AWA-APB and pastoralist over control of feral livestock
- Liaise with DOME and mining companies over exploration activities in the reserve
- Assist regional staff with the maintenance of Wildfire Threat Analysis maps.
- Contribute to Pilbara Fire Planning Team's burning proposals
- Notify Pilbara Region and Wildlife Branch of species conservation status

93/0166 - Eastern Goldfields Ranges Survey

- Liaison with region on control of mining and exploration lease conditions.

WD/0045 - Darling Scarp Survey

- Contributions to be made to the inter-departmental review of CTRC System 6.

RPP31/90 - Yanchep NP Survey

- Contribution to management plan and liaison with district operations staff

93/0034 - Cape Arid NP Survey

- Contribution to management plan and liaison with district operations staff

WD/0028, 93/0026 - Limestone range CRC survey, Kimberley surveys

- Need to purchase a reserve representing the limestone reef surfaces north of Kununurra at the time land is acquired by the WA Government to extend the Ord Irrigation Scheme.

93/0025 - Eastern Goldfields Survey

- Purchases of pastoral lands for reservation after liaison with region are already happening in Goldfields Region.
- Contributions on conservation values and reserve system status have been made to Pastoral Industry Reconstruction Task Force, and EA's IBRA Bioregional framework in assessing priorities for the National Reserve Program.

91/0057 - Survey methodology, analysis and software

- GLIM now included in survey data analysis procedures. Developments in compositional analyses now available as software modules that enhance PATN.
- Trapping methods, GLIM analyses, and PATN extension modules are being used to improve cost-efficiency of, and shorten time required for, salinity action plan survey.

93/0028 - Ecomorph & community structure

- Bat ultrasound identification now used routinely in surveys, e.g. Carnarvon, Koolan island, Little Sandy Desert surveys. Integrity of bat guilds can now be assessed; these are one of the few ecological components of mammals that have persisted intact through the last 100 years in Australia.
- Six species recovery outlines contributed to EA's Bat Action Plan.

93/0027 - Buccaneer Archipelago

- Recommendation and results overview written into Kimberley regional planning study, DEP update of CTRC System 7 report.

93/0029 - Mandora-Radi Hills

- Recommendation and results overview written into Kimberley regional planning study, DEP update of CTRC System 7 report.

94/0003 - Conservation of WA vegetations

- Areas of land will be recommended for purchase or other acquisition as reserves, or management agreements

93/0165 - Botanical survey of Lesueur

- Ongoing consultation with regional and district staff, and amendments to mgmt plan as necessary.

93/0091 - Monitoring

- Published review will be provided to regions to assist in their operations.

93/0032 - Desert Ranges Survey

- Ongoing consultation with Ngaanyatjarra and CALM regional staff, on species management and declaration of protected area for conservation in Central Aboriginal Reserve.

FORESTS AND TREE CROPS GROUP

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Ecologically Sustainable Forest Management

PROJECT LEADER

Lachlan McCaw, Manjimup

SCIENCE PROJECTS / CORE FUNCTIONS

93/0073	Effects of fire regimes on invertebrates in jarrah forest
93/0075	Effects of autumn and spring burning on small vertebrates in jarrah forest
93/0076	Prescribed burning and conservation of invertebrate communities in jarrah forest
93/0095	Characteristics of hollow-bearing jarrah and marri and their use by selected fauna
93/0098	Effects of fire and logging on floristic composition and structure of jarrah forest vegetation
93/0101	Preliminary survey of the effectiveness of *Banksia grandis* removal in reducing potential *Phytophthora cinnamomi* host material in the northern jarrah forest in the medium term
93/0106	Increasing productivity of karri regrowth stands by thinning and fertilising
93/0107	Espacement effects on the development and form of regrowth karri stands
93/0110	Use of phosphonate to determine the effect of *Phytophthora cinnamomi* infection on growth of *Eucalyptus marginata*
93/0115	Effects of timber harvesting on terrestrial vertebrates in medium rainfall jarrah forest
93/0155	Effects of logging and fire on birds in jarrah forest
94/0007	Effects of timber harvesting on invertebrates in jarrah forest
94/0008	Effects of timber harvesting on birds in karri forest
99/0009	Using ground-based electromagnetic induction to measure forest soil salt storage
TBA	Sustainability indicators for Western Australian soils (WAPIS-funded project for indicators 4.1 d & e)
TBA	Standardised measures of regeneration success for sustainable forest management in native forests (WAPIS-funded project for indicator 2.1 g)

STAFF:

Staff	Location	FTE
J. Kinal	Dwellingup	1.0
G. Liddelow	Manjimup	0.8
L. McCaw	Manjimup	0.35
J. Neal	Manjimup	0.2
J. Rooney	Manjimup	1.0
R. Smith	Manjimup	0.2
B. Ward	Manjimup	0.3
C. Ward	Manjimup	0.9
A. Wayne	Manjimup	0.9
K. Whitford	Dwellingup	1.0
I. Wheeler	Manjimup	1.0
Total		**7.65**

PROJECT OBJECTIVES:

- To determine the effects of timber harvesting and associated silvicultural treatments including prescribed fire on plants and animals in the jarrah forest.
- To investigate the changes which occur in karri forest bird communities as stands regenerate following timber harvesting.
- To investigate the relationship between tree characteristics, stand conditions and the occurrence of hollows in jarrah and marri trees.
- To investigate the development of karri regrowth stands at different levels of stand density, including the effects on tree growth and stem form.
- To evaluate potential soil-based indicators for ecologically sustainable forest management, including soil organic matter and soil bulk density.
- To develop indicators of regeneration success in native forests appropriate for national level reporting of ecologically sustainable forest management.

SIGNIFICANCE & BENEFITS:

- The principles of ecologically sustainable forest management require the development and implementation of policies and practices which maintain ecological processes, maintain biodiversity and optimise benefits to the community. There is a strong international focus on the application of criteria and indicators for assessing the sustainability of forest management practices. This project provides important baseline data necessary for the evaluation and ongoing refinement of indicators suitable for Western Australian forest ecosystems.
- This project also provides important information about trends in the populations of some key forest fauna, the response of these populations to disturbance associated with timber harvesting, and the interactions between timber harvesting and predation.

DESCRIPTION:

- The Ecologically Sustainable Forest Management Project integrates a series of related Science Project Plans which individually address the response to fire and harvesting

disturbance by vascular plants, invertebrates, small vertebrates and medium-sized mammals. The majority of the work is focussed on jarrah forest ecosystems from Collie southwards. A number of complementary studies are underway in the Kingston area near Manjimup where a large multidisciplinary project was initiated in 1994. Harvesting and post-harvest burning is now complete and the project is entering a monitoring phase.

- Allied to the studies of disturbance response is an investigation of the occurrence and characteristics of hollows in jarrah and marri trees. Information gained from this study will provide an objective basis for predicting the abundance of hollows according to stand characteristics. This will make it possible to estimate future hollow availability in stands subject to timber harvesting or other forms of disturbance.
- Research into the effects of timber harvesting on bird populations in the karri forest commenced in 1984 at Grey block west of Manjimup. Populations were monitored regularly between 1984 and 1989, and the study was re-activated in 1995 to allow longer term recovery trends to be examined. Development of even-aged stands of karri regenerated following timber harvesting is being investigated to determine the effects of stand density on growth and tree form. This information is required to validate stand growth models and allow evaluation of the effects of various silvicultural systems.
- Two studies evaluating potential indicators for sustainable forest management commenced in 1998 with funding support from Commonwealth Government Wood and Paper Industry Strategy. These studies aim to identify appropriate indicators for soils and regeneration success.

METHODOLOGY:

Kingston experimental study

- This is a Before/After/Control/Impact study design with four treatments including an unlogged control, shelterwood harvesting, and gap creation with and without retention of marked habitat trees. Controls are provided at three levels to allow evaluation of spatial influences and intermediate forms of disturbance. Sampling is based on a series of permanent trapping grids and road transects which are trapped over consecutive nights in each season. Vegetation composition and structure, and the extent of soil disturbance have been assessed at each grid location.
- Additional work has been undertaken to examine the response of selected species which are not readily studied by conventional grid-based trapping techniques. These species include the Western Ringtail Possum and the Chuditch. Radiotelemetry techniques have been employed to monitor activity patterns of Ringtail Possums in logged and unlogged stands.

Tree hollow characteristics

- The form and condition of jarrah and marri trees spanning a range of diameter classes has been assessed prior to felling. Trees are subsequently felled and a detailed assessment made of the number, location, dimension and condition of hollows found in each tree. Hollow occurrence has been examined in relation to tree age, size, condition and site factors.

Grey block bird study

- This is a Before/After/Control/Impact study design with four treatments including an unlogged/unburnt control, a burnt/unlogged treatment, clearfelling, and clearfelling with

retained patches of mature forest. Bird assemblages were sampled by mistnetting and censussing during the first five years of the study. Since 1995, census counts have been undertaken biannually in spring and autumn.

Karri stand development

- Development of stands regenerated by planting with nursery raised seedlings is being studied at two sites, established in 1982 and 1991 respectively. Height, diameter and growth are being assessed. The effects of thinning, fertiliser application and control of stump coppice are being studied at four experimental sites spanning a range of stand age and site quality.

Sustainability indicators

- The impact of forest operations including harvesting and prescribed burning on soil organic matter and bulk density is being studied at matched sites having well documented disturbance histories. The effects of disturbance will be evaluated by comparison with control areas that have remained undisturbed over the comparison period.
- The project evaluating measures for regeneration success involves collaboration between forest management agencies in all states having substantial native forest estates. Regeneration survey techniques employed in each state are being reviewed to provide a basis for comparison, and field work will be undertaken to establish the comparability of results from different techniques in major forest types. Procedures for aggregating results to allow meaningful reporting at regional and national scales will be devised.

SCHEDULE OF TASKS:

Kingston experimental study

- February, May, August, November 1998: trapping sessions (A. Wayne)
- May 1998: compile and validate fauna data base for the period 1994-1997 in preparation for major analysis (A. Wayne); commence analysis of vegetation data (B. Ward)
- September 1998: reassessment of vegetation quadrats and soil disturbance (B. Ward)
- October 1998: prepare annual progress report (A. Wayne)

Tree hollow characteristics (K. Whitford)

- March 1998: finalise definitions of hollows suitable for a range of different species
- April 1998: examine factors affecting presence and abundance of hollows suitable for a range of different species
- November 1998: finalise data analysis and development of predictive models for hollow abundance and dimensions in preparation for a review of current silvicultural specifications

Grey block bird study

- November 1998/ February 1999: bird censussing at Grey and Kingston. Additional space for time study of bird populations to be undertaken in 70 and 150 year old karri regrowth

Sustainability indicators

- August 1998: Approval of project plans by Forest and Wood Products Research and Development Corporation
- October 1998: Appointment of technical officer to undertake field work on soil indicators project
- December 1998: Preparation of detailed working plan and methodology

MILESTONES:

- May 1998: Validation of fauna data base in readiness for detailed analysis
- October 1998: Annual progress report for Kingston study
- November 1998: finalise data analysis and development of predictive models for hollow abundance and dimensions in preparation for a review of current silvicultural specifications
- December 1998: draft scientific papers on medium sized mammals and hollow characteristics of jarrah and marri

OUTPUTS:

- Annual progress report in October
- Annual seminar and field day for operations staff held in November
- Scientific papers on medium sized mammals and hollow characteristics of jarrah and marri (draft available by December 1998)
- Poster presentation on karri forest bird study to UIFRO/CIFOR forest sustainability conference in Melbourne, August 1998
- Scientific paper and Landscope article describing the results of the karri bird study

OUTCOMES:

- Silvicultural specifications for timber harvesting in jarrah forest have, and will continue to be updated to provide improved guidelines for retention of habitat trees and for protection of habitat for selected fauna likely to be impacted by harvesting operations(eg importance of grass trees as habitat for Ringtail Possum)
- Populations of a range of medium sized mammals have been found to be only mildly affected by timber harvesting and post-harvest burning operations
- The response of fauna populations following timber harvesting operations has been shown to be clearly linked to fox predation
- Bird communities in karri forest have been found to recolonise clearfelled areas as stands develop with age, and after 15 years most species have been recorded in regenerating stands. Changes in relative abundance may persist for longer.

ADOPTION STRATEGY:

- Important new findings from the study are discussed with District, Regional and Business Unit staff as a preliminary step to revising silvicultural specifications. Where appropriate, changes may be made to the specifications described in the manual for Timber Harvesting in Western Australia.

- New techniques are presented to timber industry contractors and CALM field personnel in training sessions and field days
- Findings likely to stimulate a change in planning procedures or policy are presented to senior staff in seminars and field days.
- Results are published in recognised national, and where appropriate, international scientific journals

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Forest Microbiota Management

PROJECT LEADER:

Ian Abbott, Crawley

SCIENCE PROJECTS / CORE FUNCTIONS:

93/0021	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
93/0096	Control of Jarrah leafminer (JLM): (1) Performance and reinfestation of JLM in ground coppice after crown scorch by a moderate intensity prescribed spring burn. (2) Performance and reinfestation of JLM in ground coppice after crown scorch by an autumn prescribed burn
93/0097	Control of Jarrah leafminer: Selective retention of JLM resistant trees and ground coppice in a demonstration forest plot
93/0103	Quantitative population monitoring of Gumleaf skeletonizer *Uraba lugens* and impact assessment on jarrah crowns
93/0104	Distribution of Gumleaf skeletonizer in the central and southern forest regions.
93/0105	The influence of pheromones in the mating behaviour of Tryphocaria acanthocera (Coleoptera: Cerambycidae)
93/0153	Control of insect pests in young plantations of *Eucalyptus globulus*: Early indicators of pest insect outbreaks and the beneficial impact of spiders and parasitoids
93/0154	Impact of wood boring insects on wood quality in regrowth karri in relation to site quality
97/0001	Incidence of wood borers in karri across a rainfall gradient
95/0001	Chemical control of Armillaria
98/0006	Below ground incidents of *Armillaria luteobubalina* in regrowth karri
98/0015	Effect of fire on the fruiting of fungi on karri regrowth forests
RPP 24/86	The impact of repeated defoliations on the wood growth of jarrah saplings

STAFF:

Staff	Location	FTE
I. Abbott	Crawley	0.05
T. Burbidge	Como	1.0
J. Farr	Manjimup	1.0
R. Robinson	Manjimup	1.0
A. Wills	Como	1.0
Total		**4.05**

PROJECT OBJECTIVES:

- To determine if current forest management practices cause or otherwise influence outbreaks of pest insects or fungal disease.
- To devise practical and science-based means of minimizing the development of pest insects or fungal disease in native forests and plantations.
- To investigate the mid to long term impacts of timber harvesting and planned burning on native species of invertebrates and fungi.

SIGNIFICANCE & BENEFITS:

This Project will deliver reliable knowledge on the above issues. The first two issues have obvious economic implications. The third issue underpins ecologically sustainable utilization of native eucalypt forests.

DESCRIPTION:

This Project consists of several individual projects

Jarrah leafminer

- Research into controlling outbreaks of this species, *Perthida glyphopa*, commenced in 1984. This project is now largely completed, apart from publication of some scientific papers and ongoing monitoring of the extent of this species in the northern jarrah forest and the establishment of a demonstration forest of jarrah resistant to leafminer infestation.

Gumleaf skeletonizer

- Research into controlling outbreaks commenced in 1985. Data collection has been completed, and the results are currently being written up.

Lerp

- Research into controlling outbreaks of *Cardiaspina jerramungae* commenced in 1989. Data collection has finished, and the results are currently being analysed and written up.

Live-tree borers

- *Phoracantha acanthocera* causes significant damage to timber quality in regrowth karri. Factors influencing incidence of damage have been investigated. Recent research on the biology of this species is being prepared for publication.

Insect pests in bluegum plantations

- Information on insects present in plantations of *Eucalyptus globulus* was collated for the CALM Insect Manual in 1990. Several scientific papers have been published. Detailed fieldwork has been completed and a paper is ready for publication. A formal insect scouting program is currently being tested.

Fire impact on invertebrates in red tingle and adjacent jarrah and karri forest.

- This is a retrospective study of the recovery of litter invertebrates at various times after fire. This study was initiated at the request of the NPNCA.

Effects of timber harvesting on terrestrial invertebrates in jarrah forest.

- This study is part of the Kingston project north of Manjimup, and is intended to supplement the short term PhD study, the field work for which was recently completed by K. Strehlow, Murdoch University. Spiders, cockroaches and grasshoppers only were identified to morphospecies.

Comparison of invertebrates in the foliage of pole crowns of jarrah and marri.

- This study was to ascertain whether marri supported more diverse and larger populations of insects etc. than jarrah. When this study began (1987), local entomologists and ornithologists believed that marri was a significant reservoir of biodiversity in jarrah and karri forests. Research by Majer and Recher has since disproved this notion.

The impact of repeated defoliations on the wood growth of jarrah saplings.

- This was initially an experiment which examined the impact of various degrees of manual defoliation on the stem diameter growth of jarrah saplings in high quality jarrah forest. It is now an ongoing monitoring study of the growth and survival of jarrah subject to the most extreme annual defoliation possible.

Invertebrate conservation in an urbanized landscape: The native earthworm fauna of the metropolitan sector of the Swan Coastal Plain.

- The purpose of this study was to assess the general adequacy of current nature reserves in suburbia by using a neglected bio-indicator.

Prevalence and impact of *Armillaria* in karri forests

- FMB annually survey regrowth karri stands for *Armillaria* root disease. This study will utalise surveyed areas and estimate below ground levels of the disease and determine whether infection is restricted to individual trees or is actively spreading to neighbouring trees via root contact. The effect of thinning on the spread of ARD, the impact of ARD on growth and possible biological control of ARD by cord-forming wood and litter fungi is also being investigated.

METHODOLOGY:

Jarrah leafminer

- A combination of survey and experiment was used. Damage to leaves was measured as fraction of leaf area eaten by larvae, number of cutouts per leaf, or recorded as presence/absence of cutouts. In some studies the proportion of mines parasitized was assessed. Treatments studied included prescribed burning in spring and autumn, and timber harvesting.

Gumleaf skeletonizer

- Presence/absence of egg rafts or larvae was used to map the distribution of this insect. A monitoring program involving quantitative sampling of the foliage of pole crowns from a cherrypicker was implemented in 1986.

Lerp

- A combination of survey and experiment was used. A population of the insect was monitored over nine generations to determine the biology and population dynamics. The extent and degree of infestation was determined by survey.

Live-tree borers

- A combination of destructive harvesting, assessment of external signs of damage, light-trapping of adults, and laboratory experiments was used.

Insect pests in bluegum plantations

- Fogging was the main technique used to collect arthropod faunas of crowns of bluegums. Opportunistic hand collecting of insects was used to augment the insect collections held at Como and Manjimup.

Fire impact on invertebrates in red tingle and adjacent jarrah and karri forest

- Pitfall trapping in 4 consecutive seasons was the main sampling method used. Other samples were collected by hand.

Effects of timber harvesting on terrestrial invertebrates in jarrah forest.

- The same technique used by K. Strehlow (pitfall trapping) is being used.

Comparison of invertebrates in the foliage of pole crowns of jarrah and marri

- Collection of branchlets from a cherrypicker was the method used.

The impact of repeated defoliations on the wood growth of jarrah saplings

- Method entails complete manual defoliation each December of saplings in the treatment group. Stem diameter of saplings in control and treatment groups is measured each December.

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

- Strategic hand collection of specimens in remnants of native vegetation was the method used.

Prevalence and impact of Armillaria in karri forests

- Following above ground examination, trees in plots withinin infected stands are pulled in order to examine root systems and determine the actual below ground incidence of ARD. Cultures are grown from all infected root systems and are paired in the lab to determine whether single or multiple clones of Armillaria occupy each plot. This is repeated across the range of karri regrowth to determine any site differences.
- Retrospective analyses of silvicultural trials within infested regrowth stands are being undertaken to determine the impact of thinning on ARD and the impact of ARD on growth.

- Karri regrowth stumps. naturally infected with ARD, were inoculated with 3 separate species of cord-forming fungi or alternatively treated with chemical (metham sodium). This trial was monitored for 4 years and then the stumps excavated and disected to determine the volume of each stump occupied by Armillaria or/or the biocontrol fungus.

SCHEDULE OF TASKS:

I Abbott
Finalize and submit for publication four manuscripts.
(See Milestones)

J Farr
Write up three manuscripts
(See Milestones)

R Robinson
Write up Biocontrol of ARD results, and the analyses of the impact of thinning on ARD and the effect of ARD on growth in the Warren Thinning Trial.
(See Milestones)

MILESTONES:

I Abbott

Feb 98	Re-activate Kingston litter fauna study
Feb 98	Submit herbarium/jarrah leafminer paper to journal
Mar 98	Submit globulus insect paper to journal
Apr 98	Submit jarrah leafminer/fire paper to journal
Oct 98	Tend demonstration forest plot, Collie
Nov 98	Sort vials containing earthworm samples and discriminate taxa
Dec 98	Finalize data anlaysis for native earthworm/Perth metro area study
Dec 98	Remeasure jarrah saplings in simulated insect defoliation study, Holmes block
Mar 99	Submit earthworm paper to journal
Mar 99	Develop and submit concept plan for invertebrate research (conservation and commercial) in southwest WA
Apr 99	Submit paper on comparison of invertebrate faunas of crowns of jarrah and marri to journal
May 99	Submit paper on Holmes study to journal

J Farr

Aug 98	Prepare draft paper on karri borer ecological damage
Nov 98	Prepare draft paper on gumleaf skeletonizer occurrence
Mar 99	Prepare draft paper on lerp biology, population ecology and damage to flat-topped yate foliage

R Robinson

Feb 98	Analyse results of chemical control and biological control of Armillaria

OUTPUTS:

I Abbott

- Draft report on impact of fire on litter fauna in tingle forest (P van Heurck).
- Submit the following papers for publication
  - f) Reinfestation of *Eucalyptus marginata* ground coppice by jarrah leafminer after scorch by autumn or spring fires (Abbott. I, Wills, A & Burbidge, T).
  - f) Historical incidence of Perthida leafminer species (Lepidoptera) in southwest Western Australia based on herbarium specimens (Abbott, I, Wills, A & Burbidge, T).
  - f) The impact of canopy development on arthropod faunas in recently established Eucalyptus globulus plantations in Western Australia (Abbott, I, Wills, A & Burbidge, T).
  - f) Landscape scale comparison of the invertebrate faunas of crowns of jarrah (Eucalyptus marginata) and marri (*Corymbia calophylla*) in mediterranean climate forest: Conservation management implications (Abbott, I, Wills, A, Burbidge, T and van Heurck, P).

J Farr

- Paper on karri borer ecology and damage
- Paper on gumleaf skeletonizer occurrence
- Paper on lerp biology, ecology and damage to flat-topped yate foliage

R Robinson

- Report on *Armillaria bubalina* in regrowth karri forest
- Report on ARD in the Warren 2 thinning trial
- Paper on chemical and biocontrol of Armillaria
- Report on below ground incidence of ARD

Reports, publications, seminars, field days etc.

Technical publications 1984-1997

Abbott, I 1985 Forest entomology research in Western Australia. Technical Report, Department of Conservation and Land Management Western Australia No 2 (76 pp).

Abbott, I 1990 Insect outbreaks in forests of Western Australia. In Population dynamics of insects (ed A D Watt, S R Leather , M D Hunter & N A C Kidd), 95-103. Intercept, Andover, Hampshire, UK.

Abbott, I 1992 Records of outbreaks of defoliating insects in Jarrah forest, south west Western Australia, from 1960 to 1990. Technical Report, Department of Conservation and Land Management No. 28 (29 pp).

Abbott, I, 1992 Ecological implications of insect pests in jarrah and karri forests. Occasional Paper, Department of Conservation and Land Management 2/92: 77-98.

Abbott, I 1993 Review of the ecology and control of the introduced bark beetle Ips grandicollis Eichhoff (Coleoptera: Scolytidae) in Western Australia, 1952-1990. CALMScience 1: 35-46.

Abbott, I 1993 Insect pest problems of eucalypt plantations in Australia. 6. Western Australia. Australian Forestry 56: 381-384.

Abbott, I 1993 Minimising insect pests in eucalypt plantations: a review in the context of the concepts of optimal area, polycultures and patchiness. Australian Forestry 56: 385-390.

Abbott, I 1995 Prodromus of the occurrence and distribution of insect species in the forested part of south-west Western Australia. CALMScience 1: 365-463.

Abbott, I, Burbidge, T, Williams, M & Van Heurck, P 1992 Arthropod fauna of Jarrah (Eucalyptus marginata) foliage in Mediterrean forest of Western Australia: Spatial and temporal variation in abundance, biomass, guild structure and species composition. Australian Journal of Ecology 17: 263-274.

Abbott, I, Majer, J D & Mazanec, Z 1986 Annotated bibliography of forest entomology in Western Australia to 1985. Technical Report, Department of Conservation and Land Management Western Australia No 14 (71 pp).

Abbott, I, Smith, R, Williams, M & Voutier, R 1991 Infestation of regenerated stands of Karri (Eucalyptus diversicolor) by bullseye borer (Tryphocaria acanthocera, Cerambycidae) in Western Australia. Australian Forestry 54: 66-74.

Abbott, I, Van Heurck, P & Burbidge, T 1993 Ecology of the pest insect jarrah leafminer (Lepidoptera) in relation to fire and timber harvesting in jarrah forest in Western Australia. Australian Forestry 56: 264-275.

Abbott, I, Van Heurck, P, Burbidge, T & Williams, M 1993 Damage caused by insects and fungi to eucalypt foliage: spatial and temporal patterns in Mediterranean forest of Western Australia. Forest Ecology and Management 58: 85-110.

Abbott, I, Van Heurck, P, Burbidge, T & Wills, A 1994 Factors influencing the performance of jarrah leafminer (Lepidoptera) within stands of jarrah forest. Australian Forestry 57: 165-170.

Abbott, I & Wills, A 1996 Growth of young Eucalyptus globulus in plantations after manual defoliation simulating insect herbivory. CALMScience 2: 129-132.

Farr, J D & Wheeler, I B 1997 Sex determination in the bullseye borer Phoracantha acnthocera (Macleay) (Coleoptera: Cerambycidae). CALMScience 2: 199-201.

Majer, J D & Abbott, I 1989 Invertebrates of the jarrah forest. In: The jarrah forest. A complex mediterranean ecosystem. (ed B Dell, J J Havel & N Malajczuk), 111-122. Kluwer Academic Publishers, Dordrecht.

Postle, A & Abbott, I 1991 Termites of economic significance in suburban Perth: A preliminary study of their distribution and association with types of wood (Isoptera). Journal of the Australian Entomological Society 30: 183-186.

Williams, M R & Abbott, I 1991 Quantifying average defoliation using leaf-level measurements. Ecology 72: 1510-1511.

Significant reports, manuals 1984-1997

Abbott, I 1990 Insects known to be injurious to trees. Section 3 of CALM's Insect Manual (19 pp).

[Abbott, I] 1992 Department of Conservation and Land Management Policy Statement 47. Control of Sirex woodwasp in pine plantations.

Robinson, R M 1997 A comparison of chemical and biological methods for control of Armillaria in regrowth karri.

Wills, A & Burbidge, T 1995 The Autumn gum moth Mnesampela privata: A summary of observations from Western Australia and a possible method of risk assessment.

Wills, A & Burbidge, T 1995 Variation across provenance regions and families for damage to Eucalyptus globulus leaves by chewing insects.

Educational communications 1984-1997

Abbott, I 1988 More boring insects. Landscope 4(1): 42-46

Abbott, I 1989 Out on a limb. Landscope 4(3): 18-21.

Abbott, I. Van Heurck, P. Burbidge, T & Wills, A 1995 Cutting out the leafminer. Landscope 11(1): 43-47.

Blyth, J & Abbott, I 1991 Spineless wonders: are invertebrates second-class citizens? Landscope 6(3): 28-33.

Farr, J 1992 Lerps, bugs and gum-leaves. Landscope 8(1): 50-53.

Farr, J 1997 Insects in the garden. Landscope 12(4): 28-35

Seminars, field days, conferences 1984-1997

Abbott, I 1987 Insect outbreaks in forests of Western Australia. Zoology Department, University of New England; Armidale NSW; Forestry Commission, Beecroft NSW; and Waite Institute of Agricultural Research, Glen Osmond, SA.

Abbott, I 1989 Insect outbreaks in forests of Western Australia. Heroit-Watt University, Edinburgh, Scotland (Conference)

Abbott, I 1991 Insect pest problems of eucalypt plantations in Western Australia. RWG 8 Conference, Launceston, Tas.

Abbott, I 1991 Minimizing insect pests in eucalypt plantations: a review in the context of the concepts of optimal area, polycultures and patchiness. RWG 8 Conference, Launceston, Tas.

Abbott, I 1992 Ecology of jarrah leafminer in relation to fire and timber harvesting in jarrah forest. Como.

Abbott, I 1994 Globulus entomology, at Sustainable Resources Group Technical Meeting, Como and attended by research and operations staff.

Farr, J 1988 Uraba lugens in South Australia: Biology and performance in relation to nitrogen nutrition. Seminar, CALM Como

Farr, J 1989 The role of insects in the ecosystem. Seminar, Busselton Naturalists Club Busselton.

Farr, J 1989 Gum Leaf Skeletonizer : knowledge to date and how to identify insects and damage in the forest. Training seminar, Bunbury Regional Leaders. Repeated to all region and districts for the SW forest each year to 1994.

Farr, J 1990 Cardiaspina spn on flat-topped yate. Seminar, Gnowangerup LCDC.

Farr, J 1990 Implications of procedures in plantation management on insect problems. Training seminar, Manjimup.

Farr, J 1990 Insect/host plant interrelations: a review. Conference, Australian Entomological Society, Canberra.

Farr, J 1991 Invertebrate fauna, pest species impact and management. Seminar, Workshop on Ecology of Jarrah, for Greenbushes Friends of the Forest (Perup field station).

Farr, J 1991 Cardiaspina spn. A new insect species outbreaking on Flat-topped yate (Eucalyptus occidentalis). Seminar, CALM Woodvale, Curtin University of Tech., W.A. Dept of Agriculture.

Farr, J 1991 Lerps and Remnant vegetation decline. Seminar, Welstead LCDC.

Farr, J 1991 Insects and ecosystems. Seminar, Walpole/Nornalup National Park Association.

Farr, J 1991 Insects and plantations. Training Seminar, Manjimup.

Farr, J 1991 Entomology research and wood borers. Seminar, Timber Dryers Association, Como.

Farr, J and Dick, S 1992 New species of Cardiaspina Crawford (Hemiptera: Psylloidea) outbreaks on Eucalyptus occidentalis Endl. In southern Western Australia. XIX International Congress of Entomology, Beijing, China (poster).

Farr, J 1996 Insects on eucalypts associated with establishment of revegetation schemes. Seminar, Revegetation training program, Northam.

Farr, J 1996 Sex and the bullseye borer. Como.

Robinson, R. 1977. Armillaria root disease in regrowth karri. Manjimup, meeting and field day, attended by SID Natural Resources management and FMB forest managers, to discuss priorities for ARD research in regrowth karri.

Robinson, R. 1997. Armillaria root disease: recognition of A. luteobubalina and detection of ARD. Manjimup, attended by forest managers and operations staff.

Robinson,R. 1997. Armillaria root disease: a potential problem in bluegum plantations. Bunnings Tree Farms, Manjimup.

Note Appendix1 contains a full list of publications and other outputs.

Technical publications

17 Research papers published in the period 1984-1997

Significant reports, manuals

5 Reports and manuals produced in the period 1984-1997

Educational communications 1984-1997

- 6 communications produced in the period 1984-1997
- Seminars, field days, conferences 1984-1997
- 24 seminars produced in the period 1984-1997
- Jarrah leafminer research has demonstrated that prescribed burning in spring and timber harvesting do not promote outbreaks. No policy change was therefore required.
- Ips research has demonstrated that outbreaks will not develop if pine plantations are thinned to schedule and if thinning slash is promptly removed.
- Advice about Ips, pine woolly-aphid, budworm, weevil species, wingless grasshopper and Sirex was incorporated into CALM's Pine Management Guide (1990). More detailed information for wingless grasshopper, Australian plague locust, budworm, African black beetle, spring beetles, Rutherglen bug, bluegum psyllipasture day moth, autumn gum moth, chrysomelid beetles, Ips bark beetle, pine adelgid, vegetable weevil, garden weevil, apple weevil, Sirex woodwasp, leafblister sawfly, Catasarcus weevils and cutworms was provided for CALM's Insect Manual (1990). This information was assembled and synthesized from diverse sources.
- Bullseye borer research indicated that outbreaks in karri regrowth may be reduced by thinning stands to alleviate water stress and by not planting karri in coupes where it did not occur naturally.
- Technical advice about the ecology of pest insects in bluegum plantations has been provided to operations/business unit staff (via CALM Insect Manual 1990; Wills and Burbidge reports [1995] on Autumn gum moth ecology, and on the apparent existence of bluegum provenances resistant to Leafblister sawfly infestation).
- The need for monitoring of Sirex woodwasp in pine plantations was formally recognized by CALM's Director of Forests and Corporate Executive, with endorsement of a policy statement drafted by I. Abbott.

OUTCOMES:

- Research on jarrah leafminer has demonstrated that prescribed burning in spring and timber harvesting have not promoted outbreaks. Prescribed burning in autumn (crown scorch) is ineffectual in preventing spread of leafminer populations. No changes to existing policies are therefore recommended.
- Beneficial arthropods such as predators and parasitoids are well represented in young plantations of bluegums. Application of pesticides to plantations with outbreaks of pest insects should be minimized so as not to disrupt spider and wasp populations.
- Science-based advice on whether forest management or site conditions have influenced the incidence of wood borers and Armillaria in karri regrowth.
- Science-based advice on whether forest management or site conditions have influenced the incidence of gumleaf skeletonizer in jarrah forests.

- Review of the adequacy of planning and forest management in conserving arthropod faunas living in tree crowns in jarrah forest.

ADOPTION STRATEGY:

- 93/97 When the next leafminer outbreak occurs near Collie, the Demonstration Forest will be used to show staff and the public how magnificent jarrah forest can look following removal of jarrah susceptible to leafminer.
- Proposed new SPP (Insect scouting in bluegum plantations). A pilot study is already underway; business unit staff at Albany, Collie, Manjimup and Busselton have been consulted. The results will be considered at a meeting in October 1998.
- SPP 94/7 Adoption is dependent on the results of the study (recommencing February 1998; last sampled by K. Strehlow in March 1996).
- Proposed new SPP (Fire impacts in tingle forest on litter invertebrates) Adoption will depend on the results of the study. A report by P. Van Heurck (including results of sorting by T. Burbidge, P. Van Heurck and I. Wheeler) is due March 1998. This report will be presented to NPNCA and a workshop will probably be held at Walpole, involving CALM staff, NPNCA representatives and local interested residents.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Forest Fire Management

PROJECT LEADER:

Lachlan McCaw, Manjimup

SCIENCE PROJECTS / CORE FUNCTIONS

93/0099	Fire regime effects on the structure and floristics of jarrah forests
95/0012	Reconstructing jarrah forest fire history using black boy stems
96/0010	Fire history and impact of *Phytophthora cinnamomi* in jarrah forests
97/0003	Project Vesta - prediction of high intensity fire behaviour in dry eucalypt forest

STAFF:

Staff	Location	FTE
N. Burrows	Crawley	0.01
L. McCaw	Manjimup	0.6
J. Neal	Manjimup	0.8
R. Smith	Manjimup	0.8
B. Ward	Manjimup	0.7
D. Ward	Kelmscott	1.0
Total		**3.91**

PROJECT OBJECTIVES:

- To compare the effects of a range of fire regimes on the structure and floristic composition of jarrah forest understoreys
- To quantify the changes in fire behaviour in dry eucalypt forest as fuels develop with age
- To characterise wind speed profiles in forests with different overstorey and understorey structures

- To revise the algorithms describing the relationships between fire spread and fuel load, and between fire spread and wind speed
- To reconstruct historical fire frequencies in the jarrah forest using a dating technique based on stems of grass trees, and to interpret historic fire use patterns in relation to environmental and cultural factors

SIGNIFICANCE & BENEFITS:

- Prescribed fire is used extensively in Western Australian forests for fuel reduction and to meet silvicultural objectives. Annually, CALM undertakes prescribed burning over more than 250 000 ha of forest. The use of prescribed fire is opposed by some environmental and community groups who claim that it is both ecologically destructive and ineffective in protecting community assets and forest values.
- Against this backdrop, there is good ecological and historical evidence that fire has long been a feature of south-west forest ecosystems. A recently developed fire dating technique which utilises the stems of grass trees has the potential to provide objective data on the frequency of fire across the forest landscape. Knowledge of historical fire occurrence, coupled with an understanding of aboriginal fire usage patterns and the role of lightning as an ignition agent should allow fire to be placed in its proper context as an environmental factor.
- Vegetation responses to single fire events have been studied extensively, but there is a need for long term studies to examine the effect of repeated fires at different combinations of frequency, intensity and season.
- The fire behaviour prediction system currently used in Western Australia is based on extensive field research over more than 30 years, but there is a need to better quantify the effects of fuel age and fuel characteristics on fire behaviour. The effect of fuel load and fuel age on fire spread is uncertain. Better understanding of this relationship would allow the benefits of fuel reduction burning to be properly described.

DESCRIPTION:

- CALM and the Bushfire Research and Management Group of CSIRO Forestry and Forest Products are collaborating in a major experimental study of fire behaviour at two sites in the jarrah forest. At both sites, areas have been withheld from prescribed burning for periods ranging from 2 to 20 years since fire, and a series of 4 ha experimental plots established in each of four or five different fuel ages. There are twelve replications within each fuel age. Sites are located at Dee Vee Rd (Mornington District) in forest with a low open understorey, and at McCorkhill block (Blackwood District) in forest with a tall dense shrub understorey. Experimental fires were conducted simultaneously in each fuel age at Dee Vee in February/March 1998, with further fires at both sites planned for January/February 1999.
- The study of fire history based on grass tree stems has been underway since 1995 and trees have been sampled from a range of environments throughout the south-west forest and adjoining woodlands. Further investigations have been undertaken in conjunction with the Regional Forest Agreement process and results reported upon in the Comprehensive Regional Assessment. A three year collaborative study with Dr Bryon Lamont of Curtin University commencing in 1998 will utilise the grass tree technique to prepare a fire history for John Forrest National Park.
- Long term fire ecology research plots were first established in Western Australian forests in 1972, and the network of plots was expanded in 1984. Currently there are three sets

of replicated plots which span a rainfall gradient from high rainfall western forest (Lindsay block), intermediate rainfall (McCorkhill block) to low rainfall eastern forest (Yackelup).

METHODOLOGY:

- The two sites selected for the experimental study of fire behaviour have been thoroughly surveyed to quantify important fuel characteristics including fuel loading and composition, vegetation structure, and bark condition on standing trees. Experimental fires will be conducted during dry summer conditions with open wind speeds up to 25 km/h. Winds will be measured at each plot during experimental fires. Fires will be lit with 120 m line ignitions and allowed to spread with the wind. The primary experimental variable for comparison will be forward rate of spread, but flame dimensions and spotting distances will also be recorded.
- Fire history from grass trees will be determined by examining the frequency of black bands on the stems of trees following preparation by grinding. These black bands have been found to contain a chemical compound (Lapachol) which is produced as a by-product during combustion of living leaf fronds. Chemical analysis will also be undertaken on a sub-sample of stems to investigate the distribution of mobile and immobile nutrients (Ca, P, K) within the stem. This may provide an indication of whether some nutrients are redistributed or moblised as a result following fire. The age and growth rate of individual trees will be assessed counting coloured growth zones on the stem and by extrapolation of growth rates measured during the recent past. Fire histories obtained using the grass tree technique will be compared to historical records of fire usage in selected case study sites.
- Fire ecology plots are subject to one of four fire regimes:
  - short interval (3-4 year) fires in summer/early autumn on dry soils
  - normal rotation interval (5-7 year) in both summer and autumn
  - extended rotation interval (12-14 year) in spring
  - fire exclusion

  Plots are burnt at low to moderate intensity. Vegetation attributes are assessed prior to and at intervals following fire. These attributes include species composition, seedling density, flowering status and seed production. Soil seed banks have also been examined in selected plots.

SCHEDULE OF TASKS:

Project Vesta

February, March 1998	experimental burning at Dee Vee Rd demarcation and construction of additional plots in 2 year old fuel at McCorkhill block
May, June 1998	preliminary analysis of data from Dee Vee
October/November 1998	completion of buffer burning at McCorkhill
January 1999	experimental fires at McCorkhill
April-November 1999	data validation and analysis
January-June 2000	preparation of reports and scientific manuscripts

Fire history study

June 1998	preparation of a manuscript describing the chemical basis of the pigment lapachol which forms black bands in the stems of grass
September 1998	validation of the grass tree derived fire history from a sample of at least ten sites against CALMfire burning records
December 1998	progress report on John Forrest NP study

Fire ecology study

- A detailed program showing scheduled assessments and burning regimes has been developed and is included with the Science Project Plan.

MILESTONES:

April 1998	completion of experimental burning at Dee Vee
June 1998	lapachol manuscript available for internal review prior to submission to scientific journal
August 1998	progress report documenting observed fire behaviour and comparison with predicted rates of spread from existing models
April 1999	completion of field work at McCorkhill
November 1999	detailed report on experimental fire studies
December 1999	progress report on John Forrest NP study manuscript describing 15 year results from fire ecology study available for review
June 2000	scientific manuscripts on rate of spread model ready for submission to journal

OUTPUTS:

- Annual progress reports to CALM and to external funding agencies
- Annual seminars for operations staff
- Interactive database listing ecological attributes and fire response of plants in south-west forests and shrublands

Scientific papers

- -lapachol as a biomarker for fire history
- probability of grass tree flowering in relation to plant height (accepted for publication in J Roy Soc WA)
- dating jarrah forest fires using grass tree stems
- fire history in John Forrest NP
- rate of spread of jarrah forest fires in relation to fuel age
- wind profiles in jarrah forest
- effect of repeated fire on floristics and structure of jarrah forest understorey at three contrasting sites
- time to first flowering and seed production for selected plant species in the jarrah forest

OUTCOMES:

- Quantification of the influence of fuel age and fuel quantity on rate of spread and difficulty of suppression of fires in jarrah forest
- Improved algorithms to predict fire spread in jarrah forest
- Improved understanding of wind profiles in relation to forest canopy and understorey characteristics
- A comprehensive and scientifically-based description of historical patterns of fire occurrence in jarrah forest
- A sound scientific basis on which to predict the response of jarrah forest vegetation to different fire regimes.
- Guidelines and prescriptions for fire management to achieve desired ecological outcomes.

ADOPTION STRATEGY:

- Findings from the fire behaviour experiments will provide the basis for a revision of the Forest Fire Behaviour Tables for Western Australia
- New information relating to fire behaviour and suppression difficulty will be incorporated into the Wildfire Threat Analysis System for use as a planning and simulation tool
- Key findings from the fire behaviour experiments will be presented to CALM operations staff and volunteer firefighters by means of seminars and technical publications
- Information about jarrah forest fire history and its relationship to environmental and cultural factors will be communicated by means of public presentations, popular articles, education packages and articles in academic journals
- Fire ecology knowledge will be incorporated into area management plans and other fire management planning documents. Key principles and findings will be communicated to CALM operations staff at seminars and field days, and to the scientific community and the public through appropriate publications and presentations. A fire response database will be made available on the CALM computer network.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Sandalwood Ecology and Management

PROJECT LEADER:

Jon Brand, Como

SCIENCE PROJECTS / CORE FUNCTIONS:

96/0006 Field ecology of the Western Australian Sandalwood (*Santalum spicatum* (R. Br.) A. DC.) and the impact of land management activities on sandalwood regeneration.

98/0002 Establishment and growth of sandalwood (*Santalum spicatum*) in south western Australia.

STAFF:

Staff	Location	FTE
J. Brand **B. Maslin**	Como Herbarium	1.0 0.2
Total		**1.2**

PROJECT OBJECTIVES:

Sandalwood ecology

- Investigate the level of natural sandalwood regeneration on pastoral leases, in the Goldfields and Midwest. Examine the effects of grazing, harvesting and seed enrichment planting on sandalwood regeneration.
- Document sandalwood population size structure and associations with soil type and vegetation in the rangelands.

- Examine the entire root structure of individual sandalwood trees and analyse oil composition within trees. Compare sandalwood oil percentage and composition, within and between populations.

Sandalwood establishment

- Investigate establishment techniques, long-term growth and host relationships of sandalwood on farmland in south western Australia.
- Identify superior sandalwood provenances with desirable characteristics, such as high oil content and fast growth.

SIGNIFICANCE & BENEFITS:

- Develop management procedures to improve sandalwood regeneration in the rangelands.
- Determine sandalwood establishment techniques for the Wheatbelt. Establish commercial size plantations for timber production.

DESCRIPTION:

- Conduct field ecology research to examine the effects of harvesting, grazing, soil type and vegetation on sandalwood regeneration. Examine sandalwood population size structure and monitor the level of natural regeneration for at least 10 years.
- Establish sandalwood plantation trials in the Wheatbelt and examine the effects of host species, stocking rate, soil type and fertilizer on sandalwood performance. Determine rotation length required to grow commercial size sandalwood.

METHODOLOGY:

Field ecology

- In 1996-1997 sandalwood field ecology trials were established on Burnerbinmah and Thundelarra in the Murchison, and Goongarrie and Jeedamya in the Goldfields. Burnerbinmah and Goongarrie are CALM owned stations and have been de-stocked, while Thundelarra and Jeedamya are managed for grazing. On each of these stations, the age/size structure of sandalwood growing on different land types was recorded. Seed enrichment trials were also established with different host trees on separate land types. These trials will examine the level of sandalwood regeneration for at least 10 years.
- A large factorial experiment was established on Ninghan station, Paynes Find, in June 1996. This trial was 32 ha in area and contained nine treatments examining the individual and combined effects of grazing, harvesting and seed enrichment on sandalwood regeneration. Half of the trial was fenced to exclude sheep, goats and kangaroos, while the unfenced half was open to grazing by all herbivores. Sized sandalwood trees were harvested using conventional techniques and sandalwood seeds were sown beneath different potential host species, mainly from the genus Acacia.
- Detailed oil analysis of a sandalwood tree excavated at Kalgoorlie was conducted in 1997. Further samples will be analysed from sandalwood trees growing in a range of locations. This research will form part of a program to identify sandalwood trees with high oil levels.

Sandalwood establishment

- Sandalwood silvicultural trials have been established at a range of locations in the Wheatbelt, including: Northampton, Highbury, Narrogin and Kwobrup. These trials are examining the effects of host species, soil type, and stocking rate on sandalwood performance. At each site, the host species (mainly Acacia acuminata) were planted 1-3 years before direct seeding sandalwood. Tree height and diameter measurements are recorded each year, and are used to estimate the time required for trees to reach commercial size.

SCHEDULE OF TASKS:

4/98 Rip new sandalwood trial sites at Narrogin Agriculture School, Broomehill andDandaragan
4/98 Direct sow sandalwood seeds at Narrogin provenance trial
4/98 Submit refereed paper on the Northampton sandalwood trial
6/98 Spray sandalwood sites
6/98 Plant host seedlings at Dandaragan
7/98 Plant host seedlings at Broomehill and Narrogin Agricultural College
8/98 Measure sandalwood trees at Northampton
9/98 Assess sandalwood field trials at Ninghan, Burnerbinmah and Thundelarra
10/98 Assess sandalwood field trials at Goongarrie and Jeedamya
12/98 Submit paper on sandalwood field ecology

MILESTONES:

- Submit a refereed paper on the Northampton sandalwood trial by April 1998.
- Establish new sandalwood trials at Narrogin Agriculture School, Broomehill and Dandaragan in 1998.
- Submit a paper on sandalwood field ecology by December 1998.

OUTPUTS:

- Submit a refereed paper on the Northampton sandalwood trial.
- Write 2-3 reports on sandalwood plantation establishment.
- Complete a sandalwood field ecology paper.

OUTCOMES:

- Sandalwood harvesters may have a greater seed planting obligation if sandalwood regeneration trials are successful.
- Increase planting of sandalwood for commercial use, in the Wheatbelt.
- Adoption strategy:
- CALM to manage stations in the rangelands to conserve sandalwood and promote regeneration.
- Large scale planting of host species and sandalwood in the Wheatbelt. The project to be co-ordinated by the Sandalwood Business Unit and Maritime Pine group.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Genetics and Tree Breeding

PROJECT LEADER:

Trevor Butcher, Como

SCIENCE PROJECTS / CORE FUNCTIONS:

93/0146	*Pinus pinaster* Tree Breeding
93/0147	*Eucalyptus globulus* Tree Breeding
93/0131	Assessing wood quality of *E. globulus* breeding selections.
93/0148	*Pinus radiata* Tree Breeding
93/0126	Genetic variation in quantitative traits of exotic and endemic plantation and rehabilitation species.
93/0129	Karri inbreeding / outcrossing studies.
93/0150	*Corymbia calophylla* family/provenance trials.
93/0112	Selection, screening and field testing of jarrah resistant to *Phytophthora cinnamomi*.
94/0006	Dieback resistant jarrah establishment in operational forest rehabilitation sites
96/0011	Molecular marker aided selection of jarrah (*Eucalyptus marginata*) resistance to *Phytophthora cinnamomi*.
93/0094	Jarrah establishment on dieback graveyard sites.
95/0014	Vegetative propagation by grafting of dieback resistant jarrah for seed orchard establishment.
98/0007	Genetics and molecular biology of commercial tree species.

STAFF:

Staff	Location	FTE
T Butcher	Como	1.0
M Byrne	Herbarium	0.5
M Cully	Manjimup	1.0
B Macdonald	Herbarium	0.5
M Mason	Manjimup	1.0
R Mazanec	Manjimup	1.0
M Stukely	Como	1.0
C Vellios	Manjimup	1.0
Vacant TO		1.0
Total		**8.0**

PROJECT OBJECTIVES:

- To optimise wood production, wood quality and disease resistance of all timber species used in tree planting, by the selection, breeding and production of superior genotypes.

SIGNIFICANCE & BENEFITS:

- Improving the quantity and quality of wood or fibre production through selection and development of new varieties will increase the economic viability and effective area of tree plantings. Our group liaises directly with the Plantation Business Unit to provide information and improved propagules for their use.
- Genetic resource studies for development of potential species for farm forestry.

DESCRIPTION:

- CALM breeding programs for the principal commercial species have been in place for 35 years for the pines and 10 years for the WBG. Very large and diverse base breeding populations have been developed for each species which allows for future productivity gains as well as extending the planting range through increasing adaptability.
- CALM's second string commercial species are very well represented in extensive family / provenance trials; improved varieties of each species are immediately available to develop orchards and breeding if there is a niche.
- CALM has extensive genetic variation trials and studies of endemic eucalypts, including Eucalyptus diversicolor, *E. marginata, E. calophylla, E. globulus* and *E. accedens.*
- *Phytophthora cinnamomi* disease resistant and productive varieties of jarrah and Monterey pine have been developed and are available for deployment.
- Genetic resource studies of target species for commercial exploitation in farm forestry.

METHODOLOGY:

- Essence of our work is the planting of field trials of existing or developed varieties of commercial and potentially commercial species. Trials may range from purchase of a

family seed collection from CSIRO (as were our first *E. globulus* and alternative species trials), carrying out intensive parent tree collections in our endemic species (as done for *E. marginata*, best phenotypes and also for disease resistance etc) to intensive controlled crossings as with our *P. pinaster*, *P. radiata* and *E. globulus*. In addition to field testing, glasshouse testing is used for *Phytophthora cinnamomi* disease resistance (jarrah and radiata pine), salt tolerance (*E. globulus*, *E. globulus*) and drought tolerance (*P. pinaster*, *E. globulus*).

- Control and manipulation of data and information is vital in progressing a breeding program. TBIMS is used for this with the principal species but still needs to be adopted for our other species.

MILESTONES:

- *Pinus pinaster* successful establishment of 19 hectares of breeding trials in the low rainfall agricultural zone, planted in 1997.
- *Pinus pinaster* cloning (Sept 1998) and establishment in archive of SEARCH96 selections (June 1998, June 1999).
- *Pinus pinaster* Salinity Action Plan Selection of drought tolerant phenotypes in Morocco and Portugal (March 1999), quarantine importation (April 1999) and archive establishment (June 2000).
- *Pinus pinaster* Control crossing to produce 80% > productivity propagules for CALM's cutting bed program for the Maritime Pine project (Sept 1998).
- *Pinus radiata* Planting of the Cambria population on 3 sites for gene conservation and drought tolerance studies (July 1998) and glasshouse Phytophthora screening (Nov 1998).
- *Pinus radiata* Trial assessment of RS27 Australian diallels (April 1998).
- *Eucalyptus globulus* Extension of our breeding program to areas in the 'green triangle' region of Victoria / South Australia (July 1998).
- *Eucalyptus globulus* Establishment of new series of yield trials (July 1998).
- *Eucalyptus globulus* Measure P1995 series of yield trials (April 1998).
- *Eucalyptus globulus* Intensive control crossing for breeding and deployment programs; this is a major objective in 1998.
- *Eucalyptus globulus* Pilodyne assessment in major breeding trials (Jan-March 1998).
- *Eucalyptus globulus* Selection, collection and grafting of elite genotypes for archives and known flowering parents for 3 ha orchard (Oct 1998).
- *Eucalyptus marginata* (96/0011) Final inoculation for molecular markers study including comparison of *Phytophthora cinnamomi* isolates (Mar/Apr 1998); plant full-sib trees in Manjimup Archive; data analysis and write-up (with M.Byrne, G.Moran) (1998-99).
- *Eucalyptus marginata* (94/0006) Map 1997 DRJ forest rehab. Plantings and assess survival; plant next series (June 1998) and map (spring 1998).
- *Eucalyptus marginata* (93/0112) Seed collection for further *Phytophthora cinnamomi* resistance screening, including 1st progeny of Gnangara seed orchard and 1985 field inoculation trial (Apr.1998; 1998-99).
- *Eucalyptus marginata* (95/0014) Grafting trials to continue (1998-99).
- *Eucalyptus marginata* (93/0094) Assess trials (1998-99).
- DNA fingerprinting and validation of genotypes used in CALM breeding programs (1999)
- Our group to conduct an FAO Training course in Tree Improvement and Propagation Techniques (Aug -Oct 1998).

- Assess genetic diversity and relationships in E. kochii group of oil mallees (1998)

OUTPUTS:

Trevor Butcher in 1997 gave seminars at

- South Africa - Stellenbosch University, Pathology - Disease resistance breeding.
- South Africa - Bloemfontaine University, Pathology - Disease resistance breeding.
- South Africa - Pretoria, S. African Institute of Foresters, Tree breeding programs in WA.
- Morocco. Sale University, Forestry School *Pinus pinaster* tree breeding
- Portugal - Marinha Grande, Forests Dept, *Pinus pinaster* in WA.
- Portugal - Lisbon, EFN (research HQ), *Pinus pinaster* tree breeding.
- France - Bordeaux, INRA and AFOCEL staff, *Pinus pinaster* tree breeding.
- England - Oxford, OFI post-grad students, Breeding programs and success in WA
- Murdoch Uni, CRC and WA meeting on *E. globulus* - WBG breeding program in WA.
- CALM Corporate Executive, Winston Churchill Fellowship travel in 1997.
- Attended IUFRO meeting at Rotorua in December 1997 and presented paper on "Variation in natural populations of *Pinus radiata* in resistance to *Phytophthora cinnamomi.*" And a poster presentation "Field response of *Pinus radiata* selected for resistance to *Phytophthora cinnamomi.*" Both co-authored by Mike Stukely. We were awarded the 'best poster' prize.
- Assisted with WA Institute of Foresters Field Day on 'Maritime Pine'.
- 1998 publications Disease resistance.
  Winston Churchill Fellowship reports.
  CalmScience Species Information Sheets.

Richard Mazanec in 1997, gave seminars on

- Tree breeding to Graduate certificate Course in Farm Forestry, WA.
- Murdoch Uni, CRC and WA meeting on *E. globulus* - Studies in wood density in WA.
- Farm Forestry field day presentation on CALM's tree breeding program
- 1998 publications *Eucalyptus camaldulensis*
  Eucalyptus maculata

Mike Stukely

- Attended Australasian Plant Pathology Society Biennial Conference (Perth, 27 Sept. - 2 Oct., 1997); presented Posters
- "Selection and deployment of jarrah (*Eucalyptus marginata*) resistant to *Phytophthora cinnamomi*" and "Phytophthora species in natural vegetation in Western Australia";
- co-authored Poster
- "Resistance of jarrah (*Eucalyptus marginata*) to *Phytophthora citricola* and *Phytophthora cryptogea*";
- co-authored Paper (also presented to Genetics Society of Australia Conference, Perth, 29 Sep. – 1 Oct)
- "Identification of QTL for resistance to *Phytophthora cinnamomi* in *Eucalyptus marginata*";
- Workshop (Control of *Phytophthora cinnamomi* and other diseases in native ecosystems) presentation
- "Resistant plants – where it is at/prospects for use".
- IUFRO Meeting, (Rotorua, NZ, Dec. 1997) – Co-authored Paper & Poster (see T. Butcher, above).

- Seminar presented to 4th year students, Agricultural Microbiology, UWA: "Dieback resistant jarrah" (Sept. 1997).
- Examiner for Honours student, Murdoch Univ., (1997-98): "The breeding system of jarrah".
- RWG 7 (Forest Pathology) – Prepared State Report; and CALM submissions on "Forest Health Surveys in WA" and "International Standards for Phytosanitary Measures" (1997).
- Memorandum of Understanding on DRJ completed (CALM, ALCOA, Murdoch Univ., 1997). This has been used as a model for others.
- 1998 Publications
- Molecular markers for *Phytophthora cinnamomi* resistance in jarrah (with M.Byrne et al.)
- Lesion development in jarrah seedlings inoculated with *P. cinnamomi, P. citricola and P. cryptogea* (with UWA).
- Field survival and growth of clonal DRJ.
- The breeding system of jarrah (with Murdoch Univ.).
- Dieback resistant jarrah – Landscope article.

Margaret Byrne

- Attended Genetics Society of Australia Conference (Perth, 29 Sep. – 1 Oct); presented Paper
- "Identification of QTL for resistance to *Phytophthora cinnamomi* in *Eucalyptus marginata*";
- Attended IUFRO meeting at Rotorua in December.
- Attended Genetics Society of Australia Conference (Sydney, Jul 8-12)
- Attended International Symposium on Conservation Biology (Sydney Jul 13 - 18), Presented paper "Genetic diversity and conservation of the oleosa group of oil mallees".
- Seminars presented at School of Biological Sciences, Curtin University; Department of Biochemistry. The University of Western Australia: Department of Botany, The University of western Australia.
- Gave lecture to 3rd year students in Department of Botany, The University of western Australia.
- Media interview - The West Australian, article "A gene to save jarrah near"
- Supervision of 2 honours students - Murdoch University.
- Report to Manager, Farm Forestry Unit. "Genetic diversity of the oleosa group of oil mallees"
- 1998 Publications
- Molecular markers for *Phytophthora cinnamomi* resistance in jarrah. (M.Byrne et al.)
- High genetic identities between three oil mallee taxa, *Eucalyptus kochii* ssp. *Kochii*, ssp. *Plenissima* and *E. horistes*, based on nuclear RFLP analysis. Heredity accepted
- Genetic diversity and conservation of the oleosa group of oil mallees. Australian J. Botany (special issue)
- Allozyme analysis of the mating system of Jarrah, *Eucalyptus marginata* (Myrtaceae) Australian J. Botany
- Disease effects and the conservation of forest trees. Book chapter in Forest Conservation Genetics. Principles and Practice.

OUTCOMES:

- Continuous, infusion of improved genotypes into propagule populations for immediate deployment.
- Changes to design of oil mallee seed orchards due to analysis of genetic resources.
- Adoption strategy: (Describe how outcomes will be implemented)

- Immediate, best genotypes are cloned, crossed to establish new and continuing improvement seed orchards on a rolling front.

ADOPTION STRATEGY:

- Regular meetings of Tree Breeding and Deployment Advisory Group provides the liaison and link between CALM**Science** and Plantation Business Unit for immediate implementation of CALM's best breeding material for operations use.
- Design of crossing programs and orchards for specific plantation objectives.
- DNA validation of genetic material used for CALM deployment.
- Preparation and distribution of management prescriptions and Tree Breeding "Fact sheets" for commercial species programs.
- Assistance with CALM manuals on genetic deployment.
- CALM internet site for local, Australian and International promotion of CALM**Science** tree breeding programs and current activities.
- Scientific papers (conference and journals).
- Continuous interaction with Plantation Business Unit staff on all matters pertaining to tree breeding, species selection and silviculture.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Dryland Tree Crops

PROJECT LEADER:

Richard Harper, Como

SCIENCE PROJECTS / CORE FUNCTIONS:

Site evaluation systems

93/0158	Site evaluation systems
TBA	Site evaluation for *Pinus pinaster* (FFP - Peter Ritson)

Establishment, stand management and water use

TBA	ARC medium rainfall zone water use and nutrition studies (with A/Prof. Mark Adams, UWA)
93/0151	Site specific silviculture
93/0152	Use of heat pulse methodology to measure sap flow in pine spp.
TBA	Ultra-short agroforestry rotations for salinity control (JVAP funded desktop study with UWA, CSIRO Land & Water).
TBA	Putting Trees in Their Place - optimizing tree placement across the landscape (with Agric WA, UWA, CSIRO Land & Water – NHT-FFP funded)
Proposed	One-pass planting systems (Plantations Group – seeking funding)

System development

TBA	Selection and development of multiple purpose species for large scale revegetation (NHT/FFP proposal)
93/0125	Oil eucalypt development
Proposed	Tree crops for salinity control and greenhouse gas sequestration (CALM/Japanese Universities and Industry)

STAFF:

Staff	Location	FTE
S. Crombie	Como	0.1
I. Dumbrell	Busselton	0.8
R Harper	Como	0.5
K. Mungham	Busselton	0.8
B. Read	Busselton	0.4
Total		**2.6**

*Funding approved, contracts to be signed (12/98)

Note: It is envisaged that many of the individual SPPs in this project area will run as joint projects with staff from other agencies (e.g. AgWA, University of WA, CSIRO Land and Water) with external funding (NHT-FFP, RIRDC, LWRRDC, ARC)

PROJECT OBJECTIVES:

To develop systems which allow the integration of trees into farmland and farming systems in the <600 mm rainfall zone. By:

- optimizing the growth performance of trees by determining the most suitable species, best establishment techniques and best management practices
- determining the best distribution of trees to maximise their water use and thus salinity control.
- devising practical management strategies which optimize the profitability and sustainability of trees established on farmland.
- devising strategies which take into account present and future risks to farm forestry from pests and diseases.

Developing a co-operative Western Australian approach to farm forestry R&D, developing joint funding proposals to prospective sources with partners from other institutions (e.g. Universities, Agric WA).

SIGNIFICANCE & BENEFITS:

- This project will result in improved performance (growth, survival) of farm forestry systems in the <600mm rainfall zone.
- Demonstrating successful farm forestry systems will encourage investment in this area.
- Successful farm forestry systems will have a significant impact on solving farm-land degradation caused by salinity and wind erosion, in the<600 mm rainfall zone.

DESCRIPTION:

This project consists of several inter-related SPP's. A broad break-down of these is

- Site evaluation systems: Determine factors (soils, geomorphic, climatic) which affect farm forestry performance. Develop a site evaluation system which predicts growth and water

use, site-specific management requirements (i.e. fertilizer, cultivation) and erosion risks. Assess value of ecohydrological models (i.e. TOPOG) in predicting water distribution across landscapes. Assess value of remote sensing and geophysical techniques in predicting development of salinity. Provide a framework for tree planting in the region using regional data sets (soils, climate, hydrology). Undertake land evaluations for specific projects.

- Establishment and stand management: Nutrient requirements and stand densities to optimize growth and survival. Develop an understanding of the interaction between stand density, fertilizer inputs and tree performance. Develop management systems (site-specific silviculture) which allows management regimes to be tailored to site conditions. Determine the best placement of trees on farms to optimize profitability and water use. Determine whether fast-growing strips of trees can rapidly de-water landscapes Refine the heat pulse methodology as a tool to measure water uptake. With plantations group develop a one-pass planting system for cheaply establishing trees on farms.
- System development: Select and develop a range of multiple purpose tree species to allow large-scale revegetation to occur. Take into account potential tree performance and products. This operates on assumption that large-scale tree planting will not occur unless there is a commercial driver (as seen with *Eucalyptus globulus*). More specifically develop an oil eucalypt industry (Plantations Group). Assess the performance of sandalwood. Assess a range of tree crops from their potential to fix greenhouse carbon.

Several complementary projects are being undertaken elsewhere in CALM including:

- CALM Plantations Group (weed control, cultivation, genetic deployment)
- CALM**Science** (Plantation Nutrition, Project Bluegum, Sandalwood Ecology and Management; Genetics and Tree Breeding (93/146))

METHODOLOGY:

Site evaluation systems

- Adapt existing land evaluation techniques (Australian standards) for farm forestry.
- Determine whether new techniques of land evaluation (remote sensing, airborne geophysics) provides information useful for the placement of trees.
- Develop a regional afforestation framework, using regional data sets (soils, climate). Define different growing zones.
- Regional survey of growth and site attributes (~200 plots) of *Pinus pinaster.* Development of multivariate regression equations.

Establishment, stand management and water use

- Establishment of trials across a range of sites, which define the relationship between soil fertility and water supply (rainfall, soil water storage) and demand for farm forestry species (i.e. *Pinus pinaster*). Define safe canopy sizes (Leaf area index) across the different environmental zones. Relate growth responses to soil fertility and fertilizer inputs.

System development

- Establish trial plantings and demonstration plots of potential new farm forestry species. Measurement and analysis. Determine likely markets for new species.

MILESTONES:
(only for those components that are presently funded)

Whole project

- Tour of CALM Operations with Plantations Group to outline SID plans and introduce R&D partners — July 1998
- Presentation to Agric WA/WRC/DEP on R&D aims — July 1998
- Visit to key LCDC groups — Dec 1998
- Field tour with key Federal funding managers to demonstrate scope of CALM R&D in this area — Oct 1998

Site evaluation systems

- Revised site evaluation guidelines for Pinus pinaster — April 1998
- Attend LWRRDC Salinity Workshop, Adelaide — April 1998
- Develop proposals to LWRRDC re remote sensing and geophysics — June 1998
- Seminar comparing different hydrology models and their impact on tree planting recommendations — April 1999
- Recommendations re use of EM38 for salinity assessment — Dec 1998

Establishment and stand management

- Complete heat pulse calibration and write up — June 1999
- CALM Seminar outlining ARC project — Nov 1998
- Field day early rotation nutrition — Dec 1998

OUTPUTS:

- Management prescriptions for different project components
- Land evaluation reports and maps for CALM farm forestry project proposals (i.e. BP, Gorgon)
- Adoption seminars and training sessions
- Scientific papers and conference presentations

OUTCOMES:

- Improved prescriptions for establishment and management of trees planted on farmland. Previous outputs from SPP's in this area have resulted in substantial changes in management practice (i.e. site selection, fertilization).
- More profitable (better growth, lower mortality) plantations
- Research group with national reputation for applied farm-forestry R&D.

ADOPTION STRATEGY:

- Preparation and distribution of management prescriptions (via CALM/Agric WA Farm Forestry Advisory Service Tree Note)
- Management reports elaborating on findings
- Field days/seminars for managers with results, training (if necessary) and feedback
- Scientific papers (journals and conference) to put results in the public arena
- Popular press article
- Information on CALM's Internet site
- Continual advice to plantation managers on informal basis

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Western Bluegum Plantations

PROJECT LEADER:

Richard Harper, Como

SCIENCE PROJECTS / CORE FUNCTIONS:

Site evaluation systems

93/0123	Site evaluation for *E. globulus*
93/0138	Performance of *E. globulus* on the Esperance sandplain
TBA	Subsoil constraints to tree water use by *E. globulus* (LWRRDC)

Establishment and stand management

93/0128	Early/mid rotation nutrition of *E. globulus* in south west WA
96/0003	Diagnosis and correction of manganese deficiency in *E. globulus* growing on the Esperance sand plain
TBA	Late first rotation and second rotation *E. globulus* growth and survival

Drought tolerance

93/0130	Drought deaths in *E. globulus* on the Darling Scarp
97/0006	Genetic basis for drought tolerance in *E. globulus*
TBA	Growth, drought tolerance and mortality in *E. globulus* subspecies *bicostata*, *globulus*, *maidenii* and *pseudoglobulus*.

Pests and diseases

93/0084	Parrot control methods
93/0164	Seasonal variation in parrot damage
94/0012	Silvicultural treatment of parrot damage

Laboratory analyses

TBA Analyses of soil, water and plants for CALMScience (Como Laboratory)

STAFF:

Staff	Location	FTE
S. Crombie	Como	0.9
R. Harper	Como	0.5
G. Hornum	Dwellingup	1.0
S. McArthur	Como	1.0
T. Reilly	Busselton	1.0
L. Wong	Como	1.0
Total		**5.4**

PROJECT OBJECTIVES:

- To understand nature of interactions between site (soil, hydrological and climatic) properties and *Eucalyptus globulus* performance (survival and growth) on farm-land in the >600 mm rainfall zone.
- To devise practical management strategies (fertilizer programs, safe stand density limits) which optimize the profitability and sustainability of *Eucalyptus globulus* plantations established on farmland.
- To devise strategies which take into account present and future risks to *Eucalyptus globulus* plantings from pests and diseases.
- Develop WA industry approach to *Eucalyptus globulus* R&D. Develop co-operative R&D proposals to Commonwealth funding bodies and industry with partners from other institutions (e.g. Universities, Agric WA).
- To provide soil and plant laboratory services to support this and associated programs in CALM.

SIGNIFICANCE & BENEFITS:

- This project will result in improved performance (growth, survival) of *Eucalyptus globulus* plantations established on farmland. Benefits will flow both to CALM's industry partners and the emerging blue-gum industry.
- A successful *Eucalyptus globulus* industry will have a significant impact on solving farm-land degradation caused by salinity, in the >600 mm rainfall zone.

DESCRIPTION:

This project consists of several inter-related SPP's. A broad break-down of these is:

- Site evaluation systems: Determine factors (soils, geomorphic, climatic) which affect the growth of *Eucalyptus globulus*. Develop an understanding of the nature of growth limiting factors (i.e. what soil properties inhibit root growth and hence water uptake).

- Establishment and stand management: Nutrient requirements and stand densities to optimize growth and survival. Interaction between stand density, fertilizer inputs and tree performance.
- Drought tolerance: SPP's which investigate specific aspects of drought deaths such as regional distribution, incidence in relation to soil properties and its genetic basis. Relate critical soil and site attributes to optimum stand density for different rainfall/evaporation conditions.
- Pests and diseases: Determine impacts of various pests (invertebrate and vertebrate) and diseases on the performance of *Eucalyptus globulus*.
- Soil and plant analysis: Provide soil and plant analysis services which meet requirements of this and other CALM programs.

Several complementary projects are being undertaken elsewhere in CALM including:

- CALM Plantations Group (weed control, cultivation, genetic deployment)
- CALM**Science** (Forest Invertebrates and Fungi (93/0154); Genetics and Tree Breeding (93/147))

METHODOLOGY:

Site evaluation systems

- Regional survey of growth and site attributes (~500 plots). Development of multivariate regression equations. Relationship of tree performance to existing soil classification systems and soil surveys.

Establishment and stand management

- Establishment of fertilizer trials across a range of sites, which define the relationship between water supply (rainfall, soil water storage) and demand for *Eucalyptus globulus* across the south-west. Define safe canopy sizes (Leaf area index) across the different environmental zones. Relate growth responses to soil fertility and fertilizer inputs.

Drought tolerance

- Regional survey of drought deaths in *Eucalyptus globulus* (1993) followed by annual measurements. Establishment of trials that define the range of drought tolerance in *Eucalyptus globulus* and its sub-species.

Pests and diseases

- Monitor impact of pests and diseases. From existing literature devise integrated pest management strategies.

Soil and plant analysis

- Routine and specialized analysis of a range of soil and plant materials, using standard methods.

MILESTONES:

Whole project

- Field tour with key Federal and industry managers to demonstrate scope of CALM's R&D in this area - Oct 1998
- Travelling seminar series to Collie and Albany with key results and recs - Nov 1998

Site evaluation systems

- Revised site evaluation guidelines for *Eucalyptus globulus* - April 1998
- Field days (Albany, Collie) for field staff - June 1998
- Papers relating (a) multivariate relationships between soil and site properties and *Eucalyptus globulus* performance and (b) Utility of a priori soil classifications in predicting *Eucalyptus globulus* performance - July 1998
- Completion of field work for subsoil constraints work - July 1999
- Paper relating subsoil constraints to tree growth - Dec 1999

Establishment and stand management

- Paper from SPP 93/0128 (Early rotation nutrition) - Dec 1998
- Paper from SPP 96/003 (Mn deficiency) - Dec 1998
- Field day early rotation nutrition - Dec 1998

Drought tolerance

- Paper from SPP 93/0130 (Drought deaths) - Dec 1998
- Management report from 2nd rotation study - Dec 1998
- Field day for 2nd rotation water relations - Oct 1998
- Obtain funding for 2nd rotation water relations - Dec 1998

OUTPUTS:

- Management prescriptions for different project components
- Adoption seminars and training sessions
- Scientific papers and conference presentations

OUTCOMES:

- Improved prescriptions for establishment and management of *Eucalyptus globulus* planted on farmland. Previous outputs from SPPs in this area have resulted in substantial changes in management practice (i.e. site selection, fertilization).
- More profitable (better growth, lower mortality) plantations
- Sustainable blue-gum industry.
- Research group with national reputation for applied farm-forestry R&D.

ADOPTION STRATEGY:

- Preparation and distribution of management prescriptions (via CALM/Agric WA Farm Forestry Advisory Service Tree Note)
- Management reports elaborating on findings
- Field days/seminars for managers with results, training (if necessary) and feedback
- Scientific papers (journals and conference) to put results in the public arena
- Popular press article
- Information on CALM's Internet site
- Continual advice to plantation managers on informal basis

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Softwood Plantations

PROJECT LEADER:

John McGrath, Como

SCIENCE PROJECTS / CORE FUNCTIONS

93/0121	Early rotation nutrition of *P. radiata* on the south coast of WA
93/0122	Diagnosis of nutrient deficiencies in young *P. radiata* using foliar analysis
93/0140	Mid rotation response to thinning and fertilization by *P. radiata* and *P. pinaster*.
97/0004	Early rotation silviculture for second rotation pines on the Swan Coastal Plain.
TBA	Comparative use of mineral fertilizers and biosolids on the nutrition of pines on the coastal sand plain.

Note: The following four SPPs are studies of the nutrient requirements of tree crops, however, they are located in other PTPs as they primarily deal with the establishment and maintenance of tree crops on farmland.

93/0128	Early/mid rotation nutrition of *E. globulus* in southwest WA
96/0003	Diagnosis and correction of manganese deficiency in *E. globulus* growing on the Esperance sand plain
TBA	Growth, nutrition and water use of mid-rotation *P. pinaster* in the medium rainfall zone.
TBA	Nutrition of young *P. pinaster* on ex-farmland in the medium rainfall zone (ARC project)

STAFF:

Staff	Location	FTE
I. Dumbrell	Busselton	0.2
J. McGrath	Como	0.2
K. Mungham	Busselton	0.2
Total		0.6

PROJECT OBJECTIVES:

- To maximize the wood production from high rainfall CALM owned and managed plantations. This primarily includes the *P. radiata* and *P. pinaster* plantations in the southwest and includes the *P. radiata* sharefarm plantations on the south coast.
- Wood production will be optimized by the provision of appropriate fertilizer prescriptions for plantations at all stages of the rotation based on the results of fertilizer trial work on a wide range of sites.
- Fertilizer prescriptions will be based on objective analysis of growth rates, nutrient status (soil and or plant analysis) and potential performance for a given site based on climatic and location.

SIGNIFICANCE & BENEFITS:

- The project will ensure that the department's plantations are performing at their potential. Expenditure on fertilization will be based on response data on a site by site basis. The aim is to ensure that fertilization is both timely and economic.
- Description:
- The project consists of a series of SPPs, which investigate the nutrient requirements of a range of tree crops on a range of sites under a range of climatic and silvicultural conditions. The interaction between water supply (determined by climate, soil conditions and silviculture) and nutrient supply (previous site management, fertilizer applications) has been extensively studied in a series of trials where both the tree nutrient and tree water status has been measured.

METHODOLOGY:

- The project consists of a series of fertilizer rate trials, fertilizer interaction trials (examining the response to the application of combined fertilizers) and thinning by fertilizer trials. These trials are located across the southwest from the pinaster plantations north of Perth to east of Albany.
- Trials are monitored for tree growth, soil and plant nutrient status and where appropriate soil water and tree water status (leaf water potentials are monitored at frequent intervals)

SCHEDULE OF TASKS:

- Establish biosolid trial (Jun-Dec 1998)
- Continue measurement of 6 trials (June 1998-Dec 2000)
- Draft first 6 papers (Jun –Dec 1998)
- Draft second 6 papers (Jun-Dec 1999)
- Draft third 6 papers (Jun-Dec 2000)

MILESTONES:

- There is a significant backlog of unpublished work from this area of work. While most of the findings have been implemented, the work needs to be documented in a formal way to ensure it is available in the future and all the results are implemented. There are some

trials that are still in progress and these will continue to be measured for the next few (2-3) years. The list of papers/reports that will come from this work is attached.

- Establish biosolid evaluation trial at Myalup plantation in conjunction with the Water Corporation in 1998
- Measure ongoing trials (Gnangara, Yanchep Harvey (3 trials), Vasse1, Vasse 9, Baudin 1.
- Commence Publication of backlog, the aim for 1998 is to get the first 6 publications to the stage of submission by the end of 1998.

OUTPUTS:

- Research papers covering the trial work (see attached list)
- Manuals covering the diagnosis and correction of nutrient deficiencies (currently the plantation silviculture manuals are being upgraded)
- Advice to forest managers on both a formal (seminars, field days) an informal (requests for advice) basis

OUTCOMES:

- As outlined above information on the nutrient requirements of plantations has already been made readily available to plantation managers and this has led to the implementation of a large scale plantation fertilization program (annually up to $2 m is spent on the fertilization of conifer plantations in WA)
- As appropriate (when new information is available) the plantation manuals will be modified.

ADOPTION STRATEGY:

- Research papers covering the trial work – (validation of findings).
- Manuals covering the diagnosis and correction of nutrient deficiencies (currently the plantation silviculture manuals are being upgraded).
- Advice to forest managers on both a formal (seminars, field days) an informal (requests for advice) basis.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Tropical Plantations

PROJECT LEADER:

Tanya Vernes, Kununurra

SCIENCE PROJECTs / CORE FUNCTIONS

TBA *Santalum album* : host relations. Plantation growth and heartwood development of the root hemi-parasite *Santalum album* (Indian sandalwood).

STAFF:

Staff	Location	FTE
T. Vernes	**Kununurra**	**1.0**
Total		**1.0**

PROJECT OBJECTIVES:

The single most important silvicultural parameter influencing plantation *S. album* survival and growth is host species. Although the degree of reliance on the host plant may vary widely suitable host selection benefiting parasitic growth is critical. *S. album* parasitic habit increases plantation silviculture complexity compared to traditional monoculture plantations.

Objectives of this project

- Provide a reliable and routinely used *Santalum album* silvicultural system (nursery and field) for Cununurra clay sites within the Ord River Irrigation Area.
- Identify other potential high value timber species, either for use within *S. album* plantations as long term hosts or as 'stand-alone' plantation species.
- Determine the feasibility of inducing early *S. album* heartwood formation.

- Development of a refined *S. album* : Alternanthea nana propagation system.
- Identification of suitable *S. album* intermediate hosts.

Significance & Benefits:

- The development of a routine *S. album* and host nursery and plantation silvicultural system will assist in the development of *S. album* plantation resource in northern WA.
- Western Australia has maintained an entirely export orientated sandalwood industry since mid 1840, based on the native *Santalum spicatum*. This industry generates approximately 10% of CALM's revenue. Santalum, comprising of 16 species, is perhaps the most important commercial root hemi-parasite genera. Of these *S. album* is the most commercially important species. The general move away from the exploitation of native timber species to the development of plantation resources gives impetus to *S. album* silvicultural investigations within the Ord River Irrigation Area, northern Western Australia.
- This project will deliver information on Santalum: host relations which is fundamental to understanding the silvicultural complexities of *S. album*. The project has immense practical implications and urgent demands due to considerable commercial activity and the development of private sector plantation programs.

Description:

- This project was initially established as an ACIAR collaborative project in late 1992. The initial 3 years were strongly influenced by operational responsibilities and closely followed the ACIAR project format. The research project now forms the basis of a PhD for Andrew Radomiljac at Murdoch University under supervision from Jen McComb and John McGrath.
- The project has identified suitable pot and intermediate hosts for *S. album* and has provided fundamental information on silvicultural issues, including pot size and type, time of introduction of pot host, host species propagation requirements, site preparation, weed control, seed collection and storage, seed germination, parasite: host ratios, parasite : host stand densities.

METHODOLOGY:

- A range of pot culture and field experiments, using fully randomised complete block designs are and will be used. Parasite and host survival and growth performance, dry matter partitioning, physiological and chemical assessments will continue to be used. This will involve both destructive and non-destructive assessments, including repetitive assessment over time (up to 12 months).
- Growth data will be analysed using ANOVA and Tukey's pairwise t-test using SYSTAT statistical software.

SCHEDULE OF TASKS:

In 1998 submit for publication the following manuscripts

Radomiljac, A. M., McComb, J. A. and Shea, S. R. Field establishment of *Santalum album* L. - the effect of the time of introduction of a pot host (Alternanthera nana R. Br.).

Radomiljac, A. M., McComb, J. A. and McGrath, J. F. Intermediate host influences on the root hemi-parasite *Santalum album* L. biomass partitioning.

Radomiljac, A. M., McComb, J. A., Pate, J. S. and Tennakoon, K. U. Organic solute transport and assimilation in *Santalum album* : intermediate host partnerships involving beneficial and non-beneficial hosts.

Radomiljac, A. M., McComb, J. A. and Pate, J. S. Gas exchange and water relation characteristics of the root hemi-parasite *Santalum album* L. grown in association with legume and non-legume woody hosts.

Radomiljac, A. M., Shea, S. R., McKinnell, F. H. and McComb, J. A. Potential for irrigated tropical forestry in northern Western Australia.

Radomiljac, A. M. *Santalum album* data sheet. CAB International Forestry Compendium.

Radomiljac, A. M. and McComb, J. A. *Alternanthera nana* R. Br. Nursery sowing time influences *Santalum album* L. growth following field planting. Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.

Radomiljac, A. M. and McComb, J. A. Nitrogen and non-nitrogen fixing woody host influences on the growth of the root hemi-parasite *Santalum album* L. Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.

Shea, S. R., Radomiljac, A. M., Brand, J. and Jones, P. An overview of sandalwood and the development of sandalwood in farm forestry in Western Australia. Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.

Brennan, G. K. and Radomiljac, A. M. Preliminary assessment of the potential and wood properties of plantation teak (Tectona grandis) and African mahogany (Khaya senegalensis) grown near Kununurra, Western Australia.

Radomiljac, A. M. and Bosimbi, D. *Santalum macgregorii* in Papua New Guinea.

Radomiljac, A. M. *Santalum album* L. plantation parasitism and heartwood development. PhD Thesis.

MILESTONES:

- 1/98 Submit to Forest Ecology and Management; Radomiljac, A. M., McComb, J. A. and Shea, S. R. Field establishment of *Santalum album* L. - the effect of the time of introduction of a pot host (Alternanthera nana R. Br.).
- 1/98 Submit to Australian Forestry; Radomiljac, A. M., Shea, S. R., McKinnell, F. H. and McComb, J. A. Potential for irrigated tropical forestry in northern Western Australia.
- 1/98 Submit to ACIAR proceedings; Shea, S. R., Radomiljac, A. M., Brand, J. and Jones, P. An overview of sandalwood and the development of sandalwood in farm forestry in Western Australia. Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.
- 1/98 Submit to Australian Forestry; Brennan, G. K. and Radomiljac, A. M. Preliminary assessment of the potential and wood properties of plantation teak (Tectona grandis) and African mahogany (Khaya senegalensis) grown near Kununurra, Western Australia.
- 1/98 Submit to Australian Forestry Newsletter; Radomiljac, A. M. and Bosimbi, D. Santalum macgregorii in Papua New Guinea.
- 1/98 Submit to ACIAR proceedings; Radomiljac, A. M. and McComb, J. A. Alternanthera nana R. Br. Nursery sowing time influences *Santalum album* L. growth following field planting. Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.

- 1/98 Submit to ACIAR proceedings; Radomiljac, A. M. and McComb, J. A. Nitrogen and non-nitrogen fixing woody host influences on the growth of the root hemi-parasite *Santalum album* L. Proceedings of the International Sandalwood Seminar, Bangalore India. 18-19th December 1997.
- 2/98 Visit Kununurra; meet with Don Keene and Allrange Treefarms, inspect operations; meet with Jen McComb and John Pate, collect xylem sap, assess pot study, collect haustoria – nodule connections
- 3/98 Submit to Forest Ecology and Management; Radomiljac, A. M., McComb, J. A. and McGrath, J. F. Intermediate host influences on the root hemi-parasite *Santalum album* L. biomass partitioning.
- 3/98 Submit to CABI; Radomiljac, A. M. *Santalum album* data sheet. CAB International Forestry Compendium.
- 3/98 Draft Project Team Plan prepared
- 3/98 Compile and send 7th Sandalwood Research Newsletter issue
- 4/98 Submit to journal; Radomiljac, A. M., McComb, J. A., Pate, J. S. and Tennakoon, K. U. Organic solute transport and assimilation in *Santalum album* : intermediate host partnerships involving beneficial and non-beneficial hosts.
- 4/98 ACIAR review of Australia : India sandalwood collaborative project
- 5/98 Submit to journal; Radomiljac, A. M., McComb, J. A. and Pate, J. S. Gas exchange and water relation characteristics of the root hemi-parasite *Santalum album* L. grown in association with legume and non-legume woody hosts.
- 5/98 Publish ACIAR Proceedings of the International Sandalwood Seminar, Bangalore India, 18-19th December 1997.
- 6/98 Submit to journal: *Santalum album* mineral nutrient distribution paper
- 6/98 Visit Kununurra for destructive assessment of intermediate host selection field experiment. Inspect and advise operations. Establish Acacia trachycarpa provenance experiment.
- 6/98 Assess *Santalum album* progeny experiment
- 6/98 Assess high value timber species selection experiment on clay and sand sites.
- 8/98 Submit thesis Radomiljac, A. M. *Santalum album* L. plantation parasitism and heartwood development. PhD Thesis.
- 8/98 Visit India for ACIAR project commencement
- 8/98 Advertise for ACIAR project scientist
- 9/98 Submit intermediate host selection field experiment paper to journal
- 9/98 Visit Kununurra for induction of ACIAR project scientist
- 10/98 Submit available soil N / intermediate host selection field experiment paper to journal
- 11/98 Submit plantation decline paper to journal
- 12/98 Compile reports on heartwood induction research.

OUTPUTS:

- PhD thesis
- 7-8 journal papers
- 3-5 conference papers
- 5-6 seminar presentations
- 2 field days
- 1 ACIAR published seminar proceedings
- Significant advice to operations sections
- ACIAR project funding

OUTCOMES:

- Commercialisation of research
- Direct revenue benefit to CALM
- Establishment of new forest crop / industry
- 3-6 years external funding and collaborative research on tropical forestry.
- Adoption of novel silvicultural system
- Adoption of revised silvicultural systems
- The development of a routine *S. album* silvicultural system will assist the development of a robust tropical forestry program for northern Western Australia which is highly relevant to CALM's corporate strategies.

ADOPTION STRATEGY:

- Commercialisation of research and the private sector establishment of a *S. album* plantation resource.
- Anticipated users of knowledge gained will be CALM Plantations group and operations, private sector sandalwood investors and local ORIA landowners.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Forests and Tree Crops

PROJECT TITLE:

Vegetation Health Service

PROJECT LEADER:

Francis Tay, Como

SCIENCE PROJECTS / CORE FUNCTIONS

N/A

STAFF:

Staff	Location	FTE
F Tay J Webster N D'Souza *=externally funded	Como Como Como	1.0 0.6 0.4; 0.6*
Total		**2.6**

PROJECT OBJECTIVES:

- To help maintain and protect the State's vegetation resource by providing accurate diagnosis of the cause of plant disorders and advice on cost-effective remedial measures.
- To provide an efficient diagnostic and advisory service to CALM and to paying clients by providing expert advice on treatments and management options for problems diagnosed.
- To maintain expertise in dieback disease detection and continue to build a database of the host range, and distribution of *Phytophthora* species.
- To be aware of diseases which could be a potential threat to plants, especially those of economic or conservation importance.

- To build a database of information on other important woody plant diseases other than *Phytophthora* diseases.

SIGNIFICANCE & BENEFITS:

- Provide *Phytophthora* detection results to CALM's Dieback Interpreters to assist them in making the correct operational decisions.
- Provide a comprehensive computerized database of information on the distribution of *Phytophthora* species and their host plants throughout WA.
- Provide results of the diagnosis of other plant diseases and cost effective remedial measures where possible.

DESCRIPTION:

- The VHS carries out 2 main functions
- *Phytophthora* (Dieback) Diseases Detection:
  Soil and plant samples sent in by various sections of CALM (eg. Dieback Interpreters from Forest Management Branch and Field Officers from District Offices) are processed by either the baiting or direct plating methods to detect the presence of *Phytophthora.*
- General Plant Disease Diagnosis
  Other plant diseases eg leaf diseases, stem and branch cankers, are also diagnosed by the VHS.

METHODOLOGY:

- *Phytophthora* (Dieback) Diseases Detection:
  Soil and plant are processed by either the baiting or direct plating methods to detect the presence of *Phytophthora* . When detected positive, a complete identification is carried out to determine the species and the findings are reported to the sender. All information relating to every sample, eg map reference, sampling date, host plant species, land tenure, result of identification, etc., is recorded in the VHS database.
- General Plant Disease Diagnosis:
  Other plant diseases eg leaf diseases, stem and branch cankers, etc., are also diagnosed by the VHS. Plant samples are examined and the cause of the disease determined as accurately as possible through plant tissue plating and fungal identification. The VHS can also arrange for plant nutrient analysis to be carried out if the problem is thought to be of a nutritional nature. The results of findings and recommendations are presented in a report.

SCHEDULE OF TASKS:

- Processing of samples generally takes 2 weeks.

MILESTONES:

Achievements

- The computerised database was set up in 1992 (pre-VHS). All of the useful early information was entered into the database in 1993 (VHS). Since the formation of the VHS a computerised database of information for *Phytophthora* detection and identification has been established and new information is being included with each sample processed. The total number recorded as at 30-6-98 is 15,753 samples. Total number of samples received by the VHS per year since its formation were: 1993/94 - 1074samples; 1994/95 - 999; 1995/96 - 1762; 1996/97 - 1944; 1997/98 - 2202.
- Since the formation of the VHS (ie from August 1993-June 1998), 117cases of plant diseases have been examined, involving Pinus pinaster, Pinus radiata, Eucalyptus globulus, Santalum album (Sandalwood), Oil Mallees, Jarrah, Banksias, Paperbarks, etc.
- A fee paying service was introduced in March 1995, and since then the VHS has been able to upgrade its facilities with
  - f) a new Pentium computer, to manage the expanding database of information on *Phytophthora* diseases, to accommodate future plans to produce distribution maps of *Phytophthora* isolated within Western Australia, and to produce enhanced images from the electronic key when identifying *Phytophthora* .
  - f) a new refrigerator, used to store antibiotics and agar media etc.
  - f) 3 new incubators, one used for storing live fungal cultures,and the other for incubating cultures which are being identified.
  - f) a barcoding machine and accessories to facilitate labelling and scanning of samples, and
  - f) renovations to the walk-in incubation room in order to increase efficiency and productivity, and promote safety.
  - f) an image analysis system, consisting of a digitised video camera and Pentium computer to facilitate the process of spore measurement and tabulation.

  The fee paying service has been curtailed somewhat and now all CALM's Business Unit samples are processed free-of-charge. This has subsequently reduced the income to the VHS.

- The VHS has acquired an isoenzyme laboratory for the identification of the more difficult to identify species of *Phytophthora*.
- The VHS has also acquired an electronic key for the identification of *Phytophthora* species. This key was developed by the Information Science Section (ISS) of the former Science and Information Division of CALM (since renamed the CALM**Science** Division).

OUTPUTS:

Ongoing

- Annual open day for CALM's Dieback Interpreters to find out about the operations of the VHS and to learn about *Phytophthora*.

Recent

- An article in CALMNEWS Sept/Oct 1997, "New *Phytophthora* strain found".

- A paper published in the Australasian Plant Pathology Society (APPS) journal.
- A poster paper entitled " *Phytophthora* species in Natural Vegetation in Western Australia" was presented at the APPS Conference in Perth in 1997.
- A major part of the data used for a project entitled "Development of GIS-Based Decision Support Tools and The Databasing of *Phytophthora* -sensitive Taxa" was obtained from the VHS database. This project was published in the final report of The Threatened Species and Communities Unit, Biodiversity Group Environment Australia in May 1997. The title of the report is "Control of *Phytophthora* and *Diplodina* Canker in Western Australia."

OUTCOMES:

Results of *Phytophthora* detection and diagnosis of diseases are reported to the senders of the samples and they usually facilitate the implementation of policy and management prescriptions.

ADOPTION STRATEGY:

The accurate information from diagnosis and the recommendations provided should help Field Officers make sound operational decisions.

ASTRONOMICAL SERVICES

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Perth Observatory

PROJECT TITLE:

Astronomy education services

PROJECT LEADER:

Provisionally J Biggs / To Be Decided

SCIENCE PROJECTS / CORE FUNCTION:

Provision of astronomy education services.

STAFF:

Staff	Location	FTE
J Biggs	Observatory	0.2
P Birch	Observatory	0.2
R Martin	Observatory	0.2
A Williams	Observatory	0.2
G Lowe	Observatory	0.4
J Pearse	Observatory	0.3
T Smith	Observatory	0.4
A Verveer	Observatory	0.3
Total		**2.2**

PROJECT OBJECTIVES:

- Provision of relevant and timely educational services.
- Demonstrate science in action, and the role of astronomy in everyday life.
- Facilitate the development of the tourism potential of astronomy

SIGNIFICANCE & BENEFITS:

There is a significant demand for astronomy education services from many different groups and individuals within the community. Conduct of this project works to satisfy this demand and is also in accord with the state government's Science and Technology Policy goals of assisting science education as well as facilitating an appreciation of science and technology within the general community.

METHODOLOGY:

Many methods will be employed in this project that shares many points in common with the astronomy information core function. For this project the most fundamental activity is communication. Astronomical information, recent discoveries, applications etc will be communicated to many different audiences, via many different channels and media, as appropriate. Day and night-time visits will be employed to provide the general public, and the education sector, first-hand experience of astronomy. Resources such as internet facilities will be maintained in order to foster accessible educationally meaningful astronomical activities

SCHEDULE OF TASKS:

1998

- Provide lectures, talks, workshops etc.
- Provide astronomy activities for visitors; star viewing, day tours, astronomy field nights etc.
- Maintain library.
- Maintain website.
- Maintain museum.
- Develop and market astronomy education resources.
- Plan new enclosure to facilitate public star viewing with 16" Meade telescope (1998).
- Create equipment for day-time astronomy (1998).
- Design enclosure automation for Project Astronet internet telescope (1998).

1999

- as for 1998
- Commission new enclosure for 16" Meade telescope.
- Seek sponsorship for Project Astronet operation.
- Upgrade Observatory website so that updating is more efficient.
- Establish new astronomy technical officer FTE

2000

- as for 1998
- Plan new enclosure to facilitate public star viewing with historic Catt's/UWA 16" telescope.
- Update astronomy project kits.
- Organise a "Friends of Perth Observatory Society/Programme".

MILESTONES:

1998

- Commence enclosure automation for Project Astronet internet telescope.
- Operational solar telescope.

1999

- Successful operation and use in public star viewing sessions of 16" Meade telescope in its new enclosure.
- Sponsorship for Project Astronet operation.
- Manual operation of Project Astronet telescope.
- 5% increase in tour attendance.

2000

- Operation of Project Astronet.
- Update Observatory website at least every month
- Initiation of a "Friends of Perth Observatory Society/Programme".
- 5% increase in tour attendance.

OUTPUTS:

These are detailed in Perth Observatory monthly performance statistics.

- Publications - journal articles, fact sheets, planispheres, newspaper articles etc
- Communications - lectures, presentations, workshops, Observatory visitors programme, website, media appearances, interviews etc.

OUTCOMES:

- Satisfaction of demand for educational services, and, requirements of government Science and Technology Policy.
- Reputation for excellence in astronomy education.
- Changes to policy and management not applicable.

ADOPTION STRATEGY:

Not applicable.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Perth Observatory

PROJECT TITLE:

Astronomy information services

PROJECT LEADER:

Provisionally J Biggs / To Be Decided

SCIENCE PROJECTS / CORE FUNCTION

Provision of astronomy information.

STAFF:

Staff	Location	FTE
J Biggs	Observatory	0.2
P Birch	Observatory	0.2
R Martin	Observatory	0.2
A Williams	Observatory	0.15
G Lowe	Observatory	0.2
J Pearse	Observatory	0.1
T Smith	Observatory	0.2
A Verveer	Observatory	0.1
Total		**1.35**

PROJECT OBJECTIVES:

Provision of relevant and timely astronomical information.

SIGNIFICANCE & BENEFITS:

There is a significant demand for astronomical information from many different groups and individuals within the community. Conduct of this project works to satisfy this demand and provides a service of direct relevance to the community. Also, provision of certain astronomical information is required by state law.

METHODOLOGY:

Many methods will be employed in this project that shares many points in common with the astronomy education core function. However, its most fundamental activity is communication. Astronomical information, recent discoveries, applications etc will be communicated to many different audiences, via many different channels and media as appropriate. Resources such as internet facilities will be maintained in order to foster access to astronomy information. The Observatory's archives will also be restored using standard techniques in order to facilitate access to, and survival of, these historic documents.

SCHEDULE OF TASKS:

1998

- Provide lectures, talks, workshops etc.
- Answer written and telephone enquiries.
- Maintain information telephone line.
- Provide information to the news media.
- Write fact sheets as appropriate.
- Provide natural lighting information.
- Maintain local time service
- Update astronomy project kits
- Maintain library.
- Maintain website.
- Decommission old time service equipment (1998).
- Obtain database software for library information (1998).

1999

- As for 1998
- Upgrade Observatory website so that updating is more efficient.
- Plan and design written inquiry database

2000

- As for 1998
- Restoration and digital recording of Observatory archives by volunteers.
- Create a poster display for each Observatory SPP
- Create a database of educational/informational talks/presentations/displays presented
- Create a database of posters and "transportable exhibits", and compile a list of display themes that could be undertaken given these resources

MILESTONES:

1998

- Upgrade Observatory internal time service.

1999

- Increase contacts by 2% (to account for state population growth)
- Successful utilisation of library information database software.

2000

- Increase contacts by 2% (to account for state population growth)
- Operation of active volunteer programme for the restoration and digital recording of Observatory archives.
- Update Observatory website at least every month
- Utilisation of written inquiry database
- Creation of posters for two Observatory SPPs
- Creation and use of educational/informational talks/presentations/displays database
- Creation of a database of posters and "transportable exhibits" and compilation of display themes list

OUTPUTS:

These are detailed in Perth Observatory monthly performance statistics.

- Publications - journal articles, fact sheets, planispheres, newspaper articles etc.
- Communications - lectures, presentations, workshops, Observatory visitors programme, website, media appearances, interviews etc.
- Establishment of appropriate volunteer programmes.

OUTCOMES:

- Satisfaction of demand for astronomical information.
- Satisfaction of requirements of state law.
- Changes to policy and management not applicable.

ADOPTION STRATEGY:

Not applicable.

CALM**Science** Division

PROJECT TEAM PLAN

GROUP:

Perth Observatory

PROJECT TITLE:

Astronomy Research

PROJECT LEADER:

Dr James Biggs

SCIENCE PROJECTS / CORE FUNCTION:

98/0009	Variable star observations
98/0010	Imaging and spectrophotometry of comets
98/0011	Imaging and CCD photometry of transient and variable sources
98/0012	Astrometry of minor planets, comets and targets of opportunity
98/0013	Monitoring gravitational microlenses
98/0014	Supernova search
TBA	Spectroscopy
TBA	Astronomical site testing

STAFF:

Staff	Location	FTE
J Biggs	Observatory	0.3
P Birch	Observatory	0.4
R Martin	Observatory	0.5
A Williams	Observatory	0.55
G Lowe	Observatory	0.4
J Pearse	Observatory	0.4
T Smith	Observatory	0.4
A Verveer	Observatory	0.4
Total		**3.35**

PROJECT OBJECTIVES:

- Monitor brightness changes in specific stars.
- Monitor brightness changes in comets over a wide range of heliocentric distances and image their coma and tail(s) for specific structural features in order to compare and contrast various cometary families and construct a data base of cometary properties.
- Detect changes in brightness of celestial sources, characterise these, and/or participate in their further study primarily using data acquired for other projects.
- Determine positions of minor planets (asteroids), comets and targets of opportunity and forward these to the International Astronomical Union for publication and dissemination.
- Participation in continuous, precise, rapid multi-band CCD photometry (and data reduction) of stars undergoing gravitational microlensing events.
- Search for extra-galactic supernovae in low-redshift spiral galaxies.
- Conduct spectrographic observations of relatively bright celestial objects.
- Test the suitability of appropriate Western Australian sites for astronomical observations.

SIGNIFICANCE & BENEFITS:

Conducting this project is direct participation in astronomy research. Knowledge will be obtained on the nature and orbits of Solar System objects such as comets and minor planets. Clues to the internal structure of stars will be obtained by spectroscopic and photometric observation of stars and supernovae. Microlensing observations also provides information on the number of faint galactic stars and their potential planetary companions. Site testing will provide information necessary for the planning of future facilities.

METHODOLOGY:

The project is composed of ongoing astronomical research programmes that exploit the isolated geographic location, expertise, and equipment available at Perth Observatory. Standard astronomical observing and data reduction techniques (adapted for the specific Observatory equipment) are used throughout.

In common with observatories world wide, a major thrust is to automate the observation and data acquisition processes.

Collaboration with other institutions and utilisation of their facilities will occur as appropriate. Refer to SPPs for more detail.

SCHEDULE OF TASKS

1998

- see SPPs
- Maintain and develop equipment
- Use 10" Mike Candy Telescope (MCT) for minor planet and comet astrometry.

1999

- See SPPs
- Maintain and develop equipment
- Commission spectrograph for use on 24" telescope.

2000

- see SPPs
- Maintain and develop equipment
- Commission 16" telescope for scientific use with CCD camera.
- Automate comet and minor planet observations using the MCT .

MILESTONES:

1998

- Published minor planet and comet positions acquired with MCT.
- 5 refereed publications.

1999

- Regular use of MCT for astrometric observations.
- 5 refereed publications.
- Double the yearly number of minor planet and comet positions published.

2000

- Complete commissioning of spectrograph and commencement of appropriate observing programmes.
- Characterisation of astronomical site conditions at Bickley.
- Remote control of whole night's observing on Lowell Telescope.
- 5 refereed publications.

OUTPUTS:

Refereed journal articles

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OUTCOMES:

- First-class science.
- World-wide reputation for excellence in astronomy and astrophysics.
- Scientific authority for educational and information services.
- Changes to policy and management not applicable.

ADOPTION STRATEGY:

Not applicable.

APPENDIX 1

CALM**Science** Division

LIST OF ACTIVE SCIENCE PROJECT PLANS BY REGION:

ALL REGIONS

93/0005	LANDER Nick	WA Flora Descriptive Database Research and Pilot Development. Subproject 1: Descriptive database design, issues, technology awareness. Subproject 2: Rare & Endangered & Priority Flora descriptive database.
93/0006	LANDER Nick	Taxonomic studies in the Asteraceae, tribe Asterineae
93/0008	MACFARLANE Terry	Taxonomy and inventory of WA flora: legumes, grasses and lillies
93/0010	RYE Barbara	Taxonomic review and conservation status of Western Australian plant groups
93/0011	RYE Barbara	Taxonomic studies of species on the Declared Rare and Priority Flora List.
93/0014	CHAPMAN A	Databasing (WACENSUS) and Publication of the Census of Western Australian Plants.
93/0045	PATRICK Sue	Population Surveys, Conservation Status and Area Based Wildlife Management Progams for Rare and Threatened Flora. 1. Moora District 2. Geraldton District 3. Katanning District 4. Albany District 5. Esperance District 6. Narrogin District 7. Central and Southern Forest Districts 8. Darling Scarp Endemics
93/0162	HALSE Stuart	Aquatic invertebrate surveys and atlas
94/0003	HOPKINS Angas	Regional assessment of the conservation status of vegetation units throughout Western Australia.
94/0005	GIOIA Paul/CHAPMAN Alex	An evaluation of the efficacy of remote sensing and GIS technologies for dieback mapping and monitoring
95/0009	MACFARLANE Terry	Taxonomic database of W.A. plant genera
96/0007	GIOIA Paul	Utilising GIS and BIOCLIM to examine species richness patterns of Western Australia's native biota
97/0002	KEIGHERY Greg/PIGOTT Patrick	Weeds of Western Australia:Advice, Liason, Publicity and Documentation
98/0003	BYRNE Margaret	Genetics and biosystematics for the conservation, circumscription and management of Western Australian flora
98/0007	BYRNE Margaret	Genetics and molecular biology of commercial tree species
98/0008	PINDER Adrian	Taxonomy and zoogeography of aquatic oligochaetes of Western Australia
99/0005	MASLIN Bruce	WATTLE: an electronic information system for Australian species of Acacia.

CENTRAL REGION

93/0013	WHEELER Judy	Flora of the lower south west
93/0015	FRIEND Tony	Systematics, Zoogeography and Phylogeny of the Terrestrial

		Amphipods of Australia (ABRS funded)
93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0037	GIBSON Neil	Floristic survey of the coastal communities of the Warren botanical subdistrict.
93/0042	COATES David	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES David	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0049	GIOIA Paul/CHAPMAN Alex	Development of GIS-based decision support tools in the control of Phytophthora and the management of Phytophthora-sensitive taxa and communities
93/0053	MORRIS Keith	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0054	DETORES Paul	The effect of fox control of the utilization of habitat by the mainland Quokka (*Setonix brachyurus*).
93/0059	LANE Jim	Development of guidelines for monitoring of Australia's Wetlands of International Importance (Ramsar Convention) (Externally funded)
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0070	SHEARER Brian	Control and management of *Armillaria luteobubalina* in native communities.
93/0075	WAYNE Adrian	Effects of spring and autumn prescribed burns on small vertebrates in jarrah forest.
93/0095	WHITFORD K	Characteristics of hollow-bearing jarrah and marri trees and coarse woody debris, their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them.
93/0096	ABBOTT Ian	Control of Jarrah Leaf Miner (JLM): (1) Performance and reinfestation of JLM in ground coppice after crown scorch by a moderate intensity prescribed spring burn. (2) Performance and reinfestation of JLM in ground coppice after crown scorch by an autumn prescribed burn.
93/0097	ABBOTT Ian	Control of Jarrah Leaf Miner (JLM): Selective retention of JLM resistant trees and ground coppice in a demonstration forest plot.
93/0099	BURROWS Neil	Fire regime effects on the structure and floristics of jarrah forests
93/0104	FARR Janet	Distribution of Gum-leaf Skeletonizer in the Central and Southern Forest Regions
93/0112	STUKELY Mike	Selection, screening and field testing of jarrah resistant to Phytophthora cinnamomi.
93/0122	MCGRATH John	Diagnosis of nutrient deficiencies in young *P. radiata* using foliar analysis. (Externally Funded)
93/0123	HARPER Richard	Performance of *Eucalyptus globulus*, planted on farms, in relation to soil and site attributes. (Externally Funded)
93/0126	MAZANEC Richard	Genetic variation in quantitative trials of exotic and endemic plantation and rehabilitation species.
93/0127	MOORE Richard	West Coast Pine Timberbelt Project. (Externally Funded)
93/0128	MCGRATH John	Early-mid rotation nutrition of *E. globulus* in south-west WA. (Externally Funded)
93/0130	HARPER Richard	Determining the cause of death of *Eucalyptus globulus* grown on shallow soils on the Darling Plateau. (Externally Funded)
93/0131	MAZANEC	Assessing the wood quality of *Eucalyptus globulus* breeding selections.

	Richard	(Externally Funded)
93/0137	MOORE Richard	Pine Timberbelts
93/0138	MOORE Richard	Eucalypts, for High Quality Sawlogs, Integrated with Farming.
93/0140	MCGRATH John	Mid rotation responses to thinning and fertilization by *P. radiata*.
93/0142	DE TORES Paul	Translocation of the western ringtail possum, *Pseudocheirus occidentalis*.
93/0145	FRIEND Tony	Factors affecting establishment in the numbat reintroduction program
93/0146	BUTCHER Trevour	*Pinus Pinaster* tree breeding - Strategy and Breeding Population Development & seed orchand, development and research
93/0147	BUTCHER Trevour	*Eucalyptus globulus* Tree Breeding - Strategy and breeding population development - Seed orchard development
93/0148	BUTCHER Trevour	*Pinas Radiata* Tree Breeding - Strategy and Breeding population development, Resistance Breeding - Phytophthora Cinnamomi, HAPSO development and research and Search 85 gene resource
93/0151	HARPER Richard	Site specific silviculture: making management decisions for *Pinus radiata* plantations on the basis of a site's water relations.
93/0152	CROMBIE Stuart	Measuring transpiration in *Pinus* spp. using the Heat Pulse Velocity (HPV) technique.
93/0153	ABBOTT Ian	Control of insect pests in young plantations of *Eucalyptus globulus*: Early indicators of pest insect outbreaks and the beneficial impact of spiders and parasitoids.
93/0157	DETORES Paul	Control and Ecology of the Red Fox in Western Australia - Native fauna response to 1080 baiting over large areas at three baiting frequencies.
94/0006	STUKELY Mike	Dieback-resistant jarrah establishment in operational forest rehabilitation sites
95/0007	WARD Dave	Basic information for the management of Brown Boronia (*Boronia megastigma* (Nees)) in State forest
95/0012	WARD Dave	Reconstructing fire history from leafbase patterns on grasstree stems.
96/0010	BURROWS Neil	Fire history and impact of Phytophthora cinnamomi in jarrah forests
97/0003	MCCAW Lachie	Project Vesta - prediction of high intensity fire behaviour in dry eucalypt forest
97/0004	MCGRATH John	Early rotation silviculture for second rotation pines on the Swan Coastal Plain
97/0005	DETORES Paul	Fox and cat density estimates, survivorship and home range estimates in the presence of 1080 baiting within the northern jarrah forest of southwest Western Australia - a pilot study
97/0006	CROMBIE Stuart	Drought tolerance in *Eucalyptus globulus*; early growth and water relations measurements of the EG51 trial (Lotons, Gibb Road, Collie) and EG52 (Folly Plantation, Nannup).
98/0020	GIBSON Neil/ KEIGHERY Greg	SAP – Biological survey of the agricultural zone.
99/0007	KAY Winston	First national assessment of river health – south-west forests

GASCOYNE REGION

93/0022	WILLIAMS Mark	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0040	PRINCE Bob	Conservation of Marine Turtles - Western Australian Region
93/0041	PRINCE Bob	Dugong Conservation - Northern Western Australia
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.

93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0056	MORRIS Keith	Recovery Plan for the Shark Bay Mouse (*Pseudomys fieldi*).
96/0014	ALGAR Dave	Broadscale cat control research
98/0003	BYRNE Margaret	Genetics and biosystematics for the conservation, circumscription and management of Western Australian flora
98/0004	KAY Winston	First National Assessment of River Health - North-West Australia

GOLDFIELDS REGION

93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0025	MCKENZIE Norm	Eastern Goldfields Survey
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0032	PEARSON David	Preliminary Survey of the Biological and Cultural Resources of the Ranges of the Western Desert (externally funded)
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0046	ALGAR Dave	Relative acceptability of bait materials to feral cats. (Externally funded).
93/0053	MORRIS K	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0092	PEARSON David	Fire Effects on Desert Vertebrates - Influence of Fire Season
93/0166	GIBSON NEIL	Floristic Survey of the Goldfield woodlands
95/0016	PEARSON David	Experimental Management and Monitoring of Desert Rock-wallaby Populations
96/0006	BRAND JON	Field ecology of the Western Australian Sandalwood (*Santalum spicatum* (R.Br.) A.DC.) and the impact of land management activities on sandalwood regeneration.
96/0014	ALGAR Dave	Broadscale cat control research
98/0017	MASLIN Bruce	*Acacia acuminata*: analysis of variation
99/0003	VAN LEEUWEN Steve	Biological survey of the Southern Little Sandy Desert.

GREENOUGH REGION

93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0035	BURBIDGE Allan	Biological survey of the southern Carnarvon and northern Irwin Phytogeographic Districts, WA
93/0041	PRINCE Bob	Dugong Conservation - Northern Western Australia
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0125	MOORE Richard	Oil Eucalypts as a Multi-purpose Tree Crop for the Wheatbelt. (Externally Funded)
96/0006	BRAND Jon	Field ecology of the Western Australian Sandalwood (*Santalum spicatum* (R.Br.) A.DC.) and the impact of land management activities on sandalwood regeneration.
98/0017	MASLIN Bruce	*Acacia acuminata*: analysis of variation

98/0020	GIBSON Neil KEIGHERY Greg	SAP – Biological survey of the agricultural zone.

KIMBERLEY REGION

93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0029	MCKENZIE Norm	Mandora Palaeoriver / Radi Hills Survey
93/0040	PRINCE Bob	Conservation of Marine Turtles - Western Australian Region
93/0041	PRINCE Bob	Dugong Conservation - Northern Western Australia
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0059	LANE Jim	Development of guidelines for monitoring of Australia's Wetlands of International Importance (Ramsar Convention) (Externally funded)
98/0004	KAY Winston	First National Assessment of River Health - North-West Australia
98/0016	START Tony	Status of pebble-mound mice

MIDWEST REGION

93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0035	BURBIDGE Allan	Biological survey of the southern Carnarvon and northern Irwin Phytogeographic Districts, WA
93/0046	ALGAR Dave	Relative acceptability of bait materials to feral cats. (Externally funded).
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0068	SHEARER Brian	Integrating strategies for control of Phytophthora cinnamomi with phosphorous acid.
93/0071	BURBIDGE Andrew	Monitoring the total numbers of the Lesser Noddy (*Anous tenuirostris melanops*) in Australia and the numbers of some other seabirds breeding on Pelsaert Island.
93/0127	MOORE Richard	West Coast Pine Timberbelt Project. (Externally Funded)
93/0159	PEARSON David	Ecology and Conservation of Western Australian Pythons
93/0163	FRIEND Tony	Genetics and ecology of the Western Barred Bandicoot
93/0165	HOPKINS Angas	Ecological studies, Lesueur National Park (and adjacent areas)
93/0166	GIBSON Neil	Floristic Survey of the Goldfield woodlands

95/0011	FRIEND Tony	Status and ecology of the Dibbler (*Parantechinus apicalis*) in Western Australia
96/0001	MARLOW Nicky	Fox population dynamics
96/0006	BRAND Jon	Field ecology of the Western Australian Sandalwood (*Santalum spicatum* (R.Br.) A.DC.) and the impact of land management activities on sandalwood regeneration.
96/0014	ALGAR Dave	Broadscale cat control research
98/0002	BRAND Jon	Establishment and growth of sandalwood (*Santalum spicatum*) in south western Australia
98/0017	MASLIN Bruce	*Acacia acuminata*: analysis of variation
98/0018	GIBSON Neil/HALSE Stuart	SAP – Monitoring salinity and its effects on the biota of wetlands in the agricultural zone of south-western Australia
98/0021	HOPKINS Angas/ LANGLEY Margaret	West Midlands study, planning for nature conservation.

PILBARA REGION

93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0030	VAN LEEUWEN Steve	Biological Survey of the Barlee Range Nature Reserve
93/0031	VAN LEEUWEN Steve	Botanical Survey of Central Pilbara Uplands with the Karijini National Park
93/0040	PRINCE Bob	Conservation of Marine Turtles - Western Australian Region
93/0041	PRINCE Bob	Dugong Conservation - Northern Western Australia
93/0042	COATES David	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES David	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0052	MORRIS Keith	The conservation of the Thevenard Island Mouse *Leggadina* aff. *lakedownensis*.
93/0056	MORRIS Keith	Recovery Plan for the Shark Bay Mouse (*Pseudomys fieldi*).
93/0141	VAN LEEUWEN Steve	Fire Mulga study burn and post-fire monitoring
93/0160	BURROWS Neil	Using prescribed fire to rehabilitate landscapes disturbed by mining exploration in the arid zone.
95/0005	KINNEAR Jack	A Conservation Strategy for the Western Desert Rock-Wallaby
98/0004	KAY Winston	First National Assessment of River Health - North-West Australia
98/0005	PEARSON Dave	Status, ecology and conservation of the Pilbara Olive Python (*Morelia olivacea barroni*)
98/0016	START Tony	Status of pebble-mound mice
99/0001	VAN LEEUWEN Steve	Biological survey of the Burrup Peninsula.
99/0002	VAN LEEUWEN Steve	Botanical survey of the Central Hamersley Range Tussock Grasslands.
99/0003	VAN LEEUWEN Steve	Biological survey of the Southern Little Sandy Desert.
99/0004	VAN LEEUWEN	A review of the botanical and management values of three proposed

	Steve	additions to the Hamersley Range Conservation Estate (Karijini Taskforce).

SOUTH COAST REGION

93/0013	WHEELER Judy	Flora of the lower south west
93/0015	FRIEND Tony	Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)
93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0025	MCKENZIE Norm	Eastern Goldfields Survey
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0034	BURBIDGE Allan	A biological survey of Cape Arid National Park
93/0037	GIBSON Neil	Floristic survey of the coastal communities of the Warren botanical subdistrict.
93/0040	PRINCE Bob	Conservation of Marine Turtles - Western Australian Region
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0053	MORRIS Keith	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0059	LANE Jim	Development of guidelines for monitoring of Australia's Wetlands of International Importance (Ramsar Convention) (Externally funded)
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0065	BURBIDGE Allan	Conservation of the Western Bristlebird
93/0066	BURBIDGE Allan	Radio-tracking translocated Noisy Scrub-birds
93/0068	SHEARER Brian	Integrating strategies for control of Phytophthora cinnamomi with phosphorous acid.
93/0069	SHEARER Brian	Use of debilitating factors and host resistance to control *Diplodina* canker in Banksia coccinea communities.
93/0081	KOMOREK Barbara	Control and management of Phytophthora cinnamomi in native plant communities
93/0085	MCGRATH John	Post-fire response to mallee-heath shrubland at Stirling Range National Park.
93/0086	MCGRATH John	Fire induced mosaics in semi-arid shrubland and woodland communities.
93/0090	HOPKINS Angas	Effects of fire on plant species and communities at Tutanning Nature Reserve (A25555).
93/0121	MCGRATH John	Early rotation nutrition of *P. radiata* on ex-pasture land on the south coast of W.A. (Externally Funded)
93/0122	MCGRATH John	Diagnosis of nutrient deficiencies in young *P. radiata* using foliar analysis. (Externally Funded)
93/0123	HARPER Richard	Performance of *Eucalyptus globulus*, planted on farms, in relation to soil and site attributes. (Externally Funded)
93/0125	MOORE	Oil Eucalypts as a Multi-purpose Tree Crop for the Wheatbelt.

	Richard	(Externally Funded)
93/0131	MAZANEC Richard	Assessing the wood quality of *Eucalyptus globulus* breeding selections. (Externally Funded)
93/0139	MOORE Richard	*E. globulus* as a Multi-Purpose Tree Crop on the Esperance Sandplain. (Externally Funded)
93/0147	BUTCHER Trevour	*Eucalyptus globulus* Tree Breeding - Strategy and breeding population development - Seed orchard development
93/0151	HARPER Richard	Site specific silviculture: making management decisions for *Pinus radiata* plantations on the basis of a site's water relations.
95/0007	WARD Dave	Basic information for the management of Brown Boronia (*Boronia megastigma* (Nees) in State forest
95/0011	FRIEND Tony	Status and ecology of the Dibbler (*Parantechinus apicalis*) in Western Australia
96/0003	MCGRATH John	Diagnosis and correction of manganese deficiency in *E. globulus* growing on the Esperance sandplain
96/0008	FRIEND Tony	Recovery of Gilbert's Potoroo
96/0010	BURROWS Neil	Fire history and impact of *Phytophthora cinnamomi* in jarrah forests
96/0012	SHEARER Bryan	Susceptibility of the major soil types of the Fitzgerald River National Park and region to infestation by *P. megasperma* and *P. cinnamomi.* (EXTERNALLY FUNDED).
96/0014	ALGAR Dave	Broadscale cat control research
98/0010	BIRCH Peter	Imaging and spectrophotometry of comets
98/0015	ROBINSON Richard	The effect of fire on the fruiting of fungi in karri regrowth forests
98/0018	GIBSON Neil/HALSE Stuart	SAP – Monitoring salinity and its effects on the biota of wetlands in the agricultural zone of south-western Australia
98/0022	KAY Winston	First national assessment of river health – Wheatbelt region.

SOUTHERN REGION

93/0013	WHEELER Judy	Flora of the lower south west
93/0015	FRIEND Tony	Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)
93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0037	GIBSON Neil	Floristic survey of the coastal communities of the Warren botanical subdistrict.
93/0040	PRINCE Bob	Conservation of Marine Turtles - Western Australian Region
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0053	MORRIS Keith	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0066	BURBIDGE Allan	Radio-tracking translocated Noisy Scrub-birds
93/0093	WAYNE Adrian	Conservation biology of vulnerable frogs.

93/0095	WHITFORD Kim	Characteristics of hollow-bearing jarrah and marri trees and coarse woody debris, their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them.
93/0098	BURROWS Neil	Effects of timber harvesting operations (fire and logging) on the floristics, structure and some habitat characteristics of intermediate rainfall jarrah forest.
93/0099	BURROWS Neil	Fire regime effects on the structure and floristics of jarrah forests
93/0103	FARR Janet	Quantitative population monitoring of Gum-leaf Skeletonizer *Uraba lugens* and impact assessment on Jarrah crowns.
93/0104	FARR Janet	Distribution of Gum-leaf Skeletonizer in the Central and Southern Forest Regions
93/0105	FARR Janet	The influence of pheromones in the mating behaviour of *Tryphocaria acanthocera* (Coleoptera: Cerambycidae)
93/0106	MCCAW Lachie	Increasing productivity of karri regrowth stands by thinning and fertilising
93/0107	MCCAW Lachie	Espacement effects on the development and form of regrowth karri stands.
93/0112	STUKELY Mike	Selection, screening and field testing of jarrah resistant to Phytophthora cinnamomi.
93/0115	WAYNE Adrian	Effects of timber harvesting on small vertebrates in medium rainfall jarrah forest.
93/0123	HARPER Richard	Performance of *Eucalyptus globulus*, planted on farms, in relation to soil and site attributes. (Externally Funded)
93/0126	MAZANEC Richard	Genetic variation in quantitative trials of exotic and endemic plantation and rehabilitation species.
93/0129	MAZANEC Richard	Karri inbreeding/outcrossing studies. (Externally Funded)
93/0138	MOORE Richard	Eucalypts, for High Quality Sawlogs, Integrated with Farming.
93/0142	DE TORES Paul	Translocation of the western ringtail possum, *Pseudocheirus occidentalis*.
93/0145	FRIEND Tony	Factors affecting establishment in the numbat reintroduction program
93/0146	BUTCHER Trevor	*Pinus pinaster* tree breeding - Strategy and Breeding Population Development & seed orchand, development and research
93/0147	BUTCHER Trevor	*Eucalyptus globulus* Tree Breeding - Strategy and breeding population development - Seed orchard development
93/0148	BUTCHER Trevor	*Pinas radiata* Tree Breeding - Strategy and Breeding population development, Resistance Breeding - Phytophthora Cinnamomi, HAPSO development and research and Search 85 gene resource
93/0151	HARPER Richard	Site specific silviculture: making management decisions for *Pinus radiata* plantations on the basis of a site's water relations.
93/0154	FARR Janet	Impact of wood boring insects on wood quality in regrowth Karri in relation to site quality. (Funded by WURC Forest Resources)
93/0155	WAYNE Adrian	The effects of logging and fire (Edge effects, habitat trees) on birds of the jarrah forest.
94/0007	WAYNE Adrian	Effects of timber harvesting on terrestrial invertebrates in medium rainfall jarrah forest
95/0001	ROBINSON Richard	To compare chemical and biological methods for the control of Armillaria in regrowth karri
95/0007	WARD Dave	Basic information for the management of Brown Boronia (*Boronia megastigma* (Nees)) in State forest
95/0008	MACFARLANE Terry	Taxonomy of new, rare and priority plant species of the southern forests.
95/0012	WARD Dave	Reconstructing fire history from leafbase patterns on grasstree stems.
97/0001	FARR Janet	Incidence of wood borers in 20-35 yr old regrowth Karri over a rainfall gradient

97/0007	WAYNE Adrian	The Impact of Timber Harvesting and Associated Activities on the Western Ringtail Possum (*Pseudochierus occidentalis*) in Kingston.
97/0009	BURROWS Neil	Monitoring of selected vertebrate communities in Perup Nature Reserve.
98/0006	ROBINSON Richard	Below ground incidence of *Armillaria luteobubalina* in regrowth karri
98/0015	ROBINSON Richard	The effect of fire on the fruiting of fungi in karri regrowth forests
99/0007	KAY Winston	First national assessment of river health – south-west forests

SWAN REGION

93/0015	FRIEND Tony	Systematics, Zoogeography and Phylogeny of the Terrestrial Amphipods of Australia (ABRS funded)
93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0017	BURBIDGE Andrew	Database of Mammal Records from Australian Islands.
93/0018	BURBIDGE Andrew	Seabird Breeding Islands Database
93/0021	ABBOTT Ian	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.
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0042	COATES David	Conservation biology of Western Australia's rare and threatened flora.
93/0044	COATES David	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0046	ALGAR Dave	Relative acceptability of bait materials to feral cats. (Externally funded).
93/0053	MORRIS Keith	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0054	DETORES Paul	The effect of fox control of the utilization of habitat by the mainland Quokka (*Setonix brachyurus*).
93/0059	LANE Jim	Development of guidelines for monitoring of Australia's Wetlands of International Importance (Ramsar Convention) (Externally funded)
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0063	BURBIDGE Andrew	Western Swamp Tortoise Recovery Plan
93/0068	SHEARER Bryan	Integrating strategies for control of *Phytophthora cinnamomi* with phosphorous acid.
93/0069	SHEARER Bryan	Use of debilitating factors and host resistance to control Diplodina canker in *Banksia coccinea* communities.
93/0070	SHEARER Bryan	Control and management of *Armillaria luteobubalina* in native communities.
93/0090	HOPKINS Angas	Effects of fire on plant species and communities at Tutanning Nature Reserve (A25555).
93/0095	WHITFORD Kim	Characteristics of hollow-bearing jarrah and marri trees and coarse woody debris, their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them.
93/0101	CROMBIE Stuart	Preliminary survey of the effectiveness of *B.Grandis* in removal in reducing potential *Phytophthora cinnamomi* host material in the northern jarrah forest in the medium term.
93/0110	SHEARER Brian	Use of phosphonate to determine the effect of Phytophthora cinnamomi infection on growth of *Eucalyptus marginata*.

93/0123	HARPER Richard	Performance of *Eucalyptus globulus*, planted on farms, in relation to soil and site attributes. (Externally Funded)
93/0142	DE TORES Paul	Translocation of the western ringtail possum, *Pseudocheirus occidentalis*.
93/0144	FRIEND Tony	Quenda translocation methods
93/0145	FRIEND Tony	Factors affecting establishment in the numbat reintroduction program
93/0146	BUTCHER Trevor	*Pinus pinaster* tree breeding - Strategy and Breeding Population Development & seed orchard, development and research
93/0153	ABBOTT Ian	Control of insect pests in young plantations of *Eucalyptus globulus*: Early indicators of pest insect outbreaks and the beneficial impact of spiders and parasitoids.
93/0157	DE TORES Paul	Control and Ecology of the Red Fox in Western Australia - Native fauna response to 1080 baiting over large areas at three baiting frequencies.
93/0159	PEARSON David	Ecology and Conservation of Western Australian Pythons
94/0006	STUKELY Mike	Dieback-resistant jarrah establishment in operational forest rehabilitation sites
94/0013	GIBSON Neil	Monitoring of the effects of the Dawesville Channel on the vegetation of the Peel - Harvey estuary.
95/0012	WARD Dave	Reconstructing fire history from leafbase patterns on grasstree stems.
95/0014	STUKELY Mike/ BARBOUR LIZ	Vegetative propagation by grafting of dieback-resistant jarrah for seed orchard establishment.
96/0004	WHITFORD Kim	Comparison of the cost-effectiveness of two methods of application of glyphosate herbicide to jarrah (*Eucalyptus marginata*) standing trees and cut stumps
96/0009	KEIGHERY Greg	Re-survey and analysis of F. Podger's dieback sites at 30 year interval
96/0011	STUKELY Mike	Molecular marker-aided selection of jarrah (*Eucalyptus marginata*) for resistance to *Phytophthora cinnamomi*. (EXTERNALLY FUNDED - RIRDC, Alcoa, Western Collieries).
97/0004	MCGRATH John	Early rotation silviculture for second rotation pines on the Swan Coastal Plain
97/0005	DE TORES Paul	Fox and cat density estimates, survivorship and home range estimates in the presence of 1080 baiting within the northern jarrah forest of southwest Western Australia - a pilot study
97/0008	WARD Dave	A fire history of John Forrest National Park, Perth, Western Australia
98/0001	STUKELY Mike	Selection for resistance to Phytophthora cinnamomi in Banksia coccinea
98/0009	BIRCH Peter	Variable star observations
98/0010	BIRCH Peter	Imaging and spectrophotometry of comets
98/0011	BIGGS Jamie	Imaging and CCD photometry of transient and variable sources
98/0012	BIGGS Jamie	Astrometry of minor planets, comets and targets of opportunity
98/0013	WILLIAMS Andrew J	Monitoring gravitational microlenses
98/0014	MARTIN Ralph	The Perth automated supernova search (PASS)
99/0007	KAY Winston	First national assessment of river health – south-west forests

WHEATBELT REGION

93/0016	BURBIDGE Andrew	Taxonomic Revision of Beaufortia R.Br.
93/0022	WILLIAMS Matt	Conservation status of butterflies in Western Australia
93/0028	MCKENZIE Norm	Ecomorphological Clues to Community Structure: Bat and Lizard Guild Studies. Bat Echolocation.
93/0042	COATES Dave	Conservation biology of Western Australia's rare and threatened flora.

93/0044	COATES Dave	Development and coordination of a quadrat based monitoring system for endangered flora.
93/0053	MORRIS Keith	Recovery Plan for the Chuditch (*Dasyurus geoffroii*).
93/0059	LANE Jim	Development of guidelines for monitoring of Australia's Wetlands of International Importance (Ramsar Convention) (Externally funded)
93/0060	LANE Jim	Monitoring of wetlands in nature reserves and national parks of south-Western Australia
93/0078	PIGOTT Patrick	Ecology of understorey communities and soil seed-bank of remnant salmon gum (*Eucalyptus salmonophloia* F.Muell) woodland near Lake Taarblin, WA.
93/0090	HOPKINS Angas	Effects of fire on plant species and communities at Tutanning Nature Reserve (A25555).
93/0125	MOORE Richard	Oil Eucalypts as a Multi-purpose Tree Crop for the Wheatbelt. (Externally Funded)
93/0126	MAZANEC Richard	Genetic variation in quantitative trials of exotic and endemic plantation and rehabilitation species.
93/0144	FRIEND Tony	Quenda translocation methods
93/0145	FRIEND Tony	Factors affecting establishment in the numbat reintroduction program
93/0159	PEARSON David	Ecology and Conservation of Western Australian Pythons
93/0166	GIBSON Neil	Floristic Survey of the Goldfield woodlands
95/0015	KINNEAR Jack	1080 longevity in laid meat baits
96/0005	KINNEAR Jack	Effect of feral cat control on the sex ratios of rock-wallaby populations
98/0002	BRAND Jon	Establishment and growth of sandalwood (*Santalum spicatum*) in south Western Australia
98/0018	GIBSON Neil/HALSE Stuart	SAP – Monitoring salinity and its effects on the biota of wetlands in the agricultural zone of south-western Australia
98/0022	KAY Winston	First national assessment of river health – Wheatbelt region.