RESEARCH

P L A N

1990-1991

DEPARTMENT OF CONSERVATION
AND LAND MANAGEMENT

RESEARCH

PLAN

1990-1991

DEPARTMENT OF CONSERVATION
AND LAND MANAGEMENT

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PREFACE

This, the fourth Research Plan of the Department of Conservation and Land Management, consolidates the work carried out to produce the past three Plans.

Full details of recent improvements to program organization are included.

A feature of this edition is a full listing of all Research Division publications for the first 5 year period since the formation of CALM. More than 350 publications are itemized.

I would like to thank all those who have contributed to the preparation of the Research Plan, particularly the Program Leaders, who revised their sections; Ian Abbott, who had overall responsibility for its preparation Christine Farrell, who co-ordinated its production; and Jill Pryde, Deanne Burton and Natalie Allday for Word Processing and Desk Top Publishing the document.

Andrew A. Burbidge
Director of Research

30 June 1990

EXECUTIVE SUMMARY

ADMINISTRATIVE CHANGES

In 1989-90 a review of the Herbarium Research Program was undertaken, resulting in some restructuring and better integration with the Flora Conservation Program. The existing Silviculture and Rehabilitation Programs were restructured to form two new Programs - Native Forest Silviculture and Plantation Silviculture. The Research Computing Program was also reviewed and merged with the Research Methods Program.

Administration of the budget, promotions and staff appraisal has been improved.

The appointment of Mr Richard Harper, a soil scientist, has enabled research into establishment of softwood plantations in the Albany region to be expanded.

MAJOR ACHIEVEMENTS

The overall aim of Research Division is to develop a scientific basis for conservation and land management in Western Australia by conducting research and providing expert advice.

The significant accomplishments of each program are summarized below:

EXECUTIVE AND RESEARCH SUPPORT PROGRAM

During 1989/90 the Program continued to concentrate on three main areas: bringing all staff into the same titles, awards and conditions; improving financial management and reporting; and reviewing the efficiency of and organization of Research Programs and the Research Division Policy Group (RDPG).

Further progress has now been made towards achieving a uniform system of titles, conditions and awards. Account numbers and expenditure reporting systems were revised so that Program Leaders and the RDPG are better able to control expenditure and a new financial control system for external grants was developed.

The Research Computing Program was reviewed in June 1990, resulting in new initiatives in the GIS area. A review of research into the control of *Phytophthora* species was also initiated.

BIOGEOGRAPHY

The National Rainforest Conservation Program fieldwork and write up was completed. Surveys of Shark Bay, Walpole-Nornalup National Park and Cape Arid National park were completed. A major review of the Mount Lesueur region was undertaken and published.

ENTOMOLOGY

An experimental fire near Collie in Autumn 1989 scorched an average of about half of each jarrah crown and reduced the density of Jarrah Leafminer by one third. These preliminary results therefore offer promise of a successful, practical method of controlling Leafminer outbreaks.

A survey in Collie and Manjimup Districts of adjacent stands of jarrah forest differing in time since Spring burning showed that Spring burning in 1988 did not favour Leafminer.

Surveys of Jarrah stands throughout the northern Jarrah forest resulted in the discovery of an extensive incursion of Leafminer from the Swan Coastal Plain into the Darling Range between Mundaring and the Avon Valley.

Extensive sampling of Gumleaf Skeletonizer in the southern Jarrah forest has shown a contraction in distribution and decline in abundance. Most mortality of caterpillars resulted from parasitism by the wasp *Euplectrus* sp.

Studies of *Cardiaspina brunnea*, the Lerp infesting Flat-topped Yate, show that it has three generations per year and that its biology is comparable to that of *C. albitextura*, a well studied Eastern States species.

The newly constructed Insectary at the Manjimup Research Centre was commissioned in June 1990.

The release of introduced biocontrol agents of Ips was completed in co-operation with Kirup District staff.

A scientific paper was presented at an International conference on population dynamics of forest insects held at Heriot-Watt University, Edinburgh, Scotland in September 1989.

FAUNA CONSERVATION

An experiment was carried out to test the hypothesis that the artificial diet currently being fed to captive numbats was inhibiting breeding. The hypothesis was disproved, as a female numbat maintained on the regular diet and another fed an increased proportion of termites both bred successfully at Woodvale, together producing a further seven young. This brings to 19 the number of numbat young bred in captivity since 1985, and augurs well for the future of the breeding program run by CALM and Perth Zoo.

Ten numbat young born at Karroun Hill Nature Reserve since the translocation of numbats there in 1987-8 were captured and fitted with radio-collars. This permitted the monitoring of their dispersal and showed that their condition was excellent, indicating adequate food supply, but that predation rates are significant.

A Draft Management Program for the Chuditch was finalized. A search for the Shark Bay mouse on the mainland in the Shark Bay region was carried out, funded by World Wide Fund for Nature Australia. No evidence was found that it persists on the mainland, but a number of suitable reintroduction sites were located.

Surveys for ground parrots at Fitzgerald River National Park confirmed that Hamersley Drive is an important site for these rare and endangered birds. Permanent quadrats to monitor the effect of fire on ground parrot habitat were established.

FIRE

Experimental burning has commenced in the Stirling Range National Park. This study aims to improve knowledge of fire behaviour and fire effects in mallee-health vegetation. Four plots were burnt in spring 1989 and three in autumn 1990. Initial hypotheses about the importance of wind speed and fuel moisture content on fire rate of spread and intensity have been developed. Additional data on fire behaviour under extreme weather conditions were gathered following the extensive wildfires in the Fitzgerald River National Park in late 1989.

Vertebrate and invertebrate studies in the Stirling Range National Park are progressing. A large component of the beetle fauna collected comprises new species, including a new southerly species of a restricted group of Cicindelids.

After four years of intensive monitoring of vertebrates and small vertebrates, an experimental burn on a 100 ha block of Tutanning Nature Reserve was carried out in March 1990. Monitoring of the site will continue to determine the effects of fire on the fauna. In addition, a population of the rare dasyurid *Phascogale calura* was studied before and during the experimental burn by means of grid-based trapping and radio tracking. This latter work is a joint project with the Fauna Conservation Program and is funded externally through the ANPWS Endangered Species Program. Monitoring of the *P. calura* populations will continue.

Plots established in south-west forests to examine the long term effects of fire on the vegetation were burnt in spring 1989 and autumn 1990. A detailed assessment of vegetation in plots which were burnt and plots which remain unburnt was carried out prior to burning. Seedling regeneration following the fires will be assessed in spring 1990. One of the study areas was established in 1972 and several plots have been burnt 6 times since then. A preliminary analysis of data has shown only minor changes in the vegetation composition under this extreme fire treatment. A study area containing the rare *Lambertia rariflora* was experimentally burnt in autumn 1990. The response of the *Lambertia* population will be monitored.

Thickets of *Melaleuca viminea* which occur in broad valleys on the eastern margin of the jarrah forest were surveyed for their suitability as habitat for the rare Tammar wallaby. Degenerate thickets east of Collie were burnt in autumn 1990 to create a new, healthy thicket. When the thickets have developed (in about 10 years) Tammars will be re-introduced from the Perup Nature Reserve east of Manjimup. The development of the regenerating thickets will be monitored annually. Other areas are planned for burning next autumn.

A landform soils map of the Perup Nature Reserve has been compiled and together with Landsat satellite imagery and GIS, will be used to enable Tammar habitat conditions to be optimized. A plant response master file for the Warren Botanical sub-district was completed. The file contains about 1900 records and documents species responses to fire and dieback.

Current disturbance ecology research on birds includes an eight year long study in permanent sites in karri forest in Gray forest block. Following a two year period of calibration, sites were either burnt, small group (3ha) felled, clearfelled or left as controls. Mistnetting, censusing and foraging observations have been used to study the birds for five years after the operations. The structure and floristics of the vegetation are also assessed annually.

A second aerial patch-burn was successfully executed by the Goldfields Region in the Gibson Desert Nature Reserve in September 1989. An area of about 70 000 ha was patch-burnt in preparation for the re-introduction of two rare and endangered mammals scheduled for May 1991. The project team is aiming to attract outside funding for the re-introduction project. ANPWS, through the Endangered Species Program, has provided funds for fox control studies in the Reserve.

Studies of the effects of fire on desert vertebrates are progressing. Plots in the Queen Victoria Springs Nature Reserve have been burnt and post-fire trapping is ongoing. Field work in relation to a study of fire effects on vegetation is continuing. In the Gibson Desert Nature Reserve pre-fire trapping of lizards to study the effects of patch-burning is completed. A survey of extant populations of *Petrogale lateralis* in the Central Ranges region in conjunction with the Ngaanyatjarra Council was completed.

Aboriginal people from Pupiyala Tjarutja Inc. were contracted to undertake prescribed burning for wildfire prevention in the Neales Junction Nature Reserve. The project, funded by the ANPWS contract Employment Program for Aborigines in National and Cultural Resource Management has been highly successful with some 280 km of strategic buffer burning being achieved in 10 days.

FLORA COLLECTIONS

New specimen housing for the public access Reference Herbarium and the general collections will alleviate some of the overcrowding of the specimen storage areas of the Herbarium. The new areas have been designed to accommodate the herbaria of fungi, algae, bryophytes and lichens as well as monocot families.

The WA Herbarium specimen database now comprises 85 000 entries and includes information on the Type collection, the family Rutaceae and the State's fungal collection. A grant of $11 600 from Australian National Parks and Wildlife Service has enabled the databasing of the Herbarium's voucher collections of Declared Rare Flora and the Priority One taxa of the CALM Reserve Flora List. The census of vascular plants is now databased and is referred to as the Herbarium's taxon database WACENSUS.

FLORA CONSERVATION

Publication of a book on "Western Australia's Endangered Flora" has generated considerable interest both within Western Australia and elsewhere in Australia. This publication should not only foster increased pubic interest in flora conservation generally but will hopefully also encourage direct public involvement in future volunteer projects involving Endangered Flora. The book will also be a valuable reference on endangered flora and poorly known species at risk for CALM Regional and Operations staff.

Two Wildlife Management Programs "Declared Rare Flora and other plants in need of Special Protection in the Northern Forest Region" and *"Eucalyptus rhodantha"* have been published and are the first dealing with endangered flora. The *E. rhodantha* management program demonstrates the value of detailed studies on population genetic structuring, breeding systems and population dynamics in developing management strategies for endangered plant species. Similar studies have been completed or are near completion for a number of endangered species such as *Banksia cuneata, Banksia tricuspis, Acacia anomala* and *Stylidium coroniforme which will provide the basis for Wildlife Management Programs for those species.*

FLORA INFORMATION

A workshop on regional flora writing was held at the Herbarium in October 1989. The workshop discussed the most efficient way to generate and disseminate taxonomic information. A new user-friendly flora handbook format has now been proposed and will be implemented in a new pilot project to be submitted for approval in July 1990.

The enormous task of preparing the manuscript of the Flora of the Kimberley Region is nearing completion. The project, which has taken five years to date, keys out and describes all of the flowering plants recorded in the Kimberley Region.

MARINE CONSERVATION

During its first full year of operation the program has begun to draw together existing research resources from within CALM, other government departments, tertiary institutions and private agencies into a framework capable of providing a scientific basis to marine conservation in WA.

A substantial research effort has been brought to bear on the problem of Drupella within Ningaloo Marine Park, including several studies within CALM (partly funded by ANPWS) and others from the University of WA and Murdoch University. A one-day workshop including representatives of all research programs was successfully held to co-ordinate future work. Research into the early life history of Drupella achieved a major breakthrough in inducing egg-laying and larval development. This is the first documentation anywhere of these processes for this genus.

In response to concerns of deteriorating water quality, water sampling was carried out at Monkey Mia and at Coral Bay. Bacterial and nutrient analyses were undertaken for a number of sites in winter, spring and summer. Results suggest that for Monkey Mia there may be large seasonal changes in water quality.

Several long-term programs have been established which rely on data collection by regional staff or the public. Examples are the recreational fishing survey at Marmion Marine Park and the reef assessment project. Both projects have begun to return data which will build into a valuable historical record over time.

The marine turtle project was continued with recruitment of further volunteer participation in field work and additional external support provided by WAPET, operators of the Barrow Island oilfield. The operators of the Harriet Oilfield also continued to encourage volunteer work being done on Varanus Island.

Co-operative involvement of CALM operational staff and Aboriginal community members was also maintained. The first remigrant green turtles were seen at the Lacepedes and Barrow Island and further recoveries were received from Northern Territory coastal locations.

The project work was given further recognition via an invitation to join the IUCN/SSC Marine Turtles Specialist Group.

The dugong survey of Shark Bay and Exmouth Gulf was successfully completed in collaboration with external researchers and CALM operations staff.

NATIVE FOREST SILVICULTURE

A second summer of water stress and leaf area data have been collected from trees on the Inglehope thinning trial. In combination with CSIRO nutrient cycling data, production of a growth response model for thinned and fertilized jarrah trees can now be attempted.

The high rainfall zone water catchment treatment program was completed; Higgens was thinned to a uniform $15m^2ha^{-1}$ and Jones catchment according to a variable schedule reflecting regeneration, silvicultural and disease status. Two dieback infected catchments (Warrens and Bennetts) have been mined and will be monitored to assess the effect of intensive rehabilitation on catchment water yield, dieback development and regeneration survival.

In the karri forest two major thinning experiments were remeasured, and the initial measurement and establishment of a major thinning and fertilization experiment was completed. Surveys of karri

regrowth coupes for the incidence of brown wood and associated rots were conducted.

PLANT DISEASES

A Research Scientist and Technical Assistant have been established at the Manjimup Research Centre to undertake research on the plant diseases in the South Coast and Southern Forest regions.

Trials on the control of *Phytophthora* species with phosphorous acid have been extended to *Banksia* communities on the south coast. *Banksia baxteri*, *B. brownii* and *B. coccinea* were sprayed in November 1989 and monitoring is continuing.

Potential improvements to the *P. cinnamomi* hazard rating systems for the high rainfall zone of the northern jarrah forest are being evaluated. Plant indicators are being grouped according to position in the landscape in order to facilitate prediction of hazard.

The superiority of jarrah lines resistant to *P. cinnamomi* have been maintained in field trials. The jarrah provenance screening program is well under way with a further 96 families being tested in the 1989-90 season.

Assessment of lesion extension of *P. cinnamomi* in stems of jarrah has commenced in stands thinned to different densities in the low, intermediate and high rainfall zones of the jarrah forest. Inoculation and measurement of growth rates is continuing.

An investigation of the causes of decline and death of *B. coccinea* at Cheyne Beach has commenced.

A number of canker fungi, including *Botryosphaeria* and *Diplodina*, have been isolated from dying plants and pathogenicity tests are in progress.

From mid May 1989 to mid April 1990, 319 cultures were forwarded by the detection service for identification. Sixty four of these were *Phytophthora* species all of which were identified to species level and added to the database.

PLANTATION SILVICULTURE

The phenomenon of drought death had been a recurrent problem in traditional plantation forestry in W.A., especially in the Blackwood Valley. This phenomenon was subject to detailed study for the first time during 1989, following extensive deaths in 1987/88. The major factors found to influence drought death were tree stocking, soil depth, landscape position, and aspect. A model that predicts which sites are susceptible to drought, based on these factors, was developed and presented for management application.

A major review of research into vegetation strategies to control salinity has been published (Schofield *et al.* 1989). This review incorporates several years work undertaken in the previous Rehabilitation Program, much of which was done in collaboration with other agencies. The review was timely since it had recently been concluded that tree water use, a focus of research for the past decade, was less important than tree commercial potential as a criterion for selection of tree species for reforestation. This result, along with the development of the sharefarming concept, gave rise to the push to establish a major short-rotation eucalypt pulpwood industry based on farmland.

Eucalyptus globulus has been identified as the main species for the pulpwood industry. In 1989 large breeding population trials including 51 000 pedigree seedlings planted over 56 ha were established. Along with earlier work these trials have been incorporated into a WA Breeding Co-operative to co-ordinate the *E. globulus* breeding work of Bunnings Tree Farms, Alcoa and CALM. Thirty superior trees from earlier breeding populations at Busselton, Manjimup and Dwellingup were used to produce grafted seedlings for seed orchards. It has been estimated that seed from these orchards will increase yields by 40%.

Three projects supported by National Afforestation Program funds of $1.5 milion were designed to develop the multiple benefits of tree crops in farming systems. These projects have developed and demonstrated silvicultural practices for the short-rotation eucalypts and techniques by which pulpwood crops can make an optimum contribution to farm planning. A variation on the sharefarming concept called 'timberbelt

sharefarming' was developed to make tree crops attractive to mainstream farmers. Timberbelts are planted in distributions designed to complement covnentional farming practices. The long period of research into agroforestry systems under the previous Rehabilitation Program greatly facilitated the development of the timberbelt concept. Substantial interest in timberbelts has been generated. More than 1 000 ha were planted in winter 1990. On the basis of this development CALM is to proceed with a full scale operational timberbelt program in 1991.

RESEARCH TECHNIQUES

The goal of providing each Research Scientist with access to at least one micro computer was effectively accomplished. Training courses were conducted regularly at the major research centres. The level of computer literacy, expertise and usage continue to increase. Laptops are now an integral part of field work and are becoming indispensible to researchers.

Hardware and software continue to be upgraded and there is more integration within the Division. The Herbarium's UNISON was replaced. The WAHERB system has been transferred to a new SUN 386i workstation. Work is being carried out in the area of corporate data (eg. Declared Rare Flora database has been developed and transferred to the Wildlife Branch) and in the Geographical Information Area (GIS).

The number of staff in computing has increased and the major Research Centres are now supported by research computing staff. This is an important milestone for computing as it provides support where it is most needed. It paves the way in the coming financial year for a significant increase in the level of computer usage, professionalism and support, as well as greater involvement by Research Techniques program members in the conduct of Research Projects.

In the past year 67 Research Project Plans have been inspected and modified where necessary. Some of these plans extend into the next century. Data sets drawn from the whole range of research activities have been analysed, thus contributing to many scientific publications. A new method of forest inventory has been tested and transferred to field operations. A new method of identifying ecological pattern has been invented and tested. A method of assessing leaf damage by insects has been developed. An original, systematic and constructive approach to the planning with operational management of whole research programs has been suggested. A model for the ecological management of pines in the Blackwood Valley has been developed which will avoid potential loss by drought of many millions of dollars of public money.

WETLAND AND WATERBIRDS

Significant accomplishments were:

Nomination of nine Western Australian wetlands as Wetlands of International Importance (Ramsar).

Initiation of a major new project on waterbird usage of wetlands of the Swan Coastal Plain ("Scopewest").

Publication of a major review paper on breeding seasons of Waterbirds in south-western Australia.

Further advances in methodology of monitoring and controlling populations of nuisance midges (chironomids) on Perth's wetlands.

Preparation of a draft State Wetland Conservation Policy for Western Australia.

WOOD UTILIZATION

A log stockpiling trial showed that where storage requirements were limited, a low pressure watering system could be as effective as the higher cost high pressure systems in maintaining log quality.

Sawmilling trials of regrowth jarrah, karri and marri to produce structural timber and boards were continued, while Eastern States eucalypts such as Tasmanian blue gum and rose gum were assessed.

Drying research continued to determine efficient schedules for drying timber from green to fibre saturation point (the moisture content when cell walls start to dry and shrinking commences).

Schedules for the CALM drying system were also researched. Trials of ultrasonic methods for determining moisture content were commenced at Harvey.

A major part of the research was assessing different adhesives for VALWOOD production, and the gluing behaviour of different regrowth eucalypts species.

Successful field days on timber drying at the Wood Utilization Research Centre, Harvey, resulted in research findings being taken up by industry and put into commercial practice. Wood Utilization staff delivered lectures to students in the TAFE Certificate in Timber Technology and W.A. Forest Industries Training Committee trainees. Five WURC Reports were published during the year and eleven Technical Reports for limited distribution were prepared.

ACCOMMODATION

Shortage of laboratory and office space remains a problem at the Woodvale and Dwellingup Research Centres. The Herbarium Research Centre is in the process of being extended by about one-third.

EXTERNAL LIAISON

Co-operation among Government departments and between Government departments and private organizations continues to be of an excellent standard. Research staff have often been called upon in a consultative capacity over the year. Collaborative studies have been conducted with a number of Government departments and organizations.

External funds were received to carry out and continue with a number of research projects throughout the year. Major funding bodies during 1989/90 were Australian National Parks and Wildlife Service ($380 000), Australian Biological Resources Study ($76 000), Western Australian Heritage Committee ($49 000), ALCOA ($134 000), Western Australian Water Authority ($48 000), National Parks and Nature Conservation Trust Account ($10 000), Barrack Silicon ($20 000), Department of Primary Industries and Energy - National Afforestation Program ($1 283 000). In addition funding was again received from the Western Australian Department of Agriculture as part of the National Soil Conservation Program for a three-year research project at Esperance.

RESEARCH PROJECT PLANS

All proposed research is vetted for relevance, cost effectiveness and scientific excellence. During 1989/90, 67 of these plans were approved.

PUBLICATIONS

All manuscripts are reviewed by appropriate senior staff for scientific merit and policy implications before papers are submitted to scientific journals for publication. During 1989/90, 75 papers were approved. In addition, over 145 papers and reports were published by Research Division staff during the year. Most of these appeared in journals published by organizations independent of CALM; this helps ensure that the research done receives national and international exposure, thereby maintaining the high scientific profile enjoyed by CALM.

SEMINARS

20 formal seminars were presented by Research Division staff during the year, with CALM staff outside Research Division and scientists from Tertiary institutions and other Government agencies in attendance, as well as members of the public.

PUBLICITY

Good use of the news media was made, with many interesting articles on aspects of the research of Divisional scientists being published in Perth and country newspapers. Research conducted by the Marine Conservation Program was featured on an ABC television science program.

PART 1 INTRODUCTION

SCOPE

This research plan relates to the work carried out by the Department's Division of Research and does not include research conducted in other Divisions. It is a rolling plan and will be revised each year in July.

Production of a rolling five-year plan is considered the best way of clearly describing the what, why, where, who, when and how of research.

CALM's Corporate Plan requires that each functional group within the Department prepare its own Strategic Plan. This Plan fulfils this requirement for the Division of Research. The information in this plan is correct to 30 June 1990.

HISTORICAL OVERVIEW - A Brief Synopsis

The Department of Conservation and Land Management was officially created on 22 March 1985 through the amalgamation of the Forests Department, National Parks Authority and the wildlife component of the Department of Fisheries and Wildlife. The amalgamation saw the creation of the Research and Planning Division as part of the Policy Directorate of CALM. An internal reorganization in 1986 led to the formation of a new Division placed within the Operations part of the Department. Research was at this stage divided into two branches - Production and Protection Research, and Wildlife Research. Mr Joe Havel was the first Director of Research and Planning.

The Division was further reorganized in 1987 with the appointment of Dr Andrew Burbidge as Director of Research. A program structure was adopted at this time with modifications being made in July 1988. The final structure of research programs adopted was: Executive and Administrative Support, Biogeography, Entomology, Fauna Conservation, Fire, Flora Conservation, Plant Diseases, Rehabilitation, Research Computing, Research Methods, Silviculture, Wetlands and Waterbirds and Wood Utilization. In July 1988 the West Australian Herbarium was incorporated into the Research Division of CALM. Before this the Herbarium came under the administration of the Department of Agriculture. The Herbarium was incorporated as a program. December 1988 saw the appointment of the Department's first Marine Research Scientist. A Marine Conservation Program was then developed.

In 1989-90 the Research Programs "Herbarium " and "Flora Conservation" were re-organized into three new programs - Flora Collections, Flora Information and Flora Conservation. The existing Silviculture and Rehabilitation Programs were restructured to form two new programs - Native Forest Silviculture and Plantation Silviculture.

The Research Computing Program was also merged with the Research Methods Program to become Research Techniques.

A more detailed historical overview of the Division is contained in the 2nd edition of this Plan.

PART 2 ORGANIZATION

The Division of Research is one of seven Divisions of CALM under the overall control of the General Manager and Executive Director. The Division is led by the Director of Research, and a corporate team consisting of three Senior Principal Research Scientists and three Principal Research Scientists (Figure 1). Internal organization is on the basis of Research Programs, each led by a Program Leader. Staff are located at five Research Centres, each under the administrative control of a Research Centre Manager. Some Como Research Centre staff are located at Albany, Bunbury, Busselton, Narrogin and Wanneroo District Offices. Two Woodvale staff are located at Karratha.

RESEARCH DIVISION POLICY GROUP

The Research Division Policy Group was set up for several reasons:

To spread the workload, increase efficiency and alleviate stress in the senior staff of a large, complex organization.

To allow scientists with different backgrounds and expertise to apply their skills to the benefit of the Division. The Division embraces a very broad range of research projects and areas, too many for any one person to be proficient in.

To allow senior staff to spend some of their time carrying out and applying research.

To be in line with the trend in modern management of corporate decision making.

A review of the Executive and Administrative Support Program in March 1989 resulted in modifications to the roles of RDPG members.

In broad terms, duties of the members of RDPG are as follows (for greater detail, see the Executive and Research Support Program, Part 13):

Director of Research - Andrew Burbidge

Responsible for overall final decision-making and leadership of Research Division, chairing of RDPG meetings, and attending and contributing to Departmental Corporate Executive meetings. Concentrates on the external environment, both regarding the Department and the public.

Senior Principal Research Scientist - Per Christensen

Responsible for Research Centre Managers at Como (and its outstations), Manjimup and Busselton. Responsible for the Plantation Silviculture, Wood Utilization, Native Forest Silviculture and Entomology Programs and for the administrative areas of Wood Utilization Research Centre, Directors of Research Committee (Forestry Council), Research Steering Committee, and interaction with Forest Resources Division.

Senior Principal Research Scientist - Steve Hopper

Responsible for the Woodvale (and its outstations) Research Centre Manager. Responsible for the Biogeography, Fauna Conservation, Fire, Wetlands and Waterbirds and Marine Conservation Programs. Responsible for the administrative areas of Working Group on Land Releases, interaction with Nature Conservation Division with respect to fauna, endangered fauna, land reservation, and mining (Bailey Committee procedures).

Senior Principal Research Scientist - Jim Armstrong

Responsible for the staff at the Herbarium and the Research Centre Manager at Dwellingup. Responsible for the Flora Collections, Flora Conservation, Flora Information and Plant Diseases Programs, and for the administrative areas of the Herbarium collection, interaction with Nature Conservation Division on matters relating to flora and endangered flora and with all Divisions on plant

diseases. Represents Western Australia on the Council of Heads of Australian Herbaria.

Principal Research Scientist - Tony Start

Assists SPRS Steve Hopper. Responsible for the Research Techniques Program. Responsible to the Director of Research, through RDPG, for the following administrative areas: staff administration, co-ordination of budget preparation and administration, co-ordination of the review of ERMPs, draft Management Plans and Guidelines for Necessary Operations.

Principal Research Scientist - Ian Abbott

Assists SPRS Per Christensen. Responsible for the following administrative areas: scientific publishing and SPEC (Scientific Publishing and Editorial Committee), Library Committee, organization of seminars, annual revision of this Research Plan, co-ordination of Research Division contribution to the Annual Report.

Principal Research Scientist - Neville Marchant*

Assists SPRS Jim Armstrong. Responsible for the Flora Information Program.

In addition to the above duties, SPRSs and PRSs attend all meetings of Programs under their control and meet with Research Scientists in Programs under their control at least twice per year.

Principal Research Scientist (Special Projects) - John Bartle

Not a permanent member of RDPG, but called upon as required to work on allocated special projects and integrated land use management.

PROGRAM LEADERS

Program Leaders were initially elected by members of the Program for a 3 year term but are now appointed by RDPG. Their duties, in priority order, are as follows:

Coordinate research in the program and in conjunction with their SPRS/PRS maintain scientific standards.

Review proposed Research Project Plans, manuscripts and publications from program members.

Generate momentum and *esprit de corps* in the Program.

Financial control - prepare budgets and distribute allocated finance within the program.

Provide information to the Department on costs and benefits of research carried out within the program and other matters as required.

Be the first point of contact for managers and other staff with technical questions regarding the program.

Seek opportunities for positive interaction with Managers in other Divisions.

Contribute to and revise the relevant program section of the Research Plan.

Co-ordinate program responses to technical reviews of referred documents, e.g. Draft Management Plans, Environmental Review and Management Programs, Guidelines for Necessary Operations.

Foster links between programs where appropriate.

Maintain external liaison with other research institutions, tertiary institutions and promote joint research.

Co-ordinate research grant applications for work in the program.

Participate in Program Leader meetings.

RESEARCH CENTRE MANAGERS

Research Centre Managers are appointed by RDPG. Their duties are as follows:

Promote a safe, productive and friendly work environment at the Centre;

Co-ordinate the use of facilities and equipment at the Centre and the provision of new facilities;

Prepare budgets for and control expenditure of Research Centre cost items;

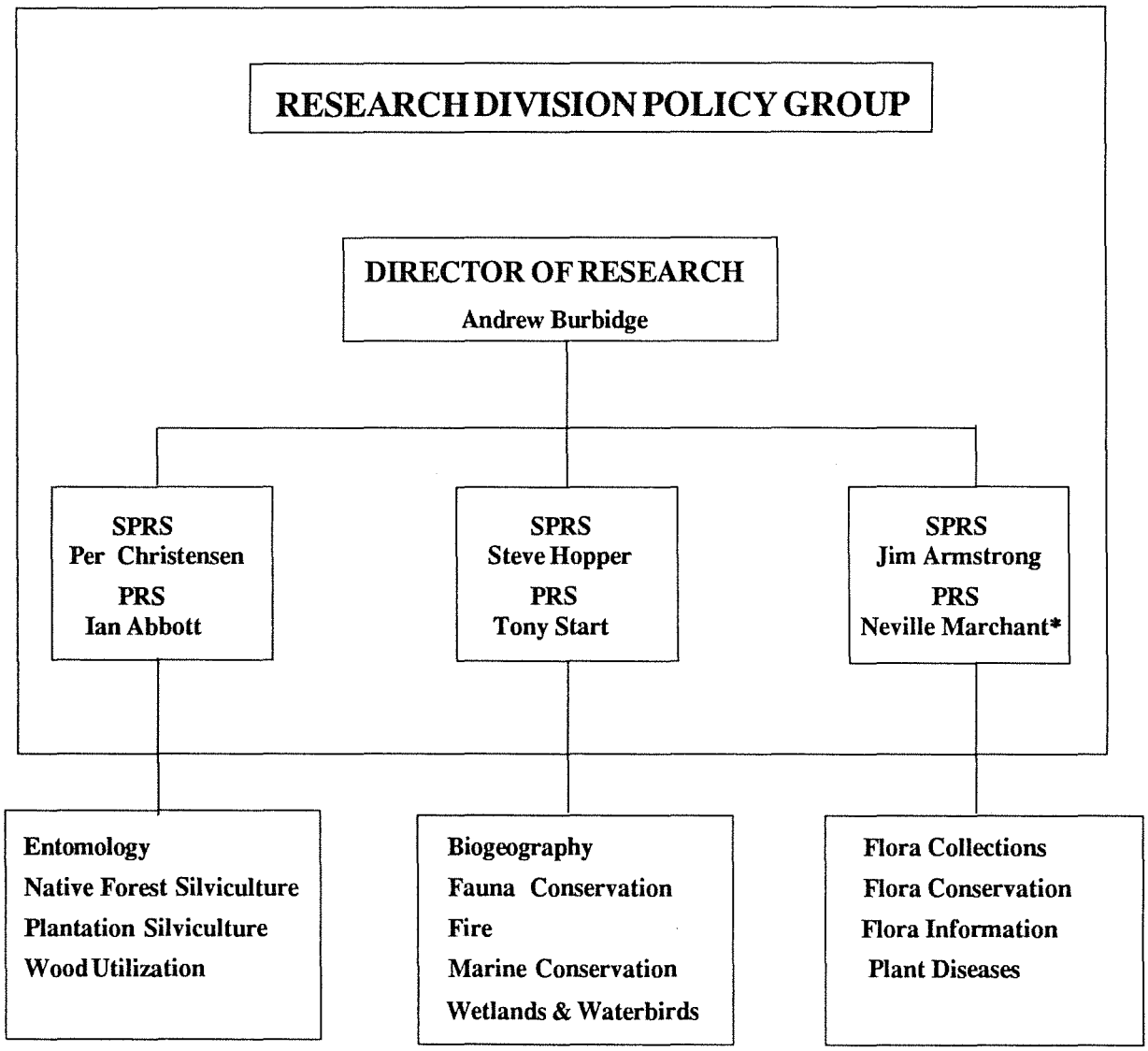
Be responsible for general management of staff based at the Centre;

Seek opportunities for positive interaction with managers of other parts of the Department, particularly within the District and Region in which the Research Centre is located.

Figure 1

Line Responsibility in RDPG

The Programs 'Executive and Research Support' and 'Research Techniques', are responsible to the Director of Research and PRS T Start.



* Acting

Table 1
Principal Officers of the Research Division

+Acting
**Co-opted as required*

Research Division Policy Group	
Director of Research	A.A. Burbidge, *BSc(Hons)PhD(W.Aust)*
Senior Principal Research Scientist	J.A. Armstrong, *BScAgr(Hons)(Sydney)*
Senior Principal Research Scientist	P. Christensen, *BSc(Hons)(Rhodes)PhD(W.Aust)*
Senior Principal Research Scientist	S.D. Hopper, *BSc(Hons)PhD(W.Aust)*
Principal Research Scientist	A.N. Start, *BSc(Hons)PhD(Aberdeen)*
Principal Research Scientist	I. Abbott, *BSc(Hons)(Sydney)PhD(Monash)*
Principal Research Scientist	N.G. Marchant, *B.Sc (Hons)(W.Aust)PhD(Cambridge)* +
Principal Research Scientist (Special Projects)	J.R Bartle, *BSc Agr(W.Aust)**
Program Leaders	
Executive and Research Support	A.A. Burbidge, *BSc(Hons)PhD(W.Aust)*
Biogeography	G.J. Keighery, *BSc(Hons)(W.Aust)*
Entomology	I. Abbott, *BSc(Hons)(Sydney)PhD(Monash)*
Fauna Conservation	J.A. Friend, *BSc(Hons)PhD(Tasmania)*
Fire	N.D. Burrrows, *BScFor(Aust.Nat.Univ)*
Flora Collections	B.R. Maslin, *BSc(Hons)MSc(W.Aust)*
Flora Conservation	D.J. Coates *BSc(Hons)PhD(W.Aust)*
Flora Information	N Lander, *BSc(Sydney)MSc(Sydney)*
Marine Conservation	J.A. Stoddart, *BSc(Hons)MSc,PhD(W.Aust.)*
Native Forest Silviculture	D.S. Crombie, *BSc(Hons)(Qld)PhD(Glasgow)*
Plant Diseases	B.L. Shearer, *BScAgr(Hons)(W.Aust)PhD(Minnesota)*
Plantation Silviculture	J. McGrath, *BScAgr(Hons)PhD(W.Aust)*
Research Techniques	M.H.C. Choo, *BSc(Hons)MSc(Loughborough)*
Wetlands & Waterbirds	J.A.K .Lane, *BSc(W.Aust)*
Wood Utilization	G.R. Siemon, *BScFor(Hons)PhD(Aust.Nat.Univ)*
Research Centre Managers	
Como	G.R. Siemon, *BScFor(Hons)PhD(Aust.Nat.Univ)*
Dwellingup	D.S. Crombie, *BSc(Hons)(Qld)PhD(Glasgow)*
Herbarium	J.A. Armstrong, *BScAgr(Hons)(Sydney)*
Manjimup	W.L. McCaw, *BForSc(Hons)(Melbourne)*
Woodvale	J.A.K. Lane, *BSc(W.Aust)*

PART 3 RESOURCES

In 1989/90 the Division comprised 56.0 Professional and 91.9 Technical and Clerical staff, totalling 147.9 persons (full time equivalent). Some of these persons were casual or part-time.

The total CRF budget in 1989/90 was $6 535 628 consisting of $4 660 628 for salaries and $1 875 000 for operating costs (research, wages, travel and plant).

In 1989/90 Research Division accounted for 8.57% of staff positions and 7.34% of the Department's total budget. The corresponding figures for 1988/89 were 9.07% and 6.66%.

Resources in 1988/89 are summarized for each Program in Tables 2 and 3.

Estimated resources for 1990/91 for each program is summarized in Table 2. Wood Utilization is omitted from all tables as its budget is managed by the Division of Forest Resources.

Table 2

Estimate of Resources 1990/91 in Research Division (CRF), as at 30 September 1990

Program	Prof Staff	Tech Cler Staff	No. People	% Staff	Staff $	Operating Budget $	Total $	Finance %
Executive & Research Support (includes Publications)	6.35	18.45	24.8	17.9	908 175	570 750	1478 925	23.4
Biogeography	5.8	4.9	10.7	7.7	396 169	114 700	510 869	8.0
Entomology	1.4	4.0	5.4	3.9	153 622	24 000	177 622	2.8
Fauna Conservation	3.95	4.85	8.8	6.3	366 321	128 200	494 521	7.8
Fire	6.0	10.55	16.55	11.9	595 926	162 700	758 626	11.9
Flora Collections	2.85	2.15	5.0	3.6	24 289	19 450	43 739	0.7
Flora Conservation	4.25	1.9	6.15	4.4	152 289	50 200	202 489	3.2
Flora Information	3.55	1.45	5.0	3.6	249 121	17 700	266 821	4.2
Marine Conservation	1.4	0.5	1.9	1.4	95 333	26 000	121 333	1.9
Native Forest Silviculture	3.1	6.4	9.5	7.0	282 919	102 300	385 219	6.0
Plant Diseases	3.3	8.8	12.1	8.7	372 475	118 350	490 825	7.7
Plantation Silviculture	8.4	15.7	24.1	17.4	743 563	170 100	913 663	14.4
Research Techniques	4.0	1.1	5.1	3.7	187 966	125 750	313 716	4.9
Wetlands & Waterbirds	1.9	1.7	3.6	2.6	155 824	43 800	199 624	3.1
Research Division Total	56.25	82.2	135.9	100	4 683 992	1 674 000	6 357 992	100

Table 3

Summary of External Resources 1990/91 in Research Division (as at June 1990)

Program	Prof Staff	Tech Cler Staff	No. People	% Staff	Salaries $	Operating Budget $	Total $	Finance %
Executive & Research Support (includes Publications)	0	2	2	13	31 898	0	31 898	6.1
Fauna Conservation	0.5	0	0.5	3.3	16 520	0	16 520	3.1
Flora Collections	0	2	2	13	49 275	0	49 275	9.3
Flora Conservation	3	0	3		93 500	31 200	124 700	23.5
Marine Conservation	1	0	1	6.5	17 500	1 500	19 000	3.6
Plant Diseases	1	1	2	13	54 560	15 000	69 560	13.2
Plantation Silviculture	4	3.8	7.8	51	121 929	0	121 929	23.1
Wetlands & Waterbirds	1	0	1	3.3	35 000	61 000	96 000	18.1
External Total	10.5	8.8	19.3	100	420 182	108 700	528 882	100

PART 4 ALLOCATION OF PRIORITIES FOR RESEARCH

Ideally research priorities should be allocated according to explicit criteria. These criteria should be able to deliver an objective and decisive priority allocation at any level of research (i.e. program, goal, project). They should be used to guide the smooth transfer of resources from terminating and low priority areas into high priority areas.

Considerable effort was put into debate and development of this ideal in preparation for this revision of the 5 year plan. it was concluded that a purely objective and explicit system was probably unattainable. Too many social and political factors which cannot be resolved into simple criteria impose a framework that constrains priority allocation and transfer of resources.

It was therefore decided to provide a general overview of major social and political factors which impinge on priority setting as well as a listing of definable criteria by which a finer tuning of priorities can be achieved.

SOCIOPOLITICAL FACTORS IN PRIORITY ALLOCATION

Relative priority of conservation versus production related research

CALM has responsibilities for both production and nature conservation research. Conservation activity is not directly revenue generating. On the other hand, production activity does generate revenue and, if well supported by research, its revenues will grow. Ultimately within society at large, it is revenue from production activity which funds conservation. To some extent, the greater the amount of activity in production, the greater is the need for research into conservation techniques. Conceptually, therefore, there must be a balance between expenditure on research for production and conservation.

Relative priority of research in different geographic areas

Areas managed by CALM include lands in the intensively used south-west, the largely unoccupied arid lands, the less developed tropical north as well as marine parks. The south-west has the greatest economic activity, population, infrastructure and CALM presence. It would seem to command the largest proportion of research resources. However, it could be argued that the less disturbed tropical north, arid interior and marine parks warrant generous research investment to establish sound management practices while they remain relatively undisturbed. On balance it seems appropriate that the south west takes the largest share of resources, but that research input to other areas be disproportionate to their present level of development. In particular there should be a commitment to undertake survey/monitoring work in these areas. The absence of a CALM management presence may make more elaborate work than this difficult to sustain.

Research relating to CALM lands vs other lands

CALM has responsibilities for conservation and timber production which extend beyond the boundaries of CALM-managed land. Also activities outside CALM lands may have direct impacts within them e.g. hydrological impacts including salinity and nutrient enrichment may be felt in drainage systems and wetlands at great distance from the disturbance; likewise feral animals, weeds and fire do not recognize the boundaries of land tenure. CALM clearly has an interest in sound land use beyond its boundaries and research priorities should reflect this.

Public and political factors in priority setting

Many issues in CALM research are of high public concern. Such issues may become politically important and pressure may grow for specific research to be undertaken. This may be a problem where the application of the internal priority process indicates that the issue is of low priority, particularly if no new resources are forthcoming. CALM has an interest in seeing that the public and political process hat may impose research priorities do so with the best available information so that the outcome is soundly based. Internal CALM debate on research priorities should be open and attempt systematically to reach a sound consensus position

which is effectively conveyed to the public arena to guide informed public debate.

Inertia in existing commitments in physical resources and staff

Priorities which involve major relocation of physical and staff resources cannot be summarily introduced. The meeting of such priorities requires longer term planning extending beyond the 5 year term. Such planning should be integrated with the planning of staff appointments, staff training, buildings and other facilities, as well as with other CALM planning.

EXPLICIT CRITERIA FOR PRIORITY ALLOCATION

For ease of use, criteria are arranged into categories depending on he level of research to which they apply. They are also arranged in order of importance within each category.

GENERALLY APPLICABLE CRITERIA

Relevance

Research must be relevant to CALM's goals and objectives as enumerated in legislation and the Department's Corporate Plan.

Departmental Priorities

research priorities will reflect overall Departmental priorities as laid down by the Corporate Executive.

Cost Effectiveness

Research should lead to substantial improvement in the economics of management on CALM lands.

Scale of the problem

The research should relate to a problem (or problems afflicting extensive areas or important industries, or important species, or many ecosystems, and be of long duration or intensive in impact.

Demand for results

The information is, or will be, sought urgently by managers.

Spread of research activity

It is desirable that some research presence is achieved in all major CALM lands, so as to develop expertise, provide surveillance and respond rapidly in the event of any major problem emerging.

Linking funding to performance

Work proposed by individuals or programs with a record of outstanding achievement will be favoured.

Innovation potential

Some high risk or speculative research will be approved where there is sufficient promise of radical advance.

Efficient use of staff expertise

New research to be undertaken will be constrained by the expertise of the individual available to lead that research. Likewise, some lower priority projects may be undertaken to utilise fully the skills available.

Matters of high public concern

A capacity to respond to soundly based public concern must be maintained.

Integration with research outside CALM

Research within CALM will be co-ordinated and integrated with related work being conducted by

other agencies. Other matters being equal, higher priority will be given to program/projects which augment or stimulate relevant external research.

Outside funding

The availability of external funding may elevate the priority rating of any research project. However, high priority research should not be delayed or displaced by the need to support partly externally funded low priority work. Gaining external funds must not be a reason for withdrawing internal funds from any individual or program.

ADDITIONAL CRITERIA FOR RANKING PROJECTS

Experimental approach

A majority of projects should be experimental so as to identify cause and effect rather than be documentary or descriptive.

Project design

Extremes of experimental treatments should be examined.

CRITERIA FOR TERMINATING PROJECTS

Completion

The project is complete and the conclusions have been implemented by Operations.

Failure

The project does not look like producing anything of value.

Insufficient resources

Resources do not allow successful completion of the project.

Irrelevance

The project is no longer relevant because of changing policies or external factors.

PART 5 ALLOCATION OF RESOURCES

REALLOCATION OF EXISTING RESOURCES

In the light of Departmental priorities, the need to reallocate resources from one area of research to another will arise during the period of this plan. However, there will not be a sudden shift of resources and, by and large, existing resource allocations are likely to stand until the completion of a project unless there are grounds for early termination (see Part 4) or there are significant overriding reasons for the transfer of resources to new projects.

Where priorities dictate the transfer of resources from one program to another, this will be achieved by:

Reviewing all staff and wages items that become vacant.

Reviewing the allocation of staff and resources when research projects are completed.

Reviewing the allocation of financial resources each financial year.

Reviewing each Research Program at least every three years.

The review process will involve a consideration of the criteria listed in Part 4. In addition, development of priorities for the Department as a whole will enable the Research Division to better decide on its own priorities.

Although the Division is involved with an extremely wide array of problems, many areas of concern are not formally addressed at present. So that emerging problems can be quickly identified the Research Division has prepared a list of staff who have or could develop expertise in a variety of subjects (Appendix III). These persons will be asked to maintain a watching brief on particular areas and alert the Director of Research to any problems that arise that may need research or management.

REVIEW OF RESEARCH PROGRAMS

Some resource reallocation within and between programs will also be achieved during reviews of each program. An initial review took place early in 1988. Following these reviews more detailed reviews will occur approximately every three years. These reviews will be carried out by Review Committees specially set up for that purpose. Each committee will consist of about three persons, plus the Program Leader, and will be chaired by the Director of Research. Members may come from Research Division, from the Corporate Executive, other Divisions or from outside the Department, as appropriate.

PRIORITIES FOR NEW RESOURCES

Recognizing the limited resources that are available to CALM, the Research Division Policy Group in March 1990 reviewed priorities for the allocation of staff and resources within the Division, should a vacancy occur. Growth areas were prioritized as follows:

1. Flora Collections
2. Flora Conservation
3. Environmental Weeds

When allocating priorities it is important that the proposals dovetail with the latest trends set for the functions of the Department as a whole.

STAFF MOVEMENTS AND APPOINTMENTS

Seven (three professional and four technical and clerical) officers joined the permanent staff of the Division in 1989/90. Two permanent officers left the Division by way of internal transfer or promotion during the period. Two officers resigned.

New Appointments 1989/90

Professional

A. Chapman - Research Scientist
R. Harper - Research Scientist
B. Glossop - Research Scientist

Technical and Clerical

B. Giles
R. Bowles
A. Winza
C. Farrell
P. Heslewood

Departures 1989/90 (transfers, promotions and resignations)

Technical and Clerical

A.K. Kennett-Smith
H. Warren
I. Freeman
J. Gilmour
M.E. McDonald

Movements Between Research Centres

Some minor movement of staff between country and metropolitan Research Centres occurred during 1989/90. Staff can be moved in order to facilitate the works program and bring them closer to study sites. Career development is seen as a major criterion for moving more junior research staff. Availability of office and laboratory accommodation is also viewed when considering any move.

During 1989/90 the following movements of staff between research locations occurred:

J. McGrath (Senior Research Scientist) from Como to Busselton
S. Crombie (Research Scientist) from Como to Dwellingup
B. Glossop (Research Scientist) from Dwellingup to Harvey
B. Bromilow (Technical Officer) from Woodvale to Karratha
J. Monck (Administrative Assistant) from Herbarium to Dwellingup

Staff Currently on Study Leave

G. Stoneman (Research Scientist)
G. Inions (Research Scientist)

PART 6 GEOGRAPHICAL DISTRIBUTION OF RESEARCH EFFORT

Research effort is spread throughout the State. Table 4 indicates the % time spent on research in each of the eleven CALM regions and interstate.

Note that the Executive and Research Support Program is not included in Table 4, as it is a service program.

Table 4
Geographical Distribution of Research by Programs 1989/90

Index

1 = KIMBERLEY
2 = PILBARA
3 = GASCOYNE
4 = GOLDFIELDS
5 = GREENOUGH
6 = WHEATBELT
7 = METROPOLITAN
8 = NORTHERN FOREST
9 = CENTRAL FOREST
10 = SOUTHERN FOREST
11 = SOUTH COAST
12 = INTERSTATE

PROGRAM	1	2	3	4	5	6	7	8	9	10	11	12*
BIOGEOGRAPHY	21	1.5	-	2	3	2	1	9	10	10	9	-
ENTOMOLOGY	-	-	-	-	-	5	2	2	41	40.0	10	-
FAUNA CONSERVATION	1	6	2	4	6	63	7	4	1.5	1.5	4	-
FIRE	-	11	-	22	2.5	11	-	2	0.5	23	28	-
FLORA COLLECTIONS	10	9	6	9	11	22	7	4	3	2	14	3
FLORA CONSERVATION	-	5	-	7	20	24	7	6	4	6	21	-
FLORA INFORMATION	50	2	2	2	5	5	5	5	5	5	5	9
MARINE CONSERVATION	-	5	50	-	5	0	40	-	-	-	-	-
NATIVE FOREST SILVICULTURE	-	-	-	-	-	18	-	48	9	25	-	-
PLANT DISEASES		-	-	-	2	-	18	52	3	6	19	-
PLANTATION SILVICULTURE		-	-	-	-	5	-	25	35	25	10	-
RESEARCH TECHNIQUES	-	-	-	-	-	-	68.5	11	6.5	14	-	-
WETLANDS & WATERBIRDS	10	-	-	-	5	10	20	20	20	10	5	-
WOOD UTILIZATION	-	-	-	-	-	-	-	30	37	33	-	-

*Research by plant taxonomists in herbaria in other states is counterbalanced by research by botanists in other states on the Western Australian flora.

PART 7 STAFFING

Research Division staff came from three different organizations that applied different titles to their professional and non-professional officers. There were also considerable differences in the conditions of employment in the former agencies, particularly for technical staff.

The RDPG remains committed to bringing titles and working conditions into a single Division-wide system. The process has been slow because many industrial issues needed to be agreed to by all parties within CALM and, in many cases, by other departments with staff employed under the same awards and/or by the Public Service Commission. Almost all issues are now finalized.

PROFESSIONAL STAFF

All professional officers are Scientific Officers bearing the title "Research Scientist" except for a few senior officers at the W.A. Herbarium who are Agricultural Scientists (because the Herbarium was previously attached to the Department of Agriculture) bearing the title "Botanist". The only industrial consequence of changing the latter from Agricultural Scientists to Scientific Officers relate to Criteria Progression.

Both groups now have progression opportunity to Level 8. The RDPG will seek changes to the criteria for progression for Scientific Officers so that Agricultural Scientists are not disadvantaged by converting to Scientific Officers.

TECHNICAL STAFF

The role of Technical staff is critical to the functioning of the Division. These officers, more than anyone, are the "doing" people. They set out and organize field work, collect and organize data, and, at higher levels, assist with data analysis and write up as well as putting results into practice. Basically their task is to assist Research Scientists, not to do their job for them.

Some technical staff are employed under the Public Service Act. Others are employed under the CALM Act. The difference is historical. It is due to the amalgamation of groups from different backgrounds into the Research Division. This situation resulted in problems because some terms and conditions of employment were different.

Most differences are resolved. The outstanding one relates to overtime. The RDPG desires a commuted overtime scheme to apply to all Technical Officers undertaking field trips involving one or more nights away from home. An additional week of leave should be tied to the agreement on the basis of one additional day for each five days field work to a maximum of five days additional leave per year.

The Division's aim is to have all technical staff employed under one Act, the Public Service Act. This aim is in line with Government policy: The whole State public sector is moving towards a "One Employer" concept and CALM is advancing with negotiations towards this goal. In the mean time Research Division will maintain its previously stated policy.

All vacancies not filled by internal transfers will be advertised as Public Service positions.

All positions will carry the titles "Technical Officer" or "Senior Technical Officer".

Until recently most CALM Act technical staff joined the Division as Cadet graduates on Level 1. However the Department will no longer allocate Cadet graduates to the Division. In future all Technical staff vacancies will be filled by internal transfer or advertisement at a base classification of Level 2. The Division will not employ any more technical staff at Level 1.

All Technical Officers now have access to Criteria Progression to Level 4. The RDPG proposed to alleviate the pressures on some Research Scientists who also act as Research Centre Managers by developing Level 5 Centre Manager positions at selected Research Centres. These would be available to suitably qualified technical staff. This will improve the effectiveness of more senior staff as well as enhancing career opportunities for Technical Officers.

A Level 5 Research Centre manager position has been created and advertised at the Wildlife Research Centre, Woodvale. Another Level 5 Technical position, a Collections Manager, is planned for the W.A. Herbarium.

ADMINISTRATIVE SUPPORT STAFF

At present four units requiring administrative support can be identified: The Executive (RDPG) with Division wide responsibilities; Large Research Centres (Como, Woodvale, Herbarium); Research Centres (Manjimup, Dwellingup, Busselton); Research Stations (Collie, Narrogin, Karratha).

The Executive

The RDPG workload requires administrative support. It is not appropriate for this to be built into Research Centre administrative structures because the issues are not confined to particular Centres. At present it comprises an Administrative Assistant L3, and a Clerk Typist Level 2. They are attached to the Director's office.

The 1988/89 edition of this plan foreshadowed creation of a position at Level 4 for a Divisional Administrative Officer. However the proposal was not approved. At present the Level 3 position provides Division-wide support in staffing matters and the Administrative Assistant, Como Research Centre, co-ordinates and oversees financial management at this level.

Large Research Centres (LRC)

RDPG considers that LRC administrative staffing structure should be O.I.C. Administrative Assistant L3, Assistant Administrative Officer/Typist L2 and Clerk Typists L1. (The number of Clerk Typists to be determined by work loads, but normally 2 unless more are warranted).

Research Centres (RC)

RC administrative staffing structure should be O.I.C. Assistant Administrative Officer L2 and Typist L1.

Research Stations

Research Stations are normally attached to Operations Division offices that provide support (eg. typing). Administratively they are treated as extensions of one or another of the Large Research Centres. The *status quo* will be maintained.

The present staffing levels fall short of these ideals. It is unlikely that the Division will win additional resources to address the shortfall, at least in the short term. Nevertheless the Division will continue to restate the situation it perceives to be optimal.

The RDPG strongly believes that, as most staff now have access to personal computers with word-processing programs, Research Scientist and Technical Officers should increasingly undertake their own typing. This will enable the Division to utilize its scarce FTE resources on research, not support.

PART 8 SCIENTIFIC PAPERS APPROVED FOR PUBLICATION

The following scientific papers were approved for publication during 1989/90. Further details on these papers can be obtained direct from the authors.

BIOGEOGRAPHY

Andersen, A., and Burbidge, A.H. The ants of a vine thicket near Broome : a comparison with the northwest Kimberley.

Burbidge, A.H. and Woinarski, J. Biogeographic patterns in rainforest birds of northern Australia.

Hobbs, R.J. and Hopkins, A.J.M. The role of conservation corridors in a changing climate.

Keighery, G and Alford, J. Vegetation (of Lancelin - Dongara Islands).

Kenneally, K.F. Checklist of vascular plants of the Kimberley, Western Australia.

McKenzie, N, Belbin, N. Margules, C. and Keighery, G. Selecting representative reserve systems in remote areas : a case study in the Nullarbor region, Australia.

Panetta, F.D. and Hopkins, A.J.M. Weeds in corridors : invasion and management.

Wardell-Johnson, G. and Roberts, J. The survival status of the *Geocrinia rosea* (Anura : Myobatrachidae) complex in riparian corridors, biogeographical implications.

ENTOMOLOGY

Abbott, I. Insect outbreaks in forests of W.A.

Abbott, I., Smith, R., Williams, M. and Voutier, R. Site factors associated with infestation of regenerated stands of Karri (*Eucalyptus diversicolor*) by Bullseye Borer (*Tryphocaria acanthocera*, Cerambycidae) in Western Australia.

Abbott, I. Annual cycle and reproductive activity of a population of *Catasarcus asphaltinus* Thompson (Coleoptera : Curculionidae) in suburban Perth, Western Australia.

Postle, A. and Abbott, I. Termites of economic significance in suburban Perth, Western Australia : their distribution and association with types of wood.

FAUNA

Andersen, A.N. and Burbidge, A.H. Ant faunas of semi-arid southern Australia : Cape Arid National Park W.A.

Burbidge, A.A. Conservation of threatened species of mammals in Australia.

Burbidge, A.A. *Ilangnalya* - Kimberley Possum.

Burbidge, A.H. and Fuller, P.J. Possible effects of fox (and/or cat) predation on ground nesting birds in W.A.

Burbidge, A.H., McNee, S., Newby, B. and Rolfe, J.K. Supplementary Report to World Wildlife Fund (Australia). Project 118 - Conservation of the Ground Parrot.

Morris, K. Chuditch - its biology and conservation.

Morris, K.D. and Bromilow, R.N. A record of the Euro (*Macropus robustus*) in John Forrest National Park.

Williams, A. New southern records of the Yellow Palmdart *Cephrenes trichopepla* (Lower) (Lepidoptera : Hesperiidae) in Western Australia.

FIRE

Burrows, N, Ward, B. and Robinson, A. Fire behaviour in spinifex fuels on the Gibson Desert Nature Reserve, Western Australia.

Burrows, N., Gairdiner, G., Ward, B., and Robinson, A. Regeneration of *Eucalyptus wandoo* Blakely, following fire.

Burrows, N. and Van Didden. Patch-burning Spinifex deserts using aircraft.

Burrows, N. and Christensen, P. A survey of Aboriginal fire patterns in the Western Desert of Australia.

Hall, G. and Friend, G. Distribution habitat and behavioural patterns of *Nickerlea sloanei* (Lea) (Coleoptera : Cicindelinae) in south western Australia.

Hall, G. Host preferences of Paropsini (Coleoptera : Chrysomelidae) in south-western Australia.

Pearson, D.J. and Robinson, A.C. New records of the Sandhill Dunnart, *Sminthopsis psammophila* (Marsupialia : Dasyuridae) in South and Western Australia.

Pearson, D.J. First records of the Mulgara, *Dasycercus cristicauda*, from the Gibson and Queen Victoria Springs Nature Reserves.

FLORA CONSERVATION

Coates, D.J. and Hnatiuk, R.J. Systematic and evolutionary inferences from isozyme studies in the genus Eremaea (Myrtaceae).

Coates, D.J. Protection of Western Australia's flora.

Hopper, S.D., van Leeuwen, S., Brown, A.P. and Patrick, S.J. Western Australia's Endangered Flora.

Kelly, A., Coates, D., Herford, Hopper, S., O'Donoghue, M, and Robson, L. Declared Rare Flora and other plants in need of special protection in the Northern Forest region.

Sampson, J.F., Hopper, S.D. and Coates, D.J. *Eucalyptus rhodantha.* CALM Wildlife Management Program

HERBARIUM

Chapman, A.R. and Maslin, B.A. A review of the *Acacia bivenosa* group.

Classen-Bockhoff, R., Armstrong, J.A. and Lehne, M. The inflorescences of the Australian Genera *Diplolaene* R.Br. and *Chorilaena* Endl. (Rutaceae).

Cowan, R.S. and Maslin, B.R. *Acacia* Miscellany - 1. Some oligoneurous species of *Acacia* (section Plurinerves : Leguminosae - Mimosoideae) from Western Australia.

Cowan, R.S. and Maslin, B.R. *Acacia* Miscellany - 3. Some new microneurous taxa of Western Australia related to *A. multilineata* (section Plurinerves : Leguminosae - Mimosoideae)

Cowan, R.S. and Maslin, B.R. *Acacia* Miscellany - 2. Species related to *A. deltoidea* (Leguiminosae : Mimosoideae : Section Plurinerves).

Cranfield, R. List of vascular plants recorded from the Murchison Catchment Survey area 1985-88.

Keighery, G. *Banksia canei* (Mountain Banksia) in Western Australia.

Keighery, G. Taxonomic review of the *Grevillea drummondii* species group (Proteaceae).

Keighery, G.J. A new species of Platysace (Apiaceae) from northern Australia.

Keighery, G.J. A new species of Arthropodium R.Br. (Anthericaceae) from central Australia.

Lander, N.S. New taxa and new combinations in *Olearia* (Asteraceae : Astereae) from New South Wales.

Maslin, B.R. Acacia Miscellany - 5. three new Western Australian species with affinities to *A. withelmiana.*

Maslin, B.A. *Acacia* Miscellany - 6. Review of *Acacia victoriae* and related species.

Wilson, P. *Philotheca citrina* (Ruthaceae), a new species from Western Australia.

Wilson, P. The Lawrencella complex (Asteraceae Gnaphalieae) of Australia.

MARINE CONSERVATION

Stoddart, J.A. Analysis of water quality in Shark Bay and Coral Bay : August/October 1989.

Stoddart, J.A. *et al.* Summary proceedings of Planning Workshop for *Drupella* research.

Stoddart, J.A. and Osborne, S. A survey of the effects of *Drupella* predation in Ningaloo Marine Park.

Trendall, J.T. and Stoddart, J.A. Barramundi genetics - how the facts can spoil a good story.

NATIVE FOREST SILVICULTURE

Borg, H. and Stoneman, G.L. The long-term implications for streamflow of changes in vegetation cover and stand height in regenerating karri stands in south-west Western Australia.

Ruprecht, J.K., Schofield, N.J., Crombie, D.S., Vertesy, R.A. and Stoneman, G.L. Early hydrological response to intense forest thinning in South-Western Australia.

PLANT DISEASES

Crombie, D.S. Leaf area, stomatal conductance and transpiration of Jarrah (*Eucalyptus marginata* Donn ex Smith) forest overstorey and understory.

Davison, E.M. and Coates, D.J. *Cryphonectria cubensis* and *Endothia gyrosa* in Western Australia.

Davison, E.M., Tay, F.C.S. and Peroni, D. *Sphaeropis sapimea* on pines in W.A.

McComb, J., Bennett, I., Stukely, M and Crane, C. Selection and propagation of Jarrah for Dieback resistance.

Willis, R.T. The ecological impact of *Phytophthora cinnamomi* in the SRNP.

PLANTATION SILVICULTURE

Loneragan, O.W. Historical review of Sandalwood (*S. spicatum*) in Western Australia.

REHABILITATION

Hopkins, A.J.M., How, R.A. and Saunders, D.A. Managing Australia's environment : future directions.

RESEARCH TECHNIQUES

Ward, D. The use of triangles to estimate the number of trees in a forest.

Ward, D. and Underwood, R. Question Mapping.

Williams, M.R. New *Gahnia* host plant records for three Western Australian skippers (Lepidoptera Hesperiidae).

Williams, M. and Abbott, I. What is the best measure of average damage caused by insects and fungi to leaves?

WETLANDS AND WATERBIRDS

Halse, S.A. *et al.* Survival and shooting mortality in Pacific Black Ducks and Grey Teal.

Halse, S. Review of bird pests research in Western Australia.

Halse, S.A., Jaensch, R.P., Munro, D.R. and Pearson, G.B. Annual waterfowl counts in south-western Australia 1988/89.

Halse, S.A. (Ed.). The natural features of Lake Gregory.

WOOD UTILIZATION

Brennan, G.K. Drying 25mm boards milled from re-growth jarrah logs.

Brennan, G.K., Glossop, B.R. and Mathews, L.R. Assessment of different watering schedules for regrowth Jarrah and Karri log stockpiles.

Brennan, G.K., Glossop, B.R. and Hanks, W.R. Drying regrowth *eucalyptus* using a low temperature Batch kiln.

Brennan, G.K. Powder post borer (*Lyctus* spp.) attack on dry timber - a review.

Brennan, G.K., Glossop, B.R. and Mathews, L.R. Assessment of different watering schedules for regrowth Jarrah and Karri log stockpiles.

Brennan, G.K. and Ward, S.L. Recovery from regrowth Jarrah sawlogs.

Donnelly, D.J. and Siemon, G.R. Effect of sapstaining and C.C.A. treatment on strength properties of radiata pine poles.

Donnelly, D.J. Evaluation of milling equipment suitable for production of Valwood feedstock.

Hanks, W.R. Sawmilling trial of Rose Gum.

Hanks, W.R. Drying and grading Marri boards.

Kent, D.L. Gum tree - general utilisation model of timber resources - economic.

Kent, D.L. Predicting the profitability of small hardwood sawmills which dry timber.

Newby, P. and Siemon, G. Adhesives for manufacture of furniture blanks.

Newby, P. Practical aspects of producing Valwood(R) blanks.

Rule, R. The Wickepin fence post trial after 57 years of service.

Shedley, P.N. Furniture manufacturing in Italy - a study tour.

Siemon, G.R. Strength properties of laminated Jarrah and Karri crossarms.

Thomson, A.B.,and Hanks, W.R. Sawmilling study of Tasmanian blue gum grown in Western Australia.

Thomson, A.B. Shrinkage, collapse and dimensional recovery of regrowth jarrah.

White, K.J. Overview of the central Gippsland sawmilling industry.

White, K.J. Comparison of low and high pressure watering systems for stockpiling regrowth jarrah logs.

White, K.J. Debarking small diameter logs using a mobile flail chair debarker.

PART 9 SEMINARS PRESENTED BY RESEARCH AND ASSOCIATED STAFF 1989/90

During 1989/90 twenty seminars were organized and presented by Research Division and associated staff. Seminar presentations are designed to disseminate information and stimulate discussion and are open to all CALM staff, tertiary institutions, other research organizations and interested members of the public. The following seminars were presented during the fiscal year:

Scientist	Topic
A.H. Burbidge	Habitat preferences of Ground Parrots: implications for conservation.
A.A. Burbidge/I. Abbott	Management of Australian islands for mammal conservation.
G. Wardell-Johnson	The ecology and taxonomy of the *Geocrinia rosea* (Anura : Myobatrachidae) complex: biogeographical implications.
M. Stukely	Genetic resistance of jarrah to the dieback fungus, *Phytophthora cinnamomi*.
L. McCaw	Fire studies in the Stirling Range National Park.
N. Lander	What truly counts can't be counted.
J. Allan	The use of invertebrates to monitor post-mining rehabilitation success.
R. Spencer	Impact of plantation expansion onto farmland in Victoria.
S. Halse	Why ducks don't mind being shot.
O. Kandler	Forest dieback in Germany.
P. Wilson	A fresh look at the classification of Australian species of Helichrysum and Helipterum.
K.D. Morris	The Barrow Island Green Turtle rookery.
J. Bartle/G. Ellis/R. Silberstein/ B. Mattinson	NAP Project Review : Integration of pulp cropping trees into farmland systems.
K. Kenneally	Kimberley research using volunteers.
G. Keighery	Western weeds.
J. Stoddart	Fact vs fantasy in conservation genetics : a fishy example.
B. Glossop	Seasoning regrowth eucalypts.
J.A. Friend	Mammal re-introductions : a WA perspective.
D. Pearson	Is fire necessary for desert lizard communities?.
N. McKenzie	Kimberley rainforest communities.
M. Williams/I. Abbott	What is the best measure of average damage caused by insect and fungi to leaves ? and; Impact of pest populations of Gumleaf Skeletonizer and Jarrah Leafminer on other invertebrates living in jarrah foliage.

PART 10 NEW RESEARCH PROJECTS

The following new Research Project Plans were approved during 1989/90. Information on these research projects can be obtained from the principal investigator

RPP No	Title	Principal Investigator
Biogeography		
7/90	Assessment of Biological Data of a-class conservation reserves considered for opening the Bailey procedures	N Gibson
9/90	Investigation of the community of Kwongan vegetation	N Gibson
10/90	Development of a catalogue of the National Parks and nature reserves of Western Australia	N Gibson
31/90	A Biological survey of the proposed Boonanarring Nature Reserve	AH Burbidge
32/90	Biological survey of Yanchep National Park	AH Burbidge
35/90	Biological survey of Cape Arid National Park	AH Burbidge
Entomology		
22/89	Impact of prescribed fire on infestation by Jarrah Leafminer	I Abbott
5/90	Impact of recent logging of Jarrah forest on the population density of Jarrah Leafminer	I Abbott
22/90	Life Cycle of *Cardiaspina brunnea*	J Farr
23/90	Population Monitoring of *Cardiaspina brunnea* on *E. occidentalis*	J Farr
24/90	Crown decline of *Eucalyptus occidentalis* due to infestation with *Cardiaspina brunnea*	J Farr
25/90	Adult Emergence of *C. brunnea*	J Farr
26/90	Stage of Development of *Cardiaspina brunnea*	J Farr
Fire		
16/89	Fire studies in shrubland at Stirling Range National Park Part 4 Effects of fire on invertebrate communities	G Friend
17/90	Effects of prescribed burning on small vertebrates in Tutanning Nature Reserve	G Friend
18/90	Effects of prescribed burning on invertebrate communities in Turanning Nature Reserve	G Friend
19/90	Effects of prescribed burning on invertebrate communities in Durokoppin and East Yorkrakine Nature Reserves	G Friend
20/90	Effects of three fire regimes on ground-dwelling invertebrates in Jarrah forest	G Friend
27/90	The association between plant communities, landform/soils units and burning history in the Perup Native Reserve	G Wardell-Johnson
Flora Conservation		
21/89	Fusilade effect on declared rare flora *Hakea aculcata* and *Daviesia oxylobium*	K Atkins
4/90	Descriptive catalogue of Western Australian plants - revision	G Keighery
Marine Conservation		
1/90	Marmion Recreational Fishing Survey	J Stoddart
2/90	Coral Reef Assessment	J Stoddart

RPP No	Title	Principal Investigator
Native Forest Silviculture		
18/89	Estimating the leaf area index (LAI) of forest plots using hemispherical photography	K Whitford
24/89	Success of infilling karri (*Eucalyptus diversicolor* F Muell) seedlings in 1 year old coupes	P Hewitt
28/89	Factors affecting the germination, establishment, survival, growth and form of *Eucalyptus marginata* seedlings	G Stoneman
Plant Diseases		
23/89	Effect of varying stand density on growth rate of *Phytophthora cinnamomi* lesions in jarrah in the high (1100mm), intermediate (900-1100mm) and low (ä mm) rainfall zones	F. Bunny
26/89	The efficacy of Phosphorous acid in protecting *Banksia brownii, B baxteri* and *B coccinea* from infection by *Phytophthora cinnamoni*	B Shearer
29/89	Infection in *Pinus radiata* clones by *Phytophthora* spp	M Stukely/E Davison
32/89	Rizolex application to pine seedlings	E Davison
36/89	Assessment of the impact of *Phytophthora* species in woodlands and shrublands of the coastal plain between Perth and Cape Leeuwin	B Shearer
3/90	Fungi associated with branch cankers and death of *Banksia coccinea* at Channel Point, Cheyne Beach	B Shearer
Plantation Silviculture		
19/89	Comparison of two high density regimes for *Pinus radiata* on sunkland	R Moore
20/89	Verification of the field interpretations and assessments for the WA Remnant Vegetation Protection Scheme	P Pigott
27/89	Tree growth response to blasting peel hardpan	John Bartle
30/89	Ecology of remnant salmon gum (*Eucaluptus salmonaphloia* F Muell) woodland near Lake Toarblin, WA	P Pigott
34/89	Wood utilization loss in *E globulus*; pilot study	B Mattinson
35/89	Tree growth response to cutting trenches in Peel hardpan	J Bartle
11/90	Integration of plantations of *Eucalyptus globulus* on farmland and its effect on groundwater and impact on production of adjacent pasture	R Silberstein
12/90	Integration of plantations of *Eucalyptus globulus* on farmland and its effect on drain runoff quantity and quality (with particular emphasis on phosphorus leaching)	R Silberstein
13/90	Comparison of production of plantations of *Eucalyptus globulus* on farmland with standard farm practice on the leaching sands of the Swan Coastal Plain	R Silberstein
14/90	The costs and benefits of effective windbreaks	R Moore
28/90	Tree growth response to subsoil ripping	J Bartle/G Ellis
29/90	Yield testing prospective pulpwood species provenances and clones	J Bartle/G Ellis
36/90	Post planting control of recurrent weeds in *E globulus* plantations using pre and post emergent berbicides applied with a side delivery nozzle	J Winchcombe
37/90	Comparison of thirteen pre-plant herbicide treatments, plus control, on the establishment and growth of *E globulus* seedlings	J Winchcombe

RPP No	Title	Principal Investigator
38/90	The use of controlled release "Marshall Auscon" insecticide grounds in the control of African Black Beetle in *E globulus*	J Winchcombe
39/90	The effect of stocking density on productivity and droughting of *E globulus* plantations established in the low rainfall zones (700mm mean annual rainfall in the South West of Western Australia)	G Ellis
40/90	Fertilisation of *E globulus* plantations established on ex-pastured sites with (1) DAP fertiliser tablets and (2) DAP Agras #1 and NPK blue special	G Ellis
41/90	The influence of container type and volume and root inhibiting paint on the survival and performance of *E globulus* seedlings planted on farmland in the South West of Western Australia	G Ellis
42/90	Multi-factor experiment - The influence of seedling container type, site preparation, weed control and fertiliser in the establishment of *E globulus* plantations on farmland in the South West of Western Australia	G Ellis
43/90	Plaid density design for investigation of the effect of stocking density and espacement on the productivity of *E globulus* plantations	G Ellis
44/90	The effect of mounding and scalping on the survival and early growth of *E globulus* seedlings established in deep, grey silicone sands on the Swan Coastal Plain	G Ellis
45/90	NP factorial fertiliser trial plus comparison with formulated fetiliser mixes - DAP agras Cu Zn Mo slow release tree tablet	G Ellis
46/90	NP Factorial fertiliser trial - the role of nitrogen and phosphorus in the establishment of *E globulus* on farmland in the South West of Western Australia	G Ellis
47/90	The benefits of various levels of post planting manual weed control in the establishment of *E globulus* plantations	G Ellis
48/90	Comparison of Roundup/Oust and Roundup/Simazine herbicide sprays for the establishment of *E globulus* seedlings on farmland	G Ellis
49/90	The role of lime phosphorus and potassium in the establishment of *E globulus* plantations on ex-bush acid sands	G Ellis
50/90	DAP Agras and Co Zn Mo, tree tablet fertiliser timing trial	G Ellis
51/90	The short and long term benefits of weed control in the establishment of *E globulus* plantations	G Ellis
Wood Utilization		
25/89	Processing - stability of regrowth and mature karri panels constructed from boards of differing moisture content	P Newbey
31/89	The effect of pre-steaming and hot-water soaking upon the drying behaviour of three Eucalupts	B Glossop
33/89	An equilibrium moisture content survey of timber in Western Australia	T Jones
15/90	Field testing of an ultra sonic moisture meter	B Glossop
16/90	Treating *Eucalyptus globulus* (Tasmanian Blue Gum) fence posts using four timber preservatives	G Brennan

PART 11 REVIEW OF PROGRAMS 1990

BACKGROUND

The Research Division Policy Group reviewed the Herbarium and Research Computing Programs in 1990. The object of this exercise was to re-assess the objectives and priorities of research in these programs and to consider the allocation of staff and financial resources. Changes made as a result of these reviews are incorporated in this revision of the Division's Research Plan.

STRUCTURE OF THE REVIEW

The procedure adopted for reviewing the programs was as follows:

1. Program Leaders arranged for a copy of their respective program (extracted from the Research Plan 1989/1990) to be circulated to the most relevant Operations staff within CALM and scientists outside CALM. This was accompanied by a questionnaire.

2. For each program two types of meetings were held:

(a) Type 1 meeting - this was attended by all RDPG members, interested scientists and technical support staff and other interested CALM personnel. Personnel from outside organizations were also invited.

At this meeting the Program Leader summarized the program goals, activities and responses to the questionnaire. Relevant program members spoke on the activities of the program.

(b) Type 2 meeting - this was attended by RDPG members, the relevant Program Leader and two invited guests from other divisions of CALM. At this meeting the Program Leader summarized the Type 1 meeting and results of the questionnaires. Consideration was also given to the confirmation of the priorities of the program, strategies adopted to achieve research objectives, new priorities, possible deletions and possible restructuring.

The following summarizes the outcome of the above processes and, in the case of the Herbarium Program, the decisions reached have been ratified by CALM's Corporate Executive. Decisions reached in the case of the Research Computing Program are yet to be submitted to the Corporate Executive.

DECISIONS REACHED

Herbarium Program

1. The Herbarium will remain in Research Division and the centre will continue to be "The Western Australian Herbarium".

2. The current title "Curator, Western Australian Herbarium" will be abolished. The existing Level 8 position will be titled "Senior Principal Research Scientist" in line with the other two Level 8 positions in Research Division. An appropriate title for the head of the Herbarium will be decided by CALM's senior management. This title is to be used for national and international liaison with kindred institutions.

3. A new Level 7 position will be created (by abolishing the consequential vacancy) and will be advertised. The duties of this position will parallel the duties of the two Level 7 positions that assist the Senior Principal Research Scientists in charge of other research programs. The position will be a member of RDPG. As well as assisting the SPRS in administration of allocated programs, the PRS will be responsible for particular tasks, especially the raising and coordination of external research funds for the Division.

4. The existing Research Programs of "Herbarium" and "Flora Conservation" will be re-organized into three new programs. These will be:

   i) Flora Collections comprising the existing Collections and Databases Sections,

ii) Flora Information comprising the existing Flora Information and Regional Flora Sections, and

iii) Flora Conservation comprising the existing Systematics Section and the existing Flora Conservation Program. Systematics research priorities will in future be directed by flora conservation requirements.

The Plant Diseases Research Program will remain under the overall management of the Senior Principal Research Scientist in charge of the three flora programs delineated above.

5. The new program will be managed in the same way as other research programs. New Program Leaders will be appointed and new Aims, Primary Objectives and Five Year and Twenty Year Goals will be developed.

6. All professional staff currently based in the Herbarium will be Research Scientists and their Job Description Forms and criteria for progression will be the same as those of other Research Scientists in the Division. There will be a transition period of one year for implementation of this decision. Until this is achieved, those professional staff that are spending much of their time on service functions will not be discriminated against in matters such as criteria progression and resource allocation. Interim arrangements will allow the definition of "botanist" in the Misuse of Drugs Act to be met.

7. All professional staff currently based at the Herbarium, and other Research Division professional staff using the Herbarium collection, will spend a proportion of their time on the research curation of the collection.

8. A Level 5 technical position will be created (by consequential abolition of the resulting vacancy) to:

(i) be Research Centre Manager for the Herbarium, and

(ii) be in charge of managing the collection.

9. All Job Description Forms for staff in Research Division affected by the above decisions will be rewritten.

10. Investigations will be carried out to see if the Herbarium's garden can be managed by a voluntary group. If this is not possible a recommendation to reduce the size of the garden to that manageable by a voluntary group or by the gardeners at State Operations Headquarters will be considered. Once this has been achieved the existing gardener will be redeployed and the staff item will eventually be transferred to a new position that assists in managing the collection.

11. The management of the journal Kingia will be transferred to the Scientific Publishing Editorial Committee (SPEC) and the Division's scientific editor will edit it. SPEC will investigate whether staff and financial savings can be achieved by using Kingia as a CALM scientific journal incorporating the existing Technical Reports and Bulletins.

12. A new Herbarium building or a substantial extension to the existing building (which is owned by the Department of Agriculture) is required within three years. A Task Force has been set up to develop a concept plan for this and other necessary flora conservation initiatives.

RESEARCH TECHNIQUES PROGRAM

1. With the aim of providing all Research Scientists access to a PC having been effectively achieved, the Program should direct its resources towards:

1.1 Throughout the Division, improving user sophistication and encouraging users to resolve their own problems .

1.2 Reducing the amount of time Program Members spend doing other Scientists' work for them.

1.3 Increasing the amount of time that Program members spend on Research Projects of their own that will benefit the Division's effectiveness. This is in line with the trend

towards appointing Research Scientists to the Program.

1.4 Developing Local Area Networks and access to Departmental Mainframe computers.

1.5 Improving the integration and accessibility of Corporate data between Research Division and the rest of the Department.

2 It was noted that the cost of maintaining, upgrading and replacing computing equipment will increase markedly as existing equipment ages. Furthermore the cost of LANs will be high. Therefore the Program budget would not be reduced.

Subsequent to the Type 2 Meeting it was suggested that, as Research Methods Program will shortly be reduced to one Member, the Programs be amalgamated. The proposal has been agreed by Members of both Programs and endorsed by the RDPG. The new Program will be called Research Techniques Program. The new structure is recognized in this Plan.

REHABILITATION PROGRAM AND SILVICULTURE PROGRAM

During the year these two programs were integrated more closely in an administrative structure which involves the Timber Production and Silviculture Branches, the three Forest Regions, and the Wheatbelt and South Coast Regions.

Consequently both programs were re-organized to fit in better with this new management system. This restructuring, necessitated by the recent plantings of *globulus* in the South West, resulted in a Native Forest Silviculture Research Program (Jarrah, Karri) and a Plantation Silviculture Research Program (Pine, *E. globulus*). Because no other research programs were affected by these changes, RDPG approved the proposed changes at its May 1990 meeting.

PART 12 AIM AND PRIMARY OBJECTIVES OF RESEARCH DIVISION

OVERALL AIM

To develop a scientific basis for conservation and land management in Western Australia by conducting research and providing expert advice.

OVERALL PRIMARY OBJECTIVES

Conservation Of Biological Resources

To provide the scientific basis for the conservation of indigenous plant and animal species, ecosystems and natural processes in natural habitats throughout the State.

To provide and maintain a plant taxonomic and a biogeographical data base of the plants, animals and ecosystems of Western Australia and to develop an understanding of the factors that cause changes in their distribution and abundance.

Management Of Biological Resources

To apply research findings and, in conjunction with Operations staff, develop, test and implement techniques that can be used to better manage plant and animal populations and lands and waters entrusted to the Department.

To provide the scientific basis for the production and regulation of the supply of those renewable resources that Government decides should be used, on a sustained yield basis and in a manner that minimizes impact on other values

Ecology

To develop an understanding of the interactions between populations, species, communities and their environments and develop appropriate ecological theories.

W.A. Herbarium

To preserve, curate and extend the State's principal reference collection of native and naturalized plants and to conduct and assist plant taxonomic research in order to provide authoritative names and other taxonomic information essential for effective conservation and management of the flora.

Communication and Advice

To communicate and provide expert advice on results of research effectively by production of scientific, technical and educational publications, input into the land management planning process, preparation of Wildlife Management Programs, liaison with other CALM staff, other Departments and the public, involvement with scientific and other conferences and by any other means available.

PART 13 THE PROGRAMS

Each of the 15 programs has, as far as practicable, a common format, as follows:

PROGRAM LEADER

CURRENT RESOURCES (1990/91) AND RESOURCES IN THE PREVIOUS YEAR (1989-90).

Normal research administration (i.e. supervision of staff, preparation of grant applications, committee meetings) is included here. However time spent by a scientist as Program Leader, Research Centre Manager, or as a member of RDPG is only included in the Executive and Administrative Support Program. The allocation of each member of Research Division to these Programs is itemized in Appendix I. Figures on financial support for 1990/91 are estimated figures only.

BACKGROUND

This provides a brief introduction to the scope and role of the Program. Major current gaps in knowledge are outlined.

ACHIEVEMENTS

This highlights the major accomplishments of the Program over the past twelve months.

AIM

This states what the Program should have achieved by 1995. It is a one-sentence statement of mission.

PRIMARY OBJECTIVES

These are in priority order, which normally entails a logical sequence in that the first objective is needed before the second one can be properly addressed. They are sufficiently general not to favour any one approach or solution. Although Primary Objectives often read like omnibus statements, they are fundamental to the structure of each Program. New projects suggested by members of a Program are always compared with the Primary Objectives of the Program. If they do not fit, they will not be approved.

20 YEAR GOALS

These are based on current resources and are in priority order. Asterisks are used to show the relative importance of each goal.

5 YEAR GOALS

These are written specifically, so that at the conclusion of 5 years it will be possible to assess whether each goal was achieved. These goals are subsets of the Primary Objectives and follow the sequence used for them. Care has to be taken to make these goals intelligible to non-scientists.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995.

These are summarized from the Table accompanying each Program

PROPOSED NEW PROJECTS - WITH ADDITIONAL RESOURCES (IN PRIORITY ORDER).

These are summarized from the same Table.

PUBLICATIONS AND REPORTS 1989/90.

Publications in scientific journals have been marked with an asterisk. Papers in press are not included. They will be recorded as publications in the next edition of this plan.

THE TABLE

This shows the relation of all research projects to the 5 Year Goals and the Primary Objectives. The full title of all RPPs (Research Project Plans or their

antecedents) is listed in Appendix II of this Plan. The specific work done on each RPP between July 1989 and June 1990 is summarized. The column entitled Targets 1990-91 is intended to convey in a telegraphic style the works program for the period July 1990 - June 1991.

EXECUTIVE & RESEARCH SUPPORT PROGRAM

PROGRAM LEADER

AA Burbidge

CURRENT RESOURCES 1990/91

This program comprises 24.8 persons (6.35 Professional and 17.45 Technical and Clerical and 1 contract Clerical). Its estimated CRF budget is $1 478 925 (including $908 175 salaries and $570 750 operating costs). Operating costs include a contingency fund, mainly used to support new or under funded high priority research projects.

RESOURCES IN PREVIOUS YEAR

This program comprised 22.65 persons (5.15 Professional and 16.50 Technical and Clerical and 1 contract Clerical). Its budget was $991 152 (including $614 945 salaries and $376 207 operating costs). External funds totalled $17 700 (salary) during the period.

BACKGROUND

This service program is responsible for the direction and administration of all activities within Research Division.

The program can be divided into two main parts. The first consists of the Research Division Policy Group (RDPG), which is responsible through the Director of Research to the General Manager for the overall leadership and direction of the Division. The second includes the Research Centre Managers and the administrative and clerical staff who administer the day to day running of the Division.

The Program was reviewed by RDPG in April 1989 and some modifications were made to the duties of RDPG members (see Part 2).

The 20 year goals and 5 year goals of RDPG members and the Scientific Editor are set out below. All members of RDPG are expected to commit a proportion of their time to carrying out research.

ACHIEVEMENTS

During 1989/90 the Program continued to concentrate on three main areas: bringing all staff into the same titles, awards and conditions; improving financial management and reporting; and reviewing the efficiency of and organization of Research Programs and the Research Division Policy Group (RDPG).

Further progress (see Part 7) has now been made towards achieving a uniform system of titles, conditions and awards. Account numbers and expenditure reporting systems were revised so that Program Leaders and the RDPG are better able to control expenditure and a new financial control system for external grants was developed.

The Research Computing Program was reviewed in June 1990, resulting in new initiatives in the GIS area. A review of research into the control of *Phytophthora* species was also initiated.

AIM

To direct, lead and administer Research Division.

PRIMARY OBJECTIVES

Executive Leadership

Through RDPG, to direct and lead the Division. To coordinate multi-program research and cooperative research with external organizations. To allocate resources provided to the Division according to the Five Year Plan and Departmental changes in priorities. To oversee scientific publishing.

Policy Development

To develop, in association with the Department's Corporate Executive and other senior staff, priorities for research. To ensure that research is carried out according to approved plans.

Motivation & Morale

To motivate and inspire all research scientists in the Division. To assist in the development of scientific skills of inexperienced scientists in the Division. To ensure that all scientists are working to capacity and that their research is conducted efficiently and effectively.

Administration

To administer the day to day operations of the Division through Research Centre Managers and administrative and clerical staff.

Communication

To ensure that research is accurately applied and rapidly and effectively communicated to users.

DIRECTOR OF RESEARCH - A.A. BURBIDGE

20 YEAR GOALS

1. Provide overall direction and leadership to Research Division.

2. Ensure that Research Division is an effective and efficient part of the Department and that as far as possible it meets the demands of the Department and the community for scientific information on conservation and land management.

3. Provide as far as possible the resources to enable the Division to meet its Overall Aim and Primary Objectives.

4. Through membership of Corporate Executive, contribute to the development of Departmental policies based on scientific information provided by the Division.

5 YEAR GOALS

1. Chair the RDPG and ensure that it is an effective mechanism for promoting corporate leadership and decision-making.

2. Through Research Centre Managers and administrative and clerical staff, administer the day-to-day operations of the Division.

3. Ensure as far as possible that the Division's staff are provided with an environment where high quality scientific research can take place. Such an environment should allow and encourage scientific excellence and allow priority setting to occur in a spirit of co-operative peer review.

4. With the assistance of the RDPG ensure that research carried out by the Division is of the highest standard and is published.

5. With the assistance of the RDPG, ensure that research carried out by the Division is applied by the Department.

6. With the assistance of the RDPG, oversee the recruitment, training and development of the Division's staff.

7. Carry out other duties as directed by the General Manager or the Executive Director.

SENIOR PRINCIPAL RESEARCH SCIENTIST - J.A. ARMSTRONG

20 YEAR GOALS

1. Provide overall direction and leadership to the plant-based programs, (Flora Collections, Flora Conservation, Flora Information, and Plant Diseases), and ensure that research carried out by the programs maintains a prestigious national and international scientific profile.

2. Encourage and co-ordinate interdisciplinary research with other Herbaria and kindred institutions to promote flora based research.

3. Extend the State Herbarium collection so that it more adequately represents taxonomic and morphologic diversity.

4. Develop a reliable database of flora information which can be easily retrieved for conservation and management purposes.

5 YEAR GOALS

1. Ensure that a new enlarged Herbarium is designed and built in Perth.

2. Develop a flora conservation strategy for Western Australia.

3. Guide the Flora Collections, Flora Conservation, Flora Information, and Plant Diseases Programs to develop their 5 year objectives.

4. Curate the Herbarium's cryptogamic collections to promote the implementation of CALM initiatives in marine conservation and plant diseases.

5. Produce a comprehensive database of WA threatened taxa to facilitate access to information essential to conservation.

SENIOR PRINCIPAL RESEARCH SCIENTIST - P. CHRISTENSEN

20 YEAR GOALS

1. Ensure that good working conditions and an *esprit de corps* are developed and maintained in the Entomology, Native Forest Silviculture, Plantation Silviculture and Wood Utilization Research Programs.

2. Develop and foster good working relationships with other Divisions and Branches of CALM and relevant outside institutions.

3. Facilitate and co-ordinate interdisciplinary research with other Departments and Institutions.

4. Ensure that all research done in the above four programs is of high standard, is relevant to the management objectives of CALM, and when completed is put into practice as soon as possible.

5 YEAR GOALS

1. Contribute effectively to decision-making in the Wood Utilization Research Centre, Director of Research Committee (Australian Forestry Council), Research Steering Committee, and relevant committees in the Forest Resources Division of CALM.

2. Achieve better links with a number of Branches within CALM as well as several outside institutions which are doing work relevant to the programs listed above e.g. Forest Resources Division, Inventory Branch, CSIRO, WAWA.

3. Institute workshops at which scientists in the above four research programs explain how their conclusions are ready for implementation by CALM managers.

4. Identify factors hampering the productivity of individual research scientists and technical staff, and arrange remedial action.

SENIOR PRINCIPAL RESEARCH SCIENTIST - S.D. HOPPER

20 YEAR GOALS

1. Ensure that research carried out in the Biogeography, Fauna Conservation, Fire, Marine Conservation and Wetlands and Waterbirds programs is of a high standard, is relevant to the management objectives of CALM and, when completed, is used to further the Department's goals and objectives.

2. Ensure that good working conditions and an *esprit de corps* are developed and maintained in the above programs and at the Woodvale Research Centre.

3. Ensure that resources required for research in these programs and the efficient running of Woodvale Research Centre are made available and used efficiently.

4. Develop and foster good working relationships with other Divisions and Branches of CALM as well as relevant outside institutions.

5. Effectively represent the Division and the Department.

5 YEAR GOALS

1. Contribute effectively to decision making by the RDPG, Working Group on Land Releases, committees associated with mining on conservation reserves and relevant CALM committees and task forces dealing with nature conservation and fire research.

2. Achieve better links with a number of branches within CALM as well as with several outside institutions that are doing work relevant to the programs listed above (e.g. CSIRO Division of Wildlife and Ecology and tertiary institutions).

3. Encourage, facilitate and provide opportunities for scientists from the programs listed above to interact with managers and planners to ensure the results of research are used to further the goals and objectives of CALM.

4. Provide opportunities and encourage scientists in the listed programs to interact with one another and with other scientists through seminars, workshops and conferences.

5. Identify and remedy factors hampering the productivity of individuals in the listed programs and at Woodvale Research Centre.

6. Ensure that the Woodvale Research Centre provides effective support for scientific research and a harmonious working environment.

PRINCIPAL RESEARCH SCIENTIST - I. ABBOTT

20 YEAR GOALS

1. Ensure that good working conditions and an *esprit de corps* are developed and maintained in the Entomology, Native Forest Silviculture, Plantation Silviculture and Wood Utilization Research Programs.

2. Ensure that all research done in these programs is of high standard, is relevant to the management objectives of CALM, and when completed is put into practice as soon as possible.

3. Facilitate and co-ordinate relevant interdisciplinary research with other Departments and Institutions.

4. Develop and foster good working relationships with other Divisions and Branches of CALM and relevant outside institutions.

5 YEAR GOALS

1. Ensure that scientists in the four research programs listed above publish in the best journals available.

2. Ensure that all research in the four research programs listed is carried out in accordance with approved Research Project Plans (RPPs).

3. Oversee scientific publishing in Research Division through chairing the Scientific Publishing Editorial Committee, and in consultation with the Scientific Editor expedite the rate of publication of papers s's goals and objectives submitted by Divisional staff for publication in CALM journals.

4. Organize an annual series of seminars for Research Division staff.

5. Devise ways Research Division can improve dissemination of research knowledge to the public at large, school students, and the scientific community.

6. Co-ordinate the annual revision of the Research Division Plan.

7. Develop and publicize methods for monitoring productivity of scientists across Research Division.

PRINCIPAL RESEARCH SCIENTIST - T. START

20 YEAR GOALS

1. Ensure that good working conditions and an *esprit de corps* is developed and maintained among all personnel in the Division.

2. Ensure that Departmental assessment of ERMPs benefits from the accumulated knowledge and stored data available within the Division.

3. Ensure that the accumulated knowledge and stored data are fully utilized by the Department in the development of Management plans and similar documents.

4. Ensure that Research Division finances are in good order and expenditure is controlled within budget allocations.

5 YEAR GOALS

1. Obtain parity in working conditions and salary structure throughout the Division.

2. Develop a satisfactory career structure for technical, support and scientific staff.

3. Develop a training program for research staff that is relevant to the working environment within the Division.

4. Assist and facilitate training of scientists in technology new to them and philosophies relevant to developing management-related research projects.

5. Establish a technical staff committee to assist with staff matters.

6. Develop an effective method of financial control relevant to the needs of the Division.

7. Ensure that Departmental assessment of ERMPs benefits from the accumulated knowledge and stored data available within the Division.

8. Ensure that the accumulated knowledge and stored data are fully utilized by the Department in the development of Management Plans and similar documents.

SCIENTIFIC EDITOR

The publication and dissemination of scientific and technical papers and reports is a major function of Research Division. Publication can be in external journals or in Departmental publications. Staff are encouraged to publish in external, refereed journals wherever possible. However, material that is not appropriate to such journals, but is of sufficient standard to be published, will continue to be produced by the Department.

Scientific publishing is overseen by the Scientific Publishing Editorial Committee (SPEC). Current membership is: Principal Research Scientist (I. Abbott), Scientific Editor, three other scientists from Research Division and a representative from Services Division.

Dr I. Abbott (Chair)
Ms M. Lewis (Scientific Editor) (Secretary)
Dr S. Crombie
Dr G. Friend
Mr K. Kenneally
Dr F. McKinnell

In 1988 Ms Lewis was transferred from Information Branch to Research Division. She spends 100% of her time on scientific publishing, including editing of publications emanating from other Divisions.

The budget allocated for scientific publishing is $32 500 (1990/91 : $31 500).

20 YEAR GOAL

Ensure rapid dissemination through publication of scientific and technical findings.

5 YEAR GOALS

1. Explain to CALM staff the purpose, scope, readership and requirements of each research and technical publication produced by the Department.

2. Edit papers for publication in Departmental Research Bulletins, Technical Reports, Occasional Papers, Wildlife Management Programs and Regional Flora Handbooks (Nuytsia and Kingia are produced by the Herbarium according to specifications in the Attachment to Policy Statement No. 5).

3. Prepare a publishing plan to minimize editorial delays and provide an efficient publishing service.

4. Establish technical standards and maintain scientific standards in collaboration with SPEC for Departmental publications.

5. Arrange graphical and design support for authors preparing research and technical publications.

PUBLICATIONS* AND REPORTS 1988/89

Abbott, I. (1989). Scientific excellence, effectiveness and productivity. (Paper prepared for RDPG).

BIOGEOGRAPHY PROGRAM

PROGRAM LEADER

GJ Keighery

CURRENT RESOURCES (1990/91)

This program comprises 10.7 persons (5.8 Professional + 4.9 Technical). Its estimated CRF budget is $510 869 (including $396 169 salaries and $114 700 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 11.15 persons (5.8 Professional + 5.35 Technical). Its budget was $490 721 (including $383 311 salaries and $107 410 operating costs).

An additional 1.5 persons were employed under a National Estate grant for Shark Bay and Environmental Protection Authority grant to prepare a report on conservation reserves of the Eastern Goldfields. Funds from these sources totalled $46 000 for salaries and $4 800 operating costs.

BACKGROUND

The Biogeography Program comprises an array of staff employed to research and carry out biological surveys throughout Western Australia. The State has the diversity, and almost the size, of a continent; for most of its 23 phytogeographic districts, species distribution data are only available for a few of the more common plants and more glamorous vertebrates. Additional surveys of districts are urgently needed.

The Program's role is to document the composition of the State's biota, i.e. to describe and monitor the patterns of distribution and status of its plants and animals. By establishing and monitoring networks of benchmark quadrats, the Program seeks to identify regional changes in the species composition of the biota (as distinct from localized fluctuations). Broad-scale quantitative biogeographic data are fundamental to the land-use decisions and management responsibilities of CALM. Such data provide an explicit basis for assessing the status of species and communities and a rational basis for setting priorities among many of the tasks that confront regional managers and management researchers.

Management priorities and decisions that are influenced or determined by biogeographic data include: legislation to protect species and communities; positioning of firebreaks and facilities for human access; selection of optimum areas of land in reserve system design and other land-use decisions; searches for additional populations of particular species and for guilds or communities of interest; proposed access to reserve system for mineral exploration; setting priorities for more specific research such as manipulative experiments on populations or communities.

At present, resources (budget allocation and staff) are too small to carry out a biogeographic survey of even a single district without substantial external funding and/or staffing. Fortunately, such assistance has been, and appears to be still, readily available where common Federal/State interests occur (Nullarbor, Eastern Goldfields, Rainforest Surveys). However, to provide even a minimum coverage of W.A. within the next 10 years, we will need to be able to survey each year at least two of the 23 Phytogeographic Districts recognized in W.A.

ACHIEVEMENTS

The National Rainforest Conservation Program fieldwork and write up was completed. Surveys of Shark Bay, Walpole-Nornalup National Park and Cape Arid National Park were completed. A major review of the Mount Lesueur region was undertaken and published.

AIM

To describe and monitor the patterns of distribution of Western Australia's plants and animals so as to maximize their effective conservation and management.

PRIMARY OBJECTIVES

Data Base

Through a systematic program of ecological surveys, to provide and maintain an up-to-date biogeographic data-base of site descriptions, based on a set of permanently marked "benchmark" quadrats, representative of the diversity of Western Australia's biota. The biophysical attributes recorded from each site will be used to seek biogeographic patterns across Western Australia.

Reserve System Design and Land-use Advice

To undertake research to select, improve and maintain a system of conservation reserves that will permanently represent Western Australia's biological diversity. To provide advice on the nature conservation importance of reserves and of areas of land outside reserves.

Management Planning

To analyse the data base to assess the conservation status of communities and species and to provide data and interpretation to planners and managers so management is carried out according to sound scientific principles. To assist with the preparation of management plans. To assess the impact on flora and fauna if particular National Parks and Nature Reserves are opened for mineral exploration or mining. To correlate available published and unpublished data and to design surveys to capture any additional data required to make such judgements.

Broad-scale Monitoring

To measure changes in composition of the plants and animals, both exotic and native, in relation to the variety of disturbances associated with various land-use regimes. To promote improvement in land management practices.

Communication

To communicate the results of research in the form of technical and scientific publications, educational literature, committee representation, training courses, public and scientific seminars, and through advice and liaison with their CALM staff, with other organizations and with the community at large.

20 YEAR GOALS (based on current resources and in priority order)

1. Extend the data base to include representation of all Phytogeographic Districts found in Western Australia and the variety of widespread land-uses that have been superimposed.***

2. Monitor, at 10 to 15 year intervals, the sites already installed.**

3. Continue small area surveys as the need arise Eastern Goldfields, Rainforest Surveys). However, to provide even a s.***

4. Re-assess the Program's applications, approaches and methodologies in the light of:

   i) ongoing projects to optimize sampling strategies, methodologies and the set of biophysical attributes recorded on the quadrats.**

   ii) the analysis of the second sessions of re-sampling in selected districts.**

5. Undertake a major review of the biogeography of Western Australia.*

5 YEAR GOALS

1. Undertake a biogeographic survey of rainforest communities in the Gardiner, Hall and Dampier Phytogeographic Districts to extend the biogeographic data base and make recommendations on reserve needs and on their conservation status and the effects of disturbances.

2. Undertake a biogeographic survey of the Irwin/Carnarvon district to improve the State-wide representation of the biogeographic data base, to extend the network of benchmark quadrats and assess reserve needs in the district, species' conservation status and the effects of disturbers on community composition.

3. Upgrade the descriptions of Eastern Goldfields sites described in the 1970's so they can be included in the biogeographic data base, and permanently mark these quadrats.

4. Undertake detailed ecological surveys at various localities (including islands and waters) of Departmental interest and responsibility in other districts, such as the wheatbelt and on the Swan Coastal Plain to assist land-use and management planning decisions (including reserve access to mining). Examples include surveys at Dryandra, Yanchep National Park, Cape Arid National Park and on islands in the North-west (see Table for others).

5. Continue research on methodologies, especially in relation to the biophysical attributes recorded on benchmark quadrats. Which biotic groups should be recorded? What are the most appropriate: scalars? size and hetrogeneity of the quadrats? sampling methodologies including the use of remote sensing and sampling invertebrates? Relevant projects are listed in the Table.

6. Publish and/or disseminate the results of surveys in a form suitable for use/interpretation in the development of the conservation reserves system and in management planning. Examples of studies still to be published include the Eastern Goldfields survey and Two Peoples Bay survey work (see Table).

7. Develop an in-house computerized system for the field entry of quadrat data, accession of extrinsic data such as those in Geographic Information Systems, for the analyses of the data sets and for the use by managers needing information.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following)

Database: 1,3,4,14-17,19-24,26,31,32,35,37

Reserve System Design and Land Use: 40,41,46,50,51,53,54

Management Planning: 62,63,67

PUBLICATIONS * AND REPORTS 1989/90

*Burbidge, A.A., Hopper, S.D. and S. van Leeuwen (eds) (1990) *Nature conservation, landscape and recreational values of the Lesueur Area.* Environmental Protection Authority Bulletin 424., E.P.A., Perth.

*Burbidge, A.A., Dixon, K.W. and Fuller, P.J. (1989) *The Flora and Fauna of vacant Crown land at White Well, Shire of Dalwallinu, Western Australia.* Department of Conservation and Land Management. Technical Report No. 24.

*Gibson, N. and Kirkpatrick, J.B. (1989) *Effects of the cessation of grazing on the grasslands and grassy woodlands of the Central Plateau, Tasmania.* Australian Journal of Botany 37: 55-63.

*Griffin, E.A., Hopper, S.D. and Hopkins, A.J.M. *Flora.* pp: 39-66. In: Nature Conservation, Landscape and Recreation Value of the Mt. Lesueur area. (Eds. A.A. Burbidge, S.D. Hopper and S. van Leeuwen) Environmental Protection Authority. Bulletin 424, E.P.A., Perth.

*Griffin, E.A. and Hopkins, A.J.M. *Vegetation* pp 27-38 In: Nature Conservation, Landscape and Recreation Value of the Mt. Lesueur area. (Eds. A.A. Burbidge, S.D. Hopper and S. van Leeuwen) Environmental Protection Authority, Bulletin 424, E.P.A., Perth.

Henry-Hall, N.J. *Nature Conservation reserves in the Eastern Goldfields, Western Australia.* (1990) Report submitted to E.P.A. Red Book Task Force.

*Hopper, S.D. and Burbidge, A.H. (1989) *Conservation status of Banksia woodlands on the Swan Coastal Plain.* Journal Royal Society of Western Australia 71: 115-116.

*Hopper, S.D. and Hopkins, A.J.M. (1989) *Mt. Lesueur: Jurien Jewel* Landscope 4(4): 28-33.

Inions, G., Wardell-Johnson, G. and Annels, A. (1990) *Classification and evaluation of sites in Karri (Eucalyptus diversicolor F.Muell.)*

regeneration, II Floristic attributes. For. Ecol. Manage. 29: xx-xx.

*Keighery, G.J. (1990) *Rainbow Desert*. Landscope 5(2): 42-45.

*Keighery, G.J. (1989) *Porongorup Plants*. Landscope 4 (4): 34

*Kenneally, K.F. (1990) *Checklist of Vascular Plants of the Kimberley, Western Australia*. W.A. Naturalist Club Handbook 14.

*McKenzie, N.L., Belbin, L., Margules, C.R. and Keighery, G.J. (1989). *Selecting Representative Reserve Systems in Remote Areas: A Case Study in the Nullarbor Region, Australia*. Biological Conservation 50: 239-261.

*Morris, K.D. (1989) *The Dampier Archipelago - managing people in a nature reserve*. In: Australian and New Zealand Islands: nature conservation values and management. (Ed. A.A. Burbidge) Conservation and Land Management, Occasional Paper 2/89.

*Morris, K.D. (1990) *Management plan for Dampier Archipelago Nature Reserves*. Conservation and Land Management.

*Morris, K.D. (1990) *Draft management proposals for the Montebello Islands and surrounding waters*. Conservation and Land Management, Technical Report.

*Wardell-Johnson, G.W., Inions, G. and Annels, A. (1989) *A floristic survey of the Walpole-Nornalup National Park, Western Australia*. For. Ecol. Manage. 28: 259-79.

*Wardell-Johnson and Smith, V. (1990) *Walpole-Nornalup... An Ancient Landscape*. Landscope 5(2): 15-21.

*Wardell-Johnson, G.W. and Roberts, D. (1989) *Endangered! Forest Frogs*. Landscope 5(1):17.

*Roberts, J.D., Wardell-Johnson, G.W. and Barendse, W. (1990) *Extended descriptions of Geocrinia vitellina and Geocrinia alba (ANURA: Myobatrachidae) from south western Australia, with comments on the status of G. lutea*. Rec. West. Aust. Mus. 14(4): 427-37.

van Leeuwen, S., Burbidge, A.A. and Hopper, S.D. (1990) *Interrelationships of plants and animals*. In: Nature conservation, landscape and recreational values of the Lesueur area. (Eds. A.A. Burbidge, S.D. Hopper and S. van Leeuwen) Environmental Protection Agency, Bulletin 424, E.P.A., Perth.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Data Base	6,7	1	Develop micro-computer entry system for survey data RS122 NL McKenzie	System up and running in various forms. Operator's manual written	Publish manual & make system available
		2	Acquire software to process and analyse survey data NL McKenzie	PATN - extended PATN memory + VAX access available	Develop further
		3	Census of Australian Plants RS92 GJ Keighery	MS submitted	Organize plant master file
		4	Atlas of W.A. Proteaceae (except Banksia Grevillea) RS56 AJ Hopkins	Maps for 6 genera finalized	Complete
	5,6	5	Searching vs pitfall trapping in Southern Forests RWP unallocated G Wardell-Johnson	Discontinued	Deleted
		6	Sampling small ground-dwelling vertebrates RS16 AH Burbidge	Discontinued	Deleted
		7	Establish CALM monitoring program RS52 AJ Hopkins	Endorsed by Policy Directorate	Begin implementation
		8	Heterogeneity of Nullarbor Quadrats RS121 NL McKenzie	No progress	Analyse
		9	Automatic bat assemblage sampling RS129 NL McKenzie	Master tape of bat ultra-sounds for 20 species compiled	Opportunistic
		10	Biogeography of flora of Southern Nullarbor RS92 GJ Keighery	Toolina re-surveyed	Continue as time allows
		11	Extending the Nullarbor data-base, do the patterns change RS120 NL McKenzie	Analysis completed	Continue as time allows

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Flora surveys of Pilbara region S Van Leeuwen		12 Biogeographic patterns versus soil attributes RS20 NL McKenzie	Field data collected and compiled by consultant	Analyse when time allows
		13 Ecol. biog. of 4 endemic forest Eucalypts RWP 44/88	Sampling completed	Analyse
		14 National Rainforest Conservation Program KF Kenneally	Sampling completed	Publish
		15 Kimberley Flora checklist KF Kenneally	Published	Delete
		16 Dampierland Peninsula survey KF Kenneally	Prepare M/S.	Publish
		17 Biological survey of existing, proposed reserves: RS 15 AH Burbidge	A (Coolcalalata area), B (John Forrest N.P.), C (Swan Coastal Plain - remnant veg.) Funding obtained. Preliminary surveys completed.	Carry out intensive surveys.
		18 Camden Harbour Survey KF Kenneally	Preparation for proposed survey June 1990	Undertake survey in June 1990
		19 Walcott Inlet survey KF Kenneally	Updating of list from rainforest survey & add herbarium records	Prepare MS
		20 Ashmore Reef survey KF Kenneally	M/S prepared.	Publish.
		21 Mitchell Plateau survey KF Kenneally	Specimens identified & added to floristic list	Ongoing
		22 Kimberley rivers survey: WA Naturalists Club KF Kenneally	Specimens identified & added to floristic list	Prepare MS
		23 Buccaneer Archipelago KF Kenneally	Further specimens identified	Prepare MS with AJ Hopkins
		24 Wongan Hills KF Kenneally	Additional records added to checklist. Provided floristic information to A Coates	Continue updating checklist

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		25 Flora surveys Pilbara region S van Leeuwen	Commenced survey(s).	Continue survey(s).
Data Base, Reserve System Design and Land-use Advice	5,6	26 Ground-truthing the Nullarbor data-base RS124 NL McKenzie	Published.	Delete.
	4,6	27 Ad hoc flora surveys of selected crown lands RS74 SD Hopper	Reports to file 1 published, 1 draft	Ongoing
		28 Walpole-Nornalup national Park survey RWP unallocated G Wardell-Johnson	Organise plant master file.	Prepare M/S.
		29 Yanchep NP survey RS15, RS99 AH Burbidge	Writing commenced.	Complete M/S.
		30 Dryandra State Forest vegetation RS99 GJ Keighery	Management plan written.	Continue fieldwork
		31 Boonanarring Reserve Survey RS15 RS99 AH Burbidge	Update M/S.	Submit MS
		32 Southern Beekeepers Reserve Survey RS15 AH Burbidge	Completed.	
		33 North-west Islands Survey KD Morris	Shark Bay Islands surveyed.	Prepare M/S.
		34 Cape Arid Survey RS15, RS99 AH Burbidge	Sampling completed	Draft report
		35 Fitzgerald River NP Survey RS127 NL McKenzie (liaison)	Publish.	
	3,4,6	36 Eastern Goldfields RS121, RS122 NL McKenzie	Goldfields vertebrate data in data-base; Cell 6 in press; Cell vegetations upgraded, field studies finished	Publish Cells 6 & 8; Prepare MS of Cells 9 & 5; Put Goldfields plant data in data-base
	1,6	37 Rainforest Survey NL McKenzie	Publish book.	

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	2	38 Irwin/Carnarvon survey RS126 GJ Keighery	Seeking funding.	
		39 Ecological catalogue of W.A. conservation reserves and proposals NL Gibson	Ongoing	
Ongoing Reserve system design and Land-Use Advice, Management Planning	6	40 Proposed Jibberding White Wells Reserve Survey AA Burbidge	Published	
		41 Salisbury Island Survey AA Burbidge	Publish	
		42 Bucaneer Archipelago Survey RS128 NL McKenzie	No progress	Compile data & maps etc for report: also RPP 23
		43 Dampier-Burrup Archipelago Survey KD Morris	Dampier mgmt plan complete. Burrup deferred	
		44 Mandora Palaeoriver/Radi Hills Survey NL McKenzie	No progress	Compile data
		45 Cooloomia Nature Reserve Survey RS75 SD Hopper	No progress	Deferred
		46 Flora Survey of Islands: Lancelin to Dongara RS94 GJ Keighery	In press	Publish
		47 Mt Leseueur Survey work RS60 AJ Hopkins	No progress	Complete draft
		48 Stirling Range & Environs flora RS95 GJ Keighery	Rare flora mapped, draft prepared	Prepare annotated flora list
		49 Dorre Island and associated Shark Bay Island survey RS141 RIT Prince	No progress	Re-sample at 15 years is due
		50 Bold Park flora survey GJ Keighery	In press	Publish

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		51 Benger Swamp Flora Survey GJ Keighery	Published	
		Tutanning Survey work RS59 AJ Hopkins	No progress	Complete draft
		53 Two Peoples Bay Survey Work RS63 AJ Hopkins	Published	
		Middle Island/Recherche Survey Work RS60 AJ Hopkins	Draft completed	Publish
		55 Dampier Archipelago Survey RS132 KD Morris	Papers in preparation	
	4,6	56 Monte Bello Island Survey RS132 KD Morris	No progress	Deferred
		57 Bird Communities of Walpole-Nornalup NP (McKenzie (liaison) RWP unallocated) G Wardell-Johnson	Discontinued	
		58 Granite outcrop plant survey SD Hopper	Several surveyed and specimens lodged in Herbarium	Ongoing
		59 Biogeography of Dugong and Seagrasses in northern W.A. RS142 RIT Prince	Transfer to Marine Programme	
		60 D'Entrecasteaux NP assessment N Gibson	Commence survey	Continued
Management Planning	4,6	61 Management guidelines for Monte Bello Island RS132 KD Morris	In press	
		62 Management Plan for North-west Islands KD Morris	Provide advice as requested by Protection Branch.	Ongoing
		63 Bucaneer Archipelago Management Plan RIT Prince	Continue to collect data	Deferred

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	5,6	64 Bat assemblages: disturbance and determinism RS129 NL McKenzie	In press	Await publication
		65 Lizard litter patch guilds RS121 NL McKenzie	No progress	Continue as time allows
		66 Distribution and taxonomy of Geocrinia complex RWP 1/83 G Wardell-Johnson	Published 2 papers	Draft 2 papers

ENTOMOLOGY PROGRAM

PROGRAM LEADER

I Abbott

CURRENT RESOURCES (1990/91)

This program comprises 5.4 persons (1.4 Professional + 4.0 Technical). Its estimated budget is $177 622 (including $153 622 salaries and $24 000 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 5.9 persons (1.6 Professional + 4.3 Technical). Its budget was $218 528 (including $184 258 salaries and $34 270 operating costs).

BACKGROUND

The entomology program was formed in 1988 as a result of a review of all research programs. It reflects CALM's commitment to protecting its forests and woodlands from infestations of pest insects.

Although outbreaks of defoliating insects have been studied by CSIRO in the Jarrah forest since the 1960s, knowledge about their ecology and control is still insufficient. Outbreaks of Leafminer have recently penetrated the northern Jarrah forest and there is an urgent need to slow down this expansion northwards. Outbreaks of Gumleaf Skeletonizer, which began in the southern Jarrah forest in 1983, have recently subsided. In certain pine plantations, the introduced bark beetle Ips has in the recent past infested trees and so a program of biological control has to be intensified. Infestations of millions of hectares of Flat-topped Yate woodland over the lower Great Southern Region by a Lerp are causing concern about the long term future of both remnants on private land and larger populations in National Parks. Finally, the continued outbreak of Sirex wasp in South Australia increases the chance that this species will eventually gain entry to Western Australia; CALM is committed to detecting it as early as possible and controlling it before it can damage the pine resource.

By 1995 there should be a considerable increase in knowledge about the ecology of these pest insects and their impacts on their host trees. We hope then to be able to indicate to land managers how stands currently free of pest insects can be kept so, and how stands currently infested can be treated so as to reduce infestation to an acceptable level.

ACHIEVEMENTS

An experimental fire near Collie in Autumn 1989 scorched an average of about half of each jarrah crown and reduced the density of Jarrah Leafminer by one third. These preliminary results therefore offer promise of a successful, practical method of controlling Leafminer outbreaks.

A survey in Collie and Manjimup Districts of adjacent stands of jarrah forest differing in time since Spring burning showed that Spring burning in 1988 did not favour Leafminer.

Surveys of Jarrah stands throughout the northern Jarrah forest resulted in the discovery of an extensive incursion of Leafminer from the Swan Coastal Plain into the Darling Range between Mundaring and the Avon Valley.

Extensive sampling of Gumleaf Skeletonizer in the southern Jarrah forest has shown a contraction in distribution and decline in abundance. Most mortality of caterpillars resulted from parasitism by the wasp *Euplectrus* sp.

Studies of *Cardiaspina bruneu*, the Lerp infesting Flat-topped Yate, show that it has 3 generations per year and that its biology is comparable to that of *C. albitextura*, a well studied Eastern States species.

The newly constructed Insectary at the Manjimup Research Centre was commissioned in June 1990.

The release of introduced biocontrol agents of Ips was completed in co-operation with Kirup District staff.

A scientific paper was presented at an International conference on population dynamics of forest insects held at Heriot-Watt University, Edinburgh, Scotland in September 1989.

AIM

To develop methods for controlling economically important insect populations and to investigate the impact of these insects on mortality, health, growth and reproduction of plants (excluding agricultural plants).

PRIMARY OBJECTIVES

Ecological Knowledge

To understand the relevant ecological characteristics of pest insect populations on trees. To investigate the impact of pest insects on the mortality, health, growth and reproduction of trees.

Stand Management

To elucidate how stands can be managed (which may include logging, thinning, regenerating, burning) in the presence of insect pests. To determine how stands differ in their resistance to insect pests and to develop a stand hazard-rating system.

Control

To develop cost-effective and scientifically-sound methods of controlling populations of pest insects on trees and in wood products.

Communication

To communicate research results in the form of technical and scientific publications, educational literature, committee representation, and to provide advice and liaison with other CALM staff, other Departments, and the community at large by way of training courses and seminars.

20 YEAR GOALS (based on current resources and in priority order)

1. Minimize the economic and conservation impact of pest insects in Jarrah, Karri and pine forest and Flat-topped Yate woodland using appropriate methods.***
2. Complete a checklist of potential pest insect species in the forests of south-western Australia, together with details of their distribution.**
3. Monitor on a broad-scale insect infestation of trees in other ecosystems in Western Australia.*
4. Expand research in conservation entomology.*

5 YEAR GOALS

1. Determine the impact of Jarrah leafminer (JLM) on foliage, crown condition, wood growth and mortality of Jarrah, and investigate the cause of, and monitor the extent of, the outbreak.
2. Determine the impact of Gumleaf Skeletonizer (GLS) on foliage, crown condition, wood growth and mortality of Jarrah, investigate the cause of and monitor the extent of the outbreak, and clarify the annual cycle of GLS and its predators and parasitoids.
3. Determine the impact of Lerp on foliage, crown condition and mortality of Flat-topped Yate, and investigate the cause of, and monitor the extent of, the outbreak.
4. Maintain liaison with advances in research into insect pests of pine in the Eastern States (mainly Ips and Sirex).
5. Investigate the impact on regrowth Karri and the causes of infestation by the borer *Tryphocaria acanthocera*.
6. Determine the composition, distribution and economic impact of the termite fauna of metropolitan Perth.
7. Curate, maintain and protect the principal State collection of forest insects.

8. Elucidate how Jarrah stands can be managed in the presence of JLM and GLS infestations.

9. Search for Flat-topped Yate trees or stands resistant to Lerp infestation.

10. Evaluate the suitability of parasitoids for biological control of JLM, GLS and Lerp.

11. Prepare detailed prescriptions for the release of parasitoids and predators of Ips in pine plantations throuhout the South West.

12. Prepare detailed prescriptions for monitoring of selected pine plantations to ensure the earliest possible detection of Sirex; also detail the action required should Sirex establish in Western Australia.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following)

1,5,10-16,19,20,23,24,26,27,28,33,37,38

PROPOSED NEW PROJECTS - with existing resources (in priority order)

Nil

PROPOSED NEW PROJECTS - with additional resources (in priority order)

1. Monitor insect outbreaks in *Eucalyptus globulus* plantations.

2. Assess the role of meteorological variables in causing outbreaks, continuing outbreaks and terminating outbreaks.

3. Measure water stress and salinity stress on Flat-topped Yate trees near Jerramungup (jointly with Native Forest Silviculture Program).

4. Undertake electrophoretic studies of GLS caterpillars from SW Australia and selected eastern states populations in order to elucidate taxa.

5. Assess whether outbreak densities of defoliating insects reduce the abundance of bird populations (jointly with Fauna Conservation Program).

6. Determine whether resistance of Jarrah to JLM or GLS infestation is genetically based (jointly with Native Forest Silviculture Program).

7. Investigate the impact of repetitive defoliation by insects on nutrient levels in, and physiological condition of, the Jarrah pole (jointly with Native Forest Silviculture and Plant Diseases Programs).

8. Assess whether application of fertilizer to Jarrah ameliorates or aggravates damage caused by JLM and GLS (jointly with Native Forest Silviculture Program).

9. Develop appropriate methods of insect pest management for Jarrah forest set aside for conservation.

PUBLICATIONS* AND REPORTS 1989/90

Abbott, I. (1989). Plantation entomology (Paper prepared for Executive Director, 9 pp).

* Abbott, I. (1989). The influence of fauna on soil structure. In "Animals in Primary Succession - The Role of Fauna in Reclaimed Lands" (ed. J.D. Majer), pp. 39-50. University Press, Cambridge.

*Christensen, P. and Abbott, I. (1989). Impact of fire in the eucalypt forest ecosystem of southern Western Australia: a critical review. Aust. Forestry 52:103-121.

Abbott, I (1990). Insect outbreaks in *Eucalyptus globulus* plantations (Paper prepared for Plantations Policy Panel, 15pp).

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Ecological Knowledge	Jarrah Leafminer (JLM)	1	Impact on wood growth (I Abbott) 24/86	Plot near Dwellingup remeasured Dec 89	Remeasure wood growth Dec 90 & write up
		2	Annual monitoring of defoliation (I Abbott)		
			44/87	Damage to tagged leaves measured Oct 89 in 20 plots, Collie District. New cohort tagged.	Measure damage to tagged leaves Oct 90
			20/84	New leaves tagged in 20 plots in Manjimup District Nov 89	Measure damage to tagged leaves Nov 90 and tag new leaves
			20/84	Leaves tagged Nov 85 in Manjimup District measured quarterly for damage up to Feb 88 - Analysis completed	Write up
			2/85	Damage to leaves tagged in NJF in Nov 85 and Nov 87 analysed	Write up
			-	Aerial survey of forest in Collie District Oct 89	Repeat Oct 90
			-	All maps of damaged forest incorporated into FMIS	Ongoing
		3	Crown decline (I Abbott) 45/87	Paper in press	-
			20/88	Crowns of selected trees rated & photographed, Collie District	Monitor
		4	Tree mortality (I Abbott) 20/88	180 trees marked, Proprietary block, Collie District	Monitor
		5	Cause of outbreak (I Abbott)	Climatic modelling being investigated by M Williams using SDI data for Manjimup & Collie	Finalize
	Gumleaf Skeletonizer (GLS)	6	Annual cycle of GLS, predators and parasitoids (J. Farr) 23/85	Data sorted and analysed. Annual Sampling of 45 trees Jan 90 for GLS only	Do annual sampling of 45 trees Jan 91

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		7	Distribution of GLS N of outbreak zone (J Farr) 48/87	Surveyed Donnybrook area & Kirup & Manjimup Districts Nov 89	Extend survey to all Southern Forest Districts using operational staff
		8	Annual monitoring of outbreak (J Farr)	Not done Jan 90 due to population decline: No observable damage	Repeat Jan 91 if damage increasing
			-	All maps of damaged forest incorporated into FMIS	Ongoing
		9	Crown decline & tree mortality (J Farr) 61/86	Crown of 45 trees rated and photographed Jan 90. Population density of GLS caterpillars measured	Repeat crown assessment Jan 91 & monitor population density
		10	Cause of outbreak (I Abbott)	Climatic factor being investigated by M Williams using SDI data for Manjimup	Complete analysis
		11	Uraba taxonomy (J Farr)	No action due to low population of GLS	Depending on population of GLS, begin breeding experiments
		12	Survival of GLS on different host plants (J Farr) 39/88	Survival examined on Jarrah only due to low population	Depending on population level, examine survival on both Jarrah & Marri
		13	Spatial distribution of pupae (J Farr) 42/88	No action due to low numbers of GLS	Examine when population levels higher
		14	Fecundity in relation to pupal mass (J Farr) 41/88	Monitored tagged leaves over 12 months; RPP prepared	Ongoing
	Lerp	15	Life cycle studies (J Farr) 22/90	Monitored tagged leaves over 12 months; RPP prepared	Ongoing
		16	Taxonomy (J Farr)	Interstate request for populations of C. brunnea in NSW	Species yet to be described. Await information on other lerp populations
		17	Crown decline & tree mortality (J Farr) 24/90	RPP prepared	Ongoing
		18	Population monitoring (J Farr) 23/90	RPP prepared	Ongoing
		19	Stadia identification (J Farr) 26/90	RPP prepared. Lerps measured over 6 months	Ongoing
		20	Adult emergence (J Farr) 25/90	RPP prepared	Ongoing

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	Pests of pine	21 Ips, Sirex (J Farr, I Abbott)	Expert advice provided to other Divisions of CALM	As required
	Other insects (potential pests) in Jarrah forest	22 Assemble basic life history details, distribution (I Abbott, J Farr)	Data collected opportunistically	Opportunistic
	Tryphocaria borer in Karri	23 Distribution & intensity of infestation (I Abbott) 32/85, 59/86	Written up	Publish
	Termite occurrence in Perth Metro area	24 Species present and location of "hot spots" in Metro area; Damage impact (I Abbott)	Written up	Publish
	Curation, maintenance & protection of pinned & spirit-collection of insects, collection of wood samples showing insect damage, and herbarium of insect-damaged foliage	25 Provide identification service of insects damaging wood or foliage, and maintain records of occurrence of infestations (I Abbott, J Farr)	80 public telephone and 40 written enquiries dealt with. Second record in WA of Anobium punctatum (common furniture borer)	Incorporate SJF samples into spirit collection. Complete computerized data base for pinned collection
		26 Checklist of insect species recorded in forests of south-western Australia (I Abbott)	Some updating of list	Prepare for publication
Stand Management	JLM	27 Stand hazard rating (I Abbott)	Pilot project with CSIRO Remote Sensing Unit	Liaison as required
		28 Frequency of occurrence of resistant trees in NJF (I Abbott) 45/87	No action	Write up
		29 Effects of fire & thinning (I Abbott) 20/88	JLM cut outs collected in cone traps Oct 89	Ongoing
		22/89	JLM cutouts counted in adjacent stands differing in period since last Spring fire	Write up
		5/90	RPP prepared	Measure impact of recent logging on JLM density

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	GLS	30 Stand hazard rating (J Farr)	No action - remote sensing not possible due to decline in abundance	-
		31 Effect of fire (J Farr) 19/87	Sampled Jan 90 & burnt Autumn 90	Resample Jan 91
		Effect of thinning (J Farr)	No action due to low population levels	Suspend until population increases
	Lerp	33 Resistant trees (J Farr)	Observations made: No apparent resistance found & no stands found with low lerp numbers	Ongoing
Control	JLM	34 Impact of parasitoids (I Abbott) 47/87	Forest between Julimar & Collie surveyed: part of Swan Coastal Plain surveyed	Ongoing - train selected Northern Forest Region staff to carry out survey
	GLS	35 Biocontrol (J Farr)	1989-90 generation. One of 3 parasitoid species caused most mortality	Continue sampling. Prepare RPP
	Lerp	36 Biocontrol (J Farr)	Sampling continued. Pilot study of rearing lerp in laboratory	Conntinue sampling. Prepare RPP
	Ips	37 Prescription for introduction of parasitoids and predators (I Abbott)	Introductions from S Aust completed in co-operation with Kirup District staff	Using caged billets, evaluate which species have established
	Sirex	38 Prescription for monitoring for presence Sirex and procedures to be followed if an outbreak occurred (I Abbott)	Monitoring carried out by Silviculture Branch	Liaise with Silviculture Branch about ongoing monitoring

FAUNA CONSERVATION PROGRAM

PROGRAM LEADER

JA Friend

CURRENT RESOURCES (1990/91)

This program comprises 8.8 persons (3.45 Professional + 0.50 Contract Professional + 4.85 Technical). Its estimated CRF budget is $494 521 (including $366 321 salaries and $128 200 operating costs).

RESOURCES IN PREVIOUS YEAR

This program in 1989/90 comprised 9.30 persons (3.95 Professional + 0.50 Contract Professional + 4.85 Technical). Its CRF budget was $432 427 (including $282 977 salaries and $149 050 operating costs). An additional $160 100 was attracted from external sources during the period.

BACKGROUND

The indigenous vertebrate fauna of Western Australia, excluding fish, comprises more than 1000 species: 475 birds; 135 mammals, including nearly 70 marsupials; 360 reptiles; and 70 amphibians. The dingo is the only mammal species 'not protected'. In addition, 16 species of venomous land snakes and all seasnakes are 'not protected'. Conversely, 43 mammals, including 27 marsupials (40%), 11 other land mammals (15%) and 5 marine mammals, 40 birds (8%), 19 land dwelling reptiles (5%) and one marine turtle, and one frog species had been declared as threatened fauna.

Among the extensive invertebrate fauna, only beetles of the Family Buprestidae and ants of the Genus *Nothomyrmecia* are presently included in the category of 'protected fauna'.

Of the recognized fauna, most species occupy land other than that dedicated for conservation (CALM controlled land). Few even of the threatened species are confined solely to CALM land. Departmental responsibility for conservation of the State's fauna thus implies a responsibility for conservation of species at large throughout the State for the most part. Fauna conservation research therefore spans the whole range, from management of abundant species such as the larger kangaroos on rangelands to protection and restoration of populations of endangered species such as the Noisy Scrub-bird. Requirements for fauna conservation research data are thus correspondingly broad.

Discovery of populations of some threatened species still depends on opportunistic observation, such as for the Dibbler in 1985, and Shortridge's mouse more recently in the Fitzgerald River National Park, and requires co-ordination of information that may come from a wide range of sources. The ability to respond to such chance events is most important.

Threatened species have perhaps received the greatest attention, but not all are amenable to an intensive formal research project internalized within CALM. Species-orientated projects may also not necessarily result in readily obtained improvements in conservation status.

Translation of research knowledge into practical operational management is another particular problem. Because of these factors, the approach adopted for conservation of threatened species is flexible. The problems likely to be posed however are not usually amenable to quick resolution and so need continuing resource commitments within CALM.

The rarer species are not the sole faunal group requiring attention. There is no infallible method for predicting which of today's currently abundant species might be tomorrow's 'threatened fauna'.

Research into adverse impacts of feral exotic species on the indigenous fauna has so far focussed on predators. The impact of predation on relict mammal populations has been demonstrated and remains a threat to conservation of the species affected. The more indirect impacts that may result from habitat modifications by grazers, interference effects and direct competition for resources have not yet been addressed.

Research aimed at management of conservation areas in ways benefiting particular species has generally been the focus of 'threatened fauna' species work in the past. Wider studies relevant to this aspect of fauna conservation overlap various other programs, particularly fire and flora conservation. The requirement for CALM to manage land for economic resource production (e.g. water and timber production, mining) also demands broadly-based research knowledge and integrated applications development where the multiple use objectives are to be satisfied in practice.

Studies on communities of fauna and the processes affecting them are thus an integral part of the fauna conservation research program.

Research on the marine fauna has to date been narrowly focussed and will remain so in the near future. Dugongs, marine turtles, seals and sealions, seabirds, and some data base applications in regard to the above and some cetaceans will continue to be dealt with under this program. Other aspects will be subject to development of the more specialized marine conservation research program.

Current resources of the fauna conservation research program do not permit any real attempt to research the invertebrate fauna.

ACHIEVEMENTS

An experiment was carried out to test the hypothesis that the artificial diet currently being fed to captive numbats was inhibiting breeding. The hypothesis was disproved, as a female numbat maintained on the regular diet and another fed an increased proportion of termites both bred successfully at Woodvale, together producing a further seven young. This brings to 19 the number of numbat young bred in captivity since 1985, and augurs well for the future of the breeding program run by CALM and Perth Zoo.

Ten numbat young born at Karroun Hill NR since the translocation of numbats there in 1987-8 were captured and fitted with radio-collars. This permitted the monitoring of their dispersal and showed that their condition was excellent, indicating adequate food supply, but that predation rates are significant.

A Draft Management Program for the Chuditch was finalised.

A search for the Shark Bay mouse on the mainland in the Shark Bay region was carried out. No evidence was found that it persists on the mainland, but a number of suitable re-introduction sites were located..

Surveys for ground parrots at Fitzgerald River NP confirmed that Hamersley Drive is an important site for these rare and endangered birds. Permanent quadrats to monitor the effect of fire on ground parrot habitat were established.

AIM

To provide scientific information to ensure effective conservation and management of Western Australia's terrestrial fauna.

PRIMARY OBJECTIVES

Knowledge

To increase knowledge of the fauna and the ecosystems in which they occur.

Community Studies

To conduct and/or promote research that will lead to better understanding of the structure and function of ecosystems and the fauna therein.

Population Studies

To identify threatened fauna and seek understanding of factors affecting the status of populations, and to prepare wildlife management programs for species that require management. To provide a sound basis for conservation and management of exploited fauna, and to prepare wildlife management programs for exploited species. To research methods and provide management programs for control of feral and other exotic species adversely affecting fauna conservation.

Management Applications

To provide a scientifically sound practical basis for implementation of fauna management, to assess the impact(s) of management and for recommending necessary modifications.

Public Involvement

To promote understanding and appreciation of fauna conservation by actively encouraging the involvement of the public in appropriate research projects and in the process of development and implementation of management applications.

Communication

To communicate effectively results of research by way of public contact, production of specialist publications, input into the management planning process, and the provision of management prescriptions as required so that transfer of research knowledge to the management area is facilitated and public appreciation of nature conservation is increased.

20 YEAR GOALS (based on current resources and in priority order).

1. Extend and expand research which promotes understanding of the structure and function of ecosystems and their fauna.***

2. Extend and expand research which promotes understanding of the biology and ecology of species and groups of fauna for which Western Australian populations are of major conservation significance.***

3. Develop and maintain a system that encourages and actively stimulates wider public involvement in fauna conservation research.***

4. Extend and continue conservation programs for threatened fauna.**

5. Extend and expand research necessary to achieve effective economic and practical management of adverse impacts of feral exotic fauna on conservation of the native fauna.**

6. Maintain and develop as necessary programs for monitoring the impact of land management activities on fauna so as to guide and redirect as required management practice(s) towards effective conservation.**

7. Develop conservation research on the non-marine invertebrate fauna.*

5 YEAR GOALS

1. Identify any additional relict populations of current threatened (rare and endangered) fauna species.

2. Develop and maintain appropriate data bases and conduct studies to integrate specialized knowledge of fauna.

3. Conduct research on faunal communities which include feral exotic fauna in cases where the nature of anticipated impacts is uncertain, but the need for more intensive future management is foreseen.

4. Develop effective economic and practical control programs for selected feral exotic fauna for implementation in cases where adverse effects on conservation of native fauna are demonstrable or clearly indicated and special management is required.

5. Conduct research and develop effective economic and practical management programs for threatened fauna requiring management support. Management may include population enhancement involving translocation and reestablishment, captive breeding programs, predator control and special habitat manipulation.

6. Increase understanding of the biology and ecology of species and groups of fauna for which Western Australian populations are of major conservation significance, and especially where such knowledge can be applied to specific management and planning needs and facilitate the process of public involvement in conservation work.

7. Develop and evaluate field study techniques applicable to fauna research studies and monitoring of management applications.

8. Develop an appropriate network of contacts and secure resources so as to increase the level of public involvement in fauna conservation field research and management applications.

9. Assist in the development of fauna management programs in cases where traditional Aboriginal exploitation is a significant factor.

10. Provide support as required to administrative and policy areas of CALM in regard to maintenance of continuity in operation of exploited species management programs, e.g. kangaroos, quota advice.

11. Establish working communications with Regions and District Offices so that the program can more effectively assist in meeting needs for specialized knowledge on fauna conservation topics and in planning to meet needs for further research.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995

1, 3-15, 17-24

PROPOSED NEW PROJECTS - with additional resources (in priority order)

Nil.

PROPOSED NEW PROJECTS - with existing resources

Nil.

PUBLICATIONS * AND REPORTS 1989/90

Algar, D. (1989). Progress report to World Wildlife Fund Australia. P106 Preparation of a manual on fox control.

Algar, D. (1989). Final report to DPIE Bureau of Rural Resources. Wildlife and Exotic Diseases Preparedness Program - 1988/89. Fox control: Determination of density and dispersal, a prerequisite for disease control.

Algar, D. (1989). Progress report to ANPWS Research and Surveys Consultancy Program 1988/89 Macropod Conservation. Fox control study Phase 3.

Algar, D. (1990). Preliminary report to DPIE Bureau of Rural Resources. Wildlife and Exotic Diseases Preparedness Program - 1988/89. Fox control: Study of the dispersal of foxes under conditions of control and no control.

Algar, D. (1990). Final report to ANPWS Research and Surveys Consultancy Program 1988/89 Macropod Conservation. Fox control study Phase 3.

*Burbidge, A.A. (1989). Desert Bigfoot. Landscope 5(2): 22-6.

*Burbidge, A.A. and McKenzie, N.L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biol. Cons. 50: 143-98.

Burbidge, A.H., McNee, S., Newbey, B. and Rolfe, J.K. (1990). Supplementary report to World Wildlife Fund Australia on Project 118: Conservation of the Ground Parrot in Western Australia.

*Friend, J.A. (1989). Myrmecobiidae. Chapter 22. In "Fauna of Australia. Volume 1B. Mammalia" (ed. D. Walton). Pp. 583-90. Bureau of Flora and Fauna, Canberra.

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*Morris, K.D. (1989). Feral animal control on W.A. islands. In "Australian and New Zealand islands: nature conservation values and management" (ed. A.A. Burbidge), CALM Occ. Pap. 2/89: 105-11.

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and New Zealand islands: nature conservation values and management" (ed. A.A. Burbidge). CALM Occ. Pap. 2/89: 219-20.

Morris, K.D., Sanders, A. and Harold, G. (1990). Final report to World Wildlife Fund Australia on Project : Search for mainland populations of the Shark Bay mouse, *Pseudomys praeconis*.

*Nagy, K.A., Bradley, A.J. and Morris, K.D. (1990). Field metabolic rates, water fluxes and feeding rates of Quokkas, *Setonix brachyurus* and Tammars, *Macropus eugenii* in Western Australia. Aust. J. Zool. 37: 533-60.

Pearson, D. (1989). Report to ANPWS Project AW05. Aborigines and wildlife conservation in the Western Desert.

*Start, A.N. and Morris, K.D. (1989). White-breasted form of the Wedge-tailed Shearwater off the Pilbara coast. West. Aust. Nat. 18: 61.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-1
Knowledge	Specialized knowledge	1	Mormopterus taxonomy (RS130) NL McKenzie	No progress	Complete work as opportunity arises
		2	Landhopper taxonomy (RS44) JA Friend	Identified part of New Caledonian collection	Complete New Caledonia material, contribute to paper. Identify SW Tasmanian collection, contribute to paper. Complete identification of collection from E. Gippsland. Plot S-W WA distribution data for paper
Knowledge; Community Studies		3	Forest fauna habitats RIT Prince	Liaison with NFR. Resources not available to proceed further	Preliminary investigation of resource base and dependent fauna
	Feral exotic; control programs	4	Fox biology and fox control (RS104, 105-111) D Algar	Follow-up assessment of baiting trials at Watheroo NP (dispersal into a control area). Established baiting program for Gibson Desert NR. Examination of fox home range at Kalbarri NP. Preliminary assessment of fox aging criteria.	Assess effectiveness of different baiting intensities. Establish extent of dispersal into a control area over time (Watheroo NP). Establish dispersal study at Namming NR (no control). Conduct baiting program in Gibson Desert NR, with follow-up assesment.
	Biology, ecology	5	Fox Ecology JE Kinnear	Prebaiting mammal census not completed and partial baiting of FRNP not achieved due to circumstances relating to park fire and bait supply problems. Biodegradation studies of 1080 completed. Census tasks of marsupial populations in wheatbelt completed	Re-assessment of FRNP study in light of recent fires. Carry out mammal census and partial baiting of park pending assessment of fire impact on experiment. Submit for publication biodegradation 1080 results. Submit for publication census results. Extend biodegradation studies on baits in situ
Knowledge; Population Studies	Identify relict populations; specialized knowledge; potential impacts of feral exotic; management support; biology and ecology	6	Rock Wallaby conservation (RS103, 104-105) JE Kinnear	Monitoring and population surveys completed	Continue
	Management support; biology and ecology	7	Rock Wallabies, Dampier Archipelago (RS108) JE Kinnear	Paper in preparation	Submit for publication

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-1
	Identify relict populations; management support; biology and ecology	8 Rock Wallabies, East Pilbara (RS108-109) JE Kinnear	Paper in preparation	Submit for publication
	Management support, biology and ecology	9 Numbat study. Habitat and food sources (RS39-41) JA Friend	Paper on feeding activity and termites, management program in preparation	Complete paper on feeding activity and termites. Complete draft management program for the numbat
	Identify relict populations; management support; biology, ecology	10 Chuditch conservation (RS147-149) KD Morris	Completed species management program and survey of John Forrest NP. Continued obtaining distribution data.	Implement management program. Continue surveys of wheatbelt area and collection of distribution data
	Management support; biology, ecology	11 Western Barred Bandicoot (RS43-44) JA Friend	Proposed field trip to Dorre Island cancelled due to lack of funds. Analysis of home range data largely completed	Prepare paper on movement and home range as time permits. Further fieldwork deferred until resources available
	Management support; biology, ecology	12 Ground parrot conservation (RS17-18) AH Burbidge	Report to WWFA submitted	Continue habitat work; prepare publications
	Management support; biology, ecology	13 Mammals of Pilbara Islands KD Morris	Continued ecological study of Leggadina Thevenard Island. Commenced study of small mammal ecology on Barrow Island	Translocate Leggadina to Delambre Island, set up monitoring program.
	Identify relict populations; develop management support programs	14 Hooded Plover conservation AH Burbidge	Funding application prepared & submitted to ANPWS	Proceed in association with RAOU if funding provided
Identify relict populations; specialized knowledge; biology, ecology; public involvement	Management Support	15 Western Swamp-Tortoise breeding (RS9-10) AA Burbidge	Funds secured via WWFA, consultancy work in progress; hatchlings produced	Continue
	Management support; techniques	16 Western Swamp-Tortoise populations (RS9-10) AA Burbidge	Seasonal work completed as required	Continue

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-1
	Management support, biology, ecology	17 Numbat study - translocation and re-establishment (RS43-43) JA Friend	Translocation to Karroun Hill NR (monitoring by radio-tracking continued). Ten young captured, radio-collared and survival monitored. Diggings survey at Boyagin NR carried out with help from Region.	Monitor survival of young at Karroun Hill. Continue monitoring diggings at Boyagin. Complete Boyagin report for WWFA and draft management program
	Management support, biology, ecology	18 Banded Hare-wallaby, Stage 3 (RS141) RIT Prince	Project suspended due to land tenure problems at Shark Bay & insufficient funds	Reactivate when problems solved with implementation of Shark Bay Region Plan
	Management support; techniques	19 Woylie Populations (2/83) PES Christensen	Major monitoring in suspense	Monitor Perup release area
	Management support; techniques	20 Woylies in NR's etc. (RS102) JE Kinnear	Completed except for FRNP program due to recent fires	FRNP work to proceed if now feasible in light of recent fires
	Identify relict populations; specialized knowledge; management support; biology and ecology	21 Red-tailed phascogale distribution and ecology JA Friend & GR Friend	ANPWS ESP funds secured. Techniques for trapping and radio-tracking animals established after trials. Definition of home ranges and nest sites at Tutanning NR	Predict potential distribution using BIOCLIM or similar program. Surveys for relict populations in Great Southern; Lake Magenta NR survey. Identify eastern population for intensive study.
Population Studies; Management Applications	Potential impacts of feral exotic; control programs; techniques; contact with Regions	22 Exotic fauna, rats on islands (RS134-135) KD Morris & RIT Prince	Examined possibility of re-introducing boodies to Boodie I.	Continue monitoring pindone levels in oats remaining on Boodie I.
	Specialized knowledge; specific needs; techniques; contact with Regions	23 Seabird database AA Burbidge	Database maintained & updated	Continue; paper(s) integrating knowledge to be prepared
	Specialized knowledge; specific needs; techniques; contact with Regions	24 Island mammal database AA Burbidge & IJ Abbott	Database maintained & updated; data incorporated into draft paper	Continue; submit paper
	Techniques; administrative support	25 Kangaroo management programs RIT Prince	Harvest quota advice provided. Planning for collaborative analysis of harvest and population data with ANPWS, NKMU personnel commenced	Ongoing

FIRE PROGRAM

PROGRAM LEADER

N Burrows

CURRENT RESOURCES (1990/91)

This program comprises 16.55 persons (6.00 Professional + 10.15 Technical + 0.40 Contract Technical). Its estimated CRF budget is $758 626 ($595 926 salaries and $162 700 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 16.60 persons (5.95 Professional + 10.25 Technical to + 0.4 contract technical). Its budget was $749 862 ($551 807 salaries and $198 055 operating costs).

BACKGROUND

Fire is an important, complex environmental factor affecting land resources administered by CALM. CALM has a legal and moral obligation to protect life and property from destruction by wildfire and to ensure appropriate fire regimes are implemented to protect and enhance production and conservation values.

Almost all land managed by CALM is fire prone. Throughout the State, periods of hot dry weather when combined with flammable vegetation provide the potential for large and costly wildfires to develop. Research into fire behaviour and fuel modification within the major vegetation types will provide managers with techniques for minimizing the impact and severity of wildfires. In the past, most fire behaviour research effort has been centred on the populated, commercial forest regions of the south west and has contributed considerably to the current high level of fire management expertise. Fire behaviour research is now extending to the heathlands, mallee shrublands and hummock grasslands where there is historical evidence of large and destructive wildfires in Parks and Reserves managed by CALM.

The ecological importance of fire to conservation of the native biota is well acknowledged. A firm understanding of fire effects and of the role of fire in maintaining natural processes is essential for determining appropriate fire regimes and for predicting temporal and spatial effects. The use of fire as a management tool is an important ecological issue which can be resolved in part by scientific research. Fire ecology research is complex and requires long term commitment of resources to ensure a sound basis for applied fire regimes. Fire ecology research will continue in forests, woodlands, heathlands and hummock grasslands. To ensure the most effective use of research resources, complementary fire behaviour - fire effects studies will be conducted in these major vegetation types and on a systematic basis. By 1993, there should be a considerable increase in knowledge of fire behaviour, fire effects and therefore fire management in major forest types, heathlands, mallee shrublands, woodlands and hummock grasslands.

ACHIEVEMENTS

Experimental burning has commenced in the Stirling Range National Park. This study aims to improve knowledge of fire behaviour and fire effects in mallee-heath vegetation. Four plots were burnt in spring 1989 and three in autumn 1990. Initial hypotheses about the importance of wind speed and fuel moisture content on fire rate of spread and intensity have been developed. Additional data on fire behaviour under extreme weather conditions were gathered following the extensive wildfires in the Fitzgerald River National Park in late 1989.

Vertebrate and invertebrate studies in the Stirling Range National Park are progressing. A large component of the beetle fauna collected comprises new species, including a new southerly species of a restricted group of Cicindelids.

After four years of intensive monitoring of invertebrates and small vertebrates, an experimental burn on a 100 ha block of Tutanning Nature Reserve was carried out in March 1990. Monitoring of the site will continue to determine the effects of fire on the fauna. In addition, a population of the rare dasyurid *Phascogale calura* was studied before and during the experimental burn by means of grid-based trapping and radio tracking. This latter work is a joint project with the Fauna Program and is funded externally through the ANPWS Endangered Species Program.

Monitoring of the *P. calura* population will continue.

Plots established in south-west forests to examine the long term effects of fire on the vegetation were burnt in spring 1989 and autumn 1990. A detailed assessment of vegetation in plots which were burnt and plots which remain unburnt was carried out prior to burning. Seedling regeneration following the fires will be assessed in spring 1990. One of the study areas was established in 1972 and several plots have been burnt 6 times since then. A preliminary analysis of data has shown only minor changes in the vegetation composition under this extreme fire treatment. A study area containing the rare *Lambertia rariflora* was experimentally burnt in autumn 1990. The response of the *Lambertia* population will be monitored.

Thickets of *Melaleuca viminea* which occur in broad valleys on the eastern margin of the jarrah forest were surveyed for their suitability as habitat for the rare Tammar wallaby. Degenerate thickets east of Collie were burnt in autumn 1990 to create a new, healthy thicket. When the thickets have developed (in about 10 years) Tammars will be re-introduced from the Perup Nature Reserve east of Manjimup. The development of the regenerating thickets will be monitored annually. Other areas are planned for burning next autumn.

A landform soils map of the Perup Nature Reserve has been compiled and together with Landsat satellite imagery and GIS, will be used to enable Tammar habitat conditions to be optimized. A plant response master file for the Warren Botanical sub-district is completed. The file contains about 1900 records and documents species responses to fire and dieback.

Current disturbance ecology research on birds includes an eight year long study in permanent sites in karri forest in Gray forest block. Following a two year period of callibration sites were either burnt, small group (3ha) felled, clearfelled or left as controls. Mistnetting, censusing and foraging observations have been used to study the birds for five years after the operations. The structure and floristics of the vegetation are also assessed annually.

A second aerial patch-burn was successfully executed by the Goldfields Region in the Gibson Desert Nature Reserve in September 1989. An area of about 70,000 ha was patch-burnt in preparation for the re-introduction of two rare and endangered mammals scheduled for May 1991. The project team are aiming to attract outside funding for the re-introduction project. ANPWS, through the Endangered Species Program, has provided funds for fox control studies in the Reserve.

Studies of the effects of fire on desert vertebrates are progressing. Plots in the Queen Victoria Springs Nature Reserve have been burnt and post-fire trapping is ongoing. Field work in relation to a study of fire effects on vegetation is continuing. In the Gibson Desert Nature Reserve pre-fire trapping of lizards to study the effects of patch-burning is completed. A survey of extant populations of *Petrogale lateralis* in the Central Ranges region in conjunction with the Ngaanyatjarra Council was completed.

Aboriginal people from Pupiyala Tjarutja Inc. were contracted to undertake prescribed burning for wildfire prevention in the Neales Junction Nature Reserve. The project, funded by the ANPWS Contract Employment Program for Aborigines in National and Cultural Resource Management has been highly successful with some 280 km of strategic buffer burning being achieved in 10 days.

AIM

To develop fire behaviour models, appropriate fire regimes and to predict the effects of various fire regimes on production, protection and conservation values.

PRIMARY OBJECTIVES

Fire Behaviour And Suppression

To develop fuel characteristic and fire behaviour prediction models for major vegetation types throughout the State. To assist with the development of operational guidelines for wildfire pre-suppression and suppression and to evaluate their effectiveness and impact on the environment.

Fire Ecology

To determine the short and long-term effects of various fire regimes on plant and animal communities, especially on sensitive or rare flora and fauna, and to prepare relevant fire management guidelines. To identify critical plant and animal species and communities which may be readily monitored and used as biological indicators of the relationship between fire and the environment.

Fire Management

To develop management systems which integrate fire behaviour, suppression, fire effects and relevant resource information for a range of biomes (habitat types in similar climatic zones). To provide advice on appropriate fire regimes and prescriptions for inclusion in management plans.

Communication

To communicate research results in the form of technical and scientific publications and educational literature, by liaison with other CALM staff, other Departments and the public, and by assisting with training courses.

20 YEAR GOALS (based on current resources and in priority order).

The favoured long term strategy is to direct Fire Program resources to deal successively with each major vegetation type, i.e. to conduct simultaneous and complementary research into all aspects of fire in one type, culminating in an integrated management system. This will not always be practical, but it is clear that there will never be sufficient resources to conduct many types of research in all vegetation types simultaneously. The 20 year goals will complete the development of management systems which integrate fire behaviour, suppression, fire effects, monitoring systems and relevant resource information for the following major vegetation types in order of priority:

1. Heathlands and mallee shrublands. ***
2. Native forests of the south-west.***
3. Semi-arid woodlands and hummock grasslands. **
4. Banksia woodlands, mulga woodlands and tropical savanna woodlands. *

This will involve a wide range of research projects within each major vegetation type in order to obtain information and understand processes. It will not be practical to concentrate solely on one type, to the exclusion of others but attempts will be made to integrate and co-ordinate research within a limited number of types as far as possible. The diversity of research undertaken within the fire program also creates difficulties in attempting to rank all projects which are clearly not comparable. Therefore, the following organization of 5 year goals is not seen as rigid.

5 YEAR GOALS (with existing resources)

a. Fire Behaviour and Suppression

1. Develop a fire model for predicting fuel dynamics and fire spread in heathlands and mallee shrublands and examine the application of fuel modification techniques such as scrub rolling and burning.
2. Develop fire behaviour and fuel models for hummock grasslands and appropriate techniques for prescribing patch burns in desert reserves and national parks.
3. Complete analysis of fire behaviour studies in jarrah forests and refine existing models.
4. Complete fire protection studies in pine plantations.

5. Prepare fuel accumulation models for Banksia low woodlands and commence fire behaviour studies.

6. Commence wind shear studies in forests.

b. Fire Ecology

1. Study the effects of fire on small mammals, herpetofauna and selected invertebrates in semi-arid land (wheatbelt) reserves.

2. Study the effects of fire on heathland and shrubland flora and fauna.

3. Study the effects of various fire regimes on forest understorey plant species and some animals.

4. Study the effects of fire on vegetation, mammals and reptiles in hummock grasslands (desert reserves).

5. Study the effects of fire on mulga dominated communities, especially in Hamersley Range National Park.

6. Study the effects of fire on selected rare and fire sensitive flora.

7. Study the effects of fire on Banksia woodlands.

8. Study the effects of logging and burning on bird communities of the Karri forest.

c. Fire Management

1. Develop fire management guidelines for heathlands and mallee-shrublands.

2. Develop an integrated, computerized fire management system for Tutanning Nature Reserve (and others).

3. Develop an integrated computerized fire management system for south-west forests,

4. Document traditional aboriginal knowledge on fire aspects (in hummock grasslands) and develop it into an integrated system for management of desert reserves.

5. Develop management strategies to protect fire vulnerable communities in the Hamersley Range National Park.

6. Prepare prescriptions for the use of fire to regenerate specific habitat in forests.

d. Communication

1. Continue to hold formal and informal workshops, meetings and seminars for researchers, managers and community groups.

2. Continue to publish findings and to produce management guidelines.

3. Continue input into land management plans.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following)

1,2,3(part),4,5,6,7,8,9,10,13,15,16,17,18,19,20,21,22, 27,34,42,44,45

PROPOSED NEW PROJECTS (with additional resources)

1. Fire regime effects on nutrient regimes in forests.

2. Fire regime effects on forest fauna.

3. Fire regime effects on understorey species in woodlands, especially rare flora.

4. Fire regime effects on northern sandplains vegetation, especially rare flora.

5. Fire regime effects on south coast heathlands vegetation.

6. Fire regime effects on mammals - heathlands.

7. An integrated, computerized fire management system for forests.

8. The impact of climate change on the fire environment.

9. The effect of fire on climate change.

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Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
Fire Behaviour and Suppression	Fuel reduction guides for karri regrowth	1	Karri regrowth fuels 2/84 (L McCaw)	Partially revised	Resubmit for publication
		2	Prescribed fire behaviour 21/85 (L McCaw)	Field work, some data analysis	Complete data analysis
		3	Fire damage to karri regrowth 15/85 (L McCaw)	Final measurement of tree growth, crown response and fuel accumulation	Analyse data and prepare draft paper
	Fire behaviour in heathlands and mallee shrublands	4	Fire behaviour in heathlands and shrublands 61/88 (L McCaw)	Fuel assessment completed and 7 plots burnt	Burn 9 plots, commence data analysis. Document behaviour of Fitzgerald River National Park fire.
	Fire behaviour and fuel models - hummock grasslands	5	Aero burning techniques 25/88 (N Burrows)	Conducted large scale aero burns in Gibson Desert Nature Reserve for Sep 1989	Publish findings
	Complete analysis and write up of fire behaviour - jarrah forest	6	Field studies - jarrah 28/78 (N Burrows)	Complete data extraction from fire maps	Analyse data
		7	Lab studies of fuels (combustion rates) 18/86 (N Burrows)	Preliminary analysis of data	Complete data analysis
		8	Spot fire development 14/86 (N Burrows)	Preliminary analysis of data	Complete data analysis
		9	A computer system for storing, retrieving and analysing wildfire data 15/86 (N Burrows)	Paper submitted for publication	Close RPP.
		10	Fuel studies in southern wetlands 47/86 (N Burrows)	Fifth annual remeasurement of structure and biomass. Progress reports submitted	Remeasure in June 1990. Submit progress reports
Fire Ecology	Effects of fire on forest understorey plant species and some animals	11	Effects of 5 fire regimes on forest understorey species 12/86 (N Burrows)	Pre-burn assessment done. Two sites burnt and post burn assessed.	Burn sites in Spring & Autumn 1990. Complete seedling counts, biomass, photography at other sites.

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
		12 Effects of 3 fire regimes on ground-dwelling invertebrates in Jarrah forest. 20/90 (G Friend)	Post summer burn trapping continuing. Seasonal sampling of all treatments	Continue seasonal trapping of all treatments
		13 Regeneration of heartleaf thickets 7/84 (G.Wardell-Johnson)	Annual assessment of post-burn thicket development	Complete sampling
		14 Fire effect on Lambertia rariflora 23/87 (N Burrows)	Site burnt March 1990	Assess postfire mortality & recruitment. Prepare progress report.
		15 An Age Series of floristics in a single community type in Karri forest 11/88 (G Wardell-Johnson)	Sampling completed, plant master file prepared.	Complete sampling & prepare for publication
	Fire effects - mesic communities.	16 The response of terrestrial vertebrate fauna to disturbance in karri forest 11/89 (G Wardell-Johnson)	Sampling completed	Prepare for publication
		17 Regeneration strategies of plant species of the Walpole-Nornalup National Park 1/89 (G Wardell-Johnson)	Sampling completed	Prepare for publication
		18 The response of bird communities to logging and burning in the karri forest 22/82 (G Wardell-Johnson)	Sampling continued	Continue sampling
		19 The association between plant communities, landform/soils and burning history, Perup Nature Reserve 27/90 (G. Wardell-Johnson)	RPP submitted, Landsat imagery tested, vegetation maps prepared	Prepare publication
	Fire effects - semi arid land reserves	20 Pitfall trapping and sampling techniques RS34 (G Friend)	Data analysed	Publish paper
		21 Effects of prescribed burning on invertebrates in Durokoppin and East Yokrakine Nature Reserve 19/90 (G. Friend)	Durokoppin burn completed. Seasonal trapping and data analysis continuing	Continue seasonal trapping, habitat assessment and data analysis

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
		22 Effects of prescribed burning on small vertebrates in Tutanning Nature Reserve 17/90 (G.Friend)	Prescribed burn completed. Seasonal trapping and data analysis continuing	Continue seasonal trapping and habitat assessment. Analyse data.
		23 Effects of prescribed burning on invertebrates in Tutanning Nature Reserve 18/90 (G. Friend)	Prescribed burn completed. Seasonal trapping and data analysis continuing	Continue seasonal trapping and habitat assessment. Analyse data.
		24 Effect of prescribed burning on Phascogale calura 21/90 (G. Friend/J.A. Friend)	Pre-fire monitoring (incl. radio tracking) completed. Prescribed burn completed. Seasonal trapping and data analysis continuing.	Continue seasonal trapping and habitat assessment. Analyse data.
		25 Effects of fire on vegetation of Tutanning N.R. RS62 RS63 (A Hopkins)	Annual assessment	Do annual assessment & prepare progress report
		26 Fire effects on vegetation - Recherche Archipelago RS60 RS61 (A Hopkins)	Annual assessment and progress report	Do annual assessment. Complete publications on work to date
	Fire effects - heathland and shrublands	27 Fire effects on vegetation - Two Peoples Bay R.R. RS63 (A Hopkins)	Annual assessment. Several draft publications, guidelines for managers - draft management plan	Do annual assessment. Complete publications on 1st 10 years' results
		28 Regeneration after wildfire Mt Lesueur N.R. RS60 (A Hopkins)	Annual assessment of program report	Do annual assessment
		29 Fire effects on vegetation - Stirling Ranges N.P. 62/88 (L McCaw)	Completed pre-fire assessment of quadrats	Burn plots.
		30 Fire effects on reptiles, frogs and small mammals. Stirling Ranges N.P. 31/88 (G Friend)	Seasonal trapping and data analysis	Conduct seasonal burns and continue trapping and habitat assessment.
		31 Fire effects on invertebrates in the Stirling Ranges National Park 16/89 (G. Friend)	Seasonal trapping, preliminary data analysis.	Conduct seasonal burn, continue trapping.

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
		32 Effects of various fire control strategies on vegetation 15/87 (L McCaw)	Draft paper on Ravensthorpe experiments prepared. Kalbarri quadrats remeasured.	Submit Ravensthorpe paper for publication. Re-measure Kalbarri plots.
	Fire effects - hummock grasslands	33 Effects of mosaic burns on birds 20/88 (AA Burbidge)	First two post-burn censuses completed	Continue post-burn censusses.
		34 Effects of season of burn and fire size on desert vertebrates 32/88 (D Pearson)	Continued trapping. Preliminary write ups on ecology of individual species. Expand trap grid.	Continue trapping, publish findings
		35 Effects of fire on medium-sized desert mammals 38/88 (P.Christensen)	Preliminary trapping and habitat survey of Dalgyte (Macrotis lagotis)	Continue habitat survey; description of habitat sites.
		36 Effects of fire season & intensity on floral succession 33/88 (D Pearson)	Vegetation mapped on aerial photos. Specimens collected	Complete field work, prepare publication.
		37 Effects of patch burning on lizards 34/88 (D Pearson)	Ongoing pre-fire trapping	Burn plots in Sept 1990. Continue trapping..
		38 Monitoring post fire vegetation response in Gibson Desert and Plumridge Lakes Nature Reserves 15/89 (N.Burrows)	Plots located. Pre-fire assessment completed. Plots burnt September 1989.	Postfire assessment in May and September 1990.
		39 Effects of patch-burning and feral predator control on the survival of rare mammals re-introduced to the Gibson Desert Nature Reserve. (P.Christensen, G. Liddelow)	Detailed proposals prepared. RPP submitted.	Locate release sites, prepare burning and baiting strategies.
		40 Appraisal of thematic mapping for mapping vegetation 35/88 (D Pearson)	Ground truthing almost completed, write-up.	Complete ground truthing and interpreting. Publish findings.
		41 Fire effects - mulga woodlands (S. van Leeuwen)	Proposal prepared, study sites established	Prepare RPP, commence assessment

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
Fire Management	Computerized fire management system - Tutanning N.R.	42 RS59 RS62 (A Hopkins)	Extensive collection of field data	Complete data collection and commence model validation
	Document Aboriginal knowledge of fire aspects (hummock grasslands) and develop it into an integrated land system	43 37/88 (D Pearson)	Completed search for extant populations of Petrogale lateralis with Ngaanyatjarra men in Central Ranges, Paper prepared.	Continue field work on fire knowledge, summarize information from other sources. Publish Petrogale lateralis survey.
	Protection of fire vulnerable communities in Hamersley Range National Park	44 Fire effects - Mulga Woodlands (T Start & S van Leeuwen)	Proposal prepared, study sites establihsed. preliminary sampling Commenced	Submit RPP Seasonal assessment of study sites.
	Prescriptions for the use of fire to regenerate specific habitat in forests of the south west.	45 Regenation of suitable habitat for Tammar wallaby using fire. (P. Christensen, G. Liddelow)	Suitable- thickets located. Regeneration burn completed. RPP submitted.	Monitor post-fire regeneration. Locate other sites.

FLORA COLLECTIONS PROGRAM

PROGRAM LEADER

B R Maslin

CURRENT RESOURCES (1990/91)

This program comprises 5 persons (2.85 professional FTE and 2.15 Technical FTE). Its estimated CRF budget is $43 739 (including $24 289 salaries and $19 450 operating costs).

ACHIEVEMENTS

New temporary specimen housing for the public access Reference Herbarium and the general collections will alleviate some of the overcrowding of the specimen storage areas of the Herbarium. The new areas have been designed to accommodate the herbaria of fungi, algae, bryophytes and lichens as well as selected phanerogam families.

The WA Herbarium specimen database now comprises 85 000 entries and includes information on the Type collection, the family Rutaceae and the State's fungal collection. A grant of $11 050 from the Australian National Parks and Wildlife Service has enabled the databasing of the Herbarium's voucher collections of Declared Rare Flora and the Priority One taxa of the CALM Reserve Flora List. The census of vascular plants is now databased and is referred to as the Herbarium's taxon database WACENSUS.

AIM

To preserve, curate and extend the State's principal reference collection of native and naturalized plants and to conduct and assist plant taxomomic research in order to provide authoritative names and other information essential for effective conservation and management of the flora.

PRIMARY OBJECTIVE

Collections

To collect and maintain a comprehensive representation of the State's vascular and cryptogamic flora and through systematic research, to keep this collection in a state of curation that accords with current taxonomic opinion. To present the results of this research in relevant pubilcations. To maintain and develop a comprehensive botanical library containing a collection of literature devoted to systematic botany as well as collections of original illustrations and photographs of the plant taxa of the State.

Databases

To provide a inventory of the flora of Western Australia and to make taxonomic, geographic and ecological information contained in the Herbarium's specimen and taxon databases readily accessible, for the purposes of systematic research and the implementation of conservation strategies.

20 YEAR GOALS (based on current resources and in priority order)

1. Prepare taxonomic treatments of selected plant taxa to facilitate effective curation of the State's flora.***
2. Make taxonomic and geographic information contained in the Herbarium's collections readily accessible.***
3. Extend the Herbarium collections so as to acquire a significant sample of the botanical diversity of the State.***

5 YEAR GOALS (with existing resources)

Collections

1. Improve curatorial procedures and maintain Herbarium collections.
2. Expand Herbarium collections in designated taxonomic categories and geographic areas.
3. Prepare taxonomic revisions and allied studies of selected plant taxa.

Databases

1. Maintain and extend the WAHERB specimen database.

2. Determine latitudes and longitudes for specimens in the WAHERB specimen database.

3. Maintain a census of W.A. plant names and develop it as an accessible computerized database.

PUBLICATIONS* AND REPORTS 1989/90

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*Maslin, B.R. and Court, A.B. (1989). *Acacia caerulescens*, a new species of *Acacia* section Phyllodineae from Victoria. Muelleria 7:131-134.

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*Wilson, P.G. (1989). Erymophyllum (Asterceae:Inuleae:Gnaphaliinae) a new Australian genus in the Helipterum complex Nuytsia 7:103-116.

Primary Objective	5 Year Goal	Projects (RPP No.)	Tasks Completed 1989/90	Targests 1990/91
Collection	Maintian Herbarium Collections	1. Curation of collections (All staff)	Incorporation of new & revised specimens. Updating of nomenclature. Monitoring of specimen order, maintenance & insect control. Loans of specimens.	As for 1989/90 & provide extra storage facility.
		2. Automated loans procedure. (C Parker & A Chapman)	New project	Design and implement procedures.
		3. Automated specimen-folder labelling. (S Curry & A Chapman)	New project	Design and implement procedure
Databases	Maintain and develop WAHERB specimen database	4. Manage WAHERB specimen database. (BR Maslin & A Chapman)	SUN Computer acquired. User Guide compiled. Specimen insertion form designed	Implement management procedures for database. Compile User Manual & Ready-access Guides. Assess lat./long. program.
		5. Integrate specimen label generation with data entry into WAHERB. (A Chapman & BR Maslin)	New Project	Develop and implement procedures
		6. Specimen entry into WAHERB (C Parker, Contractees)	Family Rutaceae databanked. Automated loans procedure commenced. Gazetted rare flora and Priority 1 flora databanked	Data bank specimens as required, esp. Priority 2-8 flora and all incoming specimens.
	Maintain and develop Census of WA plant names	7. Maintain a current census of the flora of Western Australia. Capture new records and update records as required. (PG Wilson)	Names information captured	Facilitate data entry, including infraspecific names.
		8. Develop data base from current Census files. (A Chapman & P Wilson)	Census compiled on D Base database	Design front-end for data insertion
Systematics	Chenopodiaceae	9. Halosarcia: taxonomy (PG Wilson)	-	Collect material of the known but undescribed speices.
	Colchicaceae	10. Wurmbea: taxonomy (TD Mcfarlane)	-	Prepare MS describing a new speices.

Primary Objective	5 Year Goal	Projects (RPP No.)	Tasks Completed 1989/90	Targests 1990/91
	Dasypo-gonaaceae	11. Chamaexeros: taxonomy (TD Mcfarlane)	Draft MS prepared of a new species.	Complete MS & submit for publication.
	Haemodoraceae	12. Haemodorum: revision (TD Macfarlane)	-	Complete specimen examination, prepare outline of paper.
	Leguminosae: Mimosoideae	13. Acacia sect. Phyllodineae: taxonomy and Flora of Australia treatment (BR Maslin & AR Chapman)	5 papers published or in press; Flora descriptions prepared.	Prepare MSS for miscellaneous new sp.; complete Flora descriptions illustrations and key.
		14. Acacia sect. Plurinerves: taxonomy and Flora of Australia treatment. (BR Maslin & RS Cowan)	3 papers published: Flora descriptions prepared.	Prepare MSS for miscellaneous new sp.; complete Flora descriptions, illustrations and key.
		15. Acacia sect. Juliflorae: taxonomy and Flora of Australia treatment. (BR Maslin & AR Chapman)	MSS descriptions of new species prepared; Flora descriptions prepared; application to ABRS for grant.	Publish new species; prepare Flora descriptions.
		16. Acacia sect. Alatae. (BR Maslin)	Taxa sorted	Prepare flora descriptions, illustrations and key to species
		17. Acacia sect. Pulchellae. (BR Maslin)	Flora descriptions prepared for c.30 species	Complete illustrations
		18. Acacia: assessment of generic status (BR Maslin et al.)	Seed and spirit material sent to collaborators in S. Africa, France. Germany & Switzerland. Discussions with collaborators	Analyse results from collaborators.
	Leguminosae: Papilionoideae	19. Pultenaea in W.A. revision (TD Macfarlane)	Field work conducted. Further studies on difficult species	Resolve taxonomy of difficult species-groups; describe new taxa.
	Asteraceae: Inuleae	20. Helipterum-Helichrysum group (PG Wilson)	MS prepared of genera Rhodanthe, Pteropogon & Monencyanthes	Complete MS of genera in Helichrysum group
	Rutaceae	21. WA Rutaceae JA Armstrong (PG Wilson)	-	Prepare draft MS
	Phytochemical studies	22. Cyanogenesis in Acacia subgenus Aculeiferum. (BR Maslin et al.)	Paper published	-

Primary Objective	5 Year Goal	Projects (RPP No.)	Tasks Completed 1989/90	Targests 1990/91
		23. Phebalium sens. lat. (JA Armstrong and P Waterman, Scotland)	Material from 30 taxa collected and papers prepared	Collect further material for collaboration.
		24. Tribe Boronieae (Rutaceae) (JA Armstrong)	Publication prepared	Submit for publication
	Reproductive biology	25. Pseudochaetochloa: describe dioecy (TD Macfarlane and M Lazarides, Canberra)	Illustrations prepared	complete MS & submit for publication
		26. Acacia survey of hybridity. (BR Maslin et al.)	Database of Acacia bybrids prepared	Prepare MS
	Compile catalogue of floristic lists for W.A.	27. Prepare floristic lists. (KF Kenneally)	New project	Catalogue the published floristic lists
	Provide index to information on taxonomy of WA plants	28. Develop index systems (PG Wilson, Librarian)	Index cards prepared for current year.	Continue
	General	29. Brown, R: Aiton's Hortus Kewensis contribution (BR Maslin)	-	Complete MS
		30. Cunningham, A Coastal collecting localities. (S Curry & BR Maslin)	Paper published	-
		31. Dorrien-Smith, A.A.:Plant collection from south-west WA (KF Kenneally)	Localities identified	Ongoing as time permits.
		32. Fitzgerald, W.V.:diary. (KF Kenneally)	Further editing & field surveys carried out.	Edit MS and prepare biography.
		33. Gould, J/Gilbert, J: Plant collecting in the Swan River Colony. (KF Kenneally)	Further editing & archival documents examined	Edit MS for publications.

FLORA CONSERVATION PROGRAM

PROGRAM LEADER

DJ Coates

CURRENT RESOURCES (1990/91)

This program comprises 6.15 persons (4.25 Professional + 1.9 Technical). Its estimated CRF budget is $202 489(including $152 289 salaries and $50 200 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 5.55 persons (1.30 Professional + 2.50 Contract Professional + 1.75 Technical). Its budget was $176 715 (including $113 005 salaries and $63 710 operating costs).

BACKGROUND

Western Australia has a vascular flora world-renowned for its richness (about 10 000 species) and high endemism (75%-80% for the south-west). About 2 000 species have been considered rare, endangered, vulnerable or extinct by various authorities. Some 1 500 species are used commercially in the cut wildflower, seed nursery, bee-keeping and timber industries. While there has been considerable progress in knowledge during the past few years, in most cases the taxonomy, geographical distribution, reproductive biology, population biology and conservation status of these species is inadequately documented for appropriate management to be implemented.

Due to the coincidence of greatest areas of species richness and local endemism for the State with cereal-growing areas, highest priority has been given to research on endangered and poorly known flora of the wheatbelt and Swan Coastal Plain. Although field surveys of these areas remain high priority, it is also intended to increase research on the biosystematics of endangered flora and on the population biology and management of selected endangered flora with various life histories. The latter will be achieved by establishing permanent monitoring quadrats, undertaking population ecology/genetic studies and assist in developing a computer data base on endangered flora. The expected end product will be the preparation of Declared Endangered Flora Wildlife management programs. In addition to these species' based programs, the development of regional and district based programs is also underway. Because of the increasing number of problems with environmental weeds and their effects on the native flora, research will also be expanded into the areas of weed biosystematics, ecology and control. Limited research will continue on more common flora where conservation problems are likely. These include effects of *Phytophthora* fungi and wildflower picking on Banksias; fragmentation of the range of widespread keystone species by clearing and impact of beekeeping.

ACHIEVEMENTS

Publication of a book on "Western Australia's Endangered Flora" has generated considerable interest both within Western Australia and elsewhere in Australia. This publication should not only foster increased public interest in flora conservation generally but will hopefully also encourage direct public involvement in future volunteer projects involving endangered flora. The book will also be a valuable reference on endangered flora and poorly known species at risk for CALM Regional and Operations staff.

Two Wildlife Management Programs "Declared Rare Flora and other plants in need of Special Protection in the Northern Forest Region" and "*Eucalyptus rhodantha*" have been published and are the first dealing with endangered flora. The *E. rhodantha* management program demonstrates the value of detailed studies on population genetic structuring, breeding systems and population dynamics in developing management strategies for endangered plant species. Similar studies have been completed or are near completion for a number of endangered species such as *Banksia cuneata, Banksia tricuspis, Acacia anomala* and *Stylidium coroniforme* which will provide the basis for Wildlife Management Programs for those species.

AIM

To provide scientific information that maximizes effective conservation and management of the flora of Western Australia.

PRIMARY OBJECTIVES

Rare and Endangered Flora Surveys

To undertake field surveys of rare and endangered flora and poorly known high priority species at risk. Provide accurate locality information, map individual plants within populations and make field observations on the ecology, condition and life history of the target species. To ensure accurate transfer of locality information to the endangered flora data base and to recommend on land acquisition, protection, research priorities, management strategies and conditions for Ministerial permits to take Declared Endangered Flora. To prepare Endangered Flora Wildlife Management Programs for Regions, Districts or other defined areas (ie National Parks).

Population Biology

To undertake research on the population ecology, population genetics, reproductive biology, breeding systems and management techniques (eg fire, mechanical disturbance, weed competition, grazing regimes, pest and disease control, translocation, propagation and re-establishment in the wild) of rare, endangered and other priority species at risk. To recommend on management techniques and prepared Endangered Flora Wildlife Management Programs for individual species.

Biosystematics

To conduct taxonomic research to discriminate and describe rare, endangered and poorly known taxa at risk. To undertake phylogenetic, phytogeographic and nomenclatural studies in order to provide re-assessments of classifications and determine taxonomic and evolutionary relationships.

Environmental Weeds

To undertake research on the biosystematics, ecology and control of environmental weeds. To survey major invasive weeds and assess their impact on the native flora particularly rare and endangered species. To develop a checklist and computerised data base of naturalised flora of W.A. To liaise with other CALM staff, other organisations and the public on the control of environmental weeds.

Public Involvement

To foster a sympathetic public attitude to flora conservation through direct involvement of the public in appropriate research projects.

Wildflower Industry

To undertake research and provide advice with a view to producing wildlife management programs for plants used in the wildflower industry.

Communication

To communicate research results through scientific and technical publications, through advice and liaison with other CALM staff, other organisations and the public and through involvement in training and public conferences and seminars.

20 YEAR GOALS (based on current resources and in priority order)

1. To undertake surveys on Declared Endangered Flora and other priority species at risk and prepare Wildlife Management Programs based on Regions, Districts or other defined areas so as to cover the whole State.***

2. Prepare Wildlife Management Plans and establish a network of permanent monitoring quadrats for individual Declared Endangered Flora as prioritized for Regions or Districts.***

3. To discriminate and prepare taxonomic treatments of all rare, endangered and poorly known taxa at risk in Western Australia.***

4. To identify, resolve taxonomic boundaries and develop a computerised data base for the naturalised flora of Western Australia.**

5. Involve the public in monitoring and surveys of all Declared Endangered Flora and other groups of flora.**

6. To undertake research on the management of selected priority species utilized in the wildflower industry and prepared Wildlife Management Programs.*

5 Year Goals (with existing resources)

1. Undertake field surveys of poorly known high priority species at risk, and assist in reviewing the schedule of Declared Endangered Flora, annually.

2. Carry out studies on the biosystematics, population biology and conservation status of rare, endangered and poorly known flora at risk and produce 10 Endangered Flora Wildlife Management Plans that are either species, reserve or CALM Region based.

3. Establish a network of permanent monitoring quadrats on all species for which Endangered Flora Wildlife Management Plans are produced.

4. Produce a colour book on the Declared Endangered Flora and a review of rare flora conservation in W.A.

5. Publish the Orchid atlas.

6. Complete an endangered eucalypt atlas.

7. Seek public involvement in the monitoring of declared endangered flora.

8. Undertake biosystematic studies on environmental weeds.

9. Develop a checklist and computerised data base of naturalised flora.

10. Produce, through the letting of consultancies, three Wildlife Management Plans on species used in the wildflower industry.

11. Undertake research on the management of *Boronia megastima* and other priority species in relation to commercial harvesting techniques.

12. Review research priorities regarding the wildflower industry after proclamation of the proposed flora licensing amendments to the Wildlife Conservation Act.

13. Publish educational material, field guides to eucalypts and orchids of five national parks, and books on trees and tall shrubs of Perth.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995
(numbers refer to the Table following)

PROPOSED NEW PROJECTS - with existing resources

Nil

PROPOSED NEW PROJECTS - with additional resources in priority order)

Survey of endangered and poorly known flora of extensively cleared areas such as CALM's Wheatbelt, Greenough, South Coast and Metropolitan Regions. 1.0 Professional, 1.0 Technical Officer; $50,000 over 3 years.

This project will focus on local endemics in heavily cleared areas or areas threatened with land clearing such as cereal growing or urban areas, with a view to producing Wildlife Management Programs on endangered flora.

Biology and control of invasive introduced environmental weeds. 1.0 Professional, 1.0 Technical officer; $42,000 over 3 years.

This project will review what is known about invasive environmental weeds in W.A. rank them in terms of the threat they pose, and initiate studies on the control of a small number of the most serious problem taxa.

Impact of beekeeping on native flora and fauna. 1.0 Professional, 1.0 Technical officer; $70 000 over 5 years.

After an initial review of the problem, this project will focus on those plants and animals considered to be most at risk through the impact of apiculture, and plans for management of the industry of CALM lands will be developed.

PUBLICATIONS* AND REPORTS 1989/90

*Coates, D.J. and Hnatiuk, R.J. Systematic and Evolutionary inferences from isozyme studies in the Genus *Eremaea* (Myrtaceae) Aust. Syst. Bot., 3: 59-74.

*Coates, D.J. and Sokolowski, R.E. (1989) Geographic patterns of genetic diversity in Karri (*Eucalyptus diversicolor*) F. Muell. Aust. J. Bot. 37: 145-156.

*Hopper, S.D. and Coates D.J. (1990). Conservation of genetic resources in Australia's Flora and Fauna. *Proc. Ecol. Soc. Aust.*, **16**: 567-577.

*Hopper, S.D., van Leeuwen, S., Brown, A.P. and Patrick, S.J. (1990). Western Australia's Endangered Flora and Other Plants Under Consideration for Declaration. (Dept. CALM, Perth).

*Keighery, G.J. (1990). Taxonomy of the *Grevillea brachystylis* species complex (Proteaceae). Nuytsia 7: 125-131.

*Keighery, G.J. (1990). *Caesia viscida*, a new species of Antheriacaceae (Liliaceae s.lat.) from south-western Australia. Nuytsia 7: 133-135.

*Keighery, G.J. (1990). *Patersonia spirafolia* (Iridaceae), a new species from south-western Australia. Nuytsia 7: 137-139.

*Keighery, G.J. (1989). Banksia woodland weeds Journ. Roy. Soc. Western Australia. 71: 111-112.

*Kelly, A.E., Coates, D.J., Herford, I., Hopper, S.D., O'Donoghue, M. and Robson, M. (1990). Declared Rare Flora and other plants in need of Special protection in the Northern Forest Region, *Western Australian Wildlife Management Program No. 5* (Dept. CALM, Perth).

*Sampson, J.F., Hopper, S.D. and Coates, D.J. (1990). *Eucalyptus rhodantha. Western Australian Wildlife Management Program No. 4* (Dept. CALM, Perth).

*Sampson, J.F., Hopper, S.D. and James, S.H. (1989). The mating system and population genetic structure in a bird-pollinated mallee, *Eucalyptus rhodantha. Heredity* **63** 383-393.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Rare and Endangered Flora surveys	Field surveys; assist in review of schedule, revisions of endangered flora data base. Prepare Wildlife Management Programs.	1	Ad hoc field surveys of rare and endangered flora. S. Patrick D. Coates	Several surveys; completed	continue surveys as time permits
		2	Merredin District survey. F. Mollemans D. Coates, P. Brown	Survey started	Complete surveys, prepare Wildlife Management Program. Submit report to ANPWS
		3	Metropolitan Region survey. A Kelly, A Taylor, M Langley, D Coates	Surveys started	Complete surveys. Prepare Wildlife Management Program. Submit report to ANPWS
		4	Moora District survey. S. Patrick D. Coates	Nil	Start surveys
		5	Scott Plains survey. G Keighery, D Coates	Surveys started	Complete surveys. Submit report to ANPWS
		6	Northern Forest Region survey. A Kelly, D Coates, S Hopper	Published	Assist Region in implementing
		7	Rare eucalypt survey. A Kelly, A Napier, S Hopper	Surveys completed. Report started.	Complete report.
		8	Rare Poison Plants survey. J Sampson, S Hopper	Published Report sent to World Wildlife Fund	Follow up recommendations
Population Biology	Wildlife management Programs	11	Acacia anomala D Coates	Nil	Prepare Wildlife Management Program
		10	Drakaea jeanensis S Carstairs, S Hopper, D Coates	Field studies started	Continue field, population studies
		11	Rhizanthella gardneri S Carstairs, D Coates	Field and isozyme electrophoretic studies started.	Continue field/ population studies.
		12	Diuris sp. (Kwinana) S Carstairs, D Coates	Field population/ecology studies started.	Continue field/ population studies
		13	Caladenia sp. (Northampton) S Carstairs, D Coates	Nil	Start field/ population biology studies

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		14	Caladenia sp (Cape Naturaliste) S Carstairs, D Coates	Nil	Start Field/ population biology studies
		15	Diuris purdiei D Goble-Garrett, D Coates, K Dixon	Surveys, population ecology and propagation studies started	Complete research. Prepare Wildlife Management Program.
		16	Banksia cuneata/oligantha D Coates	Population genetic, mating system studies completed	Prepare Wildlife Management Program.
		17	Stylidium coroniforme D Coates	Population genetic studies near completion.	Prepared Wildlife Management Program.
		18	Banksia brownii D Coates, G Keighery	Completed most field surveys.	Start population genetic/ ecological studies
		19	Banksia goodii D Coates	Nil	Complete field studies, re-sample monitoring quadrats.
		20	Grevillea prostrata/ involucrata D Coates	Nil	Start population genetic studies.
		21	Darwinia carnea G. Keighery, N.G. Marchant	Funds obtained commence survey	Prepare Wildlife Management Program, report to ANPWS.
	Monitoring quadrats	22	Monitoring quadrats on priority Declared Endangered Flora D Coates, S Hopper	Nil	Set up quadrats on priority taxa.
		23	Recovery of DEF on East Mt Barren S Hopper D Coates	Nil	Set up quadrats on East Mt Barren.
		24	Rare granite eucalypts S Hopper	Post Fire regeneration studies continued	Finalise post fire regeneration studies
	Conservation genetics	25	Banksia verticillata D. Coates	Nil	Defer
		26	Grevillea dryandroides D Coates	Nil	Defer
		27	Banksia ilicifolia D Coates	Population genetic, mating system studies near completion	Prepare Management Plan
		28	Tuart D Coates	Nil	Start seed collections for population genetic studies

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		29 Tetratheca species J Alford, G Keighery	Population genetic, biosystematic studies near completion	Prepare Honours thesis
Biosystematics	Phylogenetics and evolution	30 Eremaea D Coates, R Hnatiuk	Published	Determine conservation status of new taxa.
		31 Stylidium D Coates	Completed field surveys of some taxa	Continue field studies. Assess conservation status of various taxa
		32 Stylidium caricifolium species complex/ hybridisation RS31	Population genetic, chromosome studies continued.	Complete studies prepare MS
	Systematics	33 Eucalyptus wandoo and allies RS80 SD Hopper	MS completed	Publish in Nuytsia
		34 New eucalypts taxonomy RS81 SD Hopper	Complete two manuscripts	Submit for publication
		35 Caladenia, Drakaea S D Hopper, A Brown	Prepare MS	Publish in Nuytsia
		36 Caladenia, Choraea RS79 S D Hopper	MS re-submitted after amendment	Publish in Nuytsia
		37 Darwinia:conservation status of new taxa NG Marchant, GJ Keighery	Taxa identified.	Prepare MS
		38 Grevillea taxonomy, conservation status GJ Keighery	G drummondii/G acuaria species groups revised, MS prepared	Submit MSs for publication. Revise other groups
		39 Apiaceae. New species, rediscovered species of Platysace, Actinotus, Apium GJ Keighery	MS of new Platysace species submitted.	Complete descriptions of Actinotus, Apium species
		40 Helipterum-Helichrysum genetic classification PG Wilson	MS being prepared	Complete and submit MS
		41 Halosarcia: taxonomy PG wilson	Collections on undescribed taxa continued	
		42 Wurmbea: taxonomy TD MacFarlane	Nil	Prepare MS describing new species

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		43 Chamaexeros: taxonomy TD MacFarlane	Nil	Complete MS and submit for publication
		44 Haemoclorum: revision TD MacFarlane	Nil	Complete specimen examination, prepare MS
		45 Pultenaea in WA: revision TD MacFarlane	Nil	complete data analysis
		46 Loganiaceae: Taxonomy G. Perry		Annotate AD material and return. Describe two new taxa.
		47 Polygonum, s. str. G. Perry	Determination of natural groups.	Prepare draft MS.
		48 Nomenclatural status of Acacia prominens and A. fimbriata G. Perry, B. Maslin	Commenced draft MS.	Examine potential type specimens. Continue work on MS.
Environmental Weeds	Biosystematics	49 Taxonomy and nomenclature of environmental weeds. G. Perry	Continued preparation of MSS on Xanthium (with P. Michael, Sydney), Medicago Diplotaxis, Paspalum, Panicum glaucum and Spergularia.	Submit papers on Xanthium and Paspalum for publication. Continue working on the taxonomy and nomenclature of the weed flora of W.A. Present invited paper to Symposium to be held at Kew in February 1991 on "Improving the Stability of Names".
		50 Prosopis: identification of naturalized species G Perry	Continue work on: the origin of P pallida natural groupings	Continue
	Checklist and data base of naturalized flora of WA	51 Publication of annotated checklist of the naturalized flora of WA. G Perry	Continued research, modification of checklist and writing nomenclature notes.	Research and modify list as required. Refine database structure and improve accessibility and reporting capability. Continue writing nomenclature notes.
		52 Metro region weed surveys. G Keighery	Ad hoc surveys carried out	Continue surveys
		59 Weed control in Tuart woodlands. G Keighery	New project	Survey and document major invasive weeds

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Communication	Endangered Flora publications	54 Book on rare and endangered flora. S Hopper, S van Leeuwen, S Patrick, A Brown	Published	Prepare update if required
		55 Review rare flora conservation in WA RS73 S Hopper, D Coates	Review on genetic resources published	Continue/ literature review
	Other publications, educational material	53 Orchid, Stirling Range. S Hopper, A Brown	Nil	Complete MS
		54 Orchid pollination book. S Hopper, A Brown	Nil	Complete writing
		55 Native trees Perth. RS77 R Powell S Hopper	MS completed	Publish
Wildflower Industry	Management Programs	56 Kangaroo Paws: Anigozanthos pulcherrimus, Macropidia fuliginosa S D Hopper	M.App Sci Thesis completed. Reports submitted to ANPWS	Prepare mangement programs
		57 Banksia coccinea RS29 D Coates	Nil	Start population genetic studies
	Boronia harvesting	58 Boronia utilizati on and distribution D Coates, S Hopper	Nil	Prepare Boronia management plan
	Review research after licensing changes	59 Licensing and management RS70 D Coates, S Hopper	Nil	Review research following licensing changes.

FLORA INFORMATION PROGRAM

PROGRAM LEADER

N S Lander

CURRENT RESOURCES (1990/91)

The program comprises 5.0 persons (3.55 professionals and 1.45 technical). Its estimated budget is $266 821, (including $249 121 salaries and $17 700) operating costs.

BACKGROUND

The original Herbarium Program comprised five sections. Two of these, the Flora Information Section and the Regional Flora Section, were combined to form the present program following a review of the Herbarium in February 1990.

The Flora Information Section of the Herbarium was responsible for providing an identification service to scientists and the public who wished to identify native and naturalised flora.

ACHIEVEMENTS

A workshop on regional flora writing was held at the Herbarium in October 1989. The workshop discussed the most efficient way to generate and disseminate taxonomic information. A new user-friendly flora handbook format has now been proposed and will be implemented in a new pilot project to be submitted for approval in July 1990..

The enormous task of preparing the manuscript of the Flora of the Kimberley Region is nearing completion. The project, which has taken five years to date, keys out and describes all of the flowering plants recorded in the Kimberley Region.

AIM

To facilitate identification of the Western Australian flora and to disseminate accurate names and biological characteristics which can be used to provide an information base for conservation and land management practices.

PRIMARY OBJECTIVES

To generate and disseminate flora information by:-

Researching and publishing accounts of the flora in Western Australian regional handbooks, scientific journals and general extension publications.

Facilitating identification of native and naturalised Western Australia flora by enabling easy and efficient naming of taxa by means of the Reference Herbarium, expert advice and published identification guides.

20 YEAR GOALS

1. Publish regional flora accounts covering the whole of Western Australia.***
2. Publish identification manuals for all threatened taxa and for indigenous plants of economic importance.***

5 YEAR GOALS

1. Develop a user-friendly publication format for identification manuals enabling identification of the Western Australian flora.
2. Prepare and publish a pilot study identification manual of the Myrtaceae of the lower south west.
3. Commence a regional flora of Western Australia.
4. Prepare a revised edition of the Flora of the Perth Region.
5. Research and publish taxonomic studies on flora.
6. Prepare and publish identification guides to selected threatened and economically important taxa of Western Australia.
7. Improve the effectiveness of the identification service.

8. Further develop and maintain a comprehensive reference collection of Western Australian plant taxa.

9. Co-ordinate and edit the Journal *Nuytsia*.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1994

1,2,3,4,5,6,11,16

PROPOSED NEW PROJECTS - with additional resources

Identification manual for wetland plants of south west Western Australia.

PROPOSED NEW PROJECTS - with existing resources

1. Field guide to Myrtaceae of south western Australia.

2. Identification guide to threatened and Reserve List taxa.

3. Identification guide to allergenic, weedy and economically important plants.

PUBLICATIONS* AND REPORTS 1989/90

*Marchant, N.G. (1990). The contribution of the Russian botanist Turczaninov to Australian plant taxonomy pp. 121-130 In Short, P.S. (ed.) History of systematic botany in Australasia, Australian Systematic Botany Society, Melbourne.

*Marchant, N.G. (1990). The Western Australian collecting localities of J.A.L. Preiss. In Short, P.S. (ed.) History of systematic botany in Australasia. pp. 131-135 Australian Systematic Botany Society, Melbourne.

*Marchant, N.G. (1989). Sargent, Oswald Hewlett 1880-1952. In Searle, G. (ed.) Australian Dictionary of Biography, vol. 11 pp. 523. Melbourne University Press, Melbourne.

*Lander, N.S. (1989). Taxonomy of *Olearia stuartii* (Asterceae: Astereae) and allied species. Nuytsia 7:25-35.

*Lander, N.S. (1989). *Taplinia*, a new genus of Asteraceae (Inuleae) from Western Australia. Nuytsia 7:37-42.

*Lander, N.S. and Walsh N.G. (1989). *Olearia astroloba* (Asteraceae:Astereae), a new species endemic to Victoria. Muelleria 7:117-121.

*Lander, N.S. (1989) *Olearia archeri* (Asteraceae:Astereae), a new name for a familiar species from Tasmania. Muelleria 7:117-121.

*Lander N.S. (1989). The Tasmanian plant collecting localities of Ronald Gunn and Joseph Milligan - additional records. Austral. Syst. Bot. Soc. Newsletter 57:7-10.

*Lander, N.S. (1989). *Apostates* (Asteraceae: Astereae), a new genus from the south-eastern Polynesian island of Rapa. Austral. Syst. Bot. 2:129-33.

*Lander, N.S. (1990). New species of *Olearia* (Asteraceae:Astereae) endemic to Western Australia. Nuytsia 7:141-159.

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

Patrick, S.J. (1989). Guide to the establishment and maintenance of field herbaria. CALM, Como.

EDITORIAL 1989/90

Nuytsia 7(1):1-116 (1989)

Nuytsia 7(2):117-229 (1990)

Primary Objective	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989/90	Targets 1990/91
Flora Research	Regional Floras, Field Guides	1. Flora of the Kimberley Region (J Wheeler, B Rye, B Koch)	Most flora treatments prepared and edited	Publish Flora
		2. Flora of the Perth Region, Revision (N Marchant, J Wheeler)	Information collected and edited	Ongoing
		3. Planning future flora writing (N Marchant, J Wheeler)	Workshop held	Develop new format
		4. Field guide to south western Myrtaceae (N Marchant, J Wheeler)	New project	Project to commence July 1990
		5. Identification guides to threatened and Reserve List taxa (S Patrick)	New project	Project to commence July 1990
		6. Identification guides to allergenic, weedy and other economically important plants (S Patrick)	New project	Project to commence July 1990
	Taxonomic Studies	7. Asteraceae (N Lander)	Papers published on Apostates, Olearia, Taplinia	Publish new taxa; publish account of Olearia for Flora of N.S.W.
		8. Dilleniaceae (J Wheeler)	New species of Hibbertia published	Publish new species of Hibbertia
		9. Myrtaceae (N Marchant, G Keighery)	Actinodium manuscript prepared	Publish Actinodium and Chamelaucium
		10. Droseraceae (N Marchant)	New species descriptions prepared	Publish new taxa
Flora Extension	Advisory Service	11. Establishment of new identification system (various program staff)	New project	
		12. Extension of Reference collection (various program staff)		Move to new location
		13. Manual for preparation of herbarium specimens (S Patrick)	Draft prepared	Project postponed through funding reductions

Primary Objective	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989/90	Targets 1990/91
		14. Public lectures, extension courses and displays (various program staff)	Numerous lectures given	Present as required
		15. Editing of Nuytsia (K Kenneally, various program staff)	2 issues published	Publish 2 issues
		16. Editing of Kingia (various program staff)	3 issues typeset	Publish 3 issues

MARINE CONSERVATION PROGRAM

PROGRAM LEADER

JA Stoddart

CURRENT RESOURCES (1990/91)

This program comprises 1.9 persons (1.4 Professional + 0.5 Technical). Its estimated CRF budget is $121 333 (including salaries - $95 333 and $26 000 operating costs). The level of external funding should be similar to 89/90, but extend for 12 months.

RESOURCES IN PREVIOUS YEAR

Resources for 1989/90 comprised 1.9 persons (1.4 professional + 0.5 technical). Its budget was $78 368.

BACKGROUND

Marine ecosystems within Western Australian waters present a diverse array of environments, from the cold waters of the Recherche Archipelago to the coral reefs and mangrove communities of the north. CALM has initiated a program which aims to establish a system of marine parks and marine nature reserves which will conserve representatives of these many habitats and their flora and fauna. Present knowledge of the distribution and abundance of these resources is rudimentary, as is our understanding of the processes important to their conservation.

In addition to matters related to its marine estate, CALM has responsibility under the Wildlife Conservation Act for many marine organisms, including marine vertebrate fauna, invertebrates in some areas, seagrasses and marine algae. Decisions affecting the conservation of these species need a wide variety of scientific advice and often require specific research. Research projects which have been initiated amongst various CALM Divisions will benefit from a centralised focus from within Research Division.

The Marine Conservation Program was initiated in late 1988 to develop a capacity for marine research within CALM and to provide a focus for the co-ordination of marine research of relevance to CALM objectives. It's formation recognises the growing importance of marine conservation within CALM and Western Australia in general. The initial emphasis of the Program will split between survey work to compile resource inventories as an objective basis for reserve selection and studies of processes to aid in park management and monitoring.

ACHIEVEMENTS

During its first full year of operation the program has begun to draw together existing research resources from within CALM, other government departments, tertiary institutions and private agencies into a framework capable of providing a scientific basis to marine conservation in WA.

A substantial research effort has been brought to bear on the problem of *Drupella* within Ningaloo Marine Park, including several studies within CALM (partly funded by ANPWS) and others from the University of WA and Murdoch University. A one-day workshop including representatives of all research programs was successfully held to coordinate future work. Research into the early life history of *Drupella* achieved a major breakthrough in inducing egg-laying and larval development. This is the first documentation anywhere of these processes for this genus.

In response to concerns of deteriorating water quality, water sampling was carried out at Monkey Mia and at Coral Bay. Bacterial and nutrient analyses were undertaken for a number of sites in winter spring and summer. Results suggest that, for Monkey Mia there may be large seasonal changes in water quality.

Several long-term programs have been established which rely on data collection by regional staff or the public. Examples are the recreational fishing survey at Marmion Marine Park and the Reef Assessment

project. Both projects have begun to return data which will build into a valuable historical record over time.

The marine turtle project was continued with recruitment of further volunteer participation in field work and additional external support provided by WAPET, operators of the Barrow Island oilfield. The operators of the Harriet Oilfield also continued to encourage volunteer work being done on Varanus Island.

Cooperative involvement of CALM operational staff and Aboriginal community members was also maintained.

The first remigrant green turtles were seen at the Lacepedes and Barrow Island and further recoveries were received from Northern Territory coastal locations.

The project work was given further recognition via an invitation for Dr Prince to join the IUCN/SSC Marine Turtles Specialist Group.

The dugong survey of Shark bay and Exmouth Gulf was successfully completed in collaboration with external researchers and CALM operations staff.

AIM

To ensure that scientific advice on the marine environment is available to CALM managers and planners.

PRIMARY OBJECTIVES

Co-ordination

To co-ordinate marine research originating from regions and divisions to ensure that it is:

- relevant to management objectives,
- scientifically sound,
- original,
- integrated with other research within and without the Department.

Liaison

To liaise with State and Federal Authorities and tertiary institutions undertaking marine research within Australia to maximise the benefit of this research to marine conservation in WA and make certain that the results are promulgated within relevant CALM divisions.

Facilitation

To identify sources of potential funding for marine research within CALM, apply for, and assist other CALM divisions to apply for such funds. To assist other agencies to undertake research of relevance to CALM by making available CALM resources.

Field Research

To undertake selected research projects aimed at providing CALM with an inventory of marine resources of conservation significance and a better understanding of the marine environment and how it can be managed. Includes:

development of computer-based geographic information system for marine resources (in collaboration with EPA and Fisheries);

development and evaluation of monitoring programs in marine reserves;

other programs to be developed from management priorities for CALM's marine estate.

Extension

To promote the role of CALM in marine conservation within the State and Federal Government and the WA public.

20 YEAR GOALS (based on current resources and in priority order)

1. Provide a solid scientific basis on which to base management of CALM's marine estate.

2. Produce a geographic information system of WA's marine resources of significance to conservation which will allow objective operation of reserve selection criteria and assessment of impacts on the conservation of wildlife.

3. Develop monitoring protocols with well-based indicators for the success of management strategies for CALM's marine responsibilities.

4. Create a favourable profile for CALM's marine research at national and international level.

5 YEAR GOALS (based on current resources and in priority order)

1. Develop monitoring systems to document baseline data and measure change within the biota of marine parks and reserves.

2. Accumulate data on marine resources of significance to conservation within WA waters.

3. Implement an effective co-ordination mechanism for marine research within CALM.

4. Provide a central focus for marine conservation research in Western Australia.

5. Represent CALM's marine interests amongst other State and Federal Departments and the general public.

PROJECTS TO BE COMPLETED FROM JULY 1989 TO JUNE 1994 (numbers refer to the Table following)

7,8,10

PUBLICATIONS* AND REPORTS 1989/90

Stoddart, J.A. Analysis of water quality in Shark Bay and Coral Bay: August/October 1989.

Stoddart, J.A. *et al.* Summary proceedings of Planning Workshop for *Drupella* research.

Trendall, J.T. and Stoddart, J.A. Barramundi genetics - how the facts can spoil a good story.

Stoddart, J.A. and Osborne, S. A survey of the effects of *Drupella* predation in Ningaloo Marine Park.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Co-ordination	Co-ordinate research within CALM	1	Research Priority Plans J Stoddart		Prepare draft for Ningaloo Marine Park with regional staff
Field Research	Develop monitoring systems	2	Ningaloo Drupella J Stoddart	Field sites established and initial monitoring completed	Publish technical report on broadscale monitoring, resurvey permanent field sites,
		3	Seagrass monitoring J Stoddart	Preliminary comparisons of survey techniques undertaken in Marmion Marine Park, mapping seagrass from aerial photography commenced	Complete 1990/91 manta sampling, continue aerial mapping
		4	Water quality monitoring J Stoddart	Water quality assessments completed for Coral Bay and Monkey Mia	Publish results of assessments; continue monitoring at Monkey Mia
		5	Reef Assessment J Stoddart 2/90	Public release of assessment forms, initial returns began	Regular analyses of results; feedback to encourage respondents
		6	Recreational Fishing Survey J Stoddart 1/90	Survey questionnaires designed; 70 surveys carried out	Continue surveys with Marmion Park staff; analyse results
	Marine resources	7	Marine turtle conservation RS144-145, 132-133 RIT Prince	External funding for operational and Aboriginal participation work secured; field program work restructured and executed with increased volunteer support. Draft management plan commenced.	Proceed with development of project as specified, including collaborative work with University of Queensland and NT communities associated with identified feeding grounds. Further develop salvage and reporting network as required.
		8	Dugong conservation RS 142-144 RIT Prince	Shark Bay and Exmouth Gulf-Ningaloo Survey completed and applied in consideration of planning to implement of shark Bay Region Plan.	Maintain liaison with external research workers and Aboriginal communities. Continue to act as focus for salvage specimens. Develop plan(s) for Pilbara coastal surveys in association with Wildlife Management Branch.
			Dugong and Marine Turtle Management	Discussion on Pilbara population work commenced.	Proceed as funding permits.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Liaison	Represent CALM's interest	9	Marine Conservation research methods J Stoddart	Supplementary grants program initiated and grants made to external researchers for work in marine conservation	Continue grants program
	Marine resources	10	Dugong and marine turtle management RS142-145 RIT Prince	Futher field investigations for dugong carried out by Aboriginal community West Kimberley with ANPWS support. Additional personnel involved in marine turtle work with ANPWS support. Further funding applications submitted	Proceed as funding permits

NATIVE FOREST SILVICULTURE PROGRAM

PROGRAM LEADER

S Crombie

CURRENT RESOURCES (1990/91)

This program comprises 9.5 persons (3.1 Professional + 6.4 Technical). Its CRF budget is $385 219 (including $282 919 salaries and $102 300 operating costs).

RESOURCES IN PREVIOUS YEAR

Previously covered by Rehabilitation and Silviculture Programs.

BACKGROUND

The Native Forest Silviculture Program was formed in 1990. It reflects the Department's objective of efficiently managing the production of wood from forests, while increasing the water catchment, conservation and recreation values of these areas.

The Jarrah forest is arguably the most studied and scientifically the best understood ecosystem in Western Australia. Much is known about the silviculture of Jarrah, particularly factors affecting wood growth, the biology of Jarrah and its role in forest hydrology.

There is still much to be learned about this ecosystem which is the most extensive and economically the most important forest in W.A. Responses to silvicultural treatments such as thinning and fertilization are still not fully understood. The morphological and genetic variation of Jarrah over its range awaits definitive study. Knowledge about the other main eucalypt in the forest, Marri, is piecemeal.

In many respects Karri silviculture is better understood than Jarrah; however more work is needed on the mixed Jarrah/Marri/Karri forest. A high proportion of clearfelled stands will continue to be artificially regenerated by direct seeding or planting. Karri seed production areas have been established but research into techniques for further increasing seed production is required. Work in maintaining and improving the quality of growing stock is also required.

A better understanding of the environmental and stand factors affecting wood production should be gained by 1995. This should enable better silvicultural and management prescriptions to be formulated.

The Native Forest Silviculture Program has taken on some of the duties of the CALM Rehabilitation Program for management of remnant areas of native vegetation. The Rehabilitation program was established in the mid 1970s with the escalation of bauxite mining in the jarrah forest. Satisfactory progress has now been achieved in this area. Consequently the program is being wound down and its remaining responsibilities reallocated. The Research Steering Committee will continue to have input to the Native Forest Silviculture Program on matters related to land and water degradation problems, especially salinity and eutrophication.

The protection of remnant native vegetation on farmland has been upgraded in priority. The dynamics of remnant vegetation and management techniques for its conservation on private land in agricultural areas of less than 900 mm annual rainfall are being studied. Conservation is seen as the main reason for protecting remnants of native vegetation although wood production and other uses may be possible. Conservation of native vegetation in properly managed areas will assist with the current community effort to halt land degradation.

ACHIEVEMENTS

A second summer of water stress and leaf area data have been collected from Jarrah trees on the Inglehope thinning trial. In combination with CSIRO nutrient cycling data, production of a growth response model for thinned and fertilised Jarrah trees can now be attempted.

The high rainfall zone water catchment treatment program was completed; Higgens was thinned to a uniform 15 m^2ha^{-1} and Jones catchment according to a variable schedule reflecting regeneration potential, silvicultural quality and disease status. Two dieback infected catchments (Warrens and Bennetts) are being mined and will be monitored

to assess the effect of intensive rehabilitation on catchment water yield, dieback development and regeneration.

In the Karri forest two major thinning experiments were remeasured and the initial measurement and establishment of a major thinning and fertilization experiment was completed. Surveys of Karri regrowth coupes for the incidence of brown wood and associated rots were conducted.

AIM

To provide the sound scientific base necessary to optimize multiple use management of forest and woodland ecosystems in Western Australia.

PRIMARY OBJECTIVES

Site Classification

To determine how existing stands of timber species and associated tree species differ in their rates of growth, capacity for regeneration and response to disturbance (e.g. disease, insects, drought).

Stand Management

To determine the optimal silvicultural regimes (establishment, thinning, pruning, fertilization) for forests managed for timber production. To ensure that these regimes are compatible with other concurrent land uses (e.g. conservation, water yield, honey production, recreation).

Tree Breeding

To optimize wood production, wood quality and disease tolerance of all timber species by the selection, breeding and production of superior genotypes.

Modelling

To develop the capability to model relevant wood production, hydrological and water use processes. To apply this to guiding research and to the prediction of impacts over space and time.

Remnant Native Vegetation

To determine how to best protect and manage remnants of native vegetation in agricultural areas.

Communication

To communicate research results in the form of technical and scientific publications, educational literature, committee representation, advice and liaison with other CALM staff, other Departments, the community at large, and involvement in training courses and public seminars.

20 YEAR GOALS (based on current resources and in priority order)

1. Manage forests so as to maximize forest values such as wood and water production, conservation, recreational use and visual amenity.**

2. Develop silvicultural practices to maximize merchantable volume increment in forests designated for wood production.***

3. Develop models for forest protection and production which incorporate the extremes of stand stocking, stand structure, insect and fungal impact, tree form, thinning schedules, nutrition, regeneration strategies, water usage, fire regimes and yield of utilizable wood.*

4. Develop the capability for local and regional scale prediction of relevant biological and land use impacts of major types of disturbance*

5 YEAR GOALS

1. Determine the key edaphic, climatic and topographic factors that influence the growth of Karri and use this information to develop a model that predicts the productive potential of a site at the commencement of a rotation.

2. Ensure that new Karri and Jarrah stands develop adequately after logging by optimizing the establishment, fertilization and management techniques used in the forest.

3. Determine the effect of initial spacing, thinning and fertilizer application on the growth of Karri on a range of different sites.

4. Refine chemical methods of non-commercially thinning Jarrah stands.

5. Develop priorities and practices for protection and management of remnants of native vegetation in farmland.

6. Continue experimental work to define parameter inputs for models of disturbance/regeneration processes for native forests.

7. Determine the distribution of genetic variability in Karri, including those families in provenance trials, and formulate a strategy for the efficient management of this genetic resource.

8. Determine whether substantial genetic variation in growth rates, tree form, resistance to fungal and insect attack exists in Jarrah and use this variation to select appropriate genotypes for regeneration.

9. Continue studies of the biology of native plant species of importance in conserving remnant vegetation on CALM lands.

10. Investigate the breeding system of Karri and develop treatments to maximize the production of seed from orchards. The use of vegetative propagation for use in Karri breeding requires evaluation.

11. Determine the effect of stand density and fertilization on the growth rates of Jarrah poles and determine the relationship between stand density and the quantity and quality of water produced from water catchments in the Jarrah forest

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following).

1,4(most), 6, 10, 12

PROPOSED NEW PROJECTS - with existing resources (in priority order)

Genetic improvement of Karri 14, selection of remnant of native vegetation for protection 3; Jarrah Regeneration techniques 11; Seed production and cuttings propagation of Karri 14.

PROPOSED NEW PROJECTS - with additional resources (in priority order).

Monitoring in disturbed forest 5; Jarrah stand management:6 (Nitrogen sources), 7 (Understocking, competition stand structure); Jarrah Genetics 13, Marri provenance trial 13.

PUBLICATIONS* AND REPORTS 1989/90

Davison, E., Hussey, P. and Pigott, P. (Editors) (1990). Tree Decline and Revegetation Newsletter No 2. CALM.

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 90-91
Remnant Native Vegetation	Management of remnant native vegetation	1. Wandoo decline (P Pigott)		
		56/86	Terminated	Publish (P Brown)
		63/86	Terminated	Publish (P Brown)
		78/86	Terminated	Publish (P Brown)
		15/87	Terminated	Publish (P Brown)
		56/87	Treatment continued	Complete & publish
		2. Grazing exclusion (P Pigott)54/86	Monitor	Monitor
		3. Selection of remnants for protection (P Pigott)		
		20/89	Conducted survey	Report
		30/89	Established	Monitor
Site Classification	Karri site classification	4. Karri site classification 19/86 (G Inions)	Published	
		9/88 (P Hewett)	Trial mapping complete. Report prepared.	Complete report
Stand Management	Jarrah stand management	5. Monitoring in disturbed native forest (S Crombie)	Discussed with other Programs & Divisions	Complete Scott block proposal
		6. Thinning and fertilization (S Crombie)		
		2/88	Water relations and leaf area measurements continued. Tipping bucket pluviometers designed	Analyse and relate to growth. Install automated throughfall and stemflow equipment.
		Compare effectiveness of nitrogen fixation by native legumes with nitrogen fertilization on jarrah growth.	New project	Prepare RPP
		7. Thinning responses and growth rates (S Crombie)		
		49/65	No action (Maintenance)	No action
		15/66	No action	No action

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 90-91
		17/83	Maintenance and remeasurement	Maintenance and evaluate reponse to fertilizing and re-thinning of plots.
		Determine reasons for understocking and poor stand structure on some sites in NJF	New project	Prepare RPP
		Determine the effect of stump coppice and advance growth on pole and stand increment and sitte hydroogy.	New project	Prepare RPP
		Assess the relative and total effect of various tree and stand characteristics on the growth rate of jarrah sapings poles and piles.	New project	Prepare RPP
		8. Hydrology, water yield and quality (S Crombie)		
		1/77	Jones and Hansens surveyed post-treatment. Warrens and Bennetts mined	Site type, dieback survey of Yarragil 9A, rehabilitation. Warrens and Bennetts catchments
		20/82	Published	-
		16/84	Monitoring continuing	Continue monitoring
		30/85	-	-
		3/86	Study completed (MS prepared)	Publish
		9. Leaf area measurement (K Whitford) L.E. 704 L.E. 542	Manuscript of comparative methods written. Survey of Yarragil completed. Periodic survey of Ingelhope continuing.	Publish, analyse survey results, include in jarrah growth model.
	Jarrah thinning techniques	10. Chemical thinning of Jarrah (S Crombie)		
		37/84	Assessment of mortality continuing	Complete assessment
		34/85	"	"
		35/85	"	"

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 90-91
		36/85	"	"
		37/85	"	"
		39/85	"	"
		40/85	"	"
		40/85	"	"
		41/85	"	"
		30/86	"	"
		31/86	"	"
	Jarrah regeneration	11. Regeneration techniques (S Crombie)		
		34/80	Projects under review	Finalize reviews
		18/83	"	"
		19/83	"	"
		30/83	"	"
		23/83	"	"
		12/84	"	"
		13/84	"	"
		6/86	"	"
		43/86	"	"
		Identify and remedy regeneration problems in the northern Jarrah forest.	New project	Prepare RPP
	Karri stand management	12. Karri thinning, spacing and establishment (P Hewett)		
		3/84	Remeasured	Analyse and prepare paper
		25/85	Remeasured	Analyse and prepare paper
		3/89	Fertilizer applied, remeasured	Remeasure (1991)
		21/77	No action	No action
		25/86	Completed data analysis	Prepare draft report

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 90-91
		15/82	Data analysed	Prepare draft report
		13/89	Analysis and preliminary report	Finalize and close
		17/89	New project, established and assessed.	12 month assessment and report.
		24/89	Infilling surveyed	Analyse and prepare report
Tree Breeding	Jarrah genetic diversity	13. Genotype variation in Jarrah (R Mazanec)		
		3/87	Mortality count	No action
		6/87	Mortality count	No action
		9/89	Established mortality count	No action
		11/89	RPP written and initiated	Complete project
		Establish Marri Provenance trial	RPP in prep.	Seed reconnaissance and seed collection
	Karri genetic diversity	14. Genotype variation in Karri (D Coates)		
		R.S. 28	Initiated studies of mating systems in karri	Continue monitoring
		(R Mazanec) 26/78	Data processed	Measure second trial. Index selection
		Seed production	New project	Prepare RPP
		Cuttings propagation of Karri	New project	Prepare RPP

PLANT DISEASES PROGRAM

PROGRAM LEADER

BL Shearer

CURRENT RESOURCES (1990/91)

This program comprises 12.1 persons (2.3 Professional + 1 Contract Professional + 6.8 Technical + 2 Contract Technical) Its estimated CRF budget is $490 825 (including $372 475 salaries and $118 350 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 15.10 persons (3.30 Professional + 1 Contract Professional + 8,80 Technical + 2 Contract Technical). Its estimated CRF budget is $538 749 (including $379 509 salaries and $159 240 operating costs).

BACKGROUND

The plant diseases program has evolved from studies on the cause of dieback and death of Jarrah first observed in the early 1920's. In addition to the work on death of jarrah, research was undertaken on wood rots in the 1930's. The discovery that *Phytophthora cinnamomi* was associated with jarrah deaths in the late 1960's resulted in considerable research effort on the effect of the jarrah forest environment on increase and spread of *P. cinnamomi* and ways to control the pathogen. Emphasis must now be given to applying this knowledge to the management of the jarrah forest in the presence of the disease.

Phytophthora cinnamomi is a destructive pathogen not only in the jarrah forest but has killed native vegetation in woodlands and heaths and is associated wih the death of pine in plantations. *Phytophthora* species other than *P. cinnamomi* also threaten plantations and native communities of the South West of the state. As part of the development of management plans and control methods, there is a need for more research on *Phytophthora* species in areas important for conservation. Pathogens other than *Phytophthora* species cannot be ignored. *Armillaria luteobubalina* causes death of a wide range of woody hosts and cankers cause crown decline in forests, plantations and rural areas. Decay fungi destroy the quality of wood.

In addition to research, the program provides a service for the detection of *Phytophthora* species. The information provided by the service is vital to prevent the spread of *Phytophthora* species during the course of operations. A diagnostic service for nursery diseases is also provided.

By 1993 knowledge gained will be incorporated into hazard, risk and control systems for the protection and management of conservation and production areas in the presence of diseases. Information gained will be used to update a list of plant pathogens present in conservation and production areas and to rank thier importance from assessments of their impact on plant health and timber production.

ACHIEVEMENTS

A Research Scientist and Technical Assistant have been established at the Manjimup Research Centre to undertake research on the plant diseases in the South Coast and Southern Forest regions.

Trials on the control of *Phytophthora* species with phosphorous acid have been extended to *Banksia* communities on the south coast. *Banksia baxteri*, *B. brownii* and *B. coccinea* were sprayed in November 1989 and monitoring is continuing.

Potential improvements to the *P. cinnamomi* hazard rating systems for the high rainfall zone of the northern jarrah forest are being evaluated. Plant indicators are being grouped according to position in the landscape in order to facilitate prediction of hazard.

The superiority of jarrah lines resistant to *P. cinnamomi* have been maintained in field trials. The jarrah provenance screening program is well under way with a further 96 families being tested in the 1989-90 season.

Assessment of lesion extension of *P. cinnamomi* in stems of jarrah has commenced in stands thinned to different densities in the low, intermediate and high rainfall zones of the jarrah forest. Inoculation and measurement of growth rates is continuing.

An investigation of the causes of decline and death of *B. coccinea* at Cheyne Beach has commenced. A number of canker fungi, including *Botryosphaeria* and *Diplodina*, have been isolated from dying plants and pathogenicity tests are in progress.

From mid May 1989 to mid April 1990, 319 culture were forwarded by the detection service for identification. Sixty four of these were *Phytophthora* species, all of which were identified to species level and added to the database.

AIM

To diagnose causes of diseases; investigate the conditions that favour the increase and spread of pathogens; determine the effects of diseases on the health, growth and reproduction of plants in native communities, plantations and nurseries and on the quality of timber; and develop methods for control of diseases.

PRIMARY OBJECTIVES

Diagnosis

To recognize and assess the effects of disease in any situation of concern. To diagnose the causes of diseases or damage in native communities, plantations and nurseries whether they are caused by abiotic factors or infectious agents. To identify pathogens.

Assessment of Damage

To survey and assess the economic and conservation importance of diseases.

Disease Dynamics

To understand the effect of environment on host, survival, increase and dispersal of pathogens, the infection of plants and expression of host resistance. To develop risk-rating systems where appropriate.

Disease Management

To determine the effect of management practices, climate, site, and host susceptibility on consequence of diseases in plant communities, plantations and nurseries. To develop hazard-rating systems where appropriate.

Control

To develop cost-effective and scientifically sound methods of controlling diseases of woody plants. To advise as to how areas are to be best managed to maintain stable and healthy communities that are not predisposed to disease in the short and long term.

Communication

To communicate the results of research in the form of publications, educational literature, committee representation, training courses and seminars and to liaise and co-operate with the pulblic, staff of other organizations and CALM personnel.

20 YEAR GOALS (based on current resources and in priority order)

1. Develop management plans for the control of *Phytophthora cinnamomi* and other *Phytophthora* species in forests, woodlands and heaths based on knowledge of disease behaviour in response to site, vegetation and climate.***

2. Identify and rank diseases present in conservation areas from an assessment of their impact and likely threat to the health of plant communities.***

3. Identify and rank diseases of commercial tree species according to likely economic impact on timber production and quality.***

4. Develop management plans for the control of important diseases other than *Phytophthora* species based on disease behaviour in response to site, vegetation and climate.**

5. Increase the awareness of departmental staff to symptoms of disease.*

6. Maintain culture collections and establish a fungal herbarium and a system to ensure that an inventory of diseases woody plants is updated regularly.*

5 YEAR GOALS (in order of priority)

1. Test methods of controlling the spread and occurrence of disease of woody plants in native communities and Departmental nurseries.

2. Develop risk-rating systems for *Phytophthora* species from an understanding of the effects of environment and site on the survival, sporulation and dispersal of the pathogen in native plant communities.

3. Establish a data base of the distribution and importance of *Phytophthora* species and hosts susceptible to these pathogens (jointly with Flora Conservation Program).

4. Develop, apply and test hazard rating systems for *Phytophthora* species in forest, woodland and heathland communities. Develop the Shearer *P. cinnamomi* hazard rating sysem for the northern jarrah forest to incorporate the effects of disturbance and silvicultural practices.

5. Identify communities, particularly those of limited distribution, which are vulnerable to disease (jointly with Flora Conservation Program).

6. Determine the effects of *P. cinnamomi* on growth of jarrah on a range of sites and relate growth efficiency to the amount of infection and damage in root systems. Assess silvicultural methods of enhancing the resistance of jarrah stands infected with *P. cinnamomi* (jointly with Native Forest Silviculture Program).

7. Determine and select intraspecific resistance to diseases of woody plants.

8. Determine how *Phytophthora* species invade *P. radiata* and determine conditions that affect susceptibility and result in tree death.

9. Identify the fungi that cause discolouration and rot in regenerated karri. Assess their economic impact on timber and utilization and, if appropriate, recommend methods to minimize their incidence (jointly with Wood Utilization and Native Forest Silviculture Programs).

10. Evaluate the impact of *Armillaria luteobubalina* in forest, woodland and shrubland communities and elucidate the factors favouring host infection.

11. Establish the importance of canker fungi that damage the crowns and stems of woody plants and determine the factors favouring host infection.

12. Maintain the culture collection and fungal herbarium and develop a system for an inventory of diseases of woody plants.

13. Determine the incidence and distribution of *Sphaeropsis* and other pathogens of pine and evaluate the damage caused.

14. Evaluate techniques that may aid in the identification of fungi and determine the variability of pathogens (jointly with Flora Conservation Program).

15. Determine whether insect infestation predisposes trees to infection by canker and root rot pathogens (jointly with Entomology Program).

Diagnostic Services

Members of the Plant Diseases Program are involved in general inquiries relating to diagnosis of diseases for operations and nursery departmental staff. They continue to take responsibility for maintaining the Detection Service. The service is important to the maintenance of a high standard of accuracy in

dieback mapping and of hygiene in the departments operations and nurseries.

Soil samples are tested for the presence of *Phytophthora* species. Samples are processed at the Dwellingup Research Centre and *Phytophthora* species identified by Mike Stukely at the Como Research Centre. The wages of a part time assistant are provided from the budget of the Dwellingup Research Centre. Elaine Davison diagnoses diseases and gives advice on problems on nurseries when requested.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following)

5,6,7,9,10,14,20,21,22,23,24,25,26,32,33,38,48

PROPOSED NEW PROJECTS - with existing resources (in priority order)

46,29,45,13,52,29,15,19

Together with: Develop a model for *P. cinnamomi* reproduction and growth. Inoculation technique for *A. luteobubalina*.

PROPOSED NEW PROJECTS - with additional resources (in priority order)

12,50, 53

Together with: Control of *Armillaria* infection.

PUBLICATIONS* AND REPORTS 1989/90

*Davison, E.M and Tay, F.C.S. (1989). Phenology of *Eucalyptus marginata* on sites infested with *Phytophthora cinnamomi*. Australian Journal of Botany 37:193-206.

Hill, T.C.J. and Tippett, J.T. (1989). Comparison of three methods for the eradication of *Phytophthora cinnamomi* from deep leached sands. Report for the Roadside Conservation Committee.

*Shearer, B.L. and Bailey, R. (1989). Tree killer. The fight against jarrah dieback. Landscope 5(1):38-41.

*Shearer, B.L. and Hill, T.C. (1989). Diseases of *Banksia* woodlands on the Bassendean and Spearwood Dune systems. Journal of the Royal Society of Western Australia 71: 113-114.

Shearer, B.L. and Hill, T.C. (1989). Diseases threatening declared rare flora. Proceedings of the Declared Rare Flora Workshop, Department of Conservation and Land Management.

*Shearer, B.L. and Tippett, J.T. (1989). Jarrah dieback: The dynamics and management of *Phytophthora cinnamomi* in the jarrah *(Eucalyptus marginata)* forest of south- western Australia. Research Bulletin 3, Department of Conservation and Land Management.

*Tippett, J.T., McGrath, J.F. and Hill, T.C. (1989). Site and Seasonal effects on susceptibility of *Eucalyptus marginata* to *Phytophthora cinnamomi*. Australian Journal of Botany 37:481-490

Primary Objectives	5 Year Goals	Projects (RPP No)	Tasks Completed 1989-90	Targets 1990-91
Diagnosis	3,Service	1. Dieback Detection Service (M Stukely)	Phytophthora spp.identified.Database developed.	Continue identification Update database.
Publish	3,Service	2. Nursery diagnosis (E Davison)	Ongoing	Ongoing
	Service	3. Diagnosis as problems arise (All staff)	Ongoing	Ongoing
	11,14	4. Identification eucalypt canker fungi. 55/88 (E Davison)	Isozyme analysis to be completed.	Write up.
Assessment of Damage	6	5. Tree growth, Churchmans & Karnet (E Davison)	Root investigations	Complete Measurements
	6	6. Jarrah root damage by P. cinnamomi 14/84 (B Shearer)	Sites assessed	Complete analysis
	6	7. Barrier zones to P. cinnamomi 50/87 (S Crombie)	Terminated	Analyse
	6	8. Growth of jarrah in P. cinnamomi infected sites 56/88 (S Crombie)	Site prepared	Monitor and analyse
	3	9. Distribution & impact of Phytophthora spp. 23/87 (T Hill)	Survey & sampling completed	Prepare for publication
	3	10. Impact of P. cinnamomi in Stirling Range National Park. (R Wills)	Data analysed and report written	Publish
	3	11. Phytophthora impact coast plain 36/89 (B Shearer)	16 sites surveyed	Continue survey
	3	12. Impact of Phytophthora spp. on South Coast National Parks (R Wills)	Submit for external funding	Begin assessment
	6	13. Susceptibility of jarrah understorey to P. cinnamomi (B Shearer)	Assessment sheets completed	New Project. Prepare RPP
	10	14. Armillaria in Wandoo 75/86 (B Shearer)	Analysis completed	Write up

Primary Objectives	5 Year Goals	Projects (RPP No)	Tasks Completed 1989-90	Targets 1990-91
	10	15. Armillaria in coastal shrubland (B Shearer)	Assessment sheets completed	New Project. Prepare RPP
	11	16. Cankers in arboretum 73/86 (B Shearer)	Survey completed, pathogenicity tests started.	Continue pathogenicity tests, analyse
	11	17. Crown decline in tuart 49/87 (B Shearer)	Continue survey.	Continue survey.
	11	18. Cankers killing Banksia coccinea 3/90. (B Shearer)	Survey, pathogenicity tests started.	Finish patho-genicity tests, write up
	11	19. Cankers on Banksia (B Shearer)	Sampling commenced.	New project, prepare RPP.
Disease Dynamics	6	20. Jarrah Deaths 35/84,43/87 (B Shearer)	Mapping 2 m contours continuing	Enter data into Intergraph, relate to climatic data.
	2,3	21. Occurrence & rate of spread of Phytophthora spp. in woodland 22/87. (T Hill).	Sampling completed	Write up.
	2	22. P. cinnamomi population dynamics in woodland 4/87, 76/87 (B Shearer)	Sampling completed	Analyse
	2	23. P. cinnamomi dispersal model. 74/86, 37/97 (A. Kennett-Smith)	Dispersal experiments commenced	Work suspended
	2	24. Site hydrology & P. cinnamomi dispersal 23/84 (J Kinal)	Rainfall events monitored	Continue measurement
	2	25. P. cinnamomi sporulation 5/89 (B Morgan)	Techniques & experiments	Analyse &write up finalised.
	2	26. P. cinnamomi survival 6/89. (B Morgan)	Techniques & experiments finalised	Analyse & write up
	8	27. P. cinnamomi pine inoculation trials 29/89 (M Stukely & E Davison)	Inoculation commenced	Inoculate & monitor
	2	28. Analysis of climate data of South Coast (R Wills)	Techniques identified	New project, prepare RPP

Primary Objectives	5 Year Goals	Projects (RPP No)	Tasks Completed 1989-90	Targets 1990-91
	2	29. Phytophthora inoculum production on plant spp. after infection (R Wills)	Experiments designed	New project, prepare Rpp
Disease Management	4	30. P. cinnamomi hazard system development 40/83 (B Shearer)	System modified for high rainfall zone	Validate changes
	4	31. Mapping hazard 34/87 (B Shearer)	Areas mapped	Use to validate system
	4,6	32. Vegetation water stress 6/85 (S Crombie)	MS published	Submit 2nd paper
	4,6	33. Hydrological model of jarrah 52/87 (S Crombie)	Work suspended	
	4,6	34. Automated measurement of jarrah water stress & growth 32/87 (S Crombie)	Trees instrumented	Analyse
	4,6	35. Thinning & water status 51/87 (S Crombie)	Extra sites prepared	Analyse
	4,6	36. P. cinnamomi lesion extension & thinning 23/89 (F Bunny)	Sites treated	Inoculate & measure
	6	37. Water relations coppice & trees 57/88 (S Crombie)	Water relation measurements completed	Describe morphology
	4,6	38. P. cinnamomi extension & water potential (S Crombie)	Abandoned	
	2,4	39. Canopy density & temperature 8/89 (J Kinal)	Sites instrumented	Measure & analyse
	4	40. P. cinnamomi on jarrah regeneration (B Shearer)	Sites selected	New project, prepare RPP
	7	41. Jarrah resistant to P. cinnamomi 42/85 (M Stukely)	Field trials measured	Write up, monitor
	7	42. Jarrah clones resistant to P. cinnamomi (M Stukely)	Deaths in field monitored	Write up. start new field trial

Primary Objectives	5 Year Goals	Projects (RPP No)	Tasks Completed 1989-90	Targets 1990-91
	7	43 Test jarrah provenances for resistance to P. cinnamomi (M Stukely)	6 trials completed	Start new series
	7	44. Pinus radiata/P. cinnamomi screening 30/78 (M Stukely)	Series 14 inoculated & measured	Start series 15
	7	45. Seed orchard P. cinnamomi resistant jarrah (M Stukely)	Site selected	New project, prepare RPP
	7	46. Determine intraspecic resistance in B. brownii to P. cinnamomi (M Stukely)	New project, prepare RPP	Control
	1	47. Control of P. cinnamomi in B. grandis & jarrah by phosphorous acid 77/86 (B Shearer)	Dose response determined	Determine changes with time
	1	48. Control of P. cinnamomi by eradicants 24/87 (T Hill)	measurement completed, report submitted	
	1	49. Control of P. cinnamomi in Banksia communities on the south coast by phosphorous acid 26/89 (B Shearer)	Sites sprayed	Monitore mortalities with time
	1	50. Control of Phytophthora spp. in Banksia communities north of Perth by phosphorous acid (B Shearer)	Sites selected	New project, prepare RPP
	1	51. Rhizoctonia control in pine nursery 32/89 (E Davison)	First trial completed	Design & start 2nd trial
	1	52. Biological control canker fungi on Banksia (B Shearer)	Antagonist selected	New project, prepare RPP
Communication	4,6	53. Extension of P. cinnamomi in jarrah coppice and saplings. (F. Bunny)	Sites selected	New project, prepare RPP
		54. Video on Armillaria (B Shearer)	Infected sites filmed	Edit

PLANTATION SILVICULTURE PROGRAM

PROGRAM LEADER

J McGrath

CURRENT RESOURCES (1990/91)

This program comprises 24.1 persons (8.4 Professional + 15.7 Technical). Its CRF budget is $913 663 (including $743 563 salaries and $170 100 operating costs).

RESOURCES IN PREVIOUS YEAR

The resources in this program were previously included in the Rehabilitation and Silviculture Programs.

BACKGROUND

The Silviculture Program was formed following the 1988 review of research programs. It was decided in 1990 to divide the program into two parts i.e. a Native Forest and a Plantation Silviculture Program. The Plantation Silviculture Program would also absorb the tree planting aspects of the Rehabilitation Program, which was discontinued.

Plantation silviculture in W.A. has historically only been concerned with *Pinus radiata* and *P. pinaster*, and the Program continues the long-standing commitment to research to improve the productivity of these species in their traditional plantation areas.

In 1983 the State decided to discontinue the clearing of native forest for pine planting. This accentuated the already existing problem of availability of alternative land, namely, farmland for purchase. To overcome this problem CALM developed the concept of pine sharefarming where plantation is grown in partnership with farmers, using the farmers land and CALM expertise and finance. The pine sharefarming scheme, floated in traditional plantation areas in 1985, did not attract much interest. To open access to a greater supply of land, pine sharefarming was extended to the Albany region in 1985, and created considerable interest. Although scattered plots indicated good potential yield in the region there had been no prior research. The region presented a new suite of site types, establishment and management problems, for which operational planting prescriptions had to be rapidly prepared, and research became a pressing priority.

CALM had long been associated with research into salinity control, mainly arising from the interest in rehabilitation after bauxite mining. CALM's major role in this work has been in the identification of suitable reforestation species; tree establishment techniques for disturbed areas and farmland, especially salt affected soils; and tree farming systems such as agroforestry. Species selection had always focused on slow-growing eucalypts because they were expected to have good water use capacity and to be adapted to a low management regime, appropriate to a role in rehabilitation without any significant timber production. However, research into water use had shown good water use potential in some fast-growing eucalypt species, which also had good production potential. The product was pulpwood which could be produced on very short rotations and be sold onto large volume world markets with strong price projections. It was apparent that in combination with the sharefarming method a major industry could be developed. In effect the State could have an economically competitive large volume tree crop which would also give land and water rehabilitation benefits. The promise of this industry called for a rapid escalation of research and development into the silviculture of the fast-growing eucalypts.

ACHIEVEMENTS

The phenomenon of drought death has been a recurrent problem in traditional plantation forestry in W.A., especially in the Balckwood Valley. This phenomenon was subject to detailed study for the first time during 1988/89, following extensive deaths in 1987/88. The major factors found to influence drought death were tree stocking, soil depth, landscape position, and aspect. A model that predicts which sites are susceptible to drought, based on these factors, was developed and presented for management application.

A major review of research into vegetation strategies to control salinity has been published (Schofield et al. 1989). This review incorporates several years' work undertaken in the previous Rehabilitation Program, much of which was done in collaboration with other agencies. The review

was timely since it had recently been concluded that tree water use, a focus of research for the past decade, was less important than tree commercial potential as a criterion for selection of tree species for reforestation. This result, along with the development of the sharefarming concept, gave rise to the push to establish a major short-rotation eucalypt pulpwood industry based on farmland.

Eucalyptus globulus has been identified as the main species for the pulpwood industry. In 1989 large breeding population trials including 51 000 pedigree seedlings planted over 56 ha were established. Along with earlier work these trials have been incorporated into a W.A. Breeding Co-operative to co-ordinate the *E. globulus* breeding work of Bunnings Tree Farms, Alcoa and CALM. Thirty superior trees from earlier breeding populations at Busselton, Manjimup and Dwellingup were used to produce grafted seedlings for seed orchards. It has been estimated that seed from these orchards will increase yeilds by 40%.

Three projects supported by National Afforestation Program funds of $1.5 million were designed to develop the multiple benefits of tree crops in farming systems. These projects have developed and demonstrated silvicultural practices for the short-rotation eucalypts and techniques by which pulpwood crops can make an optimum contribution to farm planning. A variation on the sharefarming concept called 'timberbelt sharefarming' was developed to make tree crops attractive to mainstream farmers. Timberbelts are planted in distributions designed to complement conventional farming practices. The long period of research into agroforestry systems under the previous Rehabilitation Program greatly facilitated the development of the timberbelt concept. Substantial interest in timberbelts has been generated. More than 1 000 ha were planted in winter 1990. On the basis of this development CALM is to proceed with a full scale operational timberbelt program in 1991.

AIM

To provide the scientific information necessary to optimize economic production and environmental benefits from all plantations and tree crops in the State and ensure that management of these has a sound scientific base.

PRIMARY OBJECTIVES

Site Classification

To predict the capability of sites to grow tree crops, and to determine how existing stands of timber species differ in their rates of growth and response to disturbance (e.g. disease, insects, drought).

Stand Management

To determine the optimal silvicultural regimes (establishment, thinning, pruning, fertilization) for plantations managed for timber production and tree plantings managed for environmental benefit. To ensure that these regimes are compatible with other concurrent land use (e.g. water yield, honey production, recreation use, agricultural production).

Technique Development

To develop suitable site preparation, plant selection, revegetation techniques and on-going management practices for the rehabilitation of disturbed land.

Integrated Land/Catchment Management

To develop practices for the management of plantations and tree crops and to devise methods for their integration into productive and sustainable land use systems.

Tree Breeding

To optimize wood production, wood quality and disease tolerance of all timber species by the selection, breeding and production of superior genotypes.

Communication

To communicate research results in the form of technical and scientific publications, educational literature, demonstration, committee representation, advice and liaison with other CALM staff, other departments and agencies and the community at large.

20 YEAR GOALS

1. Develop silvicultural practices to maximize merchantable volume increment in plantations designated for wood production. ***

2. Establish plantations and tree crops with genotypes which have superior growth rates, form and wood quality and are tolerant of diseases and pests. ***

3. Establish tree cropping and forest management practices as part of integrated land/catchment management systems which will control the salinity and eutrophication problems in the lower south-west and maximize water production.***

4. Develop models for plantation and tree crop protection and production which incorporate the extremes of stand stocking, stand structure, insect and fungal impact, tree form, thinning schedules, nutrition, regeneration strategies water usage, fire regimes, yield of utilizable wood, landscape amenity and environmental benefit.*

5 YEAR GOALS

1. Relate climatic and edaphic factors to the survival and growth of tree species in southern W.A. Establish land capability assessment and growth prediction procedures for plantations and tree crops in the greater than 600 mm rainfall zone of the south-west.

2. By the introduction, selection and breeding of *P. radiata* and *P. pinaster* ensure that the genotypes used in pine plantations provide the best possible growth rates, wood quality and disease resistance.

3. Expand the range of species and improve the genetic potential of planting stock available for revegetation plantations and tree crops.

4. Establish a diverse robust breeding population from the complete natural distribution of *E. globulus*.

5. Evaluate genotype by environment performance for *E. globulus* and then subline the breeding population for future management and development.

6. Optimize genetic parameter estimation with open-pollinated mating in the breeding population for maximum gains per decade.

7. Develop seed orchard and vegetative propagation techniques to ensure the supply of improved genotypes for plantation and tree crop establishment.

8. Develop techniques to use eucalypt pulp crops to ameliorate land and water degradation.

9. Determine the optimum fertilizer applications for *P. radiata* and *E. globulus* at all stages of the rotation on the range of soils on which it is grown, and describe the interaction between stocking and fertilization.

10. Determine the relationship between stand density, tree form, tree growth rate and the ability to tolerate drought stress on the range of sites on which *P. radiata* is planted.

11. Quantify the differences in yield of different tree species managed under varying silvicultural regimes and soil types.

12. Optimize the thinning, pruning and fertilization strategies for sawlog and water production from *P. pinaster* stands on the coastal plain.

13. Establish experiments and quantify the conservation and production benefits of fully integrated management to combat salinization and eutrophication.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995
(numbers refer to the Table following).

1,2,3, 4(part: 9/82, 19/82, 1/85, 16/85, 17/85, 33/87, 18/88) 5(part : 8/85,) 6(part : 27/65, 7/66, 12/66) 7(part 2/86) 9(part: 16/58, 20/65, 54/65, 20/68, 16/69) 18(part of RS 28) 10(3/65, 20/72) 11(30/78, 39/83)

PROPOSED NEW PROJECTS - with existing resources (in priority order)

South coast *P. radiata* fertilizer requirements : 12; Hapso hormonal treatment for seed production: 21; Flowering and propagation studies with *E. globulus*: 22.

PROPOSED NEW PROJECTS - with additional resources (in priority order)

Pine Nutrition 12(Tissue analysis).

PUBLICATIONS* AND REPORTS 1989/90

*Bartle, J.R., Butcher, T. and Mazanec, R. (1990). A question of breeding. Landscope 5:51-53.

*Bartle, J.R., (1989). Eucalypt Pulpwood: A potential new crop for farmers in the lower south-west. In 'Trees - Everybody Profits'. Proc Seminar AIAS. Occas. Paper Dept Agriculture 45:41-51.

.*Mattinson, B., Morrison, D. and Eckersley P. (1989). The economics of tree farming in the south-west of Western Australia. In. 'Trees - Everybody Profits'. Proc. Seminar. AIAS Occas. Paper Dept Agriculture 45:70-83.

*McGrath, J.F. and McArthur, S.L. (1990). Influence of Fertilizer Timing on Seasonal Nutrient uptake and Dry-Matter Production by Young *Pinus radiata* in southern Western Australia.Forest Ecology and Management. 30:259-269.

McGrath, J.F., Ward, D.J., and Davison, E.M. (1990). Pine Deaths in the Blackwood Valley Plantations: a Recurrent Problem. Internal Report.

Moore, R.W. (1989). Agroforestry for profit. In: Proceedings of the third Agroforestry Conference Morwell Vic.

*Moore, R.WW., (1989). Agroforestry with widely spaced trees. In'Trees Everybody Profits'. Proc Seminar AIAS. Occas. Paper Dept Agriculture 45:55-65.

*Ritson, P., and Pettit, N.E. (1989). Salt and water Movement in Single and Double ridge mounds. Report No. WS45 Water Authority of Western Australia.

*Ritson, P., and Pettit, N.E. (1989). Mounding for Tree Establishment in Saline Seeps. Land and Water Research News Issue 2:17-18.

*Ritson, P., and Pettit., N.E. (1989). Seedling containers and Mulching for Tree Establishment in Saline Seeps. Land and Water Research News Issue 3 (2pp).

*Schofield, N.J., Loh, I.C., Scott, P.R., Bartle, J.R., Ritson, P., Bell, R.W., Borg, H., Anson, B. and Moore, R., (1989). Vegetation strategies to reduce stream salinities of water resource catchments in south-west Western Australia. Water Authority of Western Australia Report No WS33 (82pp).

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Site Classification	Pine site classification	1. Drought survey of Blackwood Valley 43/88 (J McGrath)	Data analysed; Report written	Test system. Publish externally.
		2. Soil-productivity relationships in south coast pine plantations. (R Harper)	New project. Prepare RPP	Continue soil and tree assessment.
	E. globulus site classification	3. E. globulus site assessment yield prediction and growth modelling (G Inions PhD project)	Ongoing data collection Further data collection and processing	Saline seep revegetation techniques (Goal 1)
Stand Management.	P. radiata nutrition	4. Nutrition of young P. radiata (J McGrath)		
		9/82	See 1/85	
		19/82	Growth measurements continued. Evaluated and decided to continue	Continue measurements.
		15/83	Measured	Continue measurements
		23/83	See 19/82 (sub experiment of 19/82)	
		1/85	Measurements and sampling continued. Pruned and thinned appropriate treatments. Inserted neutron access tubes	Prepare MSS on phase 1.
		16/85	Published	-
		17/85	Sampling, measurement & nutrient analyses continued.	Analyse data.
		33/87	Remeasured (final)	Prepare report
		18/88	Measured	Prepare report
		5. Nutrition of older P. radiata and nutrition x fertilizer interactions (J McGrath)		
		8/85	Progress report prepared. Measurement of 50 plots continued	Continue annual measurement. Establish another experiment in this series.
		9/87	Remeasured	Continue measurements

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		10/87	Remeasured, Retertilized	Continue measurements
		11/87	Continued sampling & measurements	Replicate on other site types (Harvey and Blackwood)
		Fertilizer requirements on the south coast	New Project	Prepare RPP
		Tissue analysis in older trees	New project	Prepare RPP
	<u>P. radiata</u> stand management	6. Plantation silviculture (R Moore)		
		27/65	Trial inspected - low level monitoring	Ongoing
		7/66	"	"
		12/66	"	"
		2/82	Volume of thinnings assessed	Monitor tree growth
		5/82	Thinning & pruning carried out, height & diameter measured	Monitor tree growth
		45/82	Pruning completed. Height & diameter measured	Continue annual measurements
		3/83	Pruning treatments carried out. Height & diameter measured	Analyse data & write progress report
		6/83	Height & diameter measured. Report written	Monitor
		7/83	Height & diameter measured. Progress report written.	Continue monitoring
		28/83	Height & diameter measured	Analyse data & write progress report
		30/83	Height & diameter measured. Estimate thinning volume. Report written.	Monitor.
		14/84	Pruned	Monitor

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	Agroforestry (R Moore)	7.	15/73	Trees measured	Monitor tree growth
			10/75	Tree growth measured	Monitor tree growth
			2/78	Height & diameter measured	Monitor tree growth
			264/51	"	Monitor
			264/52	Trees measured	Annual measurements
			264/53	Measured height	Monitor
			264/54	Trees tended and measured	Monitor tree growth
			4/80	Tree growth measured Final Pruning	Measure height and diameter. Analyse & write progress report
			4/81	Pines pruned and measured, eucalypts measured	Monitor
			10/81	Height & diameter measured	Monitor
			43/82	Established measurement plots & borefield	Monitor
			2/86	Height measured	Commence agricultural monitoring (D of A).
			27/87	Measured height culled and pruned	"
			58/88	Data collection and alalysis	Report
			59/88	Treatment of data collection	Process data and report
			NSCP grant (D Bicknell)		
			60/88	Continued data collection	Report
	Comparison of species performance	8.	Arboreta & species trials (R Moore)		
			25/67	Tree performance monitored. New signs erected	Monitor
			26/67	Tree performance monitored. New signs erected	"

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		27/67	Tree performance monitored. New signs erected	"
		44/82	Thinned & pruned	"
	P. pinaster stand management	9. P. pinaster silviculture and hydrology (T Butcher)		
		16/58	Study completed	Prepare for publication
		20/65	Study completed	Collate data; plan utilization study
		48/66	Process data	Measure in Feb 1991
		17/67	Process data	Continue monitering
		54/66	Study completed	Collate data, plan utilization study
		20/68	Study completed	Process data
		16/69	Published	No further action
		29/71	Study completed	Process data
		8/72	No action	Measure Feb 91. Thinning treatments?
		23/73	No action	Measure Feb 91. Thinning treatments.
		20/76	No action	Process data & review
		21/76	No action	Continue bi-annual measurements
		22/76	No action	Continue bi-annual measurements
		26/80	No action	Proceess data and review
		2/81	No action	Process data for publication
		7/82	Fertilizer applied	Monitor
		25/83	Review	Measure height
		29/83	No action	Review
Tree Breeding	Pine breeding	10. P. pinaster genetics (T Butcher)		
		3/65	Finalize publication	Publish

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		21/65	1. Finalize publication 2. Plant yield trials.	1. Revise Breeding Plan 2. Conduct combined index selection 3. Establish a gene pool 4. Publish
		7/72	Data collated	Prepare for publication
		Pedigree 32	Data analysis	Pinaster growth model.
		11. P. radiata genetics (T Butcher)		
		21/71	No action	No action.
		22/71	27 ha of progeny tests planted in Kirup and Collie Districts	Plant 15 ha progeny trials at Busselton, Kirup and Albany.
		19/72	Data analysis	Selection
		29/78	Data collated	Analyse results & prepare for joint publications
		30/78	Evaluated NZ parents (268,875)	1. Cytoplasmic inheritance study. 2. Screening of search 1985 selections.
		25/79	Data collated	No action
		28/82	No action	Plan diameter and BSTAF assessments
	Propagation of pine genotypes	12. Pine propagation (T Butcher)		
		19/62	7 ha of 2nd generation P. pinaster seed orchard planted at West Manjimup	1. Monitor 2. Graft new sections
		34/68	12 ha of HAPSO established at West Manjimup	1. Mass pollination of HAPSO 2. Chemical emasculation 3, Cutting Hedges Primary Objectives 4. Plant 3.5 ha of HAPSO.
	Eucalypt breeding	13. Genetic improvement of Eucalyptus globulus (T Butcher, R Mazanec		
		Breeding Plan	Prepare	Formalize Breeding Stratergy

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		EG03	Initial index selection scrub control	Intensive volume, form and weed quality assessment. Combined Index Selection and cloning for seed orchards and clone banks.
		EG05 and EG06	No action	Initial assessment
		EG07 and EG15	56 ha of breeding population trials planted	Commence initial assessment
		EG16 to EG21	nursery raising of seedlings	Plant 30 ha of breeding population tests at 3 sites
		EG22 to EG24	-	Procure seedlets of the King Island population and the W.A. and Portugal races.
		Genetic improvement (T Butcher & R Mazanec)		
		27/80 (globulus)	Converted to seed orchards	No action
		6/81 (wandoo)	Monitored	Monitor
		24/82 (wandoo)	Growth measurements	"
		25/82 (wandoo)	No Action	"
		38/82 (maculata)	"	"
		40/82 (wandoo)	"	"
		40/82 (wandoo)	"	"
		38/83 (resinfera)	"	"
		32/84 (globulus)	Performance evaluation	Ongoing growth measurements
		33/84 (accedens)	No action	No action
		34/84 (camaldulensis)	"	Monitor
		4/86 (accedens)	"	"
		5/86 (pilularis)	Monitored	"
		53/88 (muellerana)	Mortality count	"
		54/88 (muellerana)	Mortality count	Monitor
		8/87 (saligna)	Mortality count	Monitor
		5/87 (sideroxylon)	Mortality count	Growth measurement

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		10/88 (microcarpa)	Mortality count	Growth measurement
		(globulus)	Established	Mortality count
		(botryoides)	Established	Mortality count
		(viminalis)	Prepare to establish	Establish
		(grandis)	"	"
		(calophylla, patens)	Early planning	Undertake seed collection
		14. Propagation of E. globulus (T Butcher & R Mazanec)		
		Clonal seed orchard	250 grafts of 30 clones	Plant 3 ha of clonal seed orchard at 2 sites. Grafting program of 2500 ramets.
		Open pollinated seedling seed orchard (OPSSP)	6.5 ha planted	Plant 12 ha at 3 sites
		Flowering studies	New project	Prepare RRP
		Cutting propagation	New project	Prepare RPP
Technique Development	Farmland reforestation techniques	15. Direct seeding (P Pigott)		
		44/86	Prepared for reporting by P. Pigott & P Brown	Publish
		46/86	"	"
		79/86	"	"
		13/87	"	"
		26/87	"	"
		28/87	"	"
		29/87	"	"
		16. Pulpcropping practices (J Bartle & NAP project)		
		27/89	Established experiments	Initial assessments
		35/89	"	"

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		36/90	"	"
		37/90	"	"
		38/90	"	"
		39/90	"	"
		40/90	"	"
		41/90	"	"
		42/90	"	"
		43/90	"	"
		44/90	"	"
		45/90	"	"
		46/90	"	"
		47/90	"	"
		48/90-	"	"
		49/90	"	"
		50/90	"	"
		51/90	"	"
		17. Establishment (P Ritson and N Pettit)		
		49/85	No action	Complete
		70/86	Reported results	Complete
		7/87	Publish initial results	On-going meassurements
		16/87	"	"
		21/87	No action Plot failed	Terminate
		25/87	Continued measurements	Report initial results
		31/87	Reported results	Complete
		32/87	"	"
		40/87	"	"
		41/87	Continued measurements	Report results
		7/88	"	Report initial results

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
		8/88	"	"
		18. Species adaptation (P Ritson & N Pettit)		
		49/86	No action	Complete
		50/86	Continued measurements	Report results
		51/86	No action-failed	Terminate
		52/86	Continued measurement	Report results
		30/87	Reported initial results	On-going measurements
		5/88	"	"
	Species selection/Genetc improvement	19. Rehabilitation species trials (J Bartle)		
		14/76	Prepared MS for growth data	Ongoing data collection Publish come results
		12/78	Published groundwater data	Ongoing monitoring
		31/78	Prepared MS for growth data	Publish
		Pulp species trials (NAP Project)		
		29/90	Established experiments	Initial assessment
Integrated Land/Catchment Management	Production and conservation benefits	20. NAP project (R Silberstein)		
		11/90	Establish experimental catchments	Monitor borefield
		12/90	"	Monitor runoff
		13/90	"	Manage with view to future measurement of production

RESEARCH TECHNIQUES PROGRAM

PROGRAM LEADER

M Choo

CURRENT RESOURCES (1990/91)

This program comprises 5.1 persons (4.0 Professional + 1.1 Technical). Its estimated CRF budget is $313 716 (including $187 966 salaries and $125 750 operating costs).

RESOURCES IN PREVIOUS YEAR

This program is an amalgamation of the former Research Computing and Research Methods programs.

RESEARCH COMPUTING PROGRAM (1989/90)

This program consisted of 3.2 persons (3.1 Professional + 0.1 Technical). During the period, one professional position (Research Scientist) was created at the Herbarium, and Alex Chapman appointed. At Dwellingup Research, one position (Computer user support officer) was also created and filled by Adam Wincza. The program's budget in 1989/90 was $225 064 (including $108 064 salaries and $147 200 operating costs).

RESEARCH METHODS PROGRAM (1989/90)

This program consisted of 2.5 persons (2.0 Professionals + 0.5 Technical). The program's budget in 1989/90 was $92 530 (including $73 380 salaries and $19 150 other costs).

BACKGROUND

The advent of sophisticated, relatively cheap processing power has led to its rapid and widespread application by research scientists. Many tasks including data collection and analysis previously done manually are now automated. Furthermore, use of electronic data processing has made possible analysis that were too complex or lengthy to accomplish manually.

To make the most efficient use of Research resources a structured and systematic approach is required to properly address the needs of research scientists in the areas of experimental and survey design, analysis and data modelling.

The Research Techniques Program seeks to facilitate this systematic approach in providing direction, support, advice and expertise throughout the Division. However, program members are significantly and increasingly involved with research, either in collaboration with scientists in other programs or on their own.

ACHIEVEMENTS

In the past year 67 research project plans have been inspected and modified where necessary. Some of these plans extend into the next century. Data sets drawn from the whole range of research activities have been analysed, thus contributing to many scientific publications. A new method of forest inventory has been tested and transferred to field operations. A new method for identifying ecological pattern has been invented and tested. A method of assessing leaf damage by insects has been developed. An original systematic and constructive approach to the planning with operational mangement of the whole research program has been suggested. A model for the ecological management of pines in the blackwood valley has been developed which will avoid potential loss by drought of millions of dollars of public money.

The goal of providing each Research Scientist with access to at least one computer terminal was effectively accomplished. Training courses were conducted regularly at the major research centres. The level of computer literacy, expertise and usage continue to increase. Laptops are now an integral

part of field work and are becoming indispensable to some researchers.

Hardware and software continue to be upgraded and there is more integration within the Division. The Herbarium's UNISON was replaced. The WAHERB system has been transferred to a new SUN 386i workstation. Work is being carried out in the area of corporate data (eg. Declared Rare Flora database has been transferred to the Wildlife Branch) and in the Geographical Information Area (GIS).

The number of FTEs in the program has increased and the major Research Centres are now supported by qualified staff. This is an important milestone for the program as it is now able to provide support where it is most needed. It paves the way in the coming financial year for a significant increase in the level of computer usage, professionalism and support, as well as greater involvement by program members in the conduct of Research Projects.

AIM

To ensure correct experimental design, data analysis and modelling, and to explore new methods of collecting, analysing and disseminating information.

To set up and maintain an integrated information processing environment within the Research Division. To research improvements in appropriate disciplines and to collaborate with other research scientists.

PRIMARY OBJECTIVES

Research Methods

To raise and maintain standards of research methodology; its planning and analysis and to ensure efficient experimental design.

Research

To research specific problems encountered by scientists. To collaborate with scientists on Research projects requiring a high level of analytical sophistication. To research new or improved methods appropriate to the Division's requirements.

ENVIRONMENT

To provide an integrated environment for the capture, processing, analysis and dissemination of information at Centre, Divisional and Departmental levels.

SCOPE

To promote increasingly sophisticated understanding and use of computers amongst personnel with the aim of broadening the scope and increasing ability of researchers to perform their duties.

TRAINING

To increase computer literacy and expertise amongst research personnel enabling them to keep abreast of and benefit from our research results, the use of new computer technology and software.

EFFICIENCY

To maximise the efficiency and productivity of the Research Division by providing access to and training in the use of equipment that will increase the speed and extend the scope of data capture, management and analysis.

COMMUNICATION

To communicate and integrate with other groups within CALM and appropriate outside organisations to allow for exchange of research findings, ideas, data, software and other products.

SYNTHESIS

To help combine patterns and interactions into models.

20 YEAR GOALS

1. Integrate into Research Division improved systems for information management as they are developed. **

2. Ensure the systematic planning and analysis of research projects.

3. Establish and continue to upgrade a network to provide instant electronic communication with the outside world (i.e. other scientific organisations and databases). **

4. Introduce and improve systems that integrate computers with audio visual data captured via cameras and video recorders and to store and process the data using optical disk technology. *

5. Maximise the potential of the Research Division by researching improved methods and by collaborating with other research scientists on projects requiring sophisticated electronic data management techniques. **

FIVE YEAR GOALS

1. Explore, develop and implement new research methods.

2. Keep up to date the facilities for rapid processing, storage and analysis of data and provide research personnel with state-of-the-art computer based analytical tools and facilities.

3. Raise standards of research planning and analysis.

4. Extend and enhance training of Research personnel by conducting training workshops on a regular basis and encouraging computer based training.

5. Achieve a major reduction in the level of mundane manual chores performed by research staff by computerisation of as many aspects as possible of the researcher's workload, including data collection, analysis and dissemination.

6. Develop and maintain an up-to-date information base to improve the information processing and retrieval requirements of the Research Division and the Department.

7. Integrate Research databases with the Department's corporate databases and make all corporate information available across the Division/ Department.

8. Provide facilities for efficient production of publication quality outputs (reports, graphs and other illustrations) and integrate these to final publication quality outputs (hardcopy, 35mm slides and projection aids).

9. Ensure the maintenance of a uniform cohesive computing approach within the Division, continue to identify research requirements, plan, coordinate, develop, install and maintain major systems.

10. Develop & implement GIS based systems to satisfy specialised research functions and integrate these with corporate data.

11. Facilitate electronic transfer of information between the centres. Establish a distributed network to enable communications between the major research centres and the Department's host computers.

12. Establish local area networks at the major research centres so that information may be readily accessed throughout the Centres.

13. Extend communications to computers on an intra/inter government basis (e.g. SNA network) to provide ready access to non-sensitive information.

14. Through research, develop methodology to maximise opportunities offered by modern, sophisticated electronic equipment, in the areas of experimental design, data capture, information management, analysis and dissemination.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
Computing Environment	Information management & processing	1	Information Base	Information added to following databases: Animal Ecology Biological Survey Fire Ecology Fauna Trapping Flora Conservation Entomology Wetlands & Waterbirds Declared Rare Flora Land management Model Wildflower Returns	Continue to facilitate data updating & provide data management support Integration of CENSUS with CAPS Index
		2	Analysis of Data Systems Design	Installation of softwares for statistical & numerical analysis.	Continue to provide facilities & train staff to use sophisticated packages.
				Collaborated with Wetlands program to evaluate and use the ANPWS customised bird banding analysis system.	Develop customised CALM wetland & waterbirds system and integrate this to the ANPWS system.
				Collaboration with Biogeography on use of PATN for numerical analysis	Install PATN at Manjimup Research
		3	Upgrades	Continue with upgrades & reallocation of PCs & softwares. Installation of the WAHERB system on SUN 386/i	Use extended memory, link PCs by ETHERNET to other computers within CALM. Upgrade with softwares that support distributed processing.
		4	Obsolescence/ replacement program	Displaywriter, UNISON, MORROW obsolete	Phase out the TEKTRONIX Continue to pressure CALM to come up with an obsolescence policy on PCs.
		5	Geographical Information System (GIS)	Further evaluations of ARC/INFO & INTERGRAPH Development of systems	Impliment GIS systems, acquire PLOTTER'S & digitizers.
				Ongoing liaison	Liaise with LIS group & other GIS users
				Training sessions conducted	Organize training sessions at appropriate levels for computing & research staff.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
				Migrate FLORA PLOT from tektronix to VAX	complete migration of FLORA PLOT
				Collaborate with GWJ (Fire) on vegetation mapping using satellite imagery	Impliment selective GIS systems (Vege. Mapping - Manjimup) and use these for demonstrations to Research staff.
Research	Methods & applications	6	Collaboration with Fauna program	Researching best method for estimating population abandunce of short neck tortoise based on recapture data - ongoing	Develop system for population estimates
			GIS systems	Research into applications of GIS for distribution mapping and management planning	Continue research into applications of GIS for distribution mapping, predictive analysis and management planning
Training	Computer Literacy & Expertise within Research	7	Staff training	Courses conducted at Research centres throughout the year. Train computing staff in ORACLE & ARC/INFO	Basic courses, intermediate & advanced workshops at regular intervals at Woodvale, Herbarium, Manjimup, Dwellingup, Busselton & Como.
		8	Staff support	Localised computing support Regular program members meeting and visits to Research Centres, higher level of support.	Emphasis towards more advance and sophisticated use of computers, support to be at a higher level of computer usage.
		9	Computing staff	Additional staff at the Herbarium & Dwellingup	Provide professional support & training to computing staff; upgrade skills of staff in the GIS & ORACLE areas.
Automation & computerization		10	Electronic Field Loggers, Recorders & Laptops	Acquired more COMPAQ laptop computers. Developed field data acquisition applications.	Continue development of systems, evaluation of other electronic devices for field work. Develop expertise in research staff.
		11	Video Digitizer	Conitnue to promote its use	Expand on its use, encourage researchers to use its video capabilities for collecting field data.

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
		12 Computer Projection panel.	Used extensively in training courses.	Continue usage; encourage researchers to use it for seminars.
		13 Systems development	Development & implementation of systems for all areas of research.	Continue developments with emphasis in: - integration of systems - GIS & distributed areas - Herbarium Census - Rare Flora.
		14 Corporate Data	Preliminary training in ORACLE & ARC/INFO	Further training in VAX softwares, istallation of ORACLE based systems, evaluate using RMS throughout research, follow up on data custodianship, work at integrating with the rest of CALM on corporate data.
			Collaborated with Flora Cons. to develop & impliment the Declared Rare Flora system. Transfer control to Wildlife Branch	Provide expert support when needed.
		15 Desktop Publishing	Installation at Manjimup.	Training of key personnel.
		16 Publication quality output	Ventura & Harvard Presentation installed at 2 additional sites.	Work towards producing PC version of camera images for various research applications. Continue to provide various means for producing professional output for presentations & publications.
		17 Sound recognition devices	-	Investigate possibilities for use with Biogeography Program's bat data identification using calls
		18 Location by satellite	Investigated hand held computer which provides longitude & latitude by satellite.	Incorporate its use into field data capture systems

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks Completed 1989-90	Targets 1990-91
Communication		19 Between Computers	Facilitated connection to PIMS, CALM Vax	Continue liaison with Computer Services & LIS group to maintain links and to work towards integration.
			Upgrade/maintain communications within Woodvale, Manjimup Dwellingup & Herbarium.	Work at setting up ETHERNET at Woodvale, Herbarium & Manjimup.
		20 Word processor communications	Acquired conversion softwares and upgrades to softwares.	Work on replacing existing W/Processors with MS WORD at all sites.
		21 Electronic mail		Extend communications to other areas (Herbarium).

WETLANDS AND WATERBIRDS PROGRAM

PROGRAM LEADER

J Lane

CURRENT RESOURCES (1990/91)

This program comprises 3.6 persons (1.9 Professional + 1.7 Technical). Its estimated CRF budget is $199 624 (including $155 824 salaries and $43 800 operating costs).

RESOURCES IN PREVIOUS YEAR

This program comprised 3.20 persons (1.50 Professional + 1.70 Technical). Its budget was $185 247 ($126 307 salaries + $58 940 operating costs).

BACKGROUND

Western Australia has a great diversity of wetland types - greater than that of any other Australian State - ranging from the extensive mangals, tidal mudflats, tropical lakes, rivers and floodplains of the Kimberley region, through the many extensive, occasionally inundated shallow "pans" of the arid north-west and interior, to the highly seasonal, winter-filled lakes and streams of the temperate south-west.

These wetlands support an enormous abundance and substantial diversity of plant and animal life. Many sites are of international significance. Lakes Argyle, Gregory and Roebuck Bay and Eighty Mile Beach each support more than 250 000 waterbirds of 50 or more species, many of them transequatorial migrants. The seasonal swamps of Ellen Brook and Twin Swamps near Bullsbrook contain the only known populations of the endangered Western Swamp Tortoise (*Pseudemydura umbrina*), one of the rarest animals on earth.

The Wetlands and Waterbirds Program aims to ensure the conservation of these wetlands and their flora and fauna. Central to the program approach is the dual theme of conserving representative samples of wetland types and conserving the systems or networks of wetlands, many of which are seasonal, which are necessary to maintain present numbers of migratory fauna, principally waterbirds.

ACHIEVEMENTS

Significant accomplishments were:

Nomination of nine Western Australian wetlands as Wetlands of International Importance (Ramsar).

Initiation of a major new project on waterbird usage of wetlands of the Swan Coastal Plain ("Scopewest").

Publication of a major review paper on breeding seasons of waterbirds in south-western Australia.

Further advances in methodology of monitoring and controlling populations of nuisance midges (chironomids) on Perth's wetlands.

Preparation of draft State Wetland Conservation Policy for Western Australia.

AIM

To provide scientific information to ensure effective conservation and management of Western Australia's wetland ecosystems, including the maintenance of waterbird populations.

PRIMARY OBJECTIVES

Wetland Values

To identify conservation values of the wetlands and wetland systems of Western Australia, particularly with respect to reservation of a representative sample of wetland types, maintenance of species (flora and fauna) diversity and provision of habitat necessary for the maintenance of the State's waterbird populations.

Status of Waterbird Populations

To monitor and manage the State's 130 species of waterbirds, particularly those species of ducks which are harvested.

Wetland Ecosystem Dynamics

To develop an increased understanding of the functioning of wetland ecosystems, identify major degrading influences and provide management solutions.

Public Involvement

To foster a sympathetic public attitude to the conservation of waterbird populations and wetlands through direct involvement of the public in appropriate research projects and through open communication of research findings.

Communication

To communicate research results in the form of technical and scientific publications, educational literature, committee representation, and to provide advice and liaison with other CALM staff, other Departments, and the community at large by way of training courses and seminars.

20 YEAR GOALS (based on current resources and in priority order)

1. Establish an inventory of wetlands of the State and a reservation system that represents all types of wetlands, with emphasis on improved representation in areas outside the south west and along streams, rivers and tidal zones.***

2. Study factors affecting population dynamics, distribution and occurrence of waterbirds, especially game species of duck and migratory waders.**

3. Determine conservation status of wetland and stream invertebrates and native fish and examine factors affecting their occurrence.**

4. Examine the effects of environmental changes on the biota of wetlands and ways of ameliorating the effects of changes including salinization, Greenhouse effect and eutrophication.**

5. Document habitat quality of wetlands, including rivers and streams, with emphasis on riparian vegetation and water quality.*

6. Study issues related to pest management, artificial creation of wetlands and other management matters to ensure that the actions undertaken are biologically sound.*

5 YEAR GOALS

1. Establish and maintain a volunteer-based program (500+ observers) for annual assessment of the abundance of waterfowl (particularly game species of ducks) and for identification of important waterbird sites in southwestern Australia.

2. Determine waterbird usage of wetlands on the Swan Coastal Plain and identify wetland attributes that influence usage.

3. Determine the conservation value (principally the level of usage by waterbirds) of remote wetlands (Lakes Gregory, McLeod etc.) of probable international importance.

4 Assess seasonal usage by waterbirds of a number of important, poorly known, wetland sites in south-western Australia.

5. Monitor annually water levels and water quality of a sample of south-west wetlands. Use these data to assist in determining duck shooting seasons and in monitoring the condition of wetlands.

6. Analyse results of 1981-1985 RAOU Waterbird Survey project as first step in identifying the general environmental parameters within a wetland that affect its usage by waterbirds.

7. Assess the conservation status of the lentic invertebrate fauna in the south-west through wetland surveys and examine how various

environmental parameters (eg. salinity, nutrients) affect the distribution of species.

8. Assess the conservation values of different habitats in Leschenault Inlet and the effect of mosquito control on those values for waterbirds and invertebrates.

9. Study the effect of salinity on usage of wetlands by ducks for both breeding and as drought-refuges as an indication of the impact of increased salinization in the south-west on waterbirds.

10. Examine food selection in waterbirds in relation to the invertebrate prey available to gain some understanding of how changes in invertebrate species composition that result from salinization affect waterbird distribution.

11. In collaboration with other State and Local Government authorities, develop more effective and environmentally acceptable methods of midge (chironomid) nuisance control.

12. Examine pesticide levels in Herdsman Lake and animals therein in relation to both spraying for Argentine ants and other uses of insecticide within the catchment.

13. Gain a preliminary indication of the level of threat to native avifauna and wetland ecosystems posed by continued use of lead shot for waterfowl hunting in the south-west of W.A.

14 Investigate potential for lowering of salt loads of the Yenyenning Lakes system through experimental manipulation of Qualandary Crossing outflows (Yenyenning Lakes Interdepartmental Working Group.

15 Preparation of waterbird habitat protection guidelines for Vasse and Wonnerup Estuaries (CALM Vasse-Wonnerup Working Group).

16 Analyse and publish results of Australian Pelican banding and wing-tagging program.

PROJECTS TO BE COMPLETED FROM JULY 1989 TO JUNE 1994
(numbers refer to the Table following)

1-4,7,8,9,11-16,18,19,20,21

PROPOSED NEW PROJECTS - with additional resources (in priority order)

1. State of the Wetlands. Develop procedures for periodic assessment of the rate of loss (or gain) of wetland types. This information would be used to counteract the current piecemeal loss of wetland resources and to enable policy development, protective legislation, acquisition, management etc. to be targetted on areas of greatest need.

PUBLICATIONS* AND REPORTS 1989/90

Anon (1989). Progress in midge research. Midge Notes No. 3. Published by the Midge Research Steering Committee, Perth. (Prepared by J. Lane).

*Anon (1990). Wetlands nominated by the Government of Western Australia for inclusion on the List of Wetlands of International Importance. Department of Conservation and Land Management, Perth. (Prepared by S.A. Halse).

*Halse, S.A. and Jaensch. R.P. (1989). Breeding seasons of waterbirds in south-Western Australia - the importance of rainfall. *Emu* **89**: 232-249.

Halse, S.A., Pearson, G.B. and Pinder, A.M. (1990). Some biological implications of mosquito control. Abstracts, 29th Congress Australian Society for Limnology, p. 19.

Lane, J.A.K. (1989). Consideration of a possible duck-shooting season in Western Australia in 1990.

*Lane, J.A.K. (1990). Swamped with birds. *Landscope* **5**: 17-22.

*Lane, J.A.K. (1990). Bird flight. *Landscope* **5**: 28-33.

Lane, J.A.K., (1990). Draft State Wetland Conservation Policy for Western Australia.

Pusey, B.J., Storey, A.W., Davies, P.M. & Edward, D.H.D. (1989). Spatial variation in fish communities in two south-western Australian river systems. *Journal of the Royal Society of Western Australia* **71**: 69-75.

Storey, A.W. and Edward, D.H.D. (1989). The freshwater mussel, *Westralunio carteri* Iredale, as a biological monitor of organochlorine pesticides. *Australian Journal of Marine Freshwater Research* **40**: 587-593.

Storey, A.W. & Edward, D.H.D. (1989). Longitudinal variation in community structure of Chironomidae (Diptera) in two south-western Australian river systems. *Acta Biologica Debrecina Oecologica Hungarica* **3**: 315-328.

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Wetland Values	Remote wetlands	1	Kimberley surveys (RAOU, J Lane)	Final draft prepared	Publish (RAOU)
		2	Lake Gregory	Organised workshop on Lake Gregory, proceedings prepared for publication. Undertook preliminary studies at lake on waterbirds and invertebrates (with W.D. Williams)	Organise funding for further work, publish invertebrate results (W.D. Williams Adelaide Uni).
	Seasonal usage	3	South west surveys (RAOU, J Lane)	Article published concerning Vasse-Wonnerup waterbird populations (J. Lane)	Publish (RAOU)
		4	Waterbird use of wetlands of Swan Coastal Plain (S Halse, A. Storey, RAOU)	Wetlands selected, observers recruited and bird surveys undertaken. Project Biologist appointed and environmental data collected for wetlands.	Continue data collection, preliminary analysis.
	Invertebrate conservation status	5	Ostracod taxonomy (S Halse)	None	Publish prepared species descriptions (P. DeDeckkes,ANU), continue surveys and describe new species as found.
		6	South-west surveys (S Halse, A. Storey)	Sampled 40 lakes with UWA Honours students, continued analysis of earlier surveys.	Publish results from UWA work, continue to analyse and publish earlier work.
Status of waterbird Populations	Annual abundance	7	November & March counts (S Halse, RAOU)	Completed 1989/90 counts. Submitted 1988/89 work for publication.	Publish 1989/90 work and undertake 1990/91 counts.
	Duck banding	8	Analysis of historical data (S Halse)	Submitted paper on annual survival rates. Decided to delay preparation of duck movement paper because currently collecting more data.	None (project finished)
	Egret Colonies	9	Location, size and numbers (RAOU, J Lane)	Report Published (RAOU)	-
	Pelicans	10	Analysis of banding and tagging program.	None	Analyse results and prepare for publication
Wetland Ecosystem Dynamics	Wetland monitoring	11	Sept & Nov surveys (J Lane)	Sept & Nov 1989 surveys undertaken	Do Sept & Nov 1990 surveys

Primary Objectives	5 Year Goals	Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
	Environmental parameters	12 RAOU waterbird survey analysis (S Halse, M Williams)	Continuing to prepare paper on waterbird habitat preferences	Publish
	Impact of Mosquito Control	13 Leschenault Inlet (S Halse)	Preparing paper for publication	Publish
	Ducks and salinity	14 Breeding success in south-western Australia (S Halse)	Continued work on techniques as part of Swan Coastal Plain Project.	Continue development of techniques
	Food selection	15 Diet in fresh water (S Halse)	None	Continue on ad-hoc basis
	Midge nuisance control	16 Midge Research Steering Committee (J Lane)	Control methods tested. Monitoring procedures developed.	Field testing of growth regulators.
	Herdsman pesticides	17 Organochlorines in swamphens (S Halse)	None	Publish (J.Davis, Murdoch Uni)
	Wetland vegetation	18 Longterm monitoring (S Halse)	None	Publish
	Lead shot	19 Gizzard contents analysis (J Lane)	Additional wing and gizzard samples taken from selected species.	Chemical analysis. Report preparation.
	Yenyenning Lakes	20 Experimental flow control (J Lane)	Salinities, depths and flows monitored.	Preparation of final report.
	Vasse-Wonnerup Estuaries	21 Habitat protection guideline (J Lane)	Consideration of management issues.	Preparation of draft guidelines.
		22 Saltwater crocodile populations (RS12-13) (J Lane)	Advice given concerning requirements for monitoring of populations.	Contribute to preparation of crocodile management plan.

WOOD UTILIZATION PROGRAM

PROGRAM LEADER:

GR Siemon

CURRENT RESOURCES (1990/91)

This program comprises 4.8 persons (3.3 Professional + 1.5 Technical). Budget is under the control of the Division of Forest Resources.

RESOURCES IN PREVIOUS YEAR

The program comprised 5.8 persons (3.3 Professional + 1.5 Technical + 1 Contract Technical). Budget was under the control of the control of the Division of Forest Resources.

BACKGROUND

The Wood Utilization Program was formed as a result of the 1988 program review. The Wood Utilization Research Centre was developed in 1984, with staff from Research Division, Timber Production Branch and Harvey District involved. Input from Research includes the approval of research project plans. However, funding is through Forest Resources Division, with the major funding source from 1986 to 1990 being a Public Interest Project from the Commonwealth Government on a $1 for $2 basis (equal contributions from the State Government and the timber industry). A Departmental Policy Panel, comprising the Director of Forests, Director of Research (represented by Senior Principal Research Scientist) and Manager of the Forest Products Association (W.A.), reviews the research program quarterly.

The Department has an ongoing commitment to wood utilization research.

ACHIEVEMENTS

A log stockpiling trial showed that where storage requirements were limited, a low pressure watering system could be as effective as the higher cost high pressure systems in maintaining log quality.

Sawmilling trials of regrowth jarrah, karri and marri to produce structural timber and boards were continued, while Eastern States eucalypts such as Tasmanian blue gum and rose gum were assessed.

Drying research continued to determine efficient schedules for drying timber from green to fibre saturation point (the moisture content when cell walls start to dry and shrinking commences). Schedules for the CALM drying system were also researched. Trials of ultrasonic methods for determining moisture content were commenced at Harvey.

A major part of the research was assessing different adhesives for VALWOOD production (see Appendix VI), and the gluing behaviour of different regrowth eucalypts species.

Successful field days on timber drying at the Wood Utilization Research Centre, Harvey, resulted in research findings being taken up by industry and put into commercial practice. Wood Utilization staff delivered lectures to students in the TAFE Certificate in Timber Technology and to W.A. Forest Industries Training Committee trainees. Five WURC Reports were published during the year and eleven Technical Reports for limited distribution were prepared.

AIM

To provide scientific information to ensure efficient utilization of the timber resources of Western Australia.

PRIMARY OBJECTIVES

Processing and Marketing

To improve the use of the State's timber resources.

Sawmilling: To establish techniques for avoiding loss of wood quality and for recovery of maximum volume and value of timber.

Drying: To establish techniques for drying timber with a minimum of degrade and develop commercially viable equipment to operate those techniques.

Wood properties: To assess wood properties of regrowth eucalypts and other species.

Product development and marketing: To identify markets and develop processes to achieve added-value in products from regrowth eucalypts.

Use of residues: To improve the use of residues which result from wood processing.

Communication

To communicate research results in the form of technical and scientific publications, educational literature, committee representation, and to provide advice and liaison with other CALM staff, other Departments, and the community through training courses, seminars and general extension enquiries.

20 YEAR GOALS

1. Promote the efficient use of the States timber resources, with particular reference to added-value production by integrating utilization and marketing principles.

2. Maintain an ongoing research program to assess new technology and methods in timber processing, in both hardwoods and softwoods.

3. Monitor continuously wood quality in the State's timber resources.

5 YEAR GOALS

1. Develop an objective log grading system.

2. Establish optimum techniques for protecting wood quality in log stockpiles prior to processing.

3. Study techniques of log conversion best suited to converting regrowth eucalypts to high value timber.

4. Develop efficient initial curing schedules and commercial equipment which will allow subsequent defect-free drying to be carried out.

5. Establish efficient schedules and develop commercial equipment for drying timber from regrowth eucalypts.

6. Quantify the physical and mechanical properties of hardwoods and softwoods.

7. Study the wood destroying organisms which are of commercial significance in reducing the value of timber from regrowth eucalypts.

8. Develop a computer model of the forest products industry to facilitate efficient management of the forest resource.

9. Identify target markets with needs which could be supplied by timber from regrowth eucalypts.

10. Develop processes to meet the needs of target markets in obtaining added-value products.

11. Test the suitability of regrowth eucalypt residues for potential markets.

12. Provide extension and training facilities in timber utilization.

PROJECTS TO BE COMPLETED FROM JULY 1990 TO JUNE 1995 (numbers refer to the Table following)

2,3,4,5,6,7,8,9,10,11.

PROPOSED NEW PROJECTS - with existing resources in priority order)

Assessment of other species for VALWOOD;: Assessment of alternative adhesives for VALWOOD; VALWOOD structural products; CSIRO grader; Moisture meter for furniture; Drying craftwood; Drying schedule for sawn timber; Colour stabilisation in timber.

PUBLICATIONS AND REPORTS (1989-90) (Small Eucalypt Processing Study)

Brennan, G.K. (1989). Veneers from regrowth jarrah. W.U.R.C. Technical Report No. 10.

Brennan, G.K. (1990). Drying 25 mm boards milled from regrowth jarrah logs. W.U.R.C. Report No. 14.

Donnelly, D.J. (1990). Evaluation of milling equipment suitable for production of VALWOOD feedstock. W.U.R.C. Technical Report No. 12.

Donnelly, D.J. and Siemon, G.R. (1989). Effect of sapstaining and C.C.A. treatment on strength properties of radiata pine poles. W.U.R.C. Technical Report No. 9.

Hanks, W.R. (1990). Drying and grading marri boards. W.U.R.C. Technical Report No. 16.

Hanks, W.R. (1990). Sawmilling study of rose gum. W.U.R.C. Technical Report No. 17.

Newby, P. and Siemon, G.R. (1989). Adhesives for manufacture of furniture blanks. W.U.R.C. Report No. 12.

Rule, R. (1989). The Wickepin fence post trial after 57 years of service. W.U.R.C. Report No. 11.

Siamos, L. and Siemon, G.R. (1989). Effect of pencilling and furnace oil treatment on strength properties of jarrah. W.U.R.C. Report No. 10.

Shedley, P.N. (1989). Furniture manufacturing in Italy - a study tour. W.U.R.C. Technical Report No. 11.

Thomson, A.B. (1989). Shrinkage, collapse and dimensional recovery of regrowth jarrah. W.U.R.C. Report No. 13.

Thomson, A.B. and Hanks, W.R. (1990). Sawmilling study of Tasmanian blue gum grown in Western Australia. W.U.R.C. Technical Report No. 13.

White, K.J. (1989). Regrowth jarrah stockpile and sawmilling trial. W.U.R.C. Technical Report No. 7.

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Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
S.E.P.S. Sawmilling	Protection prior to processing	1	Stockpiling 18/85 (G Brennan)	W.U.R.C. Report	-
			19/88 (K White)	W.U.R.C. Technical Report No. 14	-
	Techniques of conversion	2	Sawmilling		-
			7/86 (G Brennan)	Report completed on regrowth jarrah sawmilling	-
			18/87 (G Brennan)	Report completed on regrowth karri sawmilling	-
			17/88 (K White)	Report completed on saw technology	-
			4/89 (K White)	Data collected on sawmilling of regrowth jarrah	Prepare report
Seasoning	Developing efficient drying schedules	3	28/85 (G Brennan)	W.U.R.C. Technical Report on drying marri	-
			9/86 (G Brennan)	Review of Lyctus completed	Ongoing joint trial with CSIRO
			6/88 (G Brennan)	Interim report on drying to fibre saturation point	Ongoing
			14/88 (B Glossop)	Research on shrinkage continued	Prepare final report
			31/89 (B Glossop)	Assess effects of treating timber before drying	Prepare report
			33/89 (T Jones) For. Resources	Commence trial of equilibrium moisture control	Ongoing
Wood Properties	Quantify physical and mechanical properties	4	Strength 26/86 (G Siemon)	Tests continued (Curtin Univ. co-operation)	Ongoing - sample for more tests
		5	Durability 41/86 (G Siemon)	CSIRO commenced test	Ongoing
		6	Wood quality 46/88 (E Davison)	Continue assessment of brown wood in karri - harvest inoculated trees	Prepare report
			15/90 (B Glossop)	Commence field trial ultrasonic moisture meter	Continue research. Prepare report
		7	Density 6/88 (G Brennan)	Data collection on wood density & moisture contents	Ongoing

Primary Objectives	5 Year Goals		Projects (RPP No.)	Tasks completed 1989-90	Targets 1990-91
Product Development	Develop processes for added-value products	8	49/88 (P Newby)	Report prepared on stability of jarrah VALWOOD	-
			50/88 (P Newby)	Report prepared on e.m.c. effect on VALWOOD	-
			51/88 (P Newby)	Postponed (assessment of USA grading rules for boards)	Collect data
			52/88 (P Newby)	Report on VALWOOD production completed	-
			25/89 (P Newby)	Complete data collection in manufacturing karri VALWOOD	Prepare report
			16/90 (G Brennan)	Treated E. globulus fence posts	Ongoing. Assess field performance.Prepare interim report
Residues	Suitability of regrowth residues for markets	9	Residues (A Thomson)	Report on drying rates of firewood completed	-
Mature Hardwoods	Quantify physical properties	10	2/89 (G Siemon)	Data on veneer recoveries collected	Prepare report
Softwoods	Quantify physical properties	11	Softwoods 30/82 (G Siemon)	Wood density assessment continued	Ongoing sampling from geographic range
	Techniques of conversion		21/88 (A Thomson)	Study of pine crown log sawn recovery	Publish as W.U.R.C. Report
	Develop process for added-value products		15/88 (D Donnelly)	W.U.R.C. Technical report on strength of pine power poles	-

Appendix I
Allocation of Staff to Programs

Abbreviations		
	DR	*Director of Research*
	SPRS	*Senior Principal Research Scientist*
	PRS	*Principal Research Scientist*
	SRS	*Senior Research Scientist*
	RS	*Research Scientist*

N.B. Source of funding is from Consolidated Revenue Funds (CRF) unless otherwise indicated.

EXECUTIVE AND RESEARCH SUPPORT

Professional Total = 6.35

A.A. Burbidge (Program Leader)	DR	Woodvale	75%
I. Abbott	PRS	Como	40%
J. Armstrong	SPRS	Herbarium	60%
J. Bartle	PRS	Como	30%
N. Burrows	SRS	Como	10%
P. Christensen	SPRS	Como	80%
D. Coates	SRS	Woodvale	10%
S. Crombie	RS	Dwellingup	20%
J. Friend	SRS	Woodvale	10%
S. Hopper	SPRS	Woodvale	60%
G. Keighery	SRS	Woodvale	10%
N. Lander	PRS	Herbarium	10%
J. Lane	PRS	Woodvale	10%
L. McCaw	RS	Manjimup	20%
J. McGrath	SRS	Como	20%
N. Marchant	PRS	Herbarium	30%
B. Maslin	PRS	Herbarium	10%
R. Moore	SRS	Busselton	10%
B. Shearer	SRS	Dwellingup	10%
G. Siemon	PRS	Como	20%
A. Start	PRS	Woodvale	50%
J. Stoddart	SRS	Marmion	10%

Technical & Clerical Total (CRF) = 18.45

R. Bowles	Dwellingup	50%
L. Cade	Woodvale	100%
J. Dorlandt	Como	100%
J. Eygenraam (part-time)	Herbarium	100% (of 2.5 days/week = 50%)
C. Farrell	Woodvale	100%
C. Frost (part-time)	Woodvale	100% (of 3 days/week = 60%)
B. Giles	Dwellingup	50%
R. Giles	Dwellingup	30%
G. Godfrey	Como	100%
V. Hamley	Herbarium	100%
J. Healey	Manjimup	100%
P. Heslewood	Woodvale	100%
R. Hick	Woodvale	100% (of 3 days/week = 60%)
J. Imms	Woodvale	100%
P. Jenkins	Busselton	10%
M. Lewis	Como	100%
D. Munro	Woodvale	10%
G. Pearson	Woodvale	20%
M. Pree	Manjimup	100%
J. Pryde	Woodvale	100%
B. Read	Busselton	10%
J. Rooney	Manjimup	20%
M. Cully	Manjimup	10%
J. Scott	Herbarium	100%
R. Sokolowski	Woodvale	20%
S. Suffling	Como	50%
H. Warren	Dwellingup	100%
A. Williams	Woodvale	5%
A. Wincza	Dwellingup	100%
L. Wong	Como	100%
Vacant	Dwellingup	100%
Vacant	Woodvale	100%
Vacant	Herbarium	100%
Vacant	Herbarium	100%

EXTERNALLY FUNDED

D. Burton		Como	100%

BIOGEOGRAPHY

Professional **Total =** **5.8**

G. Keighery (Program Leader)	SRS	Woodvale	70%
A.A. Burbidge	DR	Woodvale	5%
A.H.Burbidge	SRS	Woodvale	80%
N. Gibson	RS	Woodvale	100%
S. Hopper	SPRS	Woodvale	20%
A. Hopkins	SRS	Woodvale	25%
K. Kenneally	PRS	Herbarium	60%
N. McKenzie	PRS	Woodvale	90%
K. Morris	SRS	Woodvale	40%
S. van Leeuwen	RS	Karratha	50%
G. Wardell-Johnson	RS	Manjimup	50%

Technical **Total =** **4.9**

J. Alford		Woodvale	80%
T. Annels		Manjimup	50%
B. Bromilow		Karratha	50%
A. Brown		Woodvale	50%
P. Fuller		Woodvale	10%
M. Lyons		Woodvale	100%
J. Rolfe		Woodvale	80%
C. Vellios		Manjimup	50%
I. Wheeler		Manjimup	50%

ENTOMOLOGY

Professional **Total =** **1.4**

I. Abbott (Program Leader)	PRS	Como	40%
J. Farr	RS	Manjimup	100%

Technical **Total =** **4.0**

T. Burbidge		Como	100%
S. Dick		Manjimup	100%
P. Skinner		Manjimup	100%
P. Van Heurck		Como	100%

FAUNA CONSERVATION

Professional **Total =** **3.95**

J. Friend (Program Leader)	SRS	Woodvale	90%
D. Algar	RS	Woodvale	50%
A.A. Burbidge	DR	Woodvale	5%
A.H. Burbidge	SRS	Woodvale	15%
J. Kinnear	SRS	Woodvale	100%
N. McKenzie	PRS	Woodvale	10%
K. Morris	SRS	Woodvale	60%
R. Prince	SRS	Woodvale	50%
A. Start	PRS	Woodvale	5%

EXTERNALLY FUNDED

D. Algar		Woodvale	50%

Technical **Total =** **4.85**

P. Fuller		Woodvale	50%
T. Leftwich		Woodvale	100%
M. Onus		Woodvale	100%
J. Rolfe		Woodvale	20%
N. Thomas		Woodvale	100%
A. Williams		Woodvale	45%

FIRE

Professional **Total =** **6.0**

N. Burrows (Program Leader)	SRS	Como	85%
P. Christensen	SPRS	Manjimup	20%
A.A. Burbidge	DR	Woodvale	10%
G. Friend	SRS	Woodvale	100%
A. Hopkins	SRS	Woodvale	75%
L. McCaw	RS	Manjimup	80%
D. Pearson	RS	Woodvale	100%
A. Start	PRS	Woodvale	45%
S. van Leeuwen	RS	Karratha	50%
G. Wardell-Johnson	RS	Manjimup	50%

Technical **Total(CRF) = 10.55**

T. Annels		Manjimup	50%
P. Fuller		Woodvale	35%
J. Gardner		Woodvale	100%
M. Langley		Woodvale	100%
G. Liddelow		Manjimup	70%
K. Maisey		Woodvale	100%
D. Mitchell		Woodvale	100%
J. Neal		Manjimup	100%
A. Robinson		Manjimup	100%
R. Smith		Manjimup	100%
C. Vellios		Manjimup	50%
B. Ward		Manjimup	100%
I. Wheeler		Manjimup	50%

EXTERNALLY FUNDED

G. Hall		Woodvale	100% (of 2 days/week = 40%)

FLORA COLLECTIONS

Professional **Total(CRF) = 2.85**

B. Maslin (Program Leader)	PRS	Herbarium	80%
J. Armstrong	SPRS	Herbarium	40%
K. Kenneally	PRS	Herbarium	20%
B. Koch	RS	Herbarium	90% (of 2.5 days/week = 45%)
T. Macfarlane	RS	Herbarium	20%
P. Wilson	PRS	Herbarium	80%

EXTERNALLY FUNDED

R. Cowan (part-time)		Herbarium	100% (of 3 days/week = 60%
M. Trudgen (part-time)		Herbarium	100%

Technical **Total(CRF) = 2.15**

S. Curry		Herbarium	85%
C. Parker		Herbarium	100% (of 2.5 days/week = 50%)
P. Spencer		Herbarium	80%

EXTERNALLY FUNDED

D. Corbyn		Herbarium	100%
B. Keighery		Herbarium	100% (of 2 days/week = 40%)
S. Maley		Herbarium	100% (of 2 days/week = 40%)

FLORA CONSERVATION

Professional **Total (CRF) = 4.25**

D. Coates (Program Leader)	SRS	Woodvale	85%
A.A. Burbidge	DR	Woodvale	5%
A.H Burbidge	SRS	Woodvale	5%
S. Hopper	SPRS	Woodvale	20%
G. Keighery	SRS	Woodvale	20%
T. MacFarlane	SRS	Herbarium	60%
N. Marchant	PRS	Herbarium	20%
B. Maslin	PRS	Herbarium	10%
S. Patrick	RS	Herbarium	40%
G. Perry	SRS	Herbarium	100%
B. Rye	RS	Herbarium	40% (of 2.5 days/week = 40%)
P. Wilson	PRS	Herbarium	20%

EXTERNALLY FUNDED

A. Kelly		Woodvale	100%
F. Mollemans		Woodvale	100%
S. Carstairs		Woodvale	100% (of 3 days/week = 60%)
D. Goble-Garrett		Woodvale	100% (of 2.5 days/week = 50%)

Technical **Total =** **1.9**

J. Alford	Woodvale	20%
A. Brown	Woodvale	50%
R. Cranfield	Herbarium	20%
P. Fuller	Woodvale	5%
R. Sokolowski	Woodvale	75%
P. Spencer	Herbarium	20%

FLORA INFORMATION PROGRAM

Professional **Total (CRF) = 3.55**

N. Lander (Program Leader)	PRS	Herbarium	90%
K. Kenneally	PRS	Herbarium	20%
B. Koch	RS	Herbarium	10% (of 2.5 days/week = 5%)
T. Macfarlane	RS	Herbarium	20%
N. Marchant	PRS	Herbarium	50%
S. Patrick	RS	Herbarium	60%
B. Rye	RS	Herbarium	20% (of 2.5 days/week = 10%)
J. Wheeler	RS	Herbarium	100%

Technical **Total = 1.45**

R. Cranfield	Herbarium	80%
S. Curry	Herbarium	20%
W. Searle	Herbarium	100% (of 2.5 days/week = 50%)

MARINE CONSERVATION

Professional **Total = 1.4**

J. Stoddart (Program Leader)	SRS	CSIRO-Marmion	90%
R. Prince	SRS	Woodvale	50%

Technical **Total = 0.5**

A. Williams	Woodvale	50%

NATIVE FOREST SILVICULTURE

Professional **Total = 3.1**

S. Crombie(Program Leader)	RS	Dwellingup	80%
P. Hewett	RS	Manjimup	100%
R. Mazanec	RS	Dwellingup	30%
P. Piggott	RS	Narrogin	100%

Technical **Total = 6.4**

T. Birmingham		Dwellingup	30%
R. Giles		Dwellingup	70%
D. McDonald		Narrogin	100%
M. Mason		Dwellingup	40%
C. Portlock		Dwellingup	100%
C. Ward		Manjimup	100%
K. Whitford		Dwellingup	100%
S. Turner	RS	Watermans	100%

PLANT DISEASES

Professional **Total (CRF) = 3.3**

B. Shearer (Program Leader)	SRS	Dwellingup	90%
E. Davison	SRS	Como	50%
M. Stukely	RS	Como	100%
R. Wills	RS	Manjimup	100%

EXTERNALLY FUNDED

F. Bunny	Como	100%

Technical **Total (CRF) = 8.8**

R. Buehrig	Dwellingup	100%
C. Crane	Como	100%
M. Cully	Como	30%
M. Dillon	Dwellingup	100%
R. Fairman	Dwellingup	100%
J. Kinal	Dwellingup	100%
F. Tay	Como	50%
J. Webster	Dwellingup	100%

EXTERNALLY FUNDED

B. Morgan		Dwellingup	100%
J. Henderson		Como	100%

PLANTATION SILVICULTURE

Professional CRF = 8.4

J. McGrath (Program Leader)	SRS	Busselton	80%
T. Butcher	SRS	Como	100%
R. Harper	RS	Albany	(contract)100%
R. Mazanec	RS	Dwellingup	70%
R. Moore	SRS	Busselton	90%

EXTERNALLY FUNDED = 4.0

D. Bicknell	Esperance	100%
G. Ellis	Manjimup	100%
B. Mattinson	Albany	100%
R. Silberstein	Busselton/Ludlow	100%

Technical CRF 15.7

T. Birmingham	Dwellingup	70%
M Cully	Manjimup	90%
I Dumbrell	Busselton	100%
R Hingston	Busselton	100%
P. Jenkins	Busselton	90%
M. Mason	Dwellingup	60%
B. Read	Busselton	90%
P. Solar	Albany	(contract)100%
J. Stritoff	Como/Wanneroo	100%
S. Suffling	Como	100%
A. Wills	Como	100%
L. Wong	Como	90%
Vacant (ex Sanders)	Manjimup	100%

EXTERNALLY FUNDED = 3.8

D. Bennett	Busselton/Ludlow	100%
J. Merrifield	Como	100%
N. Pettit	Leederville(WAWA)	100%
D. Vincent	Esperance	80%

RESEARCH TECHNIQUES

Professional Total = 4.00

M.Choo (Program Leader)	SRS	Woodvale	100%
D. Ward	SRS	Como	100%
M. Williams	RS	Como	90%
A. Chapman	RS	Manjimup	100%

Technical Total = 1.1

P. Gioia	Woodvale	100%
A. Wincza	Dwellingup	90%
Y. Woods	Manjimup	100%

WETLANDS AND WATERBIRDS

Professional Total = 1.9

J. Lane (Program Leader)	PRS	Woodvale	90%
S. Halse	SRS	Woodvale	100%

EXTERNALLY FUNDED = 1.0

A. Storey	RS	Woodvale	100%

Technical Total = 1.7

D. Munro	Woodvale	90%
G. Pearson	Woodvale	80%

WOOD UTILIZATION

Professional	**Total =**	**3.30**		
G. Siemon (Program Leader)		PRS	Como	80%
G. Brennan		RS	Harvey	100%
E. Davison		SRS	Como	50%
B. Glossop		RS	Harvey	100%
Technical	**Total (CRF) =**	**1.50**		
F. Tay			Como	50%
J. Pitcher			Harvey	100%

Appendix II

Current Research Projects

Active Research Project Plans
(incorporating Research Working Plans and Research Plans)

The Executive and Research Support Program and the Research Techniques Program are omitted as these do not have research projects at present.

Until 1 July 1988 the Herbarium came under the control of the Department of Agriculture and did not run on a Research Project Plan system. Research Project Plans for the Flora Information Program consist only of a number transferred from the Flora Conservation Program.

** indicates RPP No. not allocated*

RPP No	TITLE	PRINCIPAL INVESTIGATOR
BIOGEOGRAPHY		
20	Biogeography patterns vs soil attributes	N McKenzie
52	Establishment of monitoring program in CALM	A Hopkins
56	Atlas of all Western Australian Proteaceae (except Banksia)	A Hopkins
59	Report on survey work at Tutanning Nature Reserve	A Hopkins
60	Report on survey work at Middle Island/Recherche Archipelago	A Hopkins
60	Report on survey work at Mount Lesueur	A Hopkins
63	Report on survey work at Two Peoples Bay	A Hopkins
75	Cooloomia Nature Reserve	AA Burbidge *et al*
92	Biogeography of the flora of southern Nullarbor	G Keighery
94	Islands: Lancelin to Dongara	GJ Keighery
95	Stirling Range and Environs Flora	GJ Keighery
99	Ecological Survey of proposed Boonanaring Reserve	AH Burbidge & GJ Keighery
120	Extending the Nullarbor data base: do the patterns change?	N McKenzie *et al.*
121	Assemblage changes over 12 months at Cocklebiddy	N McKenzie *et al.*
121	Lizard litter patch guilds	N McKenzie
122	Development of a microcomputer entry system for ecological survey data and entry of sections of the E. Goldfields vertebrate data base **(consultancy let by)**	N McKenzie
125	Biological survey of sites on the Mandora palaeoriver and Radi Hills, Great Sandy Desert	N McKenzie
126	Late Holocene mammal fauna of the Irwin & Carnarvon districts, Western Australia **(consultancy let by)**	N McKenzie
127	Fitzgerald River National Park Survey-F.R.N.P.S. Association consultants	N McKenzie
128	Buccaneer Archipelago	N McKenzie *et al.*
129	Automatic bat assemblage sampling	N McKenzie
132	Biological survey of islands in the north-west	K Morris
132	Vertebrate Fauna Survey of Dampier Archipelago	K Morris
132	Vertebrate Fauna of Monte Bello Islands	K Morris
132	Management Guidelines for Monte Bello Islands	K Morris
141	Dorre Island and Associated Shark Bay Islands - Ecological Survey	R Prince
1/83	Distribution and taxonomic status of the Geocrinia	G Wardell-Johnson
1/83	Trial mapping of community-types in regenerating Karri forest	G Wardell-Johnson
44/88	Endemic Forest Eucalypt survey	G Wardell-Johnson
*	Salisbury Island	AA Burbidge *et al.*
*	Acquire computer tape of the RAOU Atlas of Australian Birds data base for Western Australia	AH Burbidge (developmental)
*	Bibliography on, and appraisal of, the contemporary status of the vertebrae fauna of the northern Irwin and southern Carnarvon districts. **(consultancy let by)**	AH Burbidge (developmental)

RPP No	TITLE	PRINCIPAL INVESTIGATOR
*	Acquire up-to-date microcomputer software to pre-process (append and edit) and analyse large matrices of ecological survey data. Maintain and develop expertise in the use of these procedures for a wide variety of data types	N McKenzie (developmental)
*	Cape Arid Survey	AH Burbidge *et al.*
*	Yanchep National Park Survey	AH Burbidge
*	Walpole-Nornalup National Park survey	G Wardell-Johnson
*	Searching versus Pitfall Trapping in Southern Forests Surveys	G Wardell-Johnson
*	Bird census results in Southern Forests Surveys	G Wardell-Johnson
*	Rainforest Survey	N McKenzie *et al.*
*	Buccaneer Archipel. Management Plan	R Prince
*	Bat assemblage structure studies disturbance and determinism	N McKenzie
*	Vegetation of Dryandra State Forest **(consultancy let by)**	G Keighery
*	Recherche Monitoring Sites	A Hopkins
*	Interactions of Fire and Site on Vegetation in the Walpole-Nornalup National Park	G Wardell-Johnson
*	Bird communities of the Walpole-Nornalup National Park	G Wardell-Johnson
*	Assessment of effect of mining exploration on D'Entrecasteaux NP	N Gibson
*	Conservation status & biology of granite rock endemics of the Wheatbelt	SD Hopper
*	Conservation status & biology of granite rock endemics of the karri forest	SD Hoper
*	Conservation of the status and biology of granite rock endemics of the pastoral region.	SD Hopper
*	Conservation of the status and biology of granite rock endemics of the south coast	SD Hopper

ENTOMOLOGY

20/84	Leaf dynamics of Jarrah in relation to impact of Jarrah Leafminer.	I Abbott
27/84	Effect of Jarrah Leafminer on growth of Jarrah incipient ground coppice after fire.	I Abbott
2/85	Comparison of insect damage to Jarrah ground coppice in the southern and northern Jarrah forests.	I Abbott
23/85	The annual cycle of abundance and composition of the insect fauna of the southern Jarrah forest canopy, with special reference to *Uraba lugens*	I Abbott
32/85	External symptoms of infestation of Karri by the borer *Tryphocaria acanthocera*	I Abbott
24/86	The impact of repeated defoliations on the wood growth of Jarrah saplings.	I Abbott
59/86	Survey of the incidence of infestation of the borer *Tryphocaria acanthocera* in even-aged Karri.	I Abbott
61/86	Crown deterioration of Jarrah poles in the southern Jarrah forest following grazing of leaves by insects.	I Abbott
19/87	Effect of fire on Gumleaf Skeletonizer, Jarrah Leafminer and other invertebrates of Jarrah crowns in the southern Jarrah forest.	I Abbott
44/87	Damage to Jarrah foliage caused by Jarrah Leafminer in Collie District.	I Abbott
45/87	Crown condition and wood growth of codominant/subdominant Jarrah poles resistant and susceptible to Jarrah Leafminer infestation in Collie District.	I Abbott
47/87	Survey of Jarrah Leafminer in Jarrah forest between Collie and Dwellingup.	I Abbott
48/87	Survey of Gumleaf Skeletonizer in Jarrah forest between the currently infested zone and Greenbushes, Mayanup and Nannup.	I Abbott
20/88	Operational scale testing of the effectiveness of a single Autumn fire in controlling Jarrah Leafminer.	I Abbott
39/88	Survival of *Uraba lugens* on W.A. eucalypts	J Farr
41/88	Fecundity of *Uraba lugens* in relation to pupal mass.	J Farr
42/88	Spatial distribution of *Uraba lugens* pupae in relation to its Jarrah host.	J Farr
22/89	Impact of prescribed fire on infestation by Jarrah Leafminer	I Abbott
5/90	Impact of recent logging of Jarrah forest on the population density of Jarrah leafminer	I Abbott
22/90	Life cycle of *Cardiaspina brunnea*	J Farr

RPP No	TITLE	PRINCIPAL INVESTIGATOR
23/90	Population monitoring of *Cardiaspina brunnea* on *Eucalyptus occidentalis*	J Farr
24/90	Crown decline of *Eucalyptus occidentalis* due to infestation with *Cardiaspina brunnea*	J Farr
25/90	Adult emergence of *Cardiaspina brunnea*	J Farr
26/90	Stage of development of *Cardiaspina brunnea*	J Farr
FAUNA CONSERVATION		
9/86	Western Swamp Tortoise: population monitoring	AA Burbidge
10/86	Western Swamp Tortoise - captive breeding	AA Burbidge
11/86	Breeding seabirds data base	AA Burbidge
12/86	Island mammal data base	AA Burbidge & IJ Abbott
17-18/86	Conservation of the Ground Parrot in Western Australia	AH Burbidge
39-41/86	Numbat study: habitat and food sources	JA Friend
42-43/86	Numbat study: translocation and re-establishment	JA Friend
43-44/86	Ecology of the Western Barred Bandicoot	JA Friend
44/86	Taxonomy & zoogeography of Australian landhoppers	JA Friend
102-103/86	Woylie conservation studies	JE Kinnear
104/86	Rock-wallaby conservation - wheatbelt & other areas	JE Kinnear
105-106/86	Ecology of Predation by the Fox	JE Kinnear
106-8/86	Rock-wallaby conservation - Dampier Archipelago	JE Kinnear
108-9/86	Rock-wallaby conservation - Eastern Pilbara	JE Kinnear
111/86	Optimization of fox control in W.A. - fox biology and control	D Algar
130/86	Chiropteran Studies: *Mormopterus* taxonomy	N McKenzie
132/86	Mammals of Pilbara Islands - *Leggadina lakedownensis*	KD Morris
147-149/86	Conservation of the Chuditch	KD Morris
*	Kangaroo management program (Wildlife Management Policy No. 3)	RIT Prince *et al.*
*	Conservation of the Hooded Plover in Western Australia	AH Burbidge
*	Feral animal control - N.W. Islands	KD Morris
FIRE PROGRAM		
28/78	Forest fire behaviour under dry fuel conditions (Jarrah)	N Burrows.
7/84	Regeneration of heartleaf thickets	G Wardell-Johnson
8/84	Fire, season and termite activity.	G Wardell-Johnson
15/85	Fire damage to regenerated Karri stands	L Mc Caw
21/85	Prescribed fire behaviour in regenerated Karri stands.	L McCaw
12/86	Effects of five fire regimes on forest understorey species.	N Burrows
14/86	The development of spot fires in the forest.	N Burrows
15/86	A computer - based wildfire information storage and retrieval system.	N Burrows
18/86	The combustion rate of forest fuels.	N Burrows
22/86	Karri forest bird community study.	G Wardell-Johnson
47/86	Fuel studies in southern wetlands.	N Burrows
59-62	Computerized fire management system - Tutanning Nature Reserves.	A Hopkins
60	Fire effects studies on vegetation, Eneabba and Mt Lesuer.	A Hopkins
60-61	Fire effects studies on vegetation, Recherche Archipelago.	A Hopkins
62-63	Fire effects studies on vegetation, Tutanning Nature Reserves.	A Hopkins.
63	Fire effects studies on vegetation, Two peoples Bay Nature Reserve.	A Hopkins
15/87	Effects of various fire control straegies in heathland and shrubland vegetation.	L McCaw
23/87	The effect of fire on *Lambertia rariflora*	N Burrows
46/87	The formation of hollows in karri and marri trees.	G Wardell-Johnson
20/88	Effects of mosaic burns on birds in hummock grasslands	AA Burbidge
22/88	Fire behaviour in heathlands and shrublands.	L McCaw
25/88	Aerial burning techniques for hummock grasslands.	N Burrows
30/88	Effects of fire on heathland and shrubland vegetation of the Stirling Range National Park.	A Hopkins
31/88	Effects of fire on reptiles, frogs and small mammals in the Stirling Range National Park.	G Friend
32/88	Effects of season of burn and fire size on desert vertebrates.	D Pearson
33/88	Effects of fire season and intensity on floral succession in Queen Victoria Spring Nature Reserve	D Pearson
34/88	Effects of patch burning on lizards in hummock grasslands.	D Pearson

RPP No	TITLE	PRINCIPAL INVESTIGATOR
35/88	Appraisal of thematic mapping for mapping hummock grassland vegetation.	D Pearson
36/88	Computerized fire management system - forest regions.	J Beck (Protection Branch)
37/88	Aboriginal knowledge of fire management on hummock grasslands.	D Pearson
38/88	Effects of fire on medium - sized desert mammals.	P Christensen
11/88	An age series of floristics in a single community type	G Wardell-Johnson
1/89	Regeneration strategies of vascular plants of the Walpole-Nornalup National Park (a flowering calendar for the Walpole-Nornalup National Park)	G Wardell-Johnson
11/89	The response of terrestrial vertebrate fauna to disturbance in karri forest.	G Wardell-Johnson
15/89	Monitoring post fire vegetation response in the Gibson Desert and Plumbridge Lakes Nature Reserves	N Burrows
16/89	Fire effects on invertebrates in the Stirling Ranges National Park	G Friend
17/90	Effects of prescribed burning on small vertebrates in Tutanning Nature Reserve	G Friend
18/90	Effects of prescribed burning on invertebnrates in Tutanning Nature Reserve	G Friend
19/90	Effects of prescribed burning on invertebrates in Durokoppin and East Yorkrakine Nature Reserves	G Friend
21/90	Effects on prescribed burning on *Phascogale calura* (externally funded)	G Friend
*	Effects of patch-burning and feral predator control on the survival of rare mammals re-introduced to the Gibson Desert Nature Reserve	P Christensen
*	The association between plant communities, landform/soils and burning history, Perup Nature Reserve	G Wardell-Johnson
*	Regeneration of suitable habitat for the Tammar Wallaby using prescribed fire	P Christensen

FLORA CONSERVATION

25	Conservation genetics of rare flora.	DJ Coates
26	Genetic systems of rare flora.	DJ Coates
26	Life history and eco-geographic studies of rare flora.	DJ Coates *et al.*
27	Germ plasm storage program for rare and endangered and rapidly declining flora.	DJ Coates *et al.*
28	Determination of the hybrid status of some rare flora.	DJ Coates *et al.*
29	Conservation status and genetic variability in six commercially exploited, geographically restricted and dieback susceptible species.	DJ Coates
30	Conservation status and genetic variability in four dominant but rapidly declining species.	DJ Coates
30	Phylogenetic and breeding system studies in the genus *Eremaea* (Myrtaceae).	DJ Coates
31	Hybridization and gene exchange in a Stylidium contact zone.	DJ Coates
66	Additions and deletions to the declared endangered flora.	SD Hopper *et al.*
68	Presumed extinct and very rare whealtbelt plants.	SD Hopper
69	Data base on rare and geographically restricted plants of Western Australia.	SD Hopper *et al.*
70	Licensing and management of the wildflower industry.	SD Hopper *et al.*
71	Reservation status of commercially exploited taxa.	SD Hopper
72	Conservation of two kangaroo paw species. M.App.Sci students Curtin University, Supervisors and	SD Hopper
72	Harvesting techniques used in the wildflower trade.	SD Hopper
73	Review of rare flora conservation in Western Australia.	SD Hopper *et al.*
74	Flora poster, leaflets, magazine articles and public lectures.	SD Hopper *et al.*
76	Atlas of Western Australia flora pilot project (orchids).	SD Hopper
77	Native trees and tall shrubs of Perth - guide and atlas	RJ Powell/ SD Hopper
78	Orchids of metropolitan Perth.	AP Brown/ SD Hopper
82	Bird pollination, nectar flow and the mating system of *Ecualyptus caesia*	SD Hopper *et al.*
83	Conservation status, morphometrics and allozyme variation on *Eucalyptus marcrocarpa* and allied species.	SD Hopper.
87	A guide to the Eucalypts of the Stirling Range.	SD Hopper *et al.*
87	*Eucalyptus carnabyi* - rare hybrid or relict species?	SD Hopper
90	Pollination biology of the Australian flora.	SD Hopper

RPP No	TITLE	PRINCIPAL INVESTIGATOR
95	Conservation, ecology and biology of Western Australia Tremandraceae.	GJ Keighery
96	Garden escapes, naturalized flora of Western Australia.	GJ Keighery
97	Systematics of Western Australia flora.	GJ Keighery
97	Biology of Western Australia plants.	GJ Keighery
*	Undertake field surveys of poorly known high priority species at risk.	DJ Coates *et al.*
*	Endangered Flora Wildlife Management Plan for *Acacia anomala.*	DJ Coates
*	Endangered Flora Wildlife Management Plan for *Drakaea jeanensis.*	SD Hopper
*	Endangered Flora Wildlife Management Plan for *Banksia cuneata*	DJ Coates
*	Endangered Flora Management Plan for *Stylidium corniforme*	DJ Coates
*	Endangered Flora Management Plan for Northern Forest Region. **Consultant botanists**	SD Hopper
*	Reproductive biology and management of *Eucalyptus rhodantha*	J Sampson, SH James (U.W.A.), SD Hopper
*	Eucalyptus of Western Australia salt lakes including the new series *Rigentes* with three new species. MIH Brooker (CSIRO, Forest Research),	SD Hopper
*	Systematics of the genus, *Stylidum*	DJ Coates
*	Atlas of rare and endangered W.A eucalyptus.	SD Hopper *et al.*
*	Wildflower Industry Wildlife Management Plan *Anigozanthus pulcherrimus* and *Macropidia fuliginosa*	SD Hopper
*	Review the distribution and commercial utilisation of *Boronia* species and develop a Wildflower Industry Management Plan.	SD Hopper *et al.*
*	Carry out an annual review of ANPWS statistics on Western Australia's cut flower trade.	DJ Coates
*	Orchids Pollination Book.	SD Hopper *et al.*
*	Orchids of Kalbarri, Leeuwin- Naturaliste, Walpole-Nornalup, Fitzgerald River and Cape Le Grand National Park.	SD Hopper *et al.*
*	Book on rare and endangered W.A. flora.	SD Hopper
*	Garden escapes, naturalised flora of Western Australia.	S Patrick
*	Control and organisation of District Reference Field Herbaria & Regional Herbarium.	S Patrick
*	Isolation of records from incoming material for 1) Additions and deletions to the declared endangered flora 2) Presumed extinct and very rare wheatbelt plants 3) Database on rare and geographically restricted plants of W.A.	S Patrick & RJ Cranfield
*	Co-ordination of Herbarium contribution to field surveys of Declared and Rserve taxa.	N Marchant *et al.*
FLORA INFORMATION		
*	Flora of the Kimberley Region	JR Wheeler *et al.*
	Flora of the Perth Region (revision)	NG Marchant *et al*
	Field Guide to south western Myrtaceae	NG Marchant & JR Wheeler
	Identification guide to Declared and Reserve List Taxa	S Patrick
	Identification guide to allergenic plants, weeds and other economically important flora	S Patrick
*	New taxa of *Drosera*	NG Marchant
*	Revision of *Actinodium*	NG Marchand & GJ Keighery
*	Revision of *Chamelaucium*	NG Marchant & GJ Keighery
*	Revision of *Darwinia*	NG Marchant & GJ. Keighery
*	Revision of *Olearia*	NS Lander
*	Taxonomiuc studies in *Hibbertia*	JR Wheeler
MARINE CONSERVATION		
133/86	Conservation of Western Australian marine turtles	RIT. Prince *et al.*
142	Biogeography of Dugong and Seagrasses in northern Western Australia	R Prince
142-144/86	Dugong conservation - northern Western Australia	RIT Prince *et al.*
142-145/86	Management of Dugong & marine turtle exploitation in northern Western Australia	RIT Prince *et al.*
1/90	Recreational Fishing Survey - Marmion	JA Stoddart

RPP No	TITLE	PRINCIPAL INVESTIGATOR
2/90	Coral Reef Assessment	JA Stoddart

PLANT DISEASES

34/83	Long term monitoring of impact of *P. cinnamomi*	B Shearer
40/83	Prediction of impact of *P. cinnamomi* from site indication,	B Shearer
14/84	Assessment of dieback damage to jarrah roots.	B Shearer
23/84	Effect of high and moderate dieback on hillslope hydrology.	B Shearer
25/84	Long term dieback monitoring in a high/moderate impact site 10B.	B Shearer
09/85	Long term monitoring of a concave area near Deer Road.	B Shearer
42/85	Resistance of *E. marginata* to *P. cinnamomi*	M Stukely
64/86	An hydraulic model of root, stem, branch and leaf tissue of jarrah.	S Crombie
65/86	Water relations of jarrah dieback.	S Crombie
72/86	Injection of healthy *Banksia seminuda* with fungicide, (Forestyl-Al).	B Shearer
73/86	The association of pathogens with mortality of *Eucalyptus* species.	B Shearer
75/86	The impact of *A. luteobubalina* in the Wandoo forest.	B Shearer
76/86	Population dynamics of P. c. in jarrah/banksia.	B Shearer
77/86	The effect of phosphorus acid on lesion development of P.c.	B Shearer
04/87	Comparison of the rate of spread of dieback in jarrah/banksia.	B Shearer
22/87	Pattern of invasion and survival of P.c. in *Banksia attenuata*.	T Hill
23/87	Distribution of Phytophthora species north of Perth, their impact.	T Hill
24/87	Treatment of isolated outbreaks of *P.c.*	T Hill
34/87	Validation of the *P.c.* hazard rating system.	B Shearer
35/87	Phenology of *P.c.* hazard rating indicators.	B Shearer
37/87	Simulation of the hydrology of coastal heathland sandy soils in relation.	B Shearer
43/87	Quantification of jarrah deaths with time using 70 or 230mm aerial photography.	B Shearer
49/87	An investigation of the cause of death and decline of tuart.	B Shearer
50/87	Frequency of barrier zones in xylem of jarrah on dieback sites.	S Crombie
51/87	Water status of jarrah on thinned and unthinned sites in the Northern Jarrah Forest.	S Crombie
52/87	An hydraulic model of root stem, branch and leaf tissue of jarrah.	S Crombie
53/87	Measuring transpiration in jarrah using the automatic heat pulse.	S Crombie
55/88	Identification of Eucalypt canker fungi	E Davison
56/88	Water relations and growth of jarrah in high, medium and low impact	S Crombie
57/88	Water relations of jarrah coppice and trees	S Crombie
05/89	Effect of season on *P. cinnamomi* sporulation	B Morgan
06/89	Zoospore survival at different matric potentials	B Moran
08/89	Canopy density, soil temperature and *P. cinnamomi*	J Kinal
23/89	Extension of *P. cinnamomi* and thinning	F Bunny
26/89	Protect *B. brownii, B. baxteri, B. coccinea* by phosphorous acid	B Shearer
29/89	Infection *Pinus radiata* clones by *Phythophthora* spp.	Stukely/Davison
32/89	Control of *Phizoctonia* in *P. radiata* seedlings	E Davison
36/89	Impact *Phytophthora* spp. coastal plain Perth to Cape Leeuwin	B Shearer
03/90	Cankers killing *Banksia coccinea*	B Shearer
*	Extension of *P. cinnamomi* in jarrah coppice and saplings	F. Bunny
*	Field trials *P. cinnamomi* resistant jarrah	M Stukely
*	Screening jarrah provenances for *P. cinnamomi* existence	M Stukely
*	*P. radiata/Phytophthora* inoculation trials	M. Stukely
*	Jarrah growth Churchmans/Karnet	E Davison
*	Impact of *P. cinnamomi* in Stirling Range National Park	R Wills

PLANTATION SILVICULTURE

Pine

16/58	*P. pinaster* growth trial at Gnangara.	T. Butcher
19/62	*P. pinaster* seed orchards No. 1 Joondalup, No 2 Mullaloo.	T Butcher
3/65	*P pinaster* provenance trial at Gnangara	T Butcher
20/65	Basal area control of thinning in *P. pinaster,* Bassendean sands	T Butcher
21/65	*P. pinaster* progeny trials widespread throughout SW Australia	T Butcher
27/65	*P. radiata* early thinning for particle board	R Moore
7/66	*P radiata* non-commercial thinning	R Moore
12/66	*P. radiata* first thinning study	R Moore
48/66	Establishment of large pilot plots for *P. pinaster*	T Butcher
54/66	Basal area control of thinning in *P. pinaster*	T. Butcher
17/67	*P. pinaster* response to phosphate on leached Bassendean sands	T Butcher

RPP No	TITLE	PRINCIPAL INVESTIGATOR
25/67	Bussel's arboretum at Collie	R Moore
26/67	Meribup arboretum at Manjimup	R Moore
27/67	Asplin's arboretum at Nannup	R Moore
20/68	Hydrology in *P. pinaster* stands	T Butcher
34/68	*P. radiata* seed orchard at West Manjimup	T Butcher
16/69	Pine establishment trial at Mt Cooke.	T Butcher
21/71	*P. radiata* international gene pool progeny test (RS4 and RS5)	T Butcher
22/71	*P. radiata* progeny trials throughout SW Australia	T Butcher
29/71	Productivity of second rotation pine at Gnangara and Grimwade	T Butcher
8/72	Fertiliser and thinning for *P. pinaster* on Bassendean grey sand	T Butcher
19/72	*P. radiata* genetics yield trial	T Butcher
20/72	*P. pinaster* genetics yield trial	T Butcher
15/73	Grazing and forestry combination in Blackwood Valley	R Moore
23/73	Subsequent fertilisation of *P. pinaster* on yellow sands	T Butcher
10/75	Agroforestry plan for Chapman's Lease.	R Moore
20/75	Pilot plots of *P. radiata* at Moore River	T Butcher
20/76	Early fertilization of P. pinaster on marginal sites	T Butcher
21/76	Fertilization of adolescent *P. pinaster* on yellow sands	T Butcher
23/76	Fertilization of adolescent *P. pinaster* on grey sands	T Butcher
2/78	Agroforestry trial at Wonnerup	R Moore
20/78	Agroforestry regimes with P. radiata	R Moore
29/78	*P. radiata* provenance trial at Busselton [RX. 6(1979)]	T Butcher
30/78	*P radiata* genetic variation in dieback resistance	T Butcher
25/79	Provenance trials of *P. taeda* and *P. serotina* in sunkland	T Butcher/ M Stukely
4/80	Agroforestry trial jarrahwood	R Moore
7/80	Strip planting of pines for agroforestry	R Moore
26/80	*P. pinaster* high pruning trial	T Butcher
2/81	Timing of fertiliser for maximum response in *P. pinaster*	T Butcher
4/81	Agroforestry trial in Wellington Catchment	R Moore
10/81	Agroforestry species trial Vasse 2	R Moore
2/82	Silviculture alternatives for fuel reduced buffers	R Moore
5/82	Comparison of silvicultural regimes for Sunkland *P. radiata*	R Moore
7/82	*Pinus pinaster* second rotation studies	T Butcher
9/82	Forms of nitrogen nutrition for *P. radiata*	J McGrath
19/82	Phosphorus regimes for pastured pine	J McGrath
21/82	Pine progeny trials in the Wellington catchment	T Butcher
33/82	Pine cuttings for agroforestry	R Moore
42/82	Agroforestry trials at Esperance	R Moore
44/82	Phase 3 pine species trial for Sunkland (4 species)	R Moore
45/82	Effect of pruning on wide spaced *P. radiata*	R Moore
3/83	Comparison of form and set lift pruning in *P. radiata*	R Moore
6/83	Effect of *P. radiata* thinning on wind stability	R Moore
7/83	Early thinning of *P. radiata* on clover in Sunklands	R Moore
15/83	Combination of Alnus sp. and *P. radiata*	J McGrath
25/83	Adjacent 1R/2R pinaster on good/marginal sands at Yanchep	T Butcher
29/83	Cultivation and fertilisation of marginal *P. pinaster* sites at Pinjar	T Butcher
28/83	Effect of initial stocking on future growth of *P. radiata* crop trees	R Moore
30/83	*P. radiata* non commercial thinning	R Moore
39/83	Screening established *P. radiata* for dieback resistance	M Stukely
14/84	Sunkland site trial *P. radiata* Phase III	P Jenkins
1/85	Effect of nitrogen supply on *P. radiata* growth	J McGrath
8/85	*P radiata* response to N and P after thinning on red loams	J McGrath
17/85	Phosphorus supply and concentration in *P. radiata* needles	J McGrath
2/86	Timber and agricultural production from two stand densities of pine agroforestry in the Manjimup area	R Moore
9/87	Timing of fertilization in thinned *P. radiata*	J McGrath
10/87	Frequency of fertilization in thinned *P. radiata*	J McGrath
11/87	The effect of thinning and fertilization on growth of *P. radiata*	J McGrath
33/87	Initial Fertilizer requirements for *P. radiata* on the South-Coast	J McGrath
18/88	Initial weed control and fertilization of *P. radiata* on the South Coast	J McGrath
43/88	Drought survey in the Blackwood Valley pine plantations	J McGrath
*	Chemical emasculation of *P. radiata*	T Butcher
*	Search 85 radiata breeding population	T Butcher
*	Soil-productivity relationships in south-coast radiata pine plantations	R Harper
Hardwood		
14/76	Rehabilitation species trial	JR Bartle
12/78	Rehabilitation species trial	JR Bartle

RPP No	TITLE	PRINCIPAL INVESTIGATOR
31/78	Rehabilitation species trial	JR Bartle
27/80	*E. globulus* provenance trial	T Butcher
4/81	1981 Agroforestry trial - Wellington catchment	R Moore
6/81	*E. wandoo* progeny trial.	R Mazanec/ T Butcher
10/81	Agroforestry species trial (Vasse 2)	R Moore
24/82	*E. wandoo* provenance/family trial on bauxite pit site at Jarrahdale	R Mazanec/ T Butcher
25/82	*E. wandoo* provenance/family trial on Wellington catchment (Souths Farm)	R Mazanec/ T Butcher
38/82	*E. maculata* provenance trials	R Mazanec
40/82	Geographic variation in *E. wandoo*	R Mazanec/ T Butcher
43/82	Esperance Agroforestry trial	R Moore
9/83	Mulching Trial (Flynn's)	R Moore
38/83	*E resinifera* provenance trial	R Mazanec
32/84	*E globulus* family/provenance trial	R Mazanec
33/84	*E accedens* family/provenance trial	R Mazanec
34/84	*E camaldulensis* provenance trial	
5/85	*E. wandoo* gene pool	R Mazanec/ T Butcher
4/86	*E. accedens* family/provenance trial	R Mazanec
5/86	*E pilularis* family/provenance trial	R Mazanec
49/86	P85 Species performance measurements Ricetti high mounds	P Ritson
50/86	Ricetti high mounds arboretum	P Ritson
51/86	Effect of salt leaching from low soil mounds on tree establishment	P Ritson
52/86	Atriplex species trial	P Ritson
79/86	The effect of sowing depth on tree seed germination	P Piggott
2/87	Eucalypt Agroforestry Trial (Busselton, Dinninup and Middlesex)	R Moore
5/87	*E. sideroxylon* family/provenance trial	R Mazanec
7/87	Mound design for reforestation of saline seeps in the Wellington Catchment	P Ritson
8/87	*E saligna* family/provenance trial	R Mazanec
13/87	Effect of superphosphate on the germination of a variety of eucalypt and Acacia species	P Piggott
16/87	Fertilizer Trial	P Ritson
21/87	Tree spacing trial on high mounds	P Ritson
25/87	Drainage trial	P Ritson
26/87	Optimum sowing technique for direct seeding native tree species	P Piggott
28/87	Field assessment of pre and post emergent herbicides on a range of native tree species	P Piggott
29/87	The effect of post emergent herbicides on a range of native tree species	P Piggott
30/87	Species performance trial	P Ritson
31/87	Mound age trial	P Ritson
32/87	Mulching trial	P Ritson
56/87	Pyrethrum knockdowns of phytophageous insects on sapling wandoo	P Brown
40/87	Seedling containers trial	P Ritson
41/87	Fertilizer pellets trial	P Ritson
55/87	*E. globulus* coppicing trial	P Ritson
5/88	Species selection for difficult high saline/waterlogged sites	P Ritson
7/88	Hardpan ripping trial	P Ritson
8/88	Double ridge mound design trial	P Ritson
10/88	*E. microcarpa* family/provenance trial	R Mazanec
48/88	*E. microcarpa* provenance trial	T Birmingham/R Mazanec
53/88	*E. muellerana* family/provenance trial	R Mazanec
54/88	*E. muellerana* family/provenance trial	R Mazanec
(264.54)*	Flynn's Agroforestry Trial	R Moore
(264.52)*	Wellbucket Agroforestry trial	R Moore
(264.51)*	Effect of extensive tree planting on salt (Flynn's)	R Moore
(264.53)*	Landscape trial (Flynn's)	R Moore
11/89	*E. botryoides* family/provenance trial	R Mazanec
27/89	Tree growth response to blasting Peel hardpan	
28/89	Tree growth response to subsoil ripping	G Stoneman
29/90	Yield testing prospective pulpwood species, provenances and clones	J Bartle/G Ellis
35/89	Tree Regrowth response to cutting trenches in Peel hardpan	J Bartle
11/90	Integration of plantations of *Eucalyptus globulus* on farmland and its effect on groundwater and impact on production of adjacent pasture	R Silverstein

RPP No	TITLE	PRINCIPAL INVESTIGATOR
12/90	Integration of plantations of *E. globulus* on farmland and its effect on drain runoff quantity and quality (with particular emphasis on phosphorus leaching).	R Silverstein
13/90	Comparison of production of plantation of *E. globulus* on farmland with standard farm practice on the leaching sands of the Swan Coastal Plain.	R Silverstein
36/90	Post planting control of recurrent weeds in *E. globulus* plantations using pre and post emergent herbicides applied with a side delivery nozzle.	J Winchcombe
37/90	Comparison of thirteen pre-plant herbicide treatments, plus control, on the establishment and growth of *E. globulus* seedlings.	J Winchcombe
38/90	The use of controlled release "Marshall suSCon" insecticide granules in the control of African Black Beetle in *E. globulus* plantations	J Winchcombe
39/90	The effect of stocking density on productivity and droughting of *E. globulus* plantations established in the low rainfall zones (700 mm mean annual rainfall in the south west of Western Australia.	G Ellis
40/90	Fertilization of *E. globulus* plantations established on ex-pastured sites with (1) DAP fertilizer tablets and (2) DAP. Agras #1 and NPK Blue Special	G Ellis
41/90	The influence of container type and volume, and root inhibiting paint on the survival and performance of *E. globulus* seedlings planted on farmland in the South West of Western Australia	G Ellis
42/90	Multi-Factor Experiment. The influence of seedling container type, site preparation, weed control and fertilizer in the establishment of *E. globulus* plantations on farmland in the south west of Western Australia	G Ellis
43/90	Plaid density design for investigation of the effect of stocking density and espacement on the productivity of *E. globulus* plantation.	G Ellis
44/90	The effect of mounding and scalping on the survival and early growth of *E. globulus* seedlings established in deep, grey siliceous sands on the Swna Coatal Plain.	G Ellis
45/90	N P factorial fertilizer trial plus comparison with formulated fertilizer mixes - DAP. Agras Cu Zn Mo. Slow release tree tablet	G Ellis
46/90	N P factorial fertilizer trial - the role of nitrogen and pghosphorus in the establishment of *E. globulus* on farmland in the south west of W.A.	G Ellis
47/90	The benefits of various levels of post planting manual weed control in the establishment of *E. globulus* plantations.	G Ellis
48/90	Comparison of Roundup/Oust and Roundup/Simazine herbicide sprays for the establishment of *E. globulus* seedlings on farmland.	G Ellis
49/90	The role of lime, phosphorus and potassium in the establishment of *E. globulus* plantations on ex-bush acid sands	G Ellis
50/90	DAP, Agras + Co Zn Mo, tree tablet fertilizer timing trial	G Ellis
51/90	The short and long term benefits of weed control in the establishment of *E. globulus* plantations	

NATIVE FOREST SILVICULTURE

Jarrah Forest

49/65	Growth rates of pile-sized jarrah in even-aged forest at various stockings	S Crombie
15/66	Jarrah pole thinning - young poles (chalk)	S Crombie
1/77	Forest stand manipulation to increase water production	S Crombie
24/82	Enrichment planting trial	G Strelein
20/82	Comparison of the effects of a number of alternative silviculture prescriptions	S Crombie
17/83	Seasonal growth of jarrah	S Crombie
18/83	Jarrah seeding establishment trial	G Strelein
19/83	Fertilizing seeded jarrah	G Strelein
20/83	Jarrah planting establishment trials	G Strelein
23/83	Jarrah site classification project	G Strelein
12/84	Jarrah fertilizer trials 1984	G Strelein
13/84	Jarrah espacement and lignotuber development trial	G Strelein
16/83	Hydrological study of the Yarragil catchment relating quality and quantity of landscape and forest treatments	S Crombie
37/84	Comparison of round-up and Tordon timber control for killing standing jarrah and marri poles in summer	S Crombie

RPP No	TITLE	PRINCIPAL INVESTIGATOR
30/85	Rehabilitation of the dieback degraded Warren Catchment and its effect on water quality and quantity	S Crombie
34/85	The effect of delays between notching and application of roundup herbicide	S Crombie
35/85	Effect of concentration of herbicide and stand density on efficacy of Round-up for killing jarrah stump coppice by foliar spray	S Crombie
36/85	The effect of notch spacing on the success of notching with Round-up herbicide	S Crombie
37/85	Comparison of Round-up and Tordon timber control for killing standing jarrah and marri poles in winter	S Crombie
39/85	The effect of Round-up dose on its ability to kill standing jarrah and marri poles in winter using the notching method	S Crombie
40/85	The effect of coverage of foliar spray of Round-up on its ability to kill coppice	S Crombie
41/85	The effect of fire on the success of notching jarrah and marri with Round-up herbicide	S Crombie
3/86	Response of hydrologically important measures of forest density	S Crombie
6/86	Jarrah lignotuber and root development study	G Strelein
30/86	Effect of Round-up dose on ability to kill standing jarrah and marri	S Crombie
31/86	Effect of Round-up dose	S Crombie
43/86	Effects of site preparation inoculation and timing of fertilizer	G Strelein
3/87	Study of genetic variation in growth and form of jarrah	R Mazanec
6/87	Jarrah family/provenance trials	R Mazanec
2/88	Jarrah pole thinning (Inglehope)	S Crombie
11/89	Survey of genetic structure of main range jarrah forest using isozymes	R Mazanec
17/89	Effect of fertilizer on successful regeneration of *E. marginata* using broadcast seeding and mechanical disturbance	P Hewett
Karri Forest		
28	Genetic variability and breeding systems in karri	D Coates
26/78	Karri provenance trials	R Mazanec
15/82	Karri spacing experiment: Nairn	P Hewett
3/84	The effect of thinning, fertilization, and coppice control on growth and form of crop trees	P Hewett
25/85	Basal area thinning experiment - Treen Brook	P Hewett
19/86	Karri site classification	G Inions
25/86	Karri spacing experiment : Muirillup	P Hewett
3/89	The effect of thinning and fertilizing on the growth and form of crop trees on a 21 year old regrowth karri stand	P Hewett
13/89	Sheltercup sowing of *E. diversicolor* seed in regeneration coupes	P Hewett
24/89	Success of infilling karri (*E. diversicolor*) seedlings in 1yr old coupes	P Hewett
WETLANDS AND WATERBIRDS		
*	Analysis of data from the 1981/85 Waterbird Survey project and data on physical characteristics of wetlands to determine how physical parameters affect waterbird usage of wetlands and to define the ecological preferences of individual waterbird species	S Halse
*	Surveys of aquatic invertebrates in the South west to gain a preliminary idea of the conservation status of different groups and species and to develop an understanding of how the physical characteristics of a wetland affect its species richness and composition	S Halse
*	Measurement of pesticide levels in the environment and biota of Herdsman Lake and other metropolitan lakes. Joint project with Dr J Davis (Murdoch University) and Mr G Ebell (Chemistry Centre W.A.)	S Halse
*	Study of dietary selection in waterfowl in relation to availability of potential foods	S Halse
*	Ostracod taconomy	S Halse
*	Description of vegetation of wetlands of South west to provide data for long-term monitoring. Joint project with Dr P Wilson (Herbarium)	S Halse
*	Publication of results of the 1986-88 joint CALM-RAOU surveys of remote wetlands of probable international importance (RAOU)	J Lane
*	Examination of levels of exposure of native waterfowl to lead shot. Incidence of ingested lead pellets and lead levels in wing bones is being studied	J Lane
*	Annual monitoring of water levels and water quality of a sample of south-west wetlands to assist in determinating of duck shooting seasons and as a part of CALM's broader program of monitoring of the condition of the conservation estate	J Lane

RPP No	TITLE	PRINCIPAL INVESTIGATOR
*	Publication of results of 1986-88 surveys of waterbird usage of a number of important, poorly known, wetland sites in south-western Australia (RAOU)	J Lane
*	Investigation of potential for lowering salt levels of Yenyenning Lakes (Yenyenning Lakes Inter-Departmental Working Group)	J Lane
*	Preparation of waterbird protection guidelines for Vasse and Wonnerup estuaries	J Lane
*	Surveys of aquatic invertebrates in the fringing marsh of Leschenault Inlet and the diet of waterbirds in the Inlet to determine the effects of various methods of mosquito control on conservation values	S Halse

WOOD UTILIZATION

30/82	Wood quality of pinaster and radiata pine	G Siemon
7/86	Sawmilling and slicing trial on thinnings from Inglehope Plots	G Brennan
9/86	Effect of drying method on Lyctus susceptibility of W.A. sheoak and regrowth karri	G Brennan
26/86	Strength properties of regrowth eucalypts	G Siemon
41/86	Durability of Western Australian grown timber species	G Siemon
18/87	Sawing regrowth Karri from areas of high, medium and low site qualities and differing ages	G Brennan
6/88	Seasoning - Pre-drying eucalypt timbers from green to below fibre saturation point (f.s.p.) using a batch kiln	G Brennan P Newby (Forest Resources)
46/88	Brown wood in karri	E Davison
2/89	Effect of degrade in mature jarrah flitches on veneer recoveries	G Siemon
4/89	Sawn graded recoveries from a sawmilling trial of regrowth jarrah and karri	K White (Forest Resources)
14/89	Field survey of incidence of brown wood in regrowth karri	E Davison
25/89	Stability of regrowth and mature karri panels constructed from boards	P Newby (Forest Resources)
31/89	Effect of pre-steaming and hot water soaking on the drying behaviour of jarrah boards	B Glossop
33/89	An equilibrium moisture content survey of timber in Western Australia	T Jones (Forest Resources)
15/90	Field testing on an ultrasonic moisture meter	B Glossop
16/90	Treating *E. globulus* fence posts using four timber preservators	G Brennan

Appendix III

Directory of Expertise of Permanent Professional and Technical Staff

ABORIGINAL KNOWLEDGE	BURBIDGE, A.A.
ABORIGINAL LIAISON	BURBIDGE, A.A. ; FULLER, P. ; PEARSON, D. ; PRINCE, R. ; START, T.
ACACIAS	MASLIN, B.
AGROFORESTRY	JENKINS, P. ; MOORE, R.
ANGIOSPERMS, AQUATIC	MARCHANT, N.
ANIMALS see also FAUNA	
ANIMALS - ECOLOGY	KINNEAR, J.
ANIMALS - NUTRITION	KINNEAR, J.
ANIMALS - PHYSIOLOGY	KINNEAR, J.
APIACEAE	KEIGHERY, G.
ARC-INFO	PIGGOTT, P.
ARID ZONES see also DESERTS	
ARID ZONES - ECOLOGY	START, T.
ARID ZONES - FLORA - IDENTIFICATION	CRANFIELD, R.
ARID ZONES - FLORA - SURVEYS	CRANFIELD, R.
ARID ZONES - MAMMALS	PEARSON, D.
ARID ZONES - MAMMALS (SMALL)	GARDNER, J.
ARID ZONES - REPTILES	GARDNER, J. ; PEARSON, D.
ARMILLARIA	SHEARER, B.
ASTERACEAE - HELICHRYSUM	WILSON, P.
ASTERACEAE - HELIPTERUM	WILSON, P.
ASTERACEAE - OLEARIA	LANDER, N.
BANDICOOTS	FRIEND, T.
BATS	START, T.
BEAUFORTIA	BURBIDGE, A.A.
BIOGEOGRAPHY	McKENZIE, N.
BIOGEOGRAPHY - FAUNA - ISLANDS	MORRIS, K.
BIOGEOGRAPHY - ISLANDS	ABBOTT, I.
BIOGEOGRAPHY - PLANTS	GIBSON, N.
BIOLOGICAL SURVEY TECHNIQUES	LEFTWICH, T. ; ONUS, M.
BIOMETRICS	GLOSSOP, B. ; WARD, D. ; WILLIAMS, M.
BIRD PESTS	HALSE, S.
BIRDS	FULLER, P. ; START, T.
BIRDS see also FAUNA	
BIRDS - CONSERVATION	BURBIDGE, A.H.
BIRDS - DISTRIBUTION	BURBIDGE, A.H.
BIRDS - ECOLOGY	ABBOTT, I. ; BURBIDGE, A.H.
BIRDS - EGGS	FULLER, P.
BIRDS - POPULATION DYNAMICS	HALSE, S.
BOTANICAL HISTORY	CURRY, S. ; MARCHANT, N.
BURCHARDIA	MACFARLANE, T.
CANKERS	SHEARER, B.
CANNABIS IDENTIFICATION	PATRICK, S.
CAPTIVE BREEDING	FRIEND, T.
CHAMAEXEROS	MACFARLANE, T.

KARRI FOREST - WATER RELATION	CROMBIE, S.
KELLERBERRIN RESERVES	HOPKINS, A.
KIMBERLEY FLORA	KENNEALLY, K. ; KOCH, B.
KIMBERLEY RESERVES	BURBIDGE, A.A.
KWONGAN	HOPKINS, A.
LILACEAE - WESTERN AUSTRALIA	KEIGHERY, G.
LOGANIACEAE	PERRY, G.
LOMANDRA	MACFARLANE, T.
MACROPODS - ECOLOGY	ALGAR, D.
MACROPODS - MANAGEMENT	ALGAR, D.
MALVACEAE - PLAGIANTHUS	LANDER, N.
MAMMALS	BURBIDGE, A.A. ; FRIEND, T. ; START, T.
MAMMALS see also FAUNA	
MAMMALS (NATIVE)	McKENZIE, N.
MAMMALS (NATIVE) - BIOLOGY	MORRIS, K,
MAMMALS (NATIVE) - PHYSIOLOGY	MORRIS, K.
MAMMALS (SMALL) - ARID ZONES	GARDNER, J.
MAMMALS (SMALL) - SURVEYS	WILLIAMS, A.
MAMMALS - ARID ZONES	PEARSON, D.
MAMMALS - FOREST	MAISEY, K.
MAMMALS - SPECIES STUDIES	FRIEND, T.
MANGROVES	HOPKINS, A.
MANJIMUP PLOT REGISTER	ROBINSON, A.
MARIJUANA IDENTIFICATION	PATRICK, S.
MARINE BIOLOGY	STODDART, J.
MICROBIOLOGY	KINNEAR, J.
MIDGES - CONTROL	LANE, J. ; PEARSON, G.
MIMOSACEAE - ACACIA	MASLIN, B.
MINING - REHABILITATION	HOPKINS, A. ; MAZANEC, R.
MOSQUITOES - CONTROL	PEARSON, G.
MOUNT LESUEUR	HOPKINS, A.
MYCOLOGICAL PLANT DISEASES	DAVISON, E. ; TAY, F.
MYRTACEAE - BEAUFORTIA	BURBIDGE, A.A.
MYRTACEAE - CHAMELAUCIUM	KEIGHERY, G. ; MARCHANT, N.
MYRTACEAE - DARWINIA	KEIGHERY, G. ; MARCHANT, N.
MYRTACEAE - EUCALYPTUS	HOPPER, S.
MYRTACEAE - REGELIA	BURBIDGE, A.A.
NATIONAL PARK MANAGEMENT	START, T.
NATURALIZED FLORA	PERRY, G.
NATURALIZED FLORA - WESTERN AUSTRALIA	PATRICK, S.
NATURE RESERVE MANAGEMENT	START, T.
NOISY SCRUB BIRD	BURBIDGE, A.A.
NOISY SCRUB BIRD - TRANSLOCATION PROGRAM	WHEELER, I.
NORTHERN SANDPLAINS	HOPKINS, A.
NUMBATS	FRIEND, T.
OLEARIA	LANDER, N.

OPERCULARIA	KEIGHERY, G.
ORCHIDS - BIOLOGY	BROWN, A.
ORCHIDS - IDENTIFICATION	BROWN, A. ; HOPPER, S.
PAPILIONACEAE - PULTENEAE	MACFARLANE, T.
PERUP FIELD COURSE	LIDDELOW, G.
PESTICIDES	HALSE, S.
PESTS - BIRDS	HALSE, S.
PHYTOCHEMISTRY	ARMSTRONG, J.
PHYTOGEOGRAPHY	HOPPER, S.
PHYTOPHTHORA	SHEARER, B.
PINE - SILVICULTURE	HINGSTON, R. ; JENKINS, P. ; MOORE, R.
PLAGIANTHUS	LANDER, N.
PLANTS see also FLORA, TREES	
PLANTS (NATIVE) - HORTICULTURE	BROWN, A.
PLANTS - AQUATIC	MARCHANT, N.
PLANTS - BIOGEOGRAPHY	GIBSON, N.
PLANTS - BIOLOGY	LYONS, M.
PLANTS - CHEMISTRY	ARMSTRONG, J. ; McGRATH, J.
PLANTS - DISEASES	CRANE, C. ; HILL, T. ; SHEARER, B. ; STUKELY, M.
PLANTS - DISEASES - CONTROL	SHEARER, B.
PLANTS - DISEASES - EPIDEMIOLOGY	SHEARER, B.
PLANTS - DISEASES - MYCOLOGY	DAVISON, E. ; TAY, F.
PLANTS - DISEASES - RISK & HAZARD RATING	SHEARER, B.
PLANTS - ECOLOGY	GIBSON, N. ; LYONS, M.
PLANTS - EVOLUTION	HOPPER, S.
PLANTS - GEOGRAPHY	HOPPER, S.
PLANTS - GRANITE OUTCROPS	HOPPER, S.
PLANTS - IDENTIFICATION	ANNELS, A. ; CRANFIELD, R. ; PATRICK, S.
PLANTS - NAMES	PERRY, G. ; WILSON, P.
PLANTS - NUTRITION	McGRATH, J.
PLANTS - PATHOLOGY	TAY, F.
PLANTS - PHYLOGENY	ARMSTRONG, J.
PLANTS - POISONOUS	PATRICK, S.
PLANTS - POPULATION BIOLOGY	COATES, D.
PLANTS - POPULATION DYNAMICS	VAN LEEUWEN, S.
PLANTS - SPECIES SELECTION	MAZANEC, R.
PLANTS - SYSTEMATICS	COATES, D. ; HOPPER, S.
PLOT REGISTER - DWELLINGUP	DILLON, M.
PLOT REGISTER - MANJIMUP	ROBINSON, A.
POISONOUS PLANTS	PATRICK, S.
POLLINATION BIOLOGY	LYONS, M.
POLLINATION ECOLOGY	ARMSTRONG, J. ; HOPPER, S. ; VAN LEEUWEN, S.
POPULATION BIOLOGY - PLANTS	COATES, D.
POPULATION CENSUS TECHNIQUES	BROMILOW, B. ; ONUS, M.
POPULATION DYNAMICS - BIRDS	HALSE, S.
POPULATION DYNAMICS - PLANTS	VAN LEEUWEN, S.
PROTEIN ELECTROPHORETIC TECHNIQUES	COATES, D.

PROVENANCE VARIATION & TESTING	MAZANEC, R.
PULTENEAE	MACFARLANE, T.
RADIO TRACKING	BROMILOW, B. ; FRIEND, T. ; LEFTWICH, T. ; ONUS, M.
RARE FAUNA	FRIEND, T.
RARE FLORA	BROWN, A. ; HOPPER, S. ; VAN LEEUWEN, S.
RARE FLORA - SURVEYS	CRANFIELD, R.
RECHERCHE ARCHIPELAGO	HOPKINS, A.
RECRUITMENT	STODDART, J.
REGELIA	BURBIDGE, A.A.
REHABILITATION	HOPKINS, A. ; MAZANEC, R.
REMNANT BUSHLAND - WEEDS	PIGOTT, P.
REPTILES see also FAUNA	
REPTILES - ARID ZONES	GARDNER, J. ; PEARSON, D.
REPTILES - DISTRIBUTION	ROLFE, J.
REPTILES - IDENTIFICATION	ROLFE, J.
RESERVES - URBAN - MANAGEMENT	PIGOTT, P.
RISK & HAZARD RATING	SHEARER, B.
RODENTS (NATIVE) - BIOLOGY	MORRIS, K.
RODENTS (NATIVE) - PHYSIOLOGY	MORRIS, K.
RUBIACEAE - OPERCULARIA	KEIGHERY, G.
RUTACEAE	ARMSTRONG, J. ; WILSON, P.
SAFETY	ROONEY, J.
SAWMILLING	BRENNAN, G.
SEA BIRDS	BURBIDGE, A.A.
SHARK BAY REGION	PRINCE, R.
SILVICULTURE	CALVERT, G.
SILVICULTURE - HARDWOOD	CHRISTENSEN, P.
SILVICULTURE - SOFTWOOD	BUTCHER, T. ; CHRISTENSEN, P. ; HINGSTON, R. ; JENKINS, P. ; MOORE, R.
SOIL ZOOLOGY	FRIEND, T.
SPECIES SELECTION (PLANTS)	MAZANEC, R.
SPECIES STUDIES (MAMMALS)	FRIEND, T.
STATISTICS	GLOSSOP, B. ; READ, B. ; WHITFORD, K.
STATISTICS - MATHEMATICAL	WARD, D. ; WILLIAMS, M.
STIRLING RANGES	HOPKINS, A.
TAXIDERMY	WILLIAMS, A.
THYMELAEACEAE	RYE, B.
TORTOISES	BURBIDGE, A.A.
TORTOISES - WESTERN SWAMP	FULLER, P.
TREES see also FLORA, PLANTS	
TREES - BREEDING	BUTCHER, T. ; SANDERS, C. ; STRITOF, J.
TREES - CROPPING SYSTEMS FOR FARMS	BARTLE, J.
TREES - EVAPOTRANSPIRATION	BARTLE, J.
TREES - GENETICS	BUTCHER, T.
TREES - GROWTH	CROMBIE, S.
TREES - WATER RELATIONS	McGRATH, J.
TREMANDRACEAE - WESTERN AUSTRALIA	ALFORD, J.

TRIBONANTHES	MACFARLANE, T.
TUART	PIGOTT, P.
TURTLES	BURBIDGE, A.A.
TURTLES - MARINE	PRINCE, R.
TUTANNING RESERVES	HOPKINS, A.
TWO PEOPLES BAY RESERVE	HOPKINS, A.
URBAN RESERVE MANAGEMENT	PIGOTT, P.
VERTEBRATES (SMALL)	FRIEND, G. ; MITCHELL, D.
VERTEBRATES - SURVEYS	WILLIAMS, A.
WALPOLE-NORNALUP NATIONAL PARK	WARDELL-JOHNSON, G.
WATER - NUTRIFICATION	BARTLE, J.
WATER - QUALITY	BARTLE, J.
WATER - QUANTITY	BARTLE, J.
WATER - RESOURCES	BARTLE, J.
WATER - SALINITY	BARTLE, J.
WATER BIRDS	HALSE, S. ; LANE, J. ; MUNRO, D. ; PEARSON, G.
WEEDS - REMNANT BUSHLAND	PIGOTT, P.
WESTERN SWAMP TORTOISE	FULLER, P.
WETLANDS	HALSE, S. ; LANE, J. ; MUNRO, D. ; PEARSON, G.
WHEATBELT	HOPKINS, A.
WILDFLOWER INDUSTRY	BROWN, A.
WILDLIFE MANAGEMENT	PRINCE, R.
WOOD - PROPERTIES	BRENNAN, G.
WOOD - QUALITY	TAY, F.
WOOD - SEASONING	BRENNAN, G. ; GLOSSOP, B.
WOOD - UTILIZATION	SIEMON, G.
WOODLANDS - RISK & HAZARD RATING	SHEARER, B.
WURMBEA	MACFARLANE, T.

Appendix IV
Representation of Research Staff on Committees

Research Scientists

Internal	External Representing Department	External Non-Departmental
IAN ABBOTT Research Division Policy Group Scientific Publications Editorial Committee Library Committee	AFC-RWG 8 - Forest Entomology	Journal of Australian Entomological Society - member of editorial board
JIM ARMSTRONG Research Division Policy Group	Floriculture Industry Advisory Committee (Dept. of Agriculture) CONCOM WG on Endangered Flora National Cultural Heritage Committee (Expert Examiner)	Aust Academy of Science 'Flora of Australia sub-committee' of the National Committee for Plant Sciences Aust Flora Foundation (Director) Aust Flora Foundation Research Committee National Forensic Resource Registrant of the National Police Research Unit
JOHN BARTLE Research Division Policy Group (as required)	Integrated Catchment Management Policy Group (Deputy) Steering Committee for research on Land Use and Water Supply Forest Management Subcommittee Bauxite Subcommittee Water Resource Catchment Rehabilitation Sub-committee Coastal Plain Land Management Subcommittee Peel Inlet Management Authority Peel-Harvey Implementation Steering Group	
GARY BRENNAN WURC Management Committee	Timber Seasoning Working Group Wood Properties Research Working Group	
FELICITY BUNNY Phytophthora Technical Review Committee		
ALLAN BURBIDGE Endangered Fauna Working Group		RAOU WA Group Research Committee
ANDREW BURBIDGE Corporate Executive Research Division Policy Group Finance & Budget Committee Vacancies Committee Classification Review Committee Conservation Lands Acquisition Committee Nature Conservation and National Parks and Trust Account Committee	Commonwealth Endangered Species Advisory Committee Biological Surveys Committee (Chair) Scientific Advisory Committee, World Wild Fund for Nature Australia	ANZAAS, State Executive Committee (Chair) IUCN Species Survival Commission, Australian Marsupials Specialist Group IUCN Species Survival Commission, Tortoise & Freshwater Turtle Specialist Group
NEIL BURROWS Perup Ecology Centre Volunteer Co-ordinator Protection Branch Meetings Dryandra State Forest Planning Team Co-ordinator - Desert Fire Research	AFC - RWG6 - Fire Management Bush Fires Board	
TREVOR BUTCHER	AFC - RWG Forest Genetics Technical Committee - Gnangara Mound Recharge Southern Tree Breeding Association Eucalyptus Globulus Breeding Association	

Internal	External Representing Department	External Non-Departmental
MIKE CHOO Research Division Computer Users Group CALM Corporate Data Steering Committee	LISSC - Vax Users Group WALIS - Restricted Site Databases	
PER CHRISTENSEN Research Division Policy Group	Research Steering Committee Australian Forestry Council Directors of Research Committee WURC Policy Panel Aquatic Ecosystems Research Sub-committee	
DAVID COATES Wildflower Industry Review Committee. Endangered Flora Consultative Committee	Floriculture Industry Advisory Committee	
STUART CROMBIE Scientific Publications Editorial Committee Phytophthora Technical Review Committee	Research Steering Committee - Bauxite Sub-committee AFC-RWG9 Forest Hydrology	
ELAINE DAVISON Library Committee		Australasian Plant Pathology Society WA Regional Councillor
GORDON FRIEND Roadside Vegetation Conservation Workshop Committee CALM/CSIRO Research Co-ordinating Committee		
TONY FRIEND Dryandra State Forest Planning Team	Numbat Breeding Management Advisory Committee CONCOM WG on Endangered Fauna	IUCN Species Survival Commission Re-introduction Specialist Group
NEIL GIBSON	Interdepartmental Committee on Mineral Exploration in D'Entrecasteaux National Park	
STUART HALSE	Gnangara Mound Wetlands Technical Subcommittee Land Salination Working Group (Research Steering Committee on Land Use and Water Supply) WAWA Research Projects Steering Committee Jandakot Groundwater Discussion Group	Australian Society for Limnology Executive
PENNI HEWETT	AFC - RWG4 - Native Forest Silviculture (Secretary)	
ANGAS HOPKINS Two Peoples Bay N R Planning Team Monitoring Policy Implementation Committee	CONCOM WG on Mallee Conservation Mineral Sands Agreements Rehabilitation Co-ordinating Committee	Ecological Society of Australia Council
STEVE HOPPER Research Division Policy Group Wildflower Industry Review Committee Endangered Flora Consultative Committee	EPA Task Force on Red Book Reserve Recommendations EPA Working Group on Land Releases IUCN Species Survival Commission Orchid Specialist Group IUCN Species Survival Commission Australasian Plant Specialist Group	Australian Pollination Ecologists Society - Secretary Australian Orchid Foundation Research Committee Australian Flora Foundation Research Committee

Internal	External Representing Department	External Non-Departmental
GREG KEIGHERY	CONCOM Weeds Group	President Perth Branch W.A. Wildflower Society
KEVIN KENNEALLY Scientific Publications Editorial Committee Nuytsia Editorial Board	Herdsman Lake Management Committee Natural Environment Evaluation Panel (WA) of the Australian Heritage Commission	W.A. Naturalists' Club - Co-ordinator Wongan Hills Biological Survey Committee W.A. Naturalists' Club - Editor W.A. Gould League - President
NICHOLAS LANDER Flora Information Publication Committee (Chair)		
JIM LANE Vasse-Wonnerup Working Group	Midge Research Steering Committee (Chair) CONCOM WG on International Agreements Relating to Migratory and Wetland Birds Yenyenning Lakes Working Group (Chair) Associated Minerals Consolidated Wetlands Management Committee	
TERRY MACFARLANE Nuytsia Editorial Board		Australian Systematic Botany, CSIRO Editorial Committee
NEVILLE MARCHANT Nuytsia Editorial Board Flora Information Publication Committee (Chair)		Secretary, South-east Asian Botanical Program (UNESCO) Member, Scientific Advisory Board, Asian Co-ordinating Group for Chemistry
JOHN MCGRATH	AFC - RWG3 - Forests Soils and Nutrition AFC - RWG5 - Plantation Silviculture	
LACHLAN MCCAW Regional Leaders Group - Southern Forest Region Protection Branch Meetings	AFC - RWG6 - Fire Management (Secretary)	
NORM MCKENZIE Pastoral Areas Conservation Steering Committee		
RICHARD MOORE Central Forest Region, Regional Leaders' Group	Water Resource Catchment Rehabilitation Subcommittee WA Agroforestry Working Group National Agroforestry Working Group	International Tree Crops Institute (Committee Member)
KEITH MORRIS	Montebello Islands Planning Team Dampier Archipelago Working Team NW Island Management Committee	
SUSAN PATRICK Flora Information Publication Committee		Swan Shire Wandoo Heights Management Committee
DAVID PEARSON	Technical Workshop on the management of spinifex deserts for nature conservation	
GILLIAN PERRY	Biological Control Committee (Department of Agriculture)	Special Committee on lectotypification International Association of Plant Taxonomists
PATRICK PIGOTT CALM Rural Advisers Committee		

Internal	External Representing Department	External Non-Departmental
BOB PRINCE Kangaroo Management Review Group of Fauna Committee, NPNCA Dampierland Aboriginal Training Program - Project Work Working Group, Wildlife Conservation Act Revision Marine Working Group		IUCN Species Survival Commission, Sirenia Specialist Group Marine Turtle Specialist Group
BARBARA RYE Kimberley Flora Committee		
BRYAN SHEARER Dieback Photography Committee Phytophthora Technical Review Committee	Research Steering Committee - Forest Management Sub-committee Department of Agriculture - P. cinnamomi Working Party AFC -RWG7 - Forest Pathology	
GRAEME SIEMON Wood Utilization Research Centre Management Committee	Wood Fibre Research Advisory Group (representing the Standing Committee of the Australian Forestry Council WA Softwood Producers Association Technical Committee Standards Australia State Committee WA Pesticides Advisory Committee (Reviewer)	
TONY START Research Division Policy Group CALM Training and Career Development Group Hamersley Range N.P. Planning Group Rudall River N.P. Planning Group	(Perth) Millstream Management Committee	
JIM STODDART Marine Working Group Marine Parks and Reserves Selection Working Group Regional Leaders Group, Metro	Interdepartmental Committee on Aquaculture	International Society for Reef Studies - Editorial Board 'Coral Reef' WA Govt Scientific Diving Working Group DOHSW Working Party on Occupational Diving
MIKE STUKLEY Phytophthora Technical Review Committee	Research Steering committee - Bauxite Sub-committee	
DAVID WARD Corporate Data Steering Committee Research Division, Computer Users Group		
GRANT WARDELL-JOHNSON	AFC - RWG10 - Forest Fauna Walpole-Nornalup National Park Management Plan Committee	Sub-regional Co-ordinator South-west Australian Bird & Bat Banding Scheme
MATTHEW WILLIAMS Research Division, Computer Users Group		
RAY WILLS Phytophthora Technical Review Committee		
PAUL WILSON Library Committee		Bureau of Flora and Fauna Flora of Australia Committee International Seed Testing Association Nomenclature Committee Australian Systematic Botany Society: Flora of Central Australia Committee

Technical Support Staff

Internal	External Representing Department	External non- Departmental
TONY ANNELS		Manjimup Natural History Club
ANDREW BROWN Wildflower Industry Review Committee	WA Native Orchid Study and Conservation Group Endangered Orchid Species Working Group	
RAY CRANFIELD CALM Safety Committee	Department of Agriculture Laboratory Safety Committee	
RICHARD FAIRMAN Safety Committee		
PHIL FULLER Chemicals Committee		
BRETT GLOSSOP Computer Users Group	Timber Seasoning Working Group	
GRANT PEARSON	Mosquito Control Review Committee	
BETH READ Research Division, Computer Users Group		
RON SOKOLOWSKI Wildflower Industry Review Committee		
KIM WHITFORD Research Division, Computer Users Group		
ANDY WILLIAMS Firearms Policy Committee		
YVONNE WOODS Research Division, Computers Users Group	Husky Hunters Users Group	

Appendix V
Allocation of Time by Permanent Staff to Research and Extension

Research within the Division is divided into three categories i.e. actual research activities, extension within CALM and extension outside CALM. These areas are defined as follows:

Research Activities: - this is the time spent on actual research and includes planning, organizing, data collection, data analysis and writing up.

Extension within CALM: - this includes time spent on sitting on committees within CALM, answering queries from within CALM, and communicating research results to managers and other staff.

Extension outside CALM: - this includes time spent on representing CALM on external committees, attending seminars outside CALM, and attending to public enquiries

The tabulation below indicates the break-up of time (%) for both professional and technical staff in these areas.

*indicates Professional Staff

	Research Activities	Extension within CALM	Extension outside CALM	Administration
*Abbott, I	40	10	10	40
Alford, J	80	15	5	
*Algar, D	85	10	5	
Annels, A	80	10	10	
*Armstrong, J.	20	10	10	60
*Bartle, J	30	20	20	30
Birmingham, T	95	4	1	
*Brennan, G	85	7.5	7.5	
Bromilow, B	100			
Brown, A	60	30	10	
Buehrig, R	95	5		
Bunny, F.	100			
*Burbidge, AA	20	35	5	40
*Burbidge, AH	80	15	5	
Burbidge, T	90	5	5	
*Burrows, N	70	10	5	15
*Butcher, T	80	10	10	
*Chapman, A	100			
*Choo, M	90	10		
*Christensen, P	20	25	15	40
*Coates, D	60	15	15	10
Crane, C	90	10		
Cranfield, R		50	50	
*Crombie, S	60	10	10	20
Cully, M	100			
Curry, S.		50	50	
*Davison, E	70	25	5	
Dillon, M	94	5	1	
Dumbrell, I	100			

	Research Activities	Extension within CALM	Extension outside CALM	Administration
Fairman, R	98	2		
Farr, J	80	10	10	
Freeman, I	98	2		
*Friend, G	80	15	5	
*Friend, J	70	10	10	10
Fuller, P	90	5	5	
Gardner, J.	85	10	5	
*Gibson, N.	80	15	5	
Giles, R	68	2		30
*Gioia, P	90	10		
Glossop, B	85	7.5	7.5	
*Halse, S	50	30	20	
*Hewett, P	80	15	5	
Hingston, R	90	10		
*Hopkins, A	60	20	20	
*Hopper, S	25	15	20	40
Jenkins, P	70	10	10	10
*Keighery, G	60	20	10	10
*Kenneally, K	90		10	
Kinal, J	98	2		
*Kinnear, J	80	10	10	
*Koch, B (0.5 FTE)	60	20	20	
*Lander, N	75	10	5	10
Langley, M	100			
*Lane, J	30	10	10	50
Leftwich, T	100			
Liddelow, G	70	15	15	
Lyons, M	90	5	5	
*Macfarlane, T	90	5	5	
Maisey, K	90	10		
*Marchant, N	40	15	15	30
*Maslin, B	80	5	5	10
Mason, M	95	5		
*Mazanec, R	95	5		
McArthur, S	100			
*McCaw, L	70	5	5	20
McDonald, D	100			
*McGrath, J	60	20		20
*McKenzie, N	80	10	10	
Mitchell, D	90	10		
*Moore, R	60	10	20	10
*Morris, K	80	10	10	
Munro, D	80	5	5	10
Neal, J	90	10		
Onus, M	95	5		

	Research Activities	Extension within CALM	Extension outside CALM	Administration
Parker, C (0.5 FTE)		50	50	
*Patrick, S	75	20	5	
*Pearson, D	85	10	5	
Pearson, G	65	10	5	20
*Perry, G	95		5	
*Piggot, P	60	20	20	
Portlock, C	94	2	4	
*Prince, R	80	10	10	
Read, B	80	10		10
Robinson, A	90	5	5	
Rolfe, J	95	2.5	2.5	
Rooney, J	70	5	5	20
*Rye, B (0.5 FTE)	90	5	5	
Sanders, C	90			10
Searle, J (0.5 FTE)		50	50	
*Shearer, B	78	10	2	10
*Siemon, G	60	10	10	20
Skinner, P	90		10	
Smith, R	100			
Sokolowski, R	85	5		10
Spencer, P		50	50	
*Start, T	35	15	10	40
*Stoddart, J	25	40	25	10
Stritoff, J	100			
*Stukely, M	60	40		
Tay, F	75	25		
Thomas, N	95		5	
Thomson, A	85	7.5	7.5	
Van Heurck, P	90	5	5	
*Van Leeuwen, S	90	10		
Vellios, C	100			
Ward, B	90	10		
Ward, C	100			
*Ward, D	90	10		
*Wardell-Johnson, G	70	15	15	
*Wheeler, J	90	5	5	
Whitford, K	88	2	10	
Williams, A	90			10
*Williams, M	90	10		
Wills, A	100			
Wills, R	80	15		5
*Wilson, P	90	5	5	
Wong, L	100			
Woods, Y	100			

Appendix VI
Benefits of Research - Some Case Studies

Each revision of the Research Plan will include brief synopses of how research conducted by CALM has led to improvements in the conservation of species and/or the management of land in Western Australia.

Forest Genetics Research

An extensive tree breeding program aimed at improving wood quality, tree form and disease resistance of *Pinus pinaster* and *Pinus radiata* has been conducted in the last two decades. The current breeding population of *P. pinaster* is acknowledged as the most intensively selected and highest quality genetic resource of this species. The result is that *P. pinaster* has been transformed from a slow growing tree with generally poor form, into a relatively fast growing, straight boled tree with small branches that is suitable for sawn softwood production. Recently established second generation orchards at Manjimup promise a significantly better tree for future plantations.

Selection and breeding of *P. radiata* commenced at about the same time but the early emphasis was on the genetic improvement of *P. pinaster*. This has been achieved. Increased emphasis on *P. radiata* over the last decade has let to significant gains in both growth rate and tree form in the plantations. A major effort has been directed towards screening of the WA breeding and seed production population for resistance to infection by *Phytophthora cinnamomi*. Studies have shown that resistance of *Pinus radiata* to infection by *P.c.* is under strong genetic control and that the resistance appears to be controlled by a large number of genes, each having a small but additive effect. To minimize productivity losses in plantations it is essential that resistance to P.c. is included in the genetic makeup of the propagules used for WA plantations.

New and advanced technology seed orchards have been developed in Western Australia for the transfer of improved genetic material into plantations. HAPSO's (hedged artificially pollinated seed orchards) allow for the efficient development of breeding populations and a superior means of packaging the best genes for use as superior seedlings or cuttings for a specified performance. WA HAPSO's also allow for efficient co-ordination of the Australian breeding effort with *P. radiata*.

Softwood Silviculture

Studies of the relationship between plantation density and ground water recharge in the *P. pinaster* plantations growing on the coastal plain north of Perth demonstrated that recharge of the surface aquifers was inversely related to the density of the plantations. Virtually no recharge occurred beneath dense plantations. Thinning reduced water consumption by the plantations and increased recharge. This work has enabled the development of silvicultural strategies that accommodate both wood production and water production from the aquifers in this area. The management of the low density plantations was possible due to the selection and breeding of trees that produced small branches, and the development of pruning prescriptions that ensured that the wood quality in the lower bole was not reduced by the presence of knots.

Since the early 1970's considerable research has been directed at quantifying the benefits of site preparation, competition control and fertilization at establishment. This work has led to the successful establishment of the *P. radiata* plantations on the Donnybrook Sunkland. This area was previously considered to be too poor to grow *P. radiata* due to the infertility and seasonally waterlogged nature of this site. Mounding, fertilization and competition control techniques developed in this region have formed the basis of the establishment techniques used in the new pine sharefarming scheme based in the south coast region around Albany.

More recently a study of the relationship between productivity, drought susceptibility and environmental and site factors was conducted in the *P. radiata* plantations in the Blackwood Valley. This study was prompted by the serious losses that occurred following the drought years of 1986 and 1987. The major factors that were identified as contributing to the drought susceptibility of a site were soil depth, position in the landscape, aspect and plantation density. This information has been used to develop a model which predicts the basal area (plantation density) that can be carried on a site. This information should help minimize losses that occur following future droughts.

Silviculture and Hydrology of Native Forests

Site-vegetation type classification studies have recently been completed in both the major southern forest ecosystems (Karri and Jarrah). These systems which use indicator species to identify the sites were developed to aid operations staff in making decisions in relation to productivity, regeneration, and dieback susceptibility of the forest areas. This information should enable more efficient management of the forest resources.

Silvicultural research contributes to development of soundly based forest management strategies which maximize forest values. In the jarrah forest this has meant increasing wood and water production while preserving conservational and recreational attributes.

The larger dominant and co-dominant trees (ie. those emerging above and forming the general canopy respectively) have been found to grow at two to four times the rate of the shorter, dominated trees. Removing the dominated trees redirects the resources used by them to the more dynamic trees. This redistribution is so effective that mean annual basal area increment (the amount of wood produced per unit area of forest per year) is maintained through increased growth of the remaining trees as the number of stems is reduced from over 1000 stems per hectare (sph) to around 200 sph.

This understanding of forest dynamics has been used in developing forest management prescriptions for logging and forest improvement treatments necessary to maintain a vigorous, productive forest.

Water runoff from jarrah forest catchments is a small part (between 0 and 35%) of rainfall. The 'missing' water is mostly transpired by the forest vegetation. Understanding the complex relationships between rainfall, transpiration and the geological and atmospheric environments has enabled potential increases in water flow from catchments to be assessed. These predictions have been incorporated in planning the long term water supply options for the Perth region. The same understanding of the role of trees in regulating soil water flows has enabled areas of potential concern, particularly where forest operations might cause mobilization of soil salt, to be recognized.

Catchment scale experiments based on hydrological and silvicultural research are now demonstrating the effectiveness of thinning in simultaneously increasing both growth rate of productive trees and water yield to streams.

A technique for measuring stand leaf area by photographic techniques has been developed. The method will greatly improve our ability to measure changes in leaf area, a vital input for forest and catchment modelling.

Wood Utilization

It is essential to improve the standard of timber utilization from the State's forests, because the area available to satisfy community needs is being reduced consistently. The Small Eucalypt Processing Study, in which the Wood Utilization Research Program members are involved, commenced in 1986. It has two major achievements, the VALWOOD process, and the CALM drying system. In addition important research was done in sawmilling, timber drying, and timber processing and the results are availa... to the forest products industry.

VALWOOD uses small trees thinned from regrowth eucalypt forests to encourage the growth of the better trees. Thin boards (10 mm thickness) are sawn, dried and machined, and then edge and face-glued to produce furniture grade timber panels. Poorer quality material can be used in inner laminates, which improves the recoveries. Structural products such as crossarms for transmission poles and exposed beams can be made. The Department has issued a commercial licence with a pilot plant being established at Harvey. However, the major advantage is that the principles developed can be applied to other regrowth eucalypt species.

The CALM drying system is a low cost/low energy system relying mainly in solar energy for drying timber. There is an increasing need for drying timber to get value-added products, and this system can be used by sawmillers with small volume production, or by craftspersons who need to dry timber. The size of the kilns are scaled to the users needs.

Appendix VII

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